Performance Tuning and Debugging

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Why is my application slow?

- No silver bullet
- Part science, part art
  - Science: Measure performance, test hypotheses
  - Art: Finding practical balances of concerns

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Most common culprits

- **Insufficient resources**
- Configuration error
- Hardware problems

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Digression: Throughput and Latency

- What are they?

- Throughput: Operations over time
  - Requests per second
  - Transactions per minute
  - Higher is better
- Latency: Time to complete one operation
  - My server can complete an HTTP GET in .01 seconds
  - Lower is better

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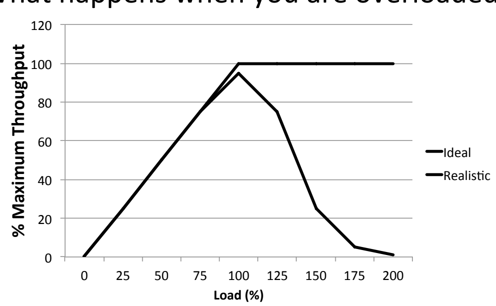
What happens when you are overloaded?



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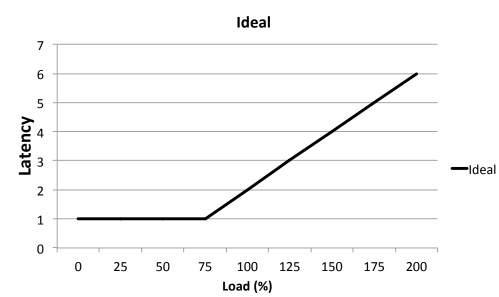

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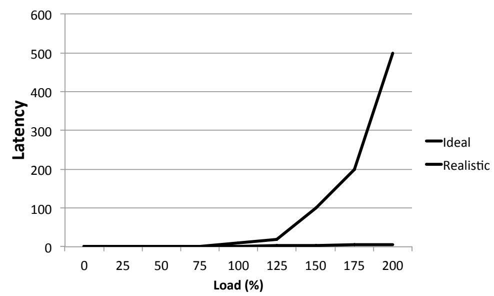

Note Change in Y Axis Scale---approaches infinity

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Graceful Degradation

- Ideally, when a system is overloaded, by n%, operation latency would increase by n% and throughput would stay constant
- In practice, systems rarely degrade gracefully when they are overloaded
- Thus, finding the “limiting factor” is essential

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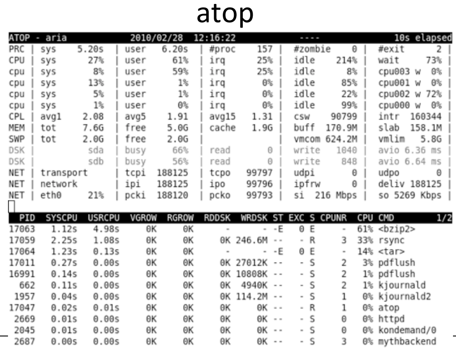

http://lwn.net/images/2010/atop/atopshot.png

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atop

- Super-useful tool that shows usage of
  - CPU
  - Memory
  - Disk
  - Network
- On a color terminal, highlights over-used resources

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CPU

- Very rarely the bottleneck
  - Actually degrades gracefully in most cases
- Nonetheless, overloaded CPUs will seem less responsive
- Note that when another resource is scarce, CPU time is used trying to compensate

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Load Average

- The average number of processes waiting for the CPU
  - Less than 1, the CPU is idle
  - Higher than 1 is ok, just means CPU is fully utilized
  - Very high values (>8) can indicate a problem
- Read from the uptime command:

```
$ uptime
20:10:13 up 20 days, 11:08,  5 users,  load average: 0.00, 0.03, 0.05
```

Memory

- Often the biggest troublemaker
- Why?
  - OSes over-commit memory to applications
  - In other words, if I have 1GB RAM, I can have 5 applications that all think they have 300 MB
  - How is this possible?
  - Swapping

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Swapping

- If the OS is running low on memory, it can take RAM away from applications
  - Save the contents to disk
  - Reuse the RAM
- If the application tries to read or write to this memory, the application is interrupted, OS notified
  - OS has to then find free RAM, replace contents for app

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The problem with swapping

- Disk reads and writes are slow (relative to CPU)
  - You very rarely wait for them before making progress
  - Except when swapping
- Mitigation: OS makes educated guesses about unlikely-to-be-used data to swap out
  - In the best case, things slow down a bit, and then return to normal
- In the worst case, data ping-pongs between disk and RAM
  - Called thrashing

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Recommendation

- If you see substantial swap usage in atop, buy more RAM
  - It is cheap, and more RAM is cheaper now than when you bought the computer
- Note: OS often uses substantial amount of RAM to cache the file system contents, so don't be mislead if total RAM usage is near 100%
  - Look at swap to detect insufficient RAM

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In a crisis…

- Linux has an out-of-memory killer
- As advertised, it just kills programs until there is enough memory

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Swappiness

- Linux tries to swap some data out before there is a crisis
- Linux has a parameter that sets how aggressively to swap data. This can get out of whack
  - /proc/sys/vm/swappiness
- I've personally had to dial this back on an Ubuntu release that set the default too high, in order for a nearly ***idle*** system to be usable

Network

- When the network is overloaded, packets are dropped
  - But the other end usually retries
- Two biggest culprit for network overload:
  - Attack (denial of service, brute-force password guessing, spam, etc)
  - Legitimate overload (slashdotted website, peak usage time)
- Need to figure out which

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Network advice

- If the overload is not legitimate, good security practice can help to reduce wasteful traffic
  - Firewall, denyhosts, spam filter, etc.
  - For DoS, there are also quality-of-service tools on many network devices to limit the share of packets delivered from any one source
- If the overload is legitimate, you may need more servers and a load-balancer
  - Like round-robin DNS

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Disks

- Very rarely the bottleneck, except:
  - (Implicitly when thrashing swap)
  - Actual disk-intensive workloads (e.g., database)
  - And when disk is nearing end-of-life
- Why rarely a problem?
  - Most disk requests are asynchronous
  - Most disk-intensive applications inherently rate-limited
- Why a problem at end-of-life?
  - Heavy remapping yields poor scheduling
  - For SSDs, internal bookkeeping can take longer as the device ages

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Disks

- In general, if the disk is getting old, the best advice is replace it
  - You also don't want to lose data
- Some file systems perform worse as they age, but these are increasingly uncommon
  - Running a "defragmenter" can help

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General advice

- Measure a performance baseline for your system
  - Application performance
  - Microbenchmarks (e.g., lmbench)
- If things seem slower, re-measure the component
  - Has my disk bandwidth degraded?
- This is the science of tuning

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Other tools

- /proc/cpuinfo, /proc/meminfo, /proc/diskstats – useful system statistics
  - Lots of goodies in /proc
- vmstat – more details on memory usage
- nice/renice – adjust scheduling priority, giving more CPU time to important applications
- swapinfo – more details on swapping
- netstat – more details about network usage
- hdparm/sdparm – measure raw disk performance
- iostat – more details about disk I/O