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Linux memory management at scale

Chris Down
Kernel, Facebook
https://chrisdown.name

Downloads

Please select the amount of RAM to download:

1GB

Overview

* 1GB CT12864AA800 Memory
* 240-pin DIMM
* DDR2 PC2-6400, CL=6

Was: ~~$99.99~~ Now: **FREE**

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2GB

Overview

* 2 GB (2 x 1 GB)
* 240-pin DIMM
* DDR2 800 MHz (PC2-6400)

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4GB

Overview

* 4 GB (2 x 2 GB)
* 240-pin DIMM
* DDR2 800 MHz (PC2-6400)

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Filmed at QCon London 2017

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cgroupv2: Linux's new unified control group system

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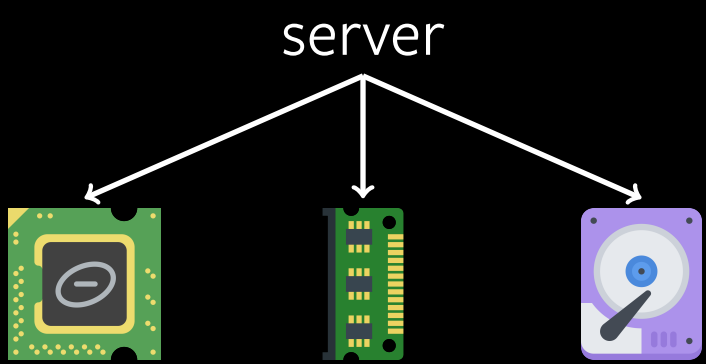
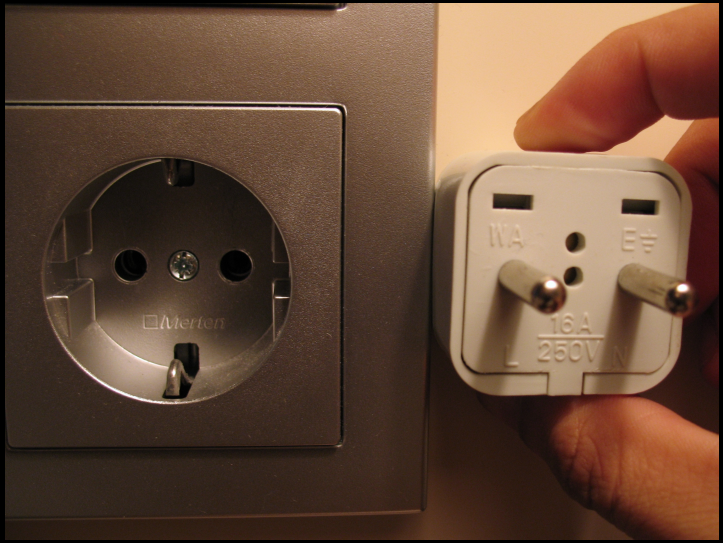

server

Image: Spc. Christopher Hernandez, US Military Public Domain



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```
 10                atomic_t mm_count;
  9
  8 #ifdef CONFIG_MMU
  7                atomic_long_t pgtables_bytes;   /* PTE page table pages */
  6 #endif
  5                int map_count;                  /* number of VMAs */
  4
  3                spinlock_t page_table_lock; /* Protects page tables and some
  2                                             * counters
  1                                             */
405                struct rw_semaphore mmap_sem;
  1
  2                struct list_head mmlist; /* List of maybe swapped mm's. These
  3                                          * are globally strung together off
  4                                          * init_mm.mmlist, and are protected
  5                                          * by mmlist_lock
  6                                          */
  7
  8
  9                unsigned long hiwater_rss; /* High-watermark of RSS usage */
 10                unsigned long hiwater_vm;  /* High-water virtual memory usage */
 11
"include/linux/mm_types.h" 740L, 23470C
```

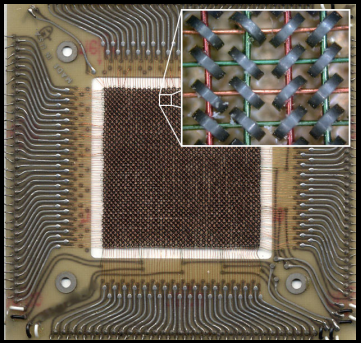

Image: Orion J on Wikimedia Commons, CC-BY

- Memory is divided in to multiple “types”: anon, cache, buffers, etc
- “Reclaimable” or “unreclaimable” is important, but not guaranteed
- RSS is kinda bullshit, sorry

bit.ly/whyswap

- Swap isn't about emergency memory, in fact that's probably harmful
- Instead, it increases reclaim equality and reliability of forward progress of the system
- Also promotes maintaining a small positive pressure (similar to `make -j cores+1`)

bit.ly/whyswap

- Swap isn't about emergency memory, in fact that's probably harmful
- Instead, it increases reclaim equality and reliability of forward progress of the system
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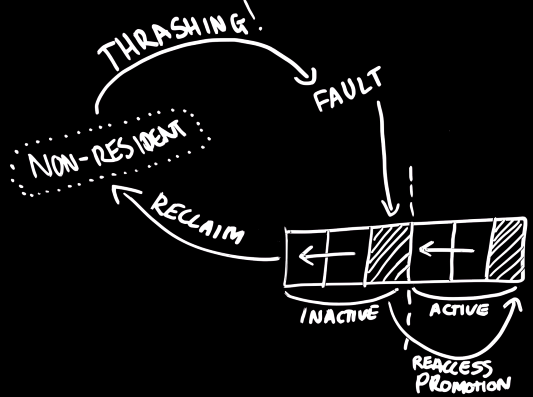
- OOM killer is reactive, not proactive, based on reclaim failure
- Hotness obscured by MMU (`pte_young`), we don't know we're OOMing ahead of time
- Can be very, very late to the party, and sometimes go to the wrong party entirely



- kswapd reclaim: background, started when resident pages goes above a threshold
- Direct reclaim: blocks application when have no memory available to allocate frames
- Tries to reclaim the coldest pages first
- Some things might not be reclaimable. Swap can help here (`bit.ly/whyswap`)

psi

“If I had more of this resource, I could probably run *N*% faster”

- Find bottlenecks
- Detect workload health issues before they become severe
- Used for resource allocation, load shedding, pre-OOM detection

```
$ cat /sys/fs/cgroup/system.slice/memory.pressure
some avg10=0.21 avg60=0.22 total=4760988587
full avg10=0.21 avg60=0.22 total=4681731696
```

oomd

bit.ly/fboomd

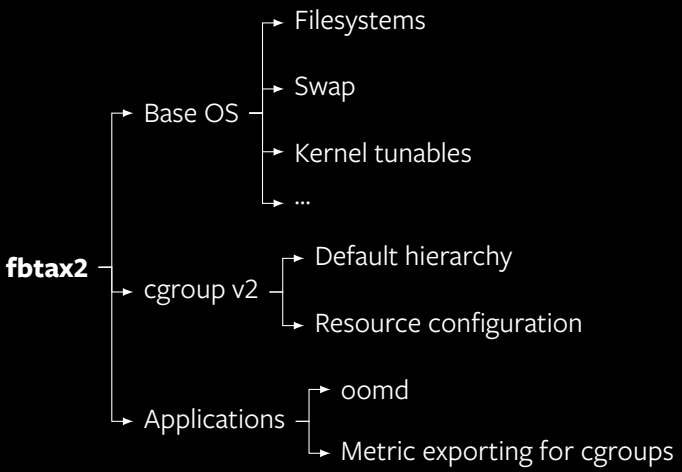
- Early-warning OOM detection and handling using new memory pressure metrics
- Highly configurable policy/rule engine
- Workload QoS and context-aware decisions

Shift to “protection” mentality

- Limits (eg. memory.{high,max}) really don’t compose well
- Prefer protection (memory.{low,min}) if possible
- Protections affect memory reclaim behaviour

fbtax2

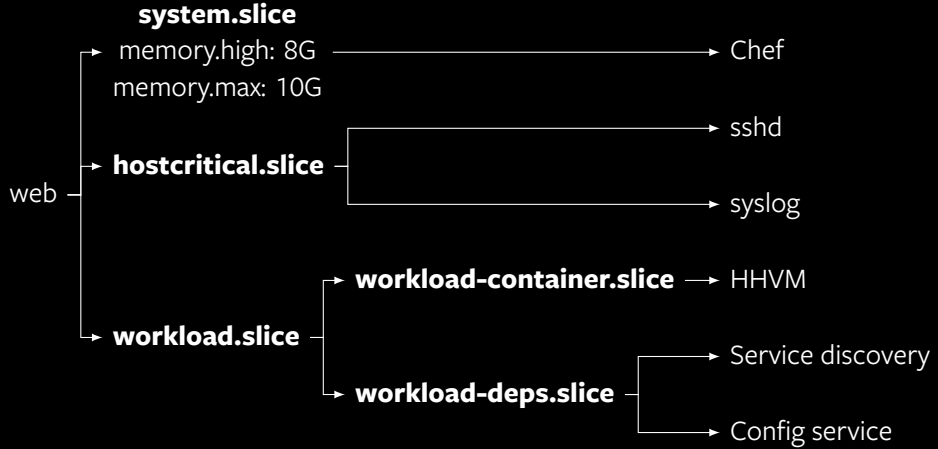
- **Workload protection**: Prevent non-critical services degrading main workload
- **Host protection**: Degrade gracefully if machine cannot sustain workload
- **Usability**: Avoid introducing performance or operational costs


fbtax2
Base OS
Filesystems
Swap
Kernel tunables
...
cgroup v2
Default hierarchy
Resource configuration
Applications
oomd
Metric exporting for cgroups

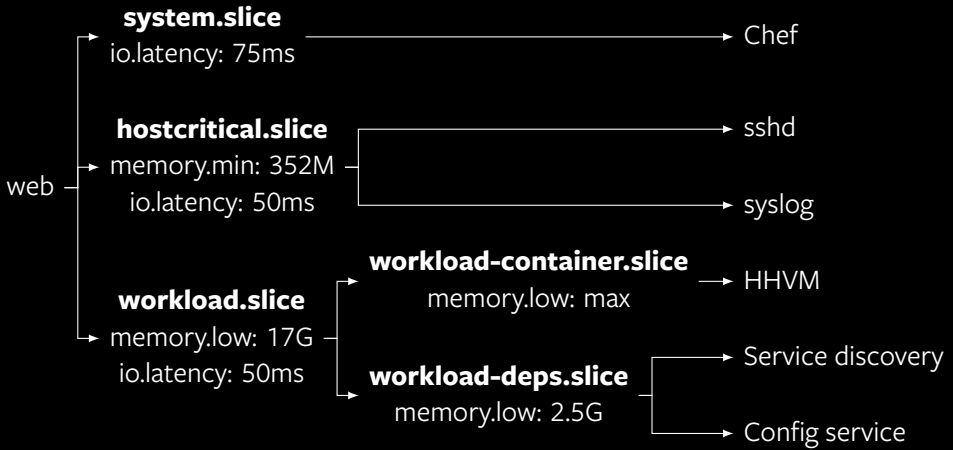
Base OS

- btrfs as `/`
  - ext4 has priority inversions
  - All metadata is annotated
- Swap
  - Yes, you really still want it (`bit.ly/whyswap`)
  - Allows memory pressure to build up gracefully
  - Usually disabled on main workload
  - btrfs swap file support to avoid tying to provisioning
- Kernel tunables
  - `vm.swappiness`
  - Writeback throttling

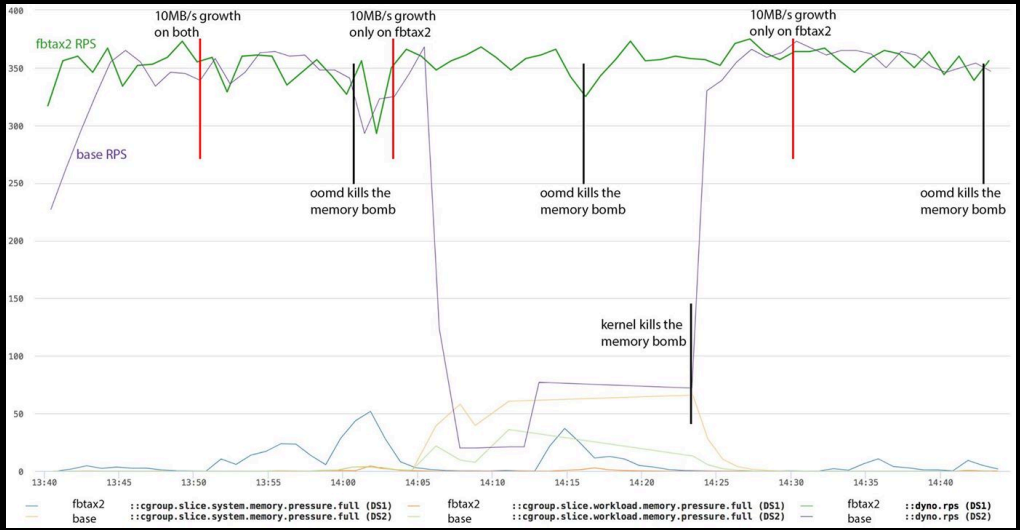
fbtax2 cgroup hierarchy: old



fbtax2 cgroup hierarchy



webservers: protection against memory starvation



Try it out: `bit.ly/fbtax2`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