SANS

Save Time with Modern Search Techniques

Mark Jeanmougin, SANS Instructor

Disclaimer

The information presented here is not intended for use by anyone. If you try to follow along at home and get a hangnail, instantiate global thermonuclear war, or have other adverse side effects: You're on your own. Mark, as well as his past, current, or future employers, family members, and pets disclaim any and all responsibility from now until the end of the Universe.

Monday Pre-Coffee

Boss discovers Alexa Top 1 Million

How often do we go there?

Before I do something like this:

```
ls SG*/SG* | while read i ; do
 zgrep -f /var/opt/ldata/paraproj/alexa/top-1m $i
done > bigOutfile.log
```

Start with

```
time zgrep -f /var/opt/ldata/paraproj/alexa/top-1m \
SG_main__470802230000.log.gz > out
```

Monday

Get coffee; check email; still running

Check open tickets; still running

Work weekend incidents; still running

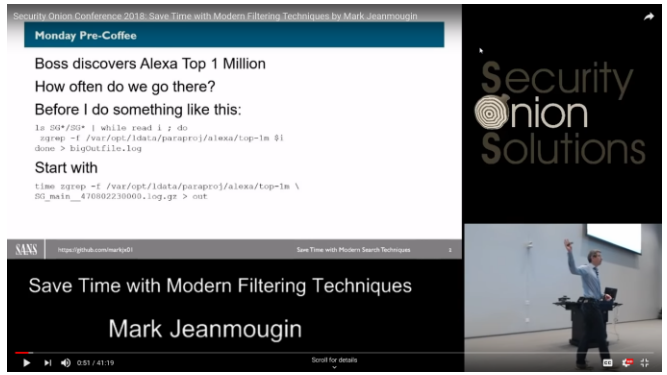
Go to lunch; STILL RUNNING

Update boss

Get cupcakes

Tuesday Morning

- STILL RUNNING!
- >990min for 1GB of logs. I have 55GB. Doing some maths…
  - This'll take >1 month! (Actually… 3y10m11d18h34m38s)
- Find a YouTube video called "Save Time with Modern Search Techniques"
- Find your boss's corporate card.
- Overnight shipping is a beautiful thing…



Wednesday Morning

Build the machine

Load the data, 20 minute copy

Using what we learn in this presentation…

```
$ time ls SG*/*lz4 | shuf | parallel --nice 14 lz4cat {} \| grep -a -F -f
/var/opt/arraytest/alexa/top-1m \| wc -l | totes1.awk
751296241

real    0m43.617s
user    10m13.816s
sys     10m47.671s
```

That's Not What I Meant!

Don't want to see what **is** on the Top 1million list!

What's **not** on it?

Re-Run with "grep –v"

```
$ time ls SG*/*lz4 | shuf | parallel --nice 14 lz4cat {} \| grep -v -a -F -f
/var/opt/arraytest/alexa/top-1m \| wc -l | totes1.awk
0

real    0m35.313s
user    8m13.341s
sys     8m30.060s
```

What about a simple example?

Maybe you get a report from your Threat Intel team saying that a certain URL is bad. So, do we have any hits to that URL from our network?

```
$ time ls SG*/*lz4 | shuf | parallel --nice 14 lz4cat {} \| grep -F
tacobell.com

real    0m28.711s
user    5m5.227s
sys     7m41.065s
```

How big is that data set, anyway?

750 mega logs (750 million logs)

305GB of data. 55GB gzip'ed

¾ of a Billion logs searched in ½ of a minute.

Rate of 1.5 Billion logs / minute

Could your SIEM do that?

What You'll Learn

I'm hear to teach techniques

I'll demo on a few data sets. Think of your data sets!

Slides at: https://github.com/markjx/search2018/

Ask questions!

Agenda

- ✓ Intro
- ❑ whoami
- ❑ Theory
- ❑ Existing Tools: xargs & GNU Parallel
- ❑ Parsing & Splitting
- ❑ At Home
- ❑ Demos
- ❑ New Tools

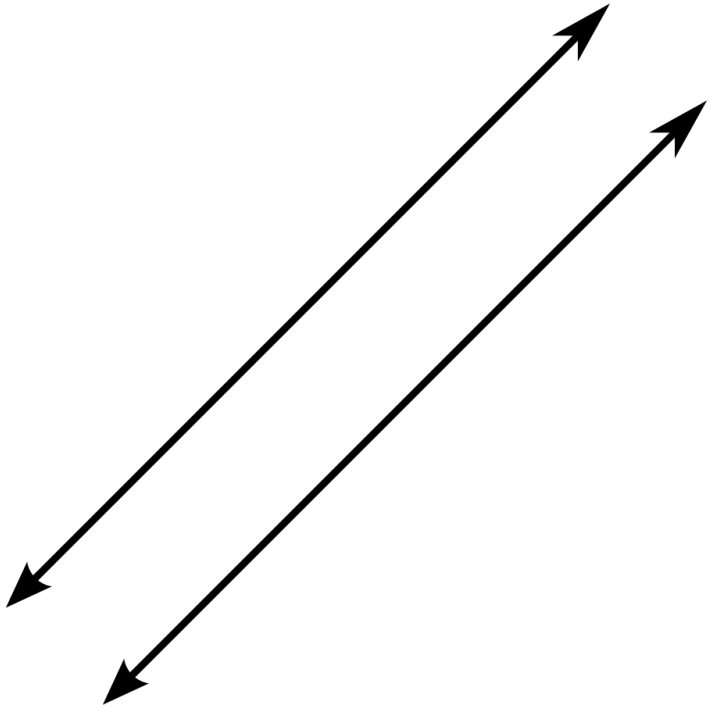
Ask Questions!

$ whoami

- Mark Jeanmougin (markjx@gmail.com / @markjx01)
- Career in Blue Team
- SANS Instructor
- Digital Forensics & Incident Response
  - Inappropriate Internet Use & Academic Fraud
- IT for >20 years. Security since 2000.
- Useless Superpowers
  - I can fold a fitted sheet & eat a single Girl Scout cookie

Parallelism is hard

- Change your Code
- Change your Data



Change your Code

- Fine Grained Parallelism
- Cinebench / Blender / Handbrake
- Some Compression / Decompression tools:
  - 7zip / pigz / pbzip2 / xz –T 30

- Coarse Grained Parallelism
  - Not Searching.
  - Fool our search tools by splitting our input data

Change your Data

- You want “many” input files. >1 per CPU core
  - Not too small: >>1 sec per file
- Only have one multi-GB file? Split to the rescue!

```
$ split -a 2 -d -l 2000000 192.168.1.13-20180113.log 192.168.1.13-20180113.spl
$ ls -al 192.168.1.13-20180113.spl?? | head -3
192.168.1.13-20180113.spl00
192.168.1.13-20180113.spl01
192.168.1.13-20180113.spl02
```

- Compress, too?

Old Code

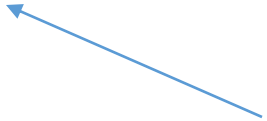
Do you go through logs like this?

```
$ time ls http-201* | while read i
do
 xzcat $i | grep badsite.org
done | wc -l
0
real    7m26.890s
user    8m0.930s
sys     0m14.689s
```

New Code - xargs

Exploit your hardware's parallelism!

```
$ time ls http-201* | xargs -P 64 -L 8 xzcat | grep badsite.org | wc -c
0
real    1m59.148s
user    12m31.649s
sys     10m56.685s
```



Explained on next slide

That's almost four times as fast!!!

xargs – Breakdown!

What's that xargs command line?

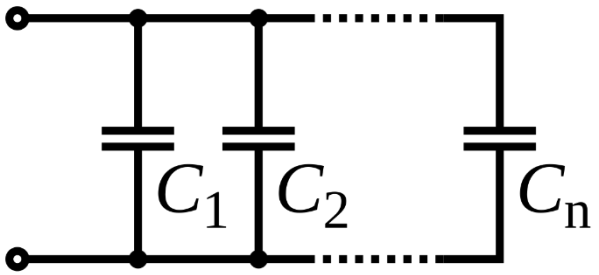
xargs -P 64 -L 8 xzcat

- xargs takes a list of arguments and executes a command one or more times with those arguments
- -P: Number of instances to kick off in Parallel
- -L: Number of Lines from the input file to assign to each job

New Tool: GNU Parallel

- Plenty of documentation:
  - 63 page man page (man -t parallel | ps2pdf - parallel.pdf)
  - man parallel_tutorial: another 44 pages of light reading
  - Total of 193 pages across 11 docs

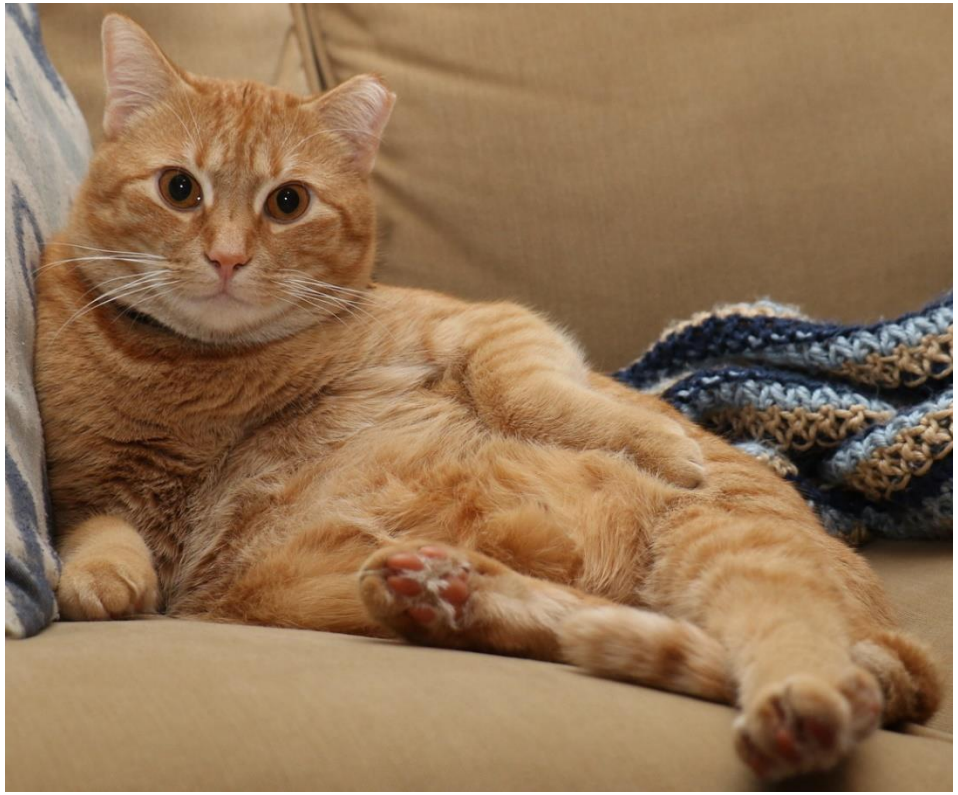
- Available in most Linux / UNIX environments



Parallel: Baseline

How long does it take? The *old* way:

```
$ time ls nvme[01]/SG*/*lz4 | while read i
do
  lz4cat $i | grep tacobell.com
done | wc -l
real    7m4.406s
user    6m15.146s
sys     1m46.403s
```



750 Megalogs & 305GB in 7m

Parallel: Step 1

```
$ time ls nvme[01]/SG*/*lz4 | \
parallel -u lz4cat {} \| grep tacobell.com | wc -l
real    0m49.910s
user    9m13.037s
sys     4m34.285s
```

7 min to <1m!

Parallel: Step 2

Use all drives better & Multiple “wc –l”s

```
$ time ls nvme[01]/SG*/*lz4 | shuf | \
parallel -u lz4cat {} \| grep tacobell.com \| wc -l | totes1.awk
real    0m44.908s
user    9m42.136s
sys     5m7.225s
```

Cut 10%

Parallel: Step 3

No more Regular Expressions!

```
$ time ls nvme[01]/SG*/*lz4 | shuf | \
parallel -u lz4cat {} \| grep -F tacobell.com \| wc -l | totes1.awk
real    0m42.402s
user    9m49.881s
sys     5m40.397s
```

Cut 5%

Parallel: Step 4

Run at >100%

```
$ time ls nvme[01]/SG*/*lz4 | shuf | \
parallel -j 110% -u lz4cat {} \| grep -F tacobell.com \| wc -l | totes1.awk
real    0m40.149s
user    10m16.371s
sys     5m42.126s
```

Cut 5%

Parallel: Command Breakdown!

- $ time ls nvme[01]/SG*/*lz4 | shuf | parallel -j 110% -u lz4cat {} \| grep -F tacobell.com \| wc -l | totes1.awk
- shuf: randomize the order of what's passed to it
- parallel
  - -j 110%: run 11 processes for each 10 CPU threads
  - -u: Output is printed as soon as possible (output from multiple jobs may be mixed)
- lz4cat: reads lz4 compressed data and dumps it out
- grep –F : Search for a string without regular expressions
- wc –l : return the number of lines
- totes1.awk: sum the first field of input (written by Mark J)

Decompression vs. "Real Work" 1/2

Threat Intel give you a list of 2320 malicious URL's & IP's. Do we have any hits?

```
$ time ls nvme[01]/SG*/*lz4 | parallel -u lz4cat {} \| grep -f
/var/opt/ldata/paraproj/malwaredomainlist/bad-urls | wc -l
```

```
real    677m29.743s
user    15936m22.485s
sys     45m0.255s
```

Decompression vs. "Real Work" 2/2

Using all our Parallel tricks & no Regular Expressions:

```
$ time ls nvme[01]/SG*/*lz4 | shuf | parallel -j 110% -u lz4cat {} \| grep -F
-f /var/opt/ldata/paraproj/malwaredomainlist/bad-urls \| wc -l | totes1.awk

real    1m36.837s
user    29m22.391s
sys     5m9.262s
```

Over ELEVEN HOURS -> 96 seconds!

Parsing, not just grep'ing

Here's an example of parsing & summarization rather than just searching

3m45s (or so) to get a report of the top 15 sites

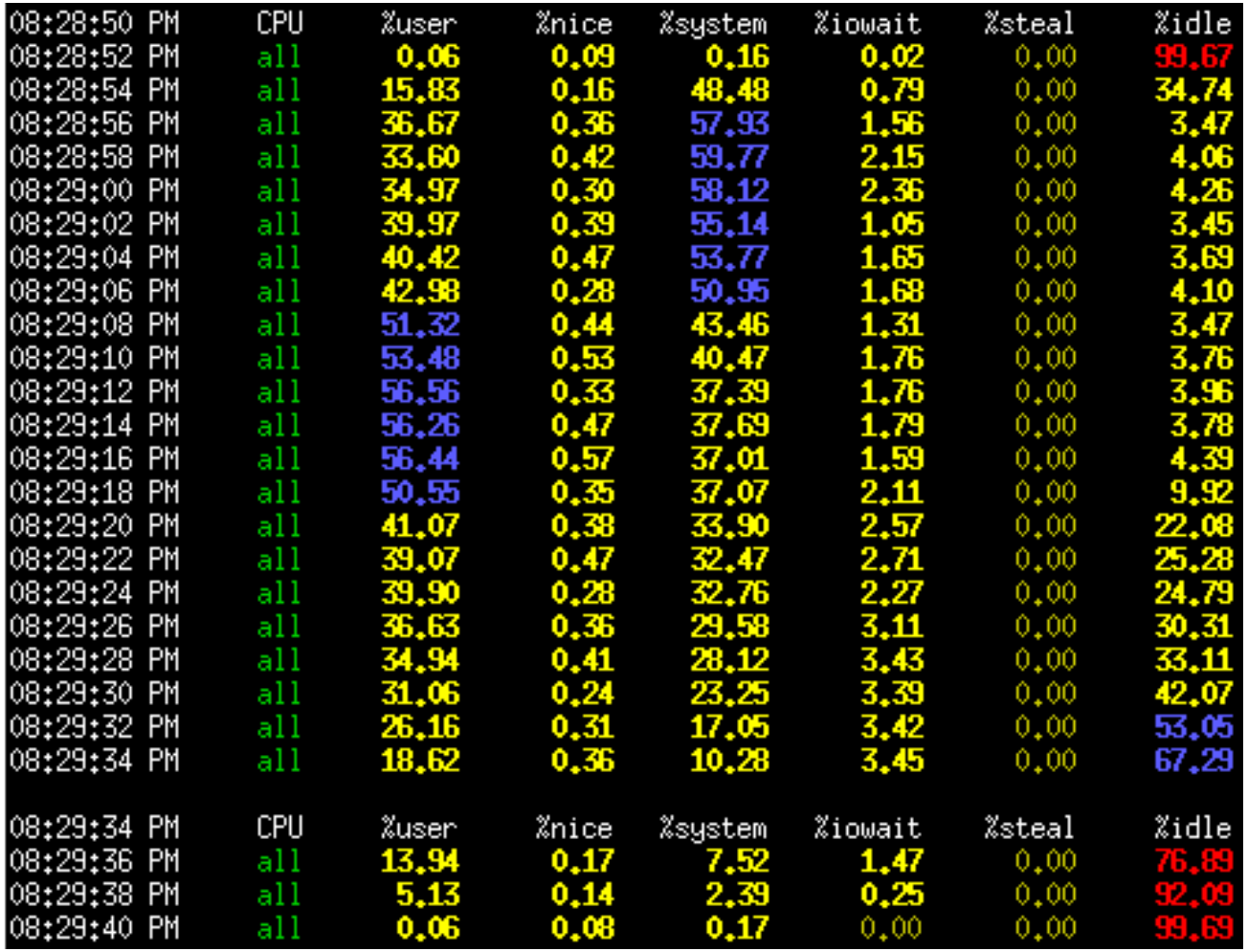
```
$ time ls nvme?/SG*/*lz4 | shuf |
 parallel -u -j 110% lz4cat {} \| printurl.awk \| sort \> {}.url
real    2m9.690s
user    37m8.133s
sys     7m2.533s

$ time sort --merge nvme?/SG*/*url > nvme0/allURL
real    0m57.226s
user    0m43.627s
sys     0m13.069s

$ time uniq -c nvme0/allURL | sort -n | tail -15
*SNIP*
real    0m35.003s
user    0m33.049s
sys     0m2.102s
```

When to Split Large Files

Split large files into chunks to maximize CPU Utilization



08:28:50 PM	CPU	%user	%nice	%system	%iowait	%steal	%idle
08:28:52 PM	all	0.06	0.09	0.16	0.02	0.00	99.67
08:28:54 PM	all	15.83	0.16	48.48	0.79	0.00	34.74
08:28:56 PM	all	36.67	0.36	57.93	1.56	0.00	3.47
08:28:58 PM	all	33.60	0.42	59.77	2.15	0.00	4.06
08:29:00 PM	all	34.97	0.30	58.12	2.36	0.00	4.26
08:29:02 PM	all	39.97	0.39	55.14	1.05	0.00	3.45
08:29:04 PM	all	40.42	0.47	53.77	1.65	0.00	3.69
08:29:06 PM	all	42.98	0.28	50.95	1.68	0.00	4.10
08:29:08 PM	all	51.32	0.44	43.46	1.31	0.00	3.47
08:29:10 PM	all	53.48	0.53	40.47	1.76	0.00	3.76
08:29:12 PM	all	56.56	0.33	37.39	1.76	0.00	3.96
08:29:14 PM	all	56.26	0.47	37.69	1.79	0.00	3.78
08:29:16 PM	all	56.44	0.57	37.01	1.59	0.00	4.39
08:29:18 PM	all	50.55	0.35	37.07	2.11	0.00	9.92
08:29:20 PM	all	41.07	0.38	33.90	2.57	0.00	22.08
08:29:22 PM	all	39.07	0.47	32.47	2.71	0.00	25.28
08:29:24 PM	all	39.90	0.28	32.76	2.27	0.00	24.79
08:29:26 PM	all	36.63	0.36	29.58	3.11	0.00	30.31
08:29:28 PM	all	34.94	0.41	28.12	3.43	0.00	33.11
08:29:30 PM	all	31.06	0.24	23.25	3.39	0.00	42.07
08:29:32 PM	all	26.16	0.31	17.05	3.42	0.00	53.05
08:29:34 PM	all	18.62	0.36	10.28	3.45	0.00	67.29
08:29:34 PM	CPU	%user	%nice	%system	%iowait	%steal	%idle
08:29:36 PM	all	13.94	0.17	7.52	1.47	0.00	76.89
08:29:38 PM	all	5.13	0.14	2.39	0.25	0.00	92.09
08:29:40 PM	all	0.06	0.08	0.17	0.00	0.00	99.69

Two Quick Examples

1. Zeek / Bro
2. ClamAV

What Started All This?

bro!

Threat Intel and “bad” Domain Names

3: Serial Small File Check

78735 bro log files; 231,244MB compressed to 15,379MB

- 637,084,430 log events

Cross Reference with Alexa Top 1million, small files, serial

```
$ time find 2* -type f | grep : | xargs zgrep -c -v -F -f \
/var/opt/data0/paraproj/alexa/top-1m | totes1.awk

real    3576m25.396s
user    3286m22.736s
sys     295m51.797s
$
```

59.6h

3: Serial Large File Check

4262 bro log files; 232,062MB compressed to 16,298MB

- 637,084,430 log events

Cross Reference with Alexa Top 1million, large files, serial

```
$ time find 2* -type f | grep -v : | xargs zgrep -c -v -F -f
/var/opt/data0/paraproj/alexa/top-1m | totes1.awk

real    403m17.795s
user    380m6.731s
sys     30m25.214s
$
```

6.7h

3: Parallel Small File Check

78735 bro log files; 231,244MB compressed to 15,379MB

- 637,084,430 log events

Cross Reference with Alexa Top 1million, small files, serial

```
$ time find 2* -type f | grep : | shuf | xargs -P 32 -L 100 \
zgrep -c -v -F -f /var/opt/data0/paraproj/alexa/top-1m | totes1.awk

real    157m54.528s
user    3688m42.650s
sys     646m56.955s
$
```

2.6h

3: Parallel Large File Check

4262 bro log files; 232,062MB compressed to 16,298MB

- 637,084,430 log events

Cross Reference with Alexa Top 1million, large files, serial

```
$ time find 2* -type f | grep -v : | shuf | xargs -P 32 -L 100 \
zgrep -c -v -F -f /var/opt/data0/paraproj/alexa/top-1m | totes1.awk

real    35m40.662s
user    576m5.104s
sys     76m35.347s
$
```

100:1 Speedup

Whatify?

dailyify: The process of converting your bro log files into daily batches rather than tiny hourly files to make searching faster

```
$ cat dailyify.sh
#!/bin/bash

time ls | cut -f 1 -d. | sort -u | while read i
do
  echo $i
  ls ${i}* | xargs zcat | pigz > daily.gz
  mv daily.gz ${i}.gz
done

$
```

bro Extracted Files & ClamAV - Serial

1922 exe files extracted by bro. 11,635MB

```
$ time clamscan -i --log=logfile ./extracted/

----------- SCAN SUMMARY -----------
Known viruses: 6673868
Engine version: 0.100.1
Scanned directories: 1
Scanned files: 1921
Infected files: 53
Data scanned: 9044.61 MB
Data read: 11627.12 MB (ratio 0.78:1)
Time: 2083.731 sec (34 m 43 s)

real    34m43.741s
user    34m16.451s
sys     0m17.710s
$
```

bro Extracted Files & ClamAV - Parallel

1922 exe files extracted by bro. 11,635MB

```
$ find extracted -type f > list
$ split -n l/48 -a 2 -d list list.
$ time ls list.* | parallel clamscan -f {} -i --log={}.log
real    3m47.688s
user    81m27.013s
sys     1m22.020s
$
```

10:1

ClamAV Breakdown

```
$ find extracted -type f > list
```

Create list of files to be examined

```
$ split -n l/48 -a 2 -d list list.
```

Split into 48 chunks at line breaks (ell over 48). 2 character **d**ecimal suffix.

```
$ time ls list.* | parallel clamscan -f {} -i --log={}.log
```

Kick off clamscan to examine each chunk of files.

How to do this at $home?

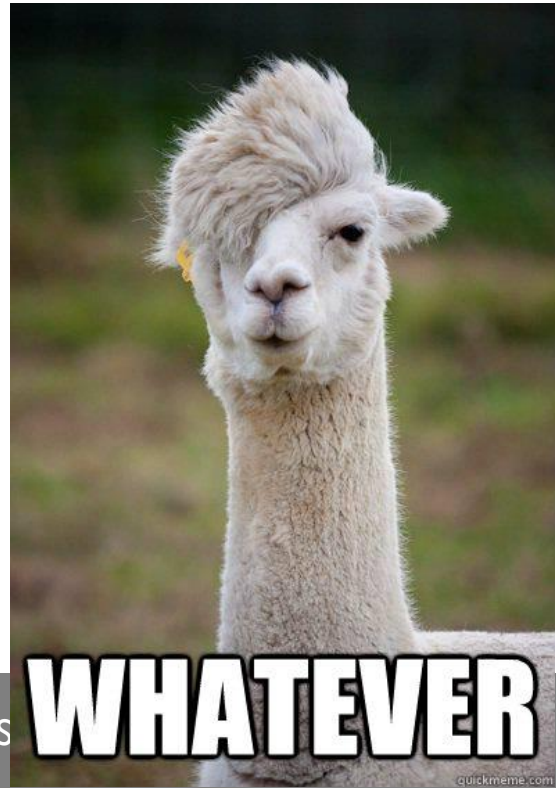
Get the data

Store the data

Process the data

Process the Data

- What do you need?
  - Multi-core CPU (Threadripper|EPYC). SSD's (NVMe FTW!)
  - ASCII Logs (jq, XML, syslog, whatever)
- How to get the hardware?
  - Xeon workstation from HP, Dell, Lenovo, etc Threadripper Pro Workstation from Lenovo, etc.
  - Build your own Threadripper box. (Gamer on helpdesk?)
  - My build: https://pcpartpicker.com/list/NLQGBc



Organizational Acceptance

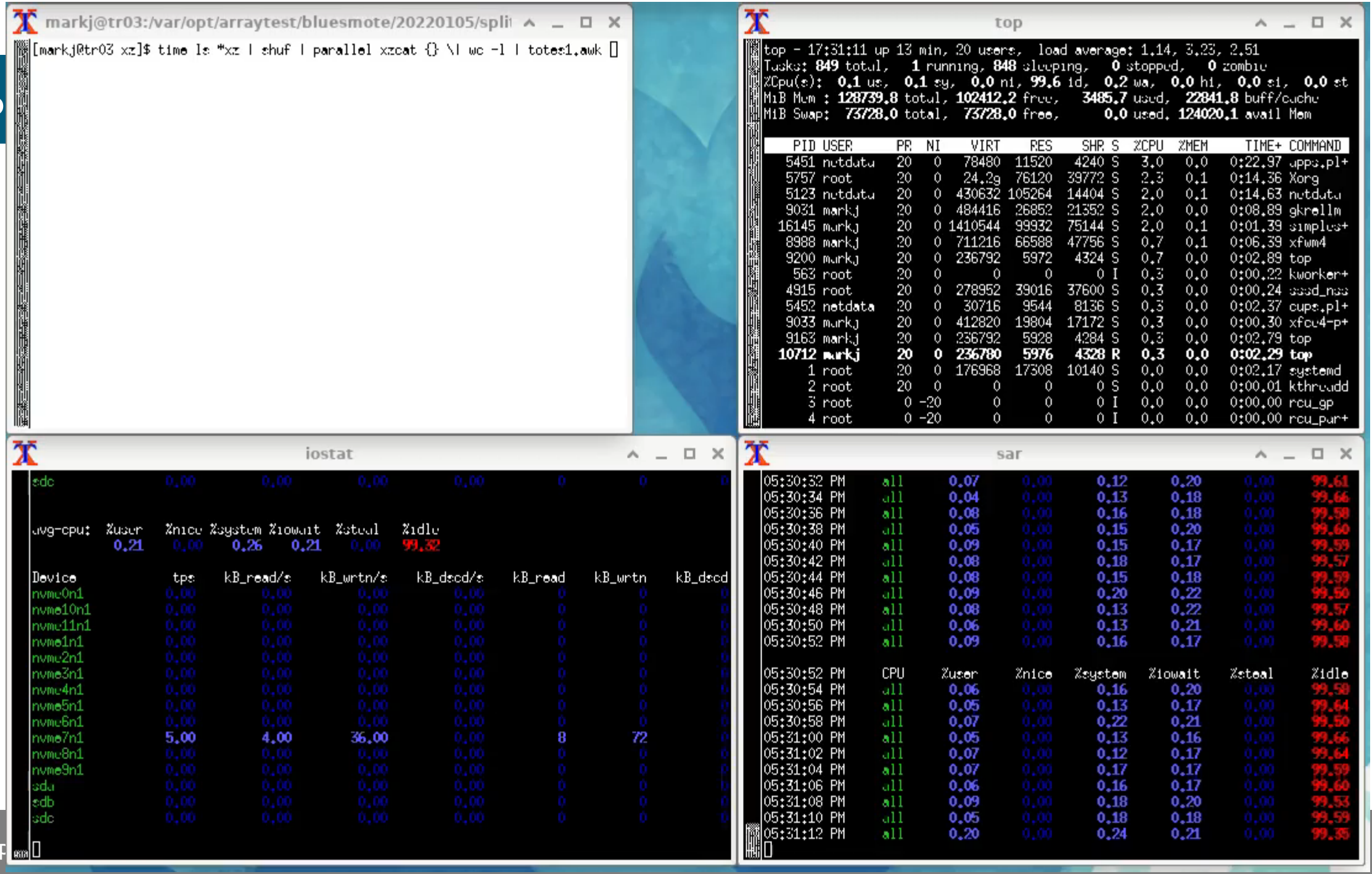
- How to justify the cost?
  - Price of a cup of coffee / day over 3y
- Hardware & Software “Support”?
  - Your IT, desktop, etc support teams with react in 1 of 2 ways: Hatred or Joy
  - Do you have other Linux workstations?
  - “Server”?
    - Security “Appliance”?
  - (Cloud? 😭)

Demos!

1. CPU intensive part is decompression
2. CPU intensive part is searching

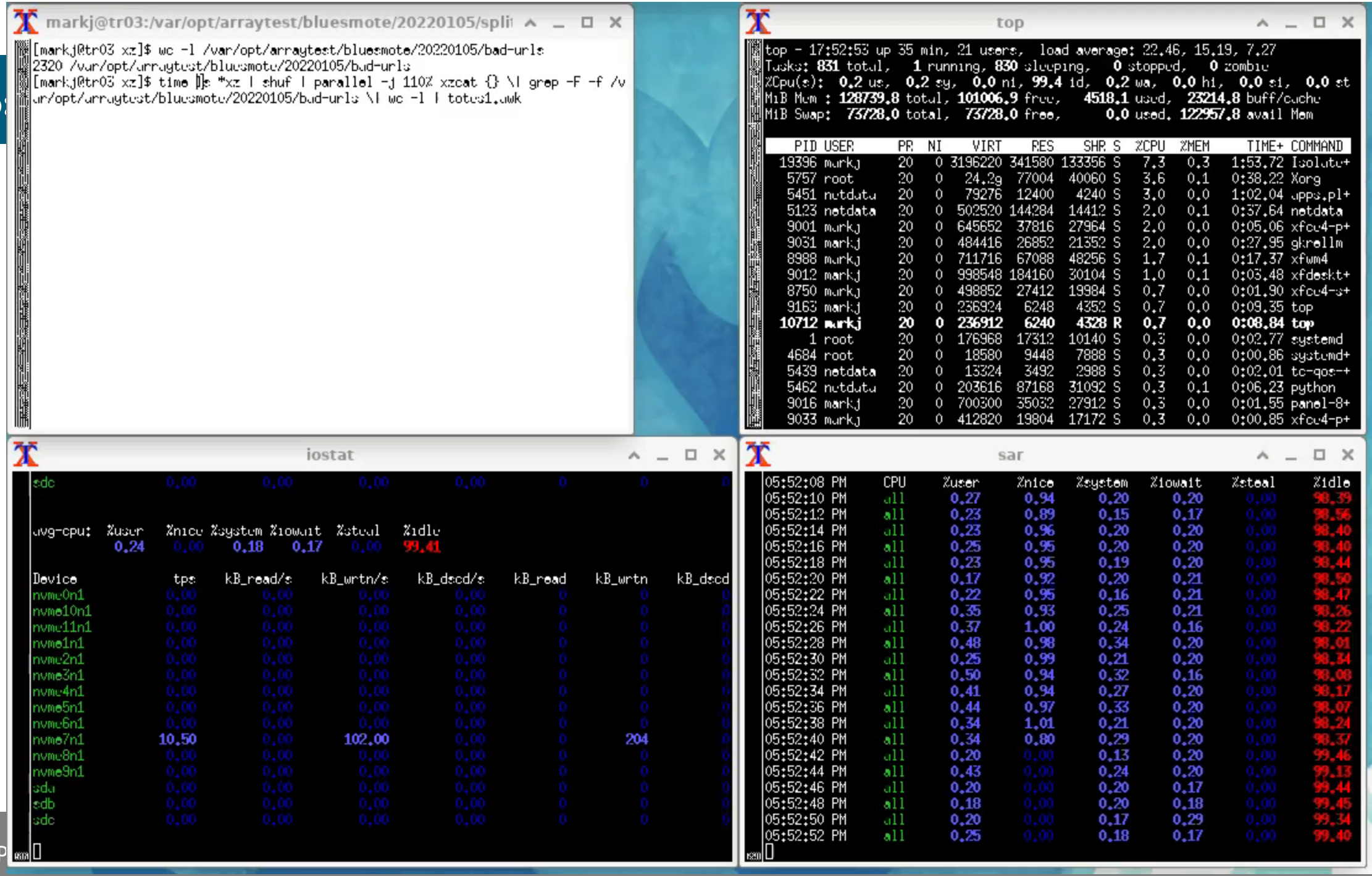
Demo

Decompres-
sion is CPU
intensive



Demo

Searching is CPU intensive



squishycat

cat compressed files

- gzip
- bzip2
- lz4
- xz

Or uncompressed!

squishycat: Use

```
[markj@tr01 20180415]$ ls S* | while read fn ; do file $fn ; squishycat $fn |
 sha1sum ; echo . ; done
SG_main__470802230000.log: Non-ISO extended-ASCII text, with very long lines
6ddafe913bf160a0a6c2c4a949de5270e19682e9  -
.
SG_main__470802230000.log.bzip2: bzip2 compressed data, block size = 900k
6ddafe913bf160a0a6c2c4a949de5270e19682e9  -
.
SG_main__470802230000.log.gzip: gzip compressed data
6ddafe913bf160a0a6c2c4a949de5270e19682e9  -
.
SG_main__470802230000.log.lz4: LZ4 compressed data (v1.4+)
6ddafe913bf160a0a6c2c4a949de5270e19682e9  -
.
SG_main__470802230000.log.xz: XZ compressed data
6ddafe913bf160a0a6c2c4a949de5270e19682e9  -
.
[markj@tr01 20180415]$
```

grepwide

Rounds up all the search techniques discussed in this paper

Files in your home directory:

- look4me: What you're searching for
  - No blank lines!
- outfile: Saves output here

```
[markj@tr01 lz4links]$ cat ~/look4me
yum.com
kfc.com
kfc.co.uk
pizzahut.com
tacobell.com
wingstreet
[markj@tr01 lz4links]$ time grepwide

real    0m49.802s
user    13m32.079s
sys     4m7.599s
[markj@tr01 lz4links]$ wc -l ~/outfile
1982 /home/markj/outfile
[markj@tr01 lz4links]$
```

Bibliography

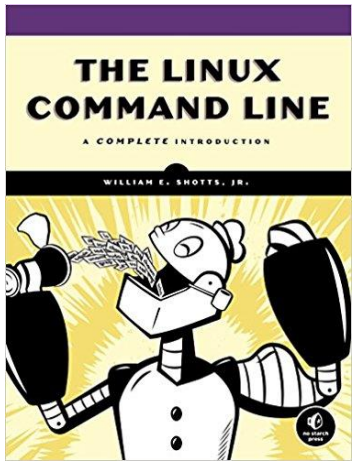
See notes for some of the sites that I found useful in this research, in no particular order

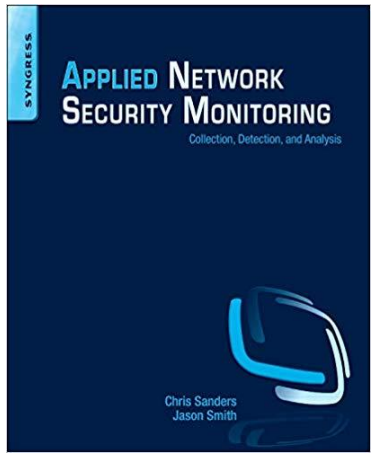
Questions?

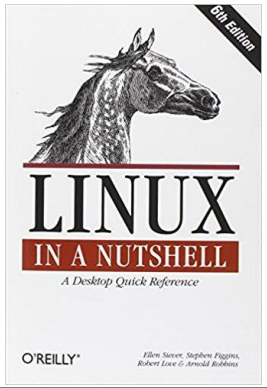
markjx@gmail.com

@markjx01 https://markjx.blogspot.com/

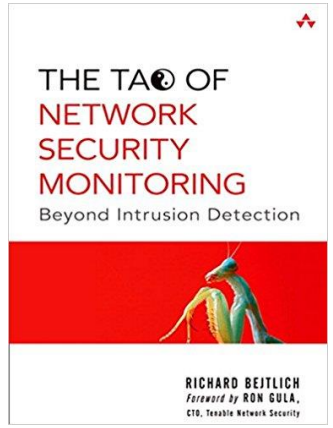
Slide Deck & Scripts:
https://github.com/markjx/search2018/

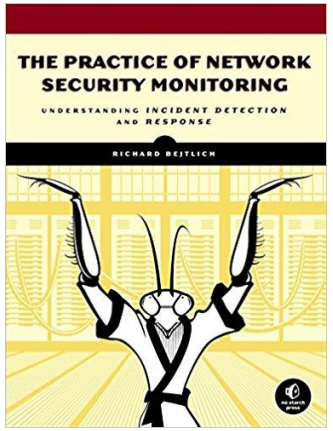






Humble Bundle





Appendix

~~Appendix~~

~~Appendixes~~

~~Appendices~~

Bonus Information!

Hardware Stopped Getting Faster

MHz **stopped** increasing in 2000. Core Count **started** increasing in 2006.

For my work: AMD Threadripper & NVMe PCIe g4 (or 5!)

This works with

- Any multi-core CPU
- Any SSD

Operating System

- Many Options!!!
  - Linux VM's or bare hardware
  - Windows Subsystem for Linux
  - Docker
- Test Yo'self!
- What's important?
  - Your skills / Institutional Support
  - Cost / Performance

7200rpm RAID vs. NVMe

7200rpm RAID

```
time ls SG*/*lz4 | shuf | parallel -u -j 110% --nice 14 lz4cat {} \|
 grep tacobell.com \| wc -l | totes1.awk
real    11m5.992s
user    6m35.496s
sys     2m1.593s
```

NVMe

```
time ls nvme[01]/SG*/*lz4 | shuf | parallel -u -j 110% --nice 14 lz4cat {} \|
 grep tacobell.com \| wc -l | totes1.awk
real    0m44.252s
user    9m39.629s
sys     5m14.836s
```

Compressed or Uncompressed?

Types of Compression

Compression vs. Decompression

What does your “off hours” usage look like?

Know your Data

Don’t be afraid to “transcompress”

Test, Test, Test

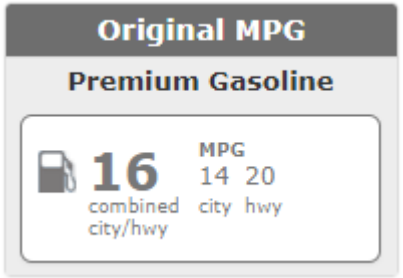
Compression Test – CERT Insider r6.2

			Space	wc -l		Time	grep -F -f		Time
		MB	Savings	real	user+sys	**Savings**	real	user+sys	**Savings**
raid5	uncompressed	86054	0.00%	563.815	71.4251	0.00%	563.154	217.85	0.00%
nvme	uncompressed	86054	0.00%	43.672	28.362	92.25%	133.874	112.378	76.23%
nvme	split	86054	0.00%	67.590	41.942	88.01%	70.403	250.432	87.50%
nvme	gzip	35375	58.89%	29.763	881.843	94.72%	37.356	1087.088	93.37%
nvme	bz2	19507	77.33%	353.441	10994.801	37.31%	425.696	12579.695	24.41%
nvme	lz4	53965	37.29%	44.730	411.786	92.07%	46.242	316.816	91.79%
nvme	xz	4519	94.75%	21.332	637.354	96.22%	27.974	853.265	95.03%

wc -l, grep -F -f (2320 lines)

Compression – Winner!

- Winner: xz
  - fast decompression & very little space on disk
  - Compared to uncompressed: 95% space & speed
  - Compared to gzip: 77% space & 27% speed
  - Downside? xz compression is much slower.



- Your Mileage May Vary
  - Other data sets work better with other algorithms

Transcompression

I don’t know if that’s a word, but I’m using it.

It is trivial to convert from one compression type to another. Something like this:

```
$ time ls nvme?/S*/*lz4 | shuf | parallel -u lz4cat {} \| gzip \> {}.gz
real    6m39.899s
user    126m0.536s
sys     3m58.523s
```

That’s 6 and a half minutes to move 305GB of data from lz4 to gz

parallel & Pictures

Resize 5,558 jpg's from 20MP -> 2.6MP

```
[markj@tr01 all]$ time make-picasa.sh ./

real    36m1.123s
user    226m15.221s
sys     142m12.921s
```

And... in parallel

```
$ mv ../picasa ../picasa.serial ; mkdir ../picasa ; time ls | \
parallel make-picasa1
real    9m50.470s
user    287m49.904s
sys     20m52.173s
```

parallel & ClamAV

Scan 80,168 files, taking 39,292MB of disk space

```
real    177m58.320s
user    174m36.915s
sys     1m45.777s
```

And... in parallel

```
$ time ls -S | shuf | xargs -L 600 -P 32 clamscan > parallel
real    13m52.956s
user    397m23.623s
sys     4m29.457s
```

parallel & ClamAV 2

An early run before I optimized the CPU usage

Another example of the importance of balancing CPU usage

See notes below

GPU's?

nVidia, AMD Radeon, Intel Xe are all processing units that specialize in SIMD. Can that help?

Maybe, but probably not.

I'm a scripter. Not a developer. Don't wanna. Feel free!

Overhead of copying to/from GPU's

People have looked into this, but not many results