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Good Practice ?

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Willful blindness ?

- Charles Babbage
  - 1822 Difference Engine
  - 1837 Analytical Engine
- Konrad Zuse
  - 1931 Z1 : 1st electric programmable computer
  - 1942 Z4 : 1st commercial computer
- 1971 Intel introduces 1st microprocessor

- 2012 : Support organisations still see cases on a regular basis where critical data can not be restored from backup

G.P. 1 : don't carry over /etc/system settings

- **Tips to make Solaris slow and unpredictable**
  - set physmem=2097152
  - set kmem_flags=0xf
  - set sq_max_size=20
  - set tune_f_flckrec=640
  - set maxusers=64

- Moral 1 : Don't carry over /etc/system settings from Solaris 2.4, 8 & 9 to Solaris 10 (and beyond)
- Moral 2 : Know what each setting does
- Moral 3 : Application vendor recommended settings are often a historical relic
- *Moral 4: There is no magic*
  - Set performance_problem_fixed=1 /etc/system setting!

G.P. 2 : change control

- Tim Uglow story
- 10's of T2000's ran well for 8 hours then stopped
- Months of admin and support time
- 5 mins to find
  - Heap had been limited to 2GB during testing
  - Carried over to production
- Heap gets to 2GB, process swapped out,
- GC starts – process swapped back in again

G.P. 3 : Be sure what is fact

- Chris Gerhard story
- Long running data corruption issue
- Customer adamant workload drives I/O subsystem flat out
- Failed to reproduce in-house
- Site visit : all columns in iostat are zero
- Disk drives start house keeping when idle for > 90s
  - Disk confused where block to write when I/O re-started
- Fixed in disk firmware
- Spawned Diskomizer

G.P. 4 : Assume the worst

- Rob Hulme story('s)
- Customer A : patched in multi-user -> boot archive corrupt
    - Better alternatives available
- Large US University admissions systems
    - 3rd party driver used unpublished/private kernel interface
    - Interface changed in Kernel Update
    - messy rebuild and restore
    - HP knowledge article noted this [2nd hit on Google]
- Use ZFS snapshot & live upgrade

Patching and upgrade good practice

- Gerry Haskins blogs
- https://blogs.oracle.com/Solaris11Life/ : S11
- https://blogs.oracle.com/patch/ : S10 and below

G.P. 5 : Hassle us to fix sysadmin gotcha's

```
# mdb -kw
  > moddebug/W 1
  > exit
  BOOM !!!
```

```
# echo “moddebug/W 1” | mdb -k
```

Will be fixed in S11u1 and patched in S10

G.P. 6 : Don't forget the firmware

- Memory intensive application very slow on T2000
- Nothing obvious from any *stat tool or compiler tools
- Ran an automated Explorer check
  - Only major item reported was firmware at F.C.S.
- Out of desperation upgraded firmware
- Application ran 4 X faster
- Can tell the same story of T5440
- Firmware release frequency declines over time
- Firmware is **thicker** than it used to be

G.P. 7 : Remember physics

- 3 full config. E25K's destined for a Johanesberg car park on monday morning

- Round trip between 2 zone on same E25K about 50 micro sec.
- Round trip between 2 E25k domains over ethernet about 200 micro-sec.
- Customer architected solution straight into production
- Lots of small packets between COBOL Batch Job and Database
- Batch job 4 times slows on E25K than previous F.J.
  - Customer conclusion : E25K must have slow CPU's

G.P. 8 : Open your mind

- Large UK Bank with SAS risk management application
- Processed many T.B.'s of data in a day
- I/O bound
  - 90% of reads and write to SAS temp files about 500GB
- Which option did they choose?
  - Refresh all of large EMC frame (10 TB) with new : 2 million
  - Put SAS workspace temp directories on fast local storage : 35K
  - Put SAS workspace temp directories in memory : 300k

- Tools did not exist to demonstrate clearly what the working set was

G.P. 8 : G is for governance

- No self respecting techie wants to admit that governance is important
- Framework for decision making and determining who makes it

- sd_max_throttle=20 missing from /etc/system
- Enterprise storage solution disk queues saturated
- Serious performance issues during acceptance testing
  - Roll out delayed

- Technical problem or governance issue?
  - Why was it omitted?

G.P. 9 ZFS

- set zfs_arc_max=0x??????? (in some cases, generally not)
  - echo “::memstat” | mdb -k or echo “::arc” | mdb -k
- Recordsize property – match blocksize

```
dtrace -n 'syscall::*read:entry,syscall::*write:entry
  /fds[arg0].fi_fs == "zfs"/ { @[probefunc] = quantize(arg2); }'
  -n tick-60s'{exit(0)}'
```

- RaidZ[1,2,3] : large sequential I/O only
- Don't run perf. critical filesystems > ~80% full
- Understand what the ZFS intent log really is
- Understand workload profile
  - Sync vs async
  - Io size
  - Random vs sequential

Observing - iostat for the informed !

Ignore!

```
v4v-t5440b-gmp03(5.10)$ iostat -xnzM 1
                extended device statistics
r/s    w/s   Mr/s   Mw/s wait actv wsvc_t asvc_t  %w  %b device
5.0  102.0    0.0   64.0  0.0 12.8    0.0  119.7   0  100 c0t1d0
                extended device statistics
r/s    w/s   Mr/s   Mw/s wait actv wsvc_t asvc_t  %w  %b device
3.0  108.0    0.0   62.3  0.0 15.5    0.0  139.8   0 100 c0t1d0
                extended device statistics
r/s    w/s   Mr/s   Mw/s wait actv wsvc_t asvc_t  %w  %b device
3.0  109.0    0.0   17.1  0.0  6.3    0.0   30.1   0  35 c0t1d0
```

Observing – What's my I/O doing?

- dtrace -n syscall:::entry'{@[probefunc] = count()}'
- dtrace -n syscall::*mmap*:entry'{@[execname] = count()}'
- dtrace -n syscall::read:entry,syscall::*write:entry' {@[probefunc, execname] = quantize(arg2)}'
- dtrace -n io:::start'{@[args[0]->b_flags & O_READ ? “R” : “W”] = quantize(args[0]->b_bcount)}'
- dtrace -n io:::start'{@[fds[arg2]->fi_pathname] = sum(args[0]->b_bcount)}'

Perfect user space memory allocator

- Space efficient for all sizes of allocations
- Fast constant time allocation
- Per cpu caches for all allocation sizes
- Does no fragment under any workload
- Returns unused memory to the OS
- No thread lock contention
- Deals with legacy coding issues such as double free

The perfect allocator can not exist

Choice of User Land Memory Allocators

- Use the right allocator for the job:
  - libc – compromise of performance / space utlisation
  - libmalloc(3LIB) – space efficient /OK performance
  - libbsdmalloc(3LIB) – good perfs / space-inefficient
  - libmapmalloc(3LIB) – returns memory to OS
  - libmtmalloc(3LIB) – MT warm (recent improvements)
  - **libumem**(3LIB) – Fast. MT, can be space efficient

- libc-malloc, bsdmalloc, libmalloc → *single threaded*
- libumem or mtmalloc → *multi-threaded hot*

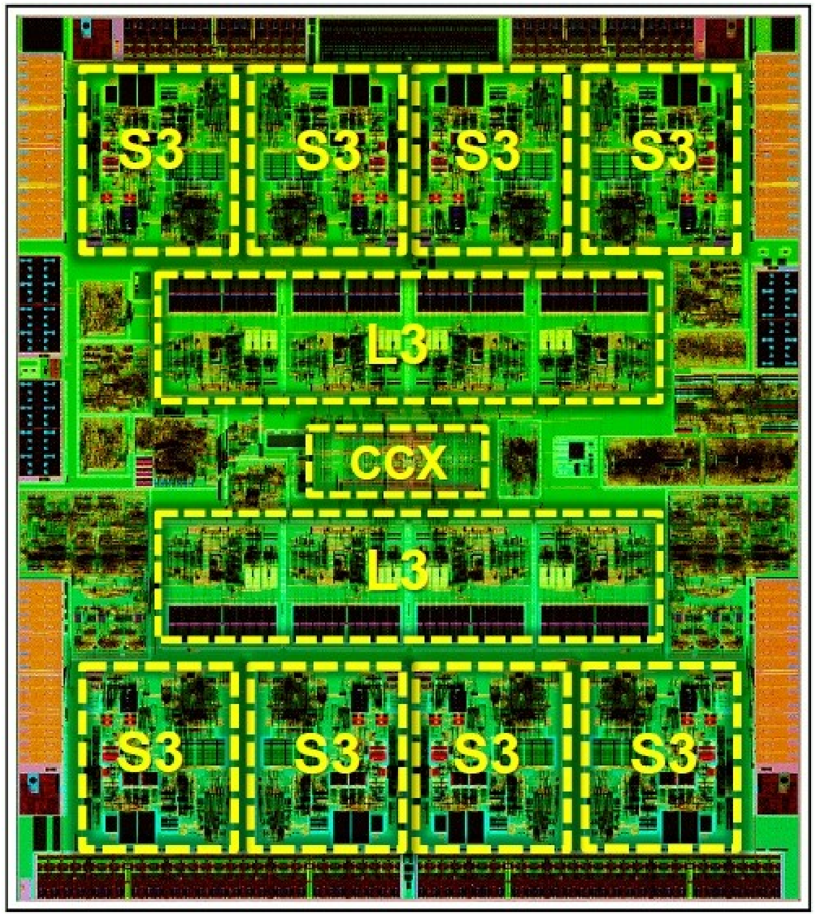
Wrong allocator ! How would I know?

- Go look ……
- prstat -m
  - LCK column is significant
- plockstat -e 30 -s 50 -p >pid<
  - Look for malloc as primary element in stack
- `dtrace -n pid???::malloc:entry'{ @[execname] = quantize(arg0)}'`
  - gives distribution of allocation sizes
  - Add calloc, realloc, valloc

Memory Fragmentation

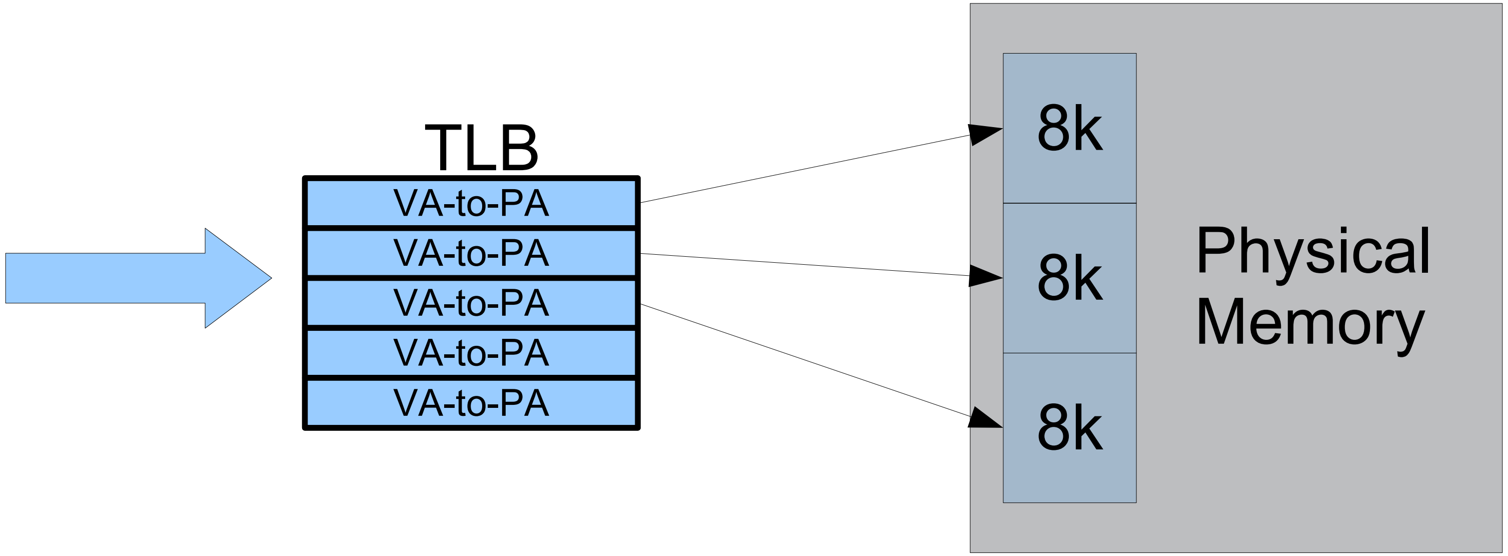
- No allocator can avoid worst case memory fragmentation
  - Worst case is different for each allocator
- For frequent large allocations (16k+)
    - libumem oversize becomes single threaded
    - mmap and munmap
    - umem_cache_alloc
  - malloctl for libmtmalloc
    - MTCHUNKSIZE : fewer calls to brk
  - Avoid realloc
    - different behaviors for libc & libumem
- Avoiding fragmentation is the applications responsibility

What is going on inside ?



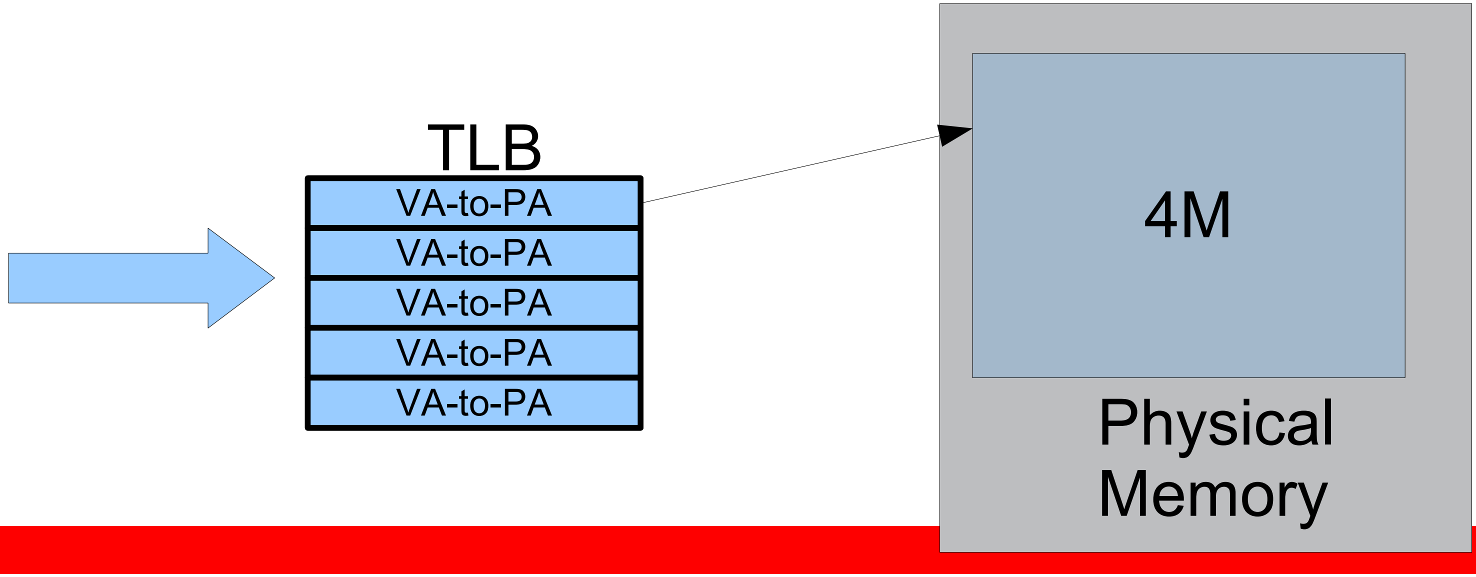
Why Large Pages?

address references
from running threads



512 8k pages for a 4MB segment, versus one 4MB page

address references
from running threads



Observing MMU traps

```
# trapstat -T 1 111
cpu m size| itlb-miss %tim itsb-miss %tim | dtlb-miss %tim dtsb-miss %tim |%tim
----------+-------------------------------+-------------------------------+----
  0 u   8k|        30  0.0         0  0.0 |   2170236 46.1         0  0.0 |46.1
  0 u  64k|         0  0.0         0  0.0 |         0  0.0         0  0.0 | 0.0
  0 u 512k|         0  0.0         0  0.0 |         0  0.0         0  0.0 | 0.0
  0 u   4m|         0  0.0         0  0.0 |         0  0.0         0  0.0 | 0.0
- - - - - + - - - - - - - - - - - - - - - - + - - - - - - - - - - - - - - - - + - -
  0 k   8k|         1  0.0         0  0.0 |      4174  0.1        10  0.0 | 0.1
  0 k  64k|         0  0.0         0  0.0 |         0  0.0         0  0.0 | 0.0
  0 k 512k|         0  0.0         0  0.0 |         0  0.0         0  0.0 | 0.0
  0 k   4m|         0  0.0         0  0.0 |         0  0.0         0  0.0 | 0.0
==========+===============================+===============================+====
      Ttl |        31  0.0         0  0.0 |   2174410 46.2        10  0.0 |46.2
```

This application **could** potentially run 2x faster using large pages!

Performance Instrumentation Counters

- Enable us to track low level events happening on the CPU
  - 80/90% performance issues resolved by standard tools
  - 10% of performance cases require further drill down

- Cpustat(1M) – entire system or cputrack(1M) – per process
    - Generic Events [generic_events(3CPC)]
    - Platform Specific Events, use cpustat -h to find out what's available

- DTrace CPC Provider
  - Generic L2 data cache miss for http executable
    - L2 cache miss → going to RAM which is expensive!

```
dtrace -n 'cpc:::PAPI_l2_dcm-all-10000 /execname == "httpd"/
{@[ufunc(arg1)] = count();}'
```

CPC Counters meet DTrace

Solaris 8   : CPC [Cpu Performance Counter]

Solaris 11 : DTrace CPC provider

PAPI (Performance Application Prog. Interface)

- Cpustat -h
  - Generic Events [generic_events(3CPC)]
  - Platform Specific Events
- PAPI_l2_dcr : Level 2 data cache read
  - AMD 0xF & 0x10 processor : DC+refill_from_L2
  - Intel Pentium Pro : l2_ld
  - US III/IIIi/IV, USIV+ : No

Calculating CPI

- PAPI_tot_cyc
  - AMD Opteron : BU_cpc_clk_unhalted
  - Intel Pentium IV : global_power_events
  - Intel Pentum Pro : cpu_clk_unhalted
  - US I/II/III/IIIi/IV/IV+ : Cycle_cnt

- PAPI_tot_ins
  - Opteron : FR_retired_x86_instr_w_excp_intr
  - Pentium : instr_retired
  - US III/III+ : instr_cnt
  - US IV/IV+ : instruction_counts
  - US T2 : Instr_cnt

- Example

```
root@x4640-tvp540-b:~# cpustat -nc pic0=BU_cpu_clk_unhalted,pic1=FR_retired_x86_instr_w_excp_intr 10 1 | awk '{ printf "%s %.2f cpi\n",$0,$4/$5; }'
10.001   0  tick  18895367  35135759  0.54 cpi
10.002   1  tick 243526553 235456833  1.03 cpi
10.002   2  tick    211986     65399  3.24 cpi
10.003   3  tick   8560908   2016222  4.25 cpi
<snip>
```

What does CPI tells us?

- If CPI is low
  - Examine the application for unnecessary CPU work
  - Get faster CPUs
  - Get more CPUs
- If CPI is high
  - Examine application for unnecessary memory work
  - Recompile with optimization with Oracle C compiler
  - Processor sets to improve memory locality (maybe?)
  - Get CPUs with larger caches
  - Test different CPU architectures (multi-core/multi-threaded)

Questions