SANS

Save Time with Modern Search Techniques

Mark Jeanmougin, SANS Community Instructor

Abstract: Many of our tools and techniques for working with large data sets are tweaked versions of what we did back when we had one CPU and a mechanical hard drive. This presentation explores how to approach these data sets with multi-core CPU's and fast NVMe storage. Special attention is paid to Digital Forensics & Incident Response (DFIR) use cases, but the techniques are more general. This is a trip into GNU Parallel, xargs, and other techniques to maximize the parallel processing capabilities of modern CPU's and storage. Examples include searching, anti-virus, and photo processing. The techniques are generally applicable.

Author: Mark Jeanmougin / markjx@gmail.com / @markjx01
Supplemental material at https://github.com/markjx/search2018

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.

The author, presenter, and other people who's information is contained in this document disclaim any and all responsibility for any use of any information contained herein.

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
```

If these commands don't make sense, don't worry. We'll get there.

The Alexa Top 1 Million went away… and then came back. See also:

- https://support.alexa.com/hc/en-us/articles/200449834-Does-Alexa-have-a-list-of-its-top-ranked-websites-
- https://www.alexa.com/topsites
- http://s3.amazonaws.com/alexa-static/top-1m.csv.zip
- https://blog.majestic.com/development/alexa-top-1-million-sites-retired-heres-majestic-million/
- https://umbrella.cisco.com/blog/2016/12/14/cisco-umbrella-1-million/

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

That runs for 30 minutes while you get coffee and check your email.

That runs for another 30 minutes while you check for updates to your open vendor cases about their stuff not working they way they told your boss it would

It runs for another hour while you triage open tickets from the weekend.

It runs through lunch while you finally get to your day job.

You get back from lunch (That fancy Indian place that Hannah likes. Chicken Tikka Masala. It was delicious.) and IT IS STILL RUNNING! Update the boss to keep him off your back.

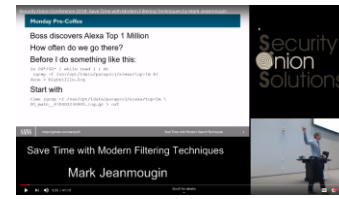
At first, it was nice to have this keep running; it kept your boss off your back. Now, any investigation of employee activity is slower because this stupid query is still running.

Update boss: let it run over night. Remind him that you're only looking at a fraction of the logs.

Time to go 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…



That runs all night.

The zgrep has been running all night. At this point, it has taken 990min of CPU time. Your test search is on 1GB of logs, you have 55GB of logs. Do some math…

THIS WILL TAKE OVER A MONTH!

There's gotta be a better way!

Find a YouTube video of a SANS presentation called "Save Time with Modern Search Techniques". And watch it.

* https://www.youtube.com/watch?v=gOcBaY0e5AA

Where's that corporate credit card? :)

Amazon Prime next day delivery FTW!!!

FYI 1: The zgrep takes ~23GB of RAM. If you can't give that much to the process, then expect things to slow down due to swapping.

FYI 2: I ran the 1GB file for 14.16 days to get through 580,465,728 bytes (cat /proc/79780/io). At that rate (40MB/day), it'd take 1406 days with this method. That's 3y 10m 11d 18h 34m 38s; approximately. ☺

Wednesday Morning

Build the machine

Load the data, 20 minute copy

Wednesday Morning

Build the machine

Load the data, 20 minute copy

```
$ 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
```

SANS https://github.com/markjx

This uses GNU Parallel, which I'll cite by saying:

```
Academic tradition requires you to cite works you base your article on.
When using programs that use GNU Parallel to process data for publication
please cite:

  O. Tange (2011): GNU Parallel - The Command-Line Power Tool,
  ;login: The USENIX Magazine, February 2011:42-47.
```

```
$ time ls nvme?/SG*/*lz4 | shuf | parallel -u -j 14 --nice 14 lz4cat {} \|
grep -F -f /var/opt/ldata/paraproj/alexa/top-1m \| wc -l | totes1.awk
696951104
real    6m44.586s
user    79m3.388s
sys     11m41.322s
```

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
```


We'll explain the command specifics later…

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
```

You need to provide a report of all activity for one user going back as far as you can. Or, 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?

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?

Many people really like their SIEM. Some people are going to SEC455 or SEC555 later this week and are going to learn awesome ways to build and use SIEM's.

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!

I'm primarily here to teach you some techniques. I'll demonstrate those techniques on some data sets. Throughout this presentation, be thinking of other data sets you have where these techniques may work.

Ask questions! Although, I reserve the right to ask you to hold certain questions until the end.

Agenda

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

Ask Questions!

When you're watching TV with someone and they rewind to see a funny part, or the make sure they caught a key part of the plot, or rewatch a particularly sporty part of a sports thing, they're also saying this is important to me and I want to share it with you.

$ 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

Mark Jeanmougin
markjx@gmail.com / https://twitter.com/markjx01
https://markjx.blogspot.com/
https://github.com/markjx
https://www.linkedin.com/in/markjx

Blue Team for my whole career.
SANS Community Instructor
Digital Forensics & Incident Response
Security Operations Center Analyst & Manager
Started "Experimenting" with UNIX in college.
Been doing IT stuff for over 20 years now. Security since 2000.

While I do have a $DayJob, this work is not endorsed or sponsored by them.

Surprisingly, it looks like there's no Trademark associated with the phrase "Girl Scout Cookie". At least, according to: https://www.girlscouts.org/en/cookies/all-about-cookies.html on 4/17/2018 .

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

Coarse Grained Parallelism

Plenty of things don't; like searching. BUT, if you have huge amounts of data, you can run the same search against multiple pieces of data in parallel. In Cyber Security, we certainly have plenty of 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?

split man page:

```
NAME
       split - split a file into pieces

SYNOPSIS
       split [OPTION]... [FILE [PREFIX]]

DESCRIPTION
       Output  pieces of FILE to PREFIXaa, PREFIXab, ...; default size is 1000
       lines, and default PREFIX is 'x'.

       -a, --suffix-length=N
              generate suffixes of length N (default 2)

       -d     use numeric suffixes starting at 0, not alphabetic

       -l, --lines=NUMBER
              put NUMBER lines/records per output file

       -n, --number=CHUNKS
              generate CHUNKS output files; see explanation below
```

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
```

Done on the “CERT-insider r5.2” dataset.

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 zcat

- 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

Done on the cert-insider r5.2 dataset on a single NVMe drive.

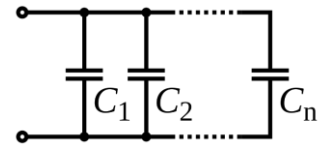
-P 64 was basically chosen at random. I wanted a number greater than my number of CPU cores (16). So I quadrupled it. My gut tells me that there's not much speed improvement going for 32-64, but #YOLO!

-L 8 gave me about 100 jobs to run. I wanted to L to be > 2x P. This seemed about right.

Had this been a scientific study or a production implementation, I'd have done some more testing here.

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



I needed something to do multiple downloads in parallel from a video sharing site. I was going to write a shell script to do this, then found parallel.

Available in:
Fedora: dnf install parallel
CentOS: yum install epel-release; yum install parallel
Ubuntu 20.04 LTS (REMnux, SIFT, etc): apt install parallel
Ubuntu 21.10: apt install parallel

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

Photo Credit: My cat, Ollie, just chillin' like a villin.

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!

Normally, parallel "chunks" up the output so that it is put out in the same order as it is generated. For many applications, this is the desired behavior. For this run, I just want to know how many people went to tacobell.com in search of tasty tacos. The "-u" option to parallel tells it to output data as it is ready rather than in order. According to the man page, this is faster.

Photo Credit: My cat, Ceili, having recently been shaved.

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%

Photo Credit: An Indy Lights car (I think?) at Mid-Ohio 2018. Taken by Mark Jeanmougin.

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%

We'll do a more dramatic RE / no RE example later…

Photo Credit: An IndyCar at Mid-Ohio 2018. Taken by Mark Jeanmougin.

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%

I did some testing in 10% increments starting at 100% going to 150%. 110% seemed to be the sweet spot.

- Your mileage may vary.

Photo Credit: Ferrari Formula One car driven by Sebastian Vettel at Montreal 2018. Taken by Mark Jeanmougin.

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)

This slide is more for viewing printouts.

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
```


List is courtesy of: http://www.malwaredomainlist.com/forums/index.php?topic=3270.0

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!

The "-F" option to grep tells it to treat data as strings, not as regular expressions. MUCH faster.

Parsing, not just grep'ing

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

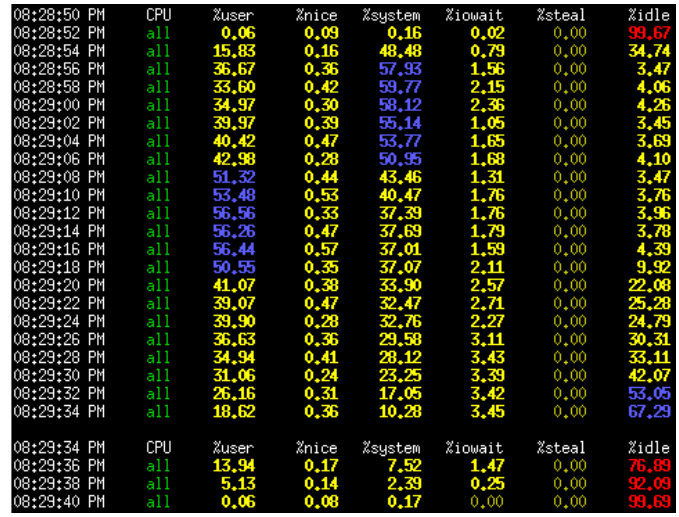
3m45s (or so) to get a report of the top 15 sites

```
$ 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
```


printurl.awk is available from the Github site. Written by Mark Jeanmougin.

When to Split Large Files

Split large files into chunks to maximize CPU Utilization



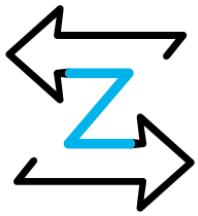
08:28:50 PM	CPU	%user	%nice	%system	%iowait	%steal	%idle
08:28:52 PM	all	0.06	0.09	0.16	0.02	0.00	99.67
08:28:54 PM	all	15.83	0.16	48.48	0.79	0.00	34.74
08:28:56 PM	all	36.67	0.36	57.93	1.56	0.00	3.47
08:28:58 PM	all	33.60	0.42	59.77	2.15	0.00	4.06
08:29:00 PM	all	34.97	0.30	58.12	2.36	0.00	4.26
08:29:02 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

Output of “sar 2” command.

See how CPU utilization trails off over time? That’s bad. Split your largest files into chunks so the work is more balanced.

Two Quick Examples

1. Zeek / Bro
2. ClamAV



I had a customer with about 10-15 Security Onion sensors that we're seeing about 1Gbit/sec of traffic each. The traffic was more small sessions than large ones. Searching through dozens of GB's of bro (or zeek) logs was normal. Management was frustrated that searches took too long. SOC was frustrated: Searching a few days took "too long"; no sense in asking to go back a few weeks. They were frustrated that they had so much data but couldn't get value out of it.

This was before ELK was incorporated into Security Onion.

For just a few thousand dollars, we stood up a 32core machine with a few TB of NVMe storage.

Example 3 in this section is the best example, but it is also the best thing to cut for time if you need.

What Started All This?

bro!

Threat Intel and “bad” Domain Names

I had a customer with about 10-15 Security Onion sensors that we’re seeing about 1Gbit/sec of traffic each. The traffic was more small sessions than large ones. Searching through dozens of GB’s of bro (or zeek) logs was normal. Management was frustrated that searches took too long. SOC was frustrated: Searching a few days took “too long”; no sense in asking to go back a few weeks. They were frustrated that they had so much data but couldn’t get value out of it.

This was before ELK was incorporated into Security Onion.

For just a few thousand dollars, we stood up a 32core machine with a few TB of NVMe storage.

Example 3 in this section is the best example, but it is also the best thing to cut for time if you need.

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

Don't take these speedup percentages for this exercise as Gold Standard. During testing, the computer was doing other things at the time with up to 6 cores pegged for other tasks.

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

Don't take these speedup percentages for this exercise as Gold Standard. During testing, the computer was doing other things at the time with up to 6 cores pegged for other tasks.

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

Don't take these speedup percentages for this exercise as Gold Standard. During testing, the computer was doing other things at the time with up to 6 cores pegged for other tasks.

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

Don't take these speedup percentages for this exercise as Gold Standard. During testing, the computer was doing other things at the time with up to 6 cores pegged for other tasks.

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

$
```


Available from:

https://github.com/markjx/search2018/blob/master/dailyify.sh

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

Don't take these speedup percentages for this exercise as Gold Standard. During testing, the computer was doing other things at the time with up to 6 cores pegged for other tasks.

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

Get the Data

Syslog

FTP / SCP daily exports

Store the Data

I like having one log file per generator per day. For example:

2018/02/06/firewall1.log

2018/02/06/firewall2.log

2018/02/06/proxy1.log

2018/02/06/proxy2.log

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

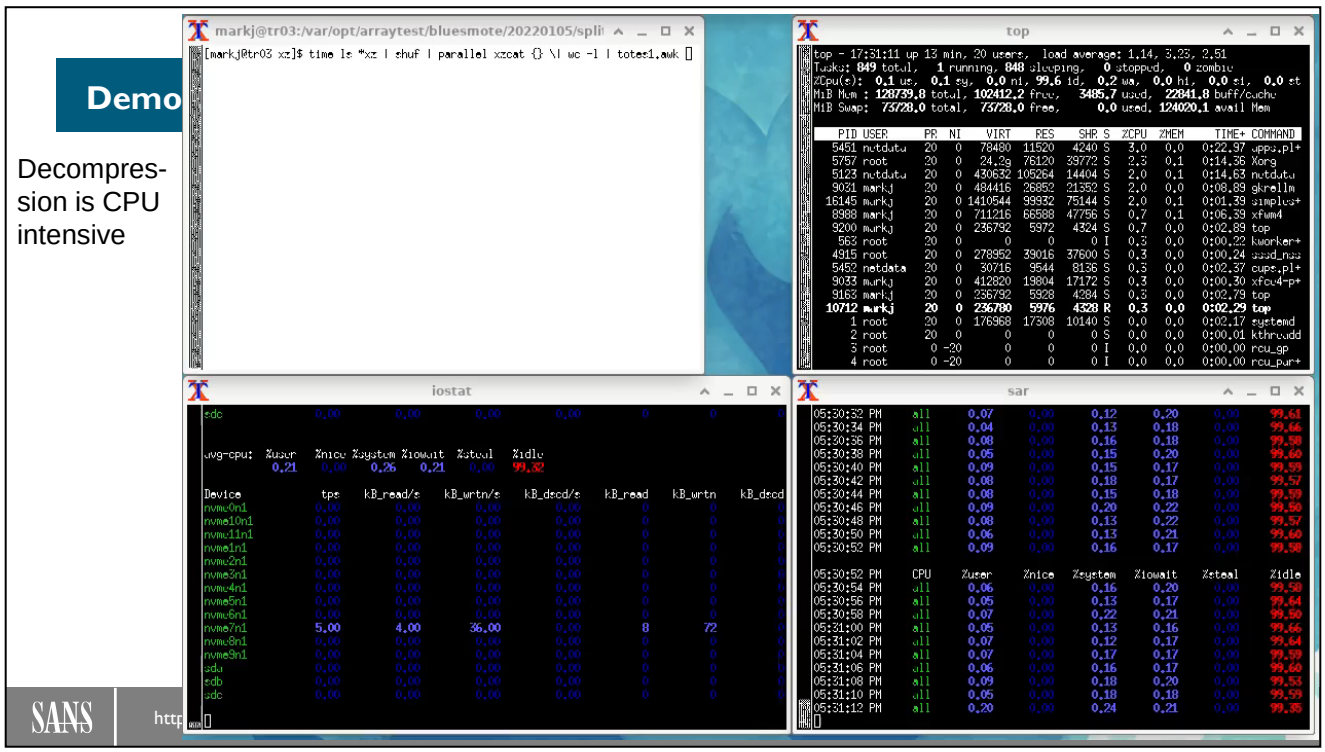
You'll also need a Linux environment. From what I know about PowerShell, it isn't powerful enough for this … yet.

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



50sec video

Setup is something like:

xterm &

xterm –rv –e sar 2 &

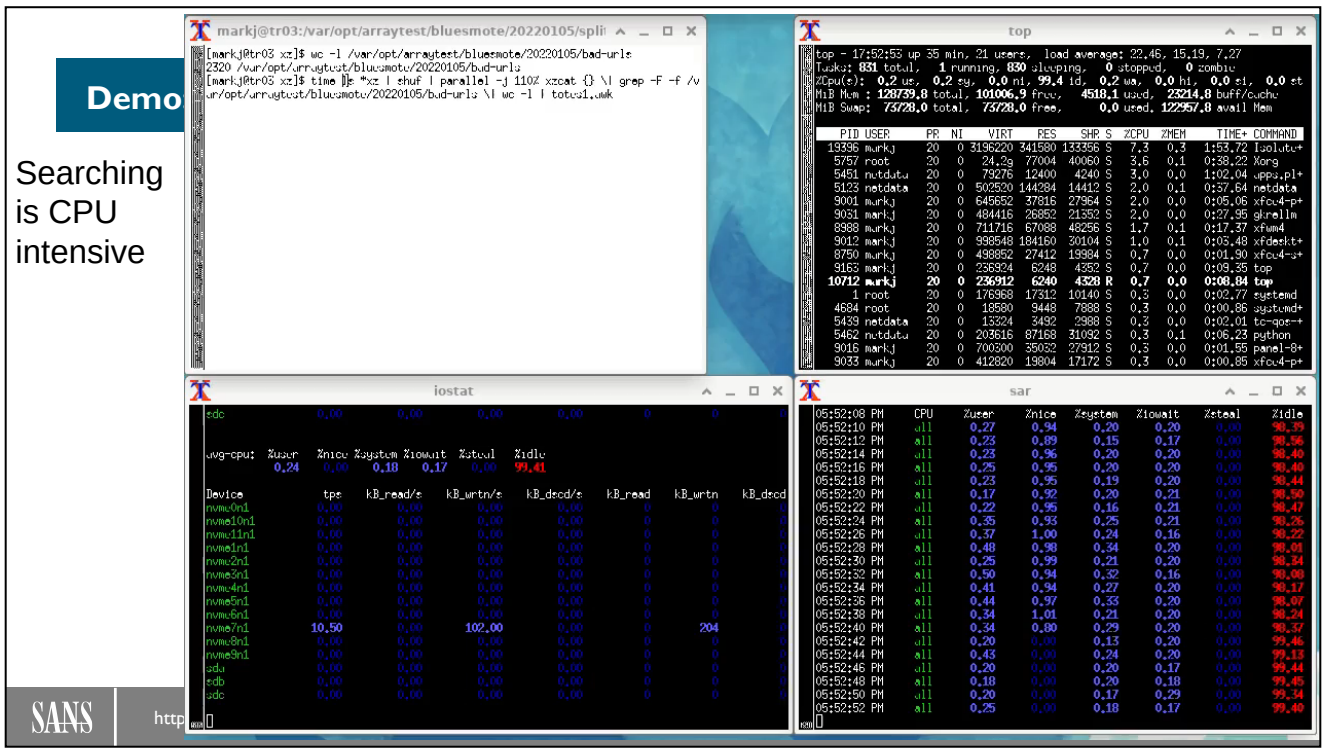
xterm –rv –e iostat 2 /dev/sd? /dev/nvme?p1 &

xterm –e top &

Command:

time ls nvme?/SG*/*lz4 | shuf | parallel lz4cat {} \| wc –c | totes1.awk

I recorded this on my Fedora workstation with “recordmydesktop –x 2570 –y 1 --width 1000 --height 700”. The output is ogv, which PowerPoint doesn’t like. I converted to mp4 with “ffmpeg -i demo.ogv -f mp4 demo.mp4”. You can also use the “--windowid” option to only record a single window. You find out the windowid with the “xwininfo” command



65sec video

Command:

wc -l /var/opt/data0/paraproj/malwaredomainlist/bad-urls

time ls nvme?/SG*/*lz4 | shuf | parallel –j 110% lz4cat {} \| grep -F -f /var/opt/data0/paraproj/malwaredomainlist/bad-urls \| wc -l | totes1.awk

For a live demo, ask people for interesting sites and do something like

$ time ls nvme?/SG*/*lz4 | shuf | parallel lz4cat {} \| grep -F -e tacobell.com -e microsoft.com -e oracle.com \| wc -c | totes1.awk

squishycat

cat compressed files

- **gzip**
- **bzip2**
- **lz4**
- **xz**

Or uncompressed!

Photo Credit: My cat, Ceili, just before and after being shaved. Taken by Mark Jeanmougin.
https://github.com/markjx/search2018/

squishycat is like the normal UNIX cat command except: When dealing with normal ASCII text, it just cats it. When dealing with data compressed, it decompresses it first, then cat's it. It currently supports gzip, bzip2, lz4, and xz.

squishycat: Use

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


Generated compressed files:

```
ifn=SG_main__470802230000.log ;
for i in gzip bzip2 xz lz4
 do
  ofn=${i}.out ;
  (time cat $ifn | $i > ${ifn}.$i) >$ofn 2>&1 &
 done
```

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]$
```


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

grepwide implements the parallelization techniques in this presentation. It uses two files in your home directory:

- look4me: list of regular expressions, one per line, that you're looking for. NO BLANK LINES!
- outfile: whatever lines match the RE's in look4me are saved in this file

Bibliography

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

Some of the sites that proved useful in this research, in no particular order:

http://www.secrepo.com/
https://www.netresec.com/?page=PcapFiles
https://virusshare.com/about.4n6
https://archive.org/details/datasets
http://www.unb.ca/cic/datasets/index.html
https://www.unsw.adfa.edu.au/australian-centre-for-cyber-security/cybersecurity/ADFA-NB15-Datasets/
https://cloudstor.aarnet.edu.au/plus/index.php/s/2DhnLGDdEECo4ys?path=%2FUNSW-NB15%20-%20pcap%20files
http://kdd.ics.uci.edu/databases/kddcup99/kddcup99.html
http://commoncrawl.org/the-data/get-started/
https://registry.opendata.aws/
https://mcfp.felk.cvut.cz/publicDatasets/CTU-Malware-Capture-Botnet-318-1/
https://ictf.cs.ucsb.edu/pages/the-2016-2017-ictf.html
https://download.netresec.com/pcap/
ftp://download.iwlab.foi.se/dataset/smia2012/network_traffic/pcap/

ftp://download.iwlab.foi.se/dataset/smia2011/Network_traffic/
ftp://download.iwlab.foi.se/dataset/smia2012/network_traffic/pcap/
ftp://ftp.bro-ids.org/enterprise-traces/hdr-traces05/
http://cybercrime-tracker.net/
http://cybercrime-track er.net/all.php

http://dfir.to/DFIRCON-Challenge-15
http://dfir.to/FOR572-Challenge-Data
http://downloads.digitalcorpora.org/corpora/files/govdocs1/zipfiles/
http://log-sharing.dreamhosters.com/
http://osint.bambenekconsulting.com/feeds/dga-feed.txt
https://archive.org/download/2011_04_02_enron_email_dataset
https://download.netresec.com/pcap/maccdc-2012/
https://download.netresec.com/pcap/smia-2011/
https://download.netresec.com/pcap/smia-2012/
https://drive.google.com/file/d/0B_IN6RzP69b2TkNrYVdOMnQ4LVE/view
https://ictf.cs.ucsb.edu/pages/the-2016-2017-ictf.html
https://ransomwaretracker.abuse.ch/feeds/csv/
https://www.ll.mit.edu//ideval/data/1999data.html
https://www.ll.mit.edu/ideval/data/1999/training/week1/index.html
https://www.uvic.ca/engineering/ece/isot/datasets/index.php#section0-0
https://zeustracker.abuse.ch/blocklist.php
https://zeustracker.abuse.ch/blocklist.php?download=baddomains
https://zeustracker.abuse.ch/blocklist.php?download=badips
http://www.gwern.net/DNM-archives
http://www.malwaredomainlist.com/forums/index.php?topic=3270.0
http://www.netresec.com/?page=PcapFiles

Some books that I found useful:

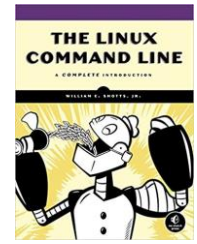
- Linux Command Line, 2nd Edition: https://nostarch.com/tlcl2 If you buy from No Starch Press directly, it includes the DRM-free ebook.
- Linux in a Nutshell from O'Reilly https://www.amazon.com/Linux-Nutshell-Desktop-Quick-Reference/dp/0596154488/
- The Tao of Network Security Monitoring https://www.amazon.com/Tao-Network-Security-Monitoring-Intrusion/dp/0321246772
- The Practice of Network Security Monitoring: https://nostarch.com/nsm If you buy from No Starch Press directly, it includes the DRM-free ebook.
- Applied Network Security Monitoring by Chris Sanders & Jason Smith. https://www.amazon.com/Applied-Network-Security-Monitoring-Collection/dp/0124172083/

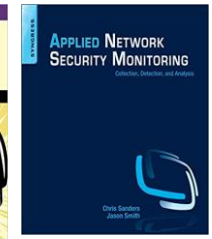
Keep an eye on Humble Bundle. They periodically do bundles from O'Reilly, No Starch Press, and other great publishers.

Questions?

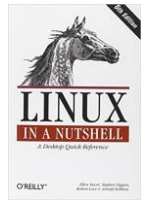
markjx@gmail.com

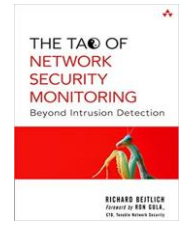
@markjx01 https://markjx.blogspot.com/

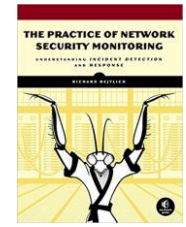




Slide Deck & Scripts:
https://github.com/markjx/search2018/







Books that may be useful:

Linux Command Line, 2nd Edition: https://nostarch.com/tlcl2 If you buy from No Starch Press directly, it includes the DRM-free ebook. Support the author at http://linuxcommand.org/tlcl.php

Linux in a Nutshell from O'Reilly https://www.amazon.com/Linux-Nutshell-Desktop-Quick-Reference/dp/0596154488/

The Tao of Network Security Monitoring https://www.amazon.com/Tao-Network-Security-Monitoring-Intrusion/dp/0321246772

The Practice of Network Security Monitoring: https://nostarch.com/nsm If you buy from No Starch Press directly, it includes the DRM-free ebook.

Applied Network Security Monitoring by Chris Sanders & Jason Smith. https://www.amazon.com/Applied-Network-Security-Monitoring-Collection/dp/0124172083/

Keep an eye on Humble Bundle (https://www.humblebundle.com/). They periodically do bundles from O'Reilly, No Starch Press, and other great publishers.

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

I'm Using: CPU: AMD 3970X "Threadripper"

NVMe solid state drives from Samsung (like the 980 Pro gen 4x4) as well as the Inland drives from Micro Center (gen3 and gen4). Things like the ASUS Hyper M.2 X16 Gen 4 are helpful.

But really, these techniques work with: Any multi-core CPU & Any SSD

Stop thinking that VM's are just as good as bare hardware. Stop thinking that you need "server class" hardware.

The Pentium 4 (2000) was the last CPU where Intel tried to chase MHz. It was replaced by the Core architecture (2006), itself highly based on the P6 architecture of the Pentium Pro (1995). That was an excellent architecture, but as of 2018, the only thing people will remember about is that it was Intel's first CPU with the Speculative Execution Vulnerabilities known as Spectre & Meltdown.

Fastest MHz Offered:

Pentium 4 HT 3.8F: 3.80GHz / Nov 2004

Ryzen 9 5950X (16 core): 4.9GHz / Nov 2020

Intel i9-112900 (8P+8E core): 5.1GHz / Jan 2022

Intel i9-10980XE (18 core): 4.6GHz / Dec 2019

Threadripper 3970X (32 core): 4.5GHz / Nov 2019

What is Hyper-Threading? Or Simultaneous Multi-Threading?

- One execution core with multiple register sets

- Two queues, two registers, one cashier.
- When someone goes “uh…”, the cashier pays attention the person in the other queue.

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
```


The RAID I used is five 7200rpm 2TB drives in RAID 5. This is meant to be representative of an Enterprise configuration.

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

Most important thing to take away from this section: Small compression differences have HUGE impacts. Test for your environment. Different data sets may want different compression schemes.

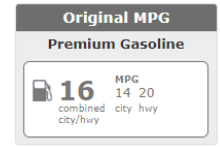
Compression Test – CERT Insider r6.2

			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

The 6m39s time was on my Threadripper 1950X.

On my 3970X, I was able to convert from lz4 to xz in 29m.

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
```


The dataset is 5558 jpg files from my vacation to Montreal in Summer 2017 which total to about 30GB of data.

The script converts the ~20MP files from my Canon 7D Mark II to ~2.6MP files with higher compression rates suitable for sharing on social media.

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

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

And... in parallel

[markj@tr01 all]$ 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
```


Approximately 80,168 files taking up 39,292MB of disk space. Files came from https://archive.org/download/virusshare_malware_collection_000 They are basically all malicious.

Going through sequentially:

```
[markj@tr01 virusshare]$ time clamscan -l serial -r .

----------- SCAN SUMMARY -----------
Known viruses: 6470742
Engine version: 0.99.4
Scanned directories: 20
Scanned files: 80148
Infected files: 46706
Data scanned: 59250.00 MB
Data read: 39007.12 MB (ratio 1.52:1)
Time: 10678.307 sec (177 m 58 s)

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


```
$ time find . -type f | xargs -L 400 -P 32 clamscan | tee parallel
real    28m17.375s
user    370m27.567s
sys     4m56.347s
```

the job finished at about 21:21. Here's what sar recorded in that time:

```
08:54:27 PM     all     47.96      0.00      1.58      0.05      0.00     50.42
08:56:17 PM     all     97.37      0.00      2.48      0.04      0.00      0.12
08:58:27 PM     all     98.10      0.00      1.84      0.02      0.00      0.05
09:00:25 PM     all     97.81      0.00      2.10      0.02      0.00      0.06
09:02:12 PM     all     97.25      0.00      2.61      0.03      0.00      0.10
09:04:17 PM     all     81.68      0.00      1.77      0.04      0.00     16.51
09:06:27 PM     all     13.06      0.01      0.31      0.05      0.00     86.57
09:08:17 PM     all      9.19      0.00      0.15      0.01      0.00     90.65
09:10:27 PM     all      6.16      0.00      0.10      0.01      0.00     93.73
09:12:27 PM     all      6.16      0.01      0.11      0.02      0.00     93.70
09:14:17 PM     all      6.17      0.00      0.10      0.04      0.00     93.68
09:16:27 PM     all      6.17      0.00      0.11      0.01      0.00     93.70
09:18:27 PM     all      6.17      0.00      0.10      0.00      0.00     93.72
09:20:17 PM     all      6.18      0.00      0.12      0.01      0.00     93.69
09:22:09 PM     all      3.59      0.00      0.53      0.07      0.00     95.81
Average:        all      3.43      0.13      1.00      0.05      0.00     95.40
```

The box worked hard for about 10 minutes. Then was only running a few threads for 12 minutes.

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

In early 2020, I did some research on this. There are some academic projects done starting in 2012 about porting grep to GPU's.

- There is some speedup for matching multiple patterns to one data stream. This is the use case of checking a URL history log against a Top 1 million list
- There's probably not much speedup for looking for one site in a URL history log.

I've also talked to people at Sourcefire (prior to the Cisco acquisition) about this. They found that the overhead of moving packets to a co-processor is so much slower than intra-CPU that it wasn't worth it.

If I had a Computer Science Intern, I'd give them a fast CPU and a few fast GPU's and see what they could come up with. But, I'm doubtful.

SIMD: Single Instruction (that operates on) Multiple Data (objects). One type of hardware parallelism.