
NEXT
5 km
TRANS CANADA
$12.00

Linux/Moose endangered or extinct?

An update on this atypical embedded Linux botnet

by Olivier Bilodeau

$ apropos

- Statically linked stripped ELF challenges
- Moose DNA (description)
- Moose Herding (the Operation)
- A Strange Animal
- Latest Developments

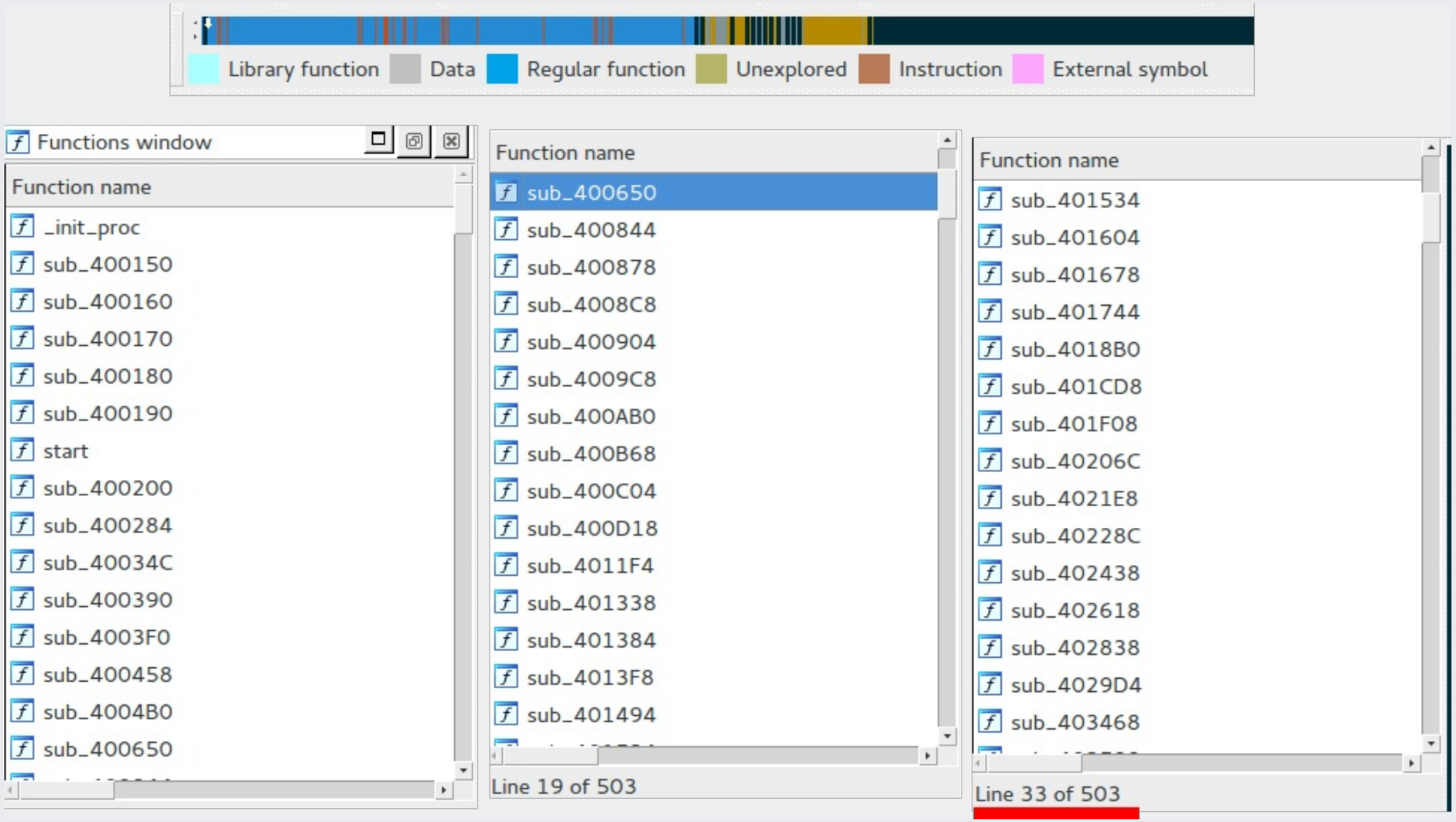
$ whoami

- Malware Researcher at ESET
- Infosec lecturer at ETS University in Montreal
- Previously
  - infosec developer, network admin, linux system admin
- Co-founder Montrehack (hands-on security workshops)
- Founder NorthSec Hacker Jeopardy

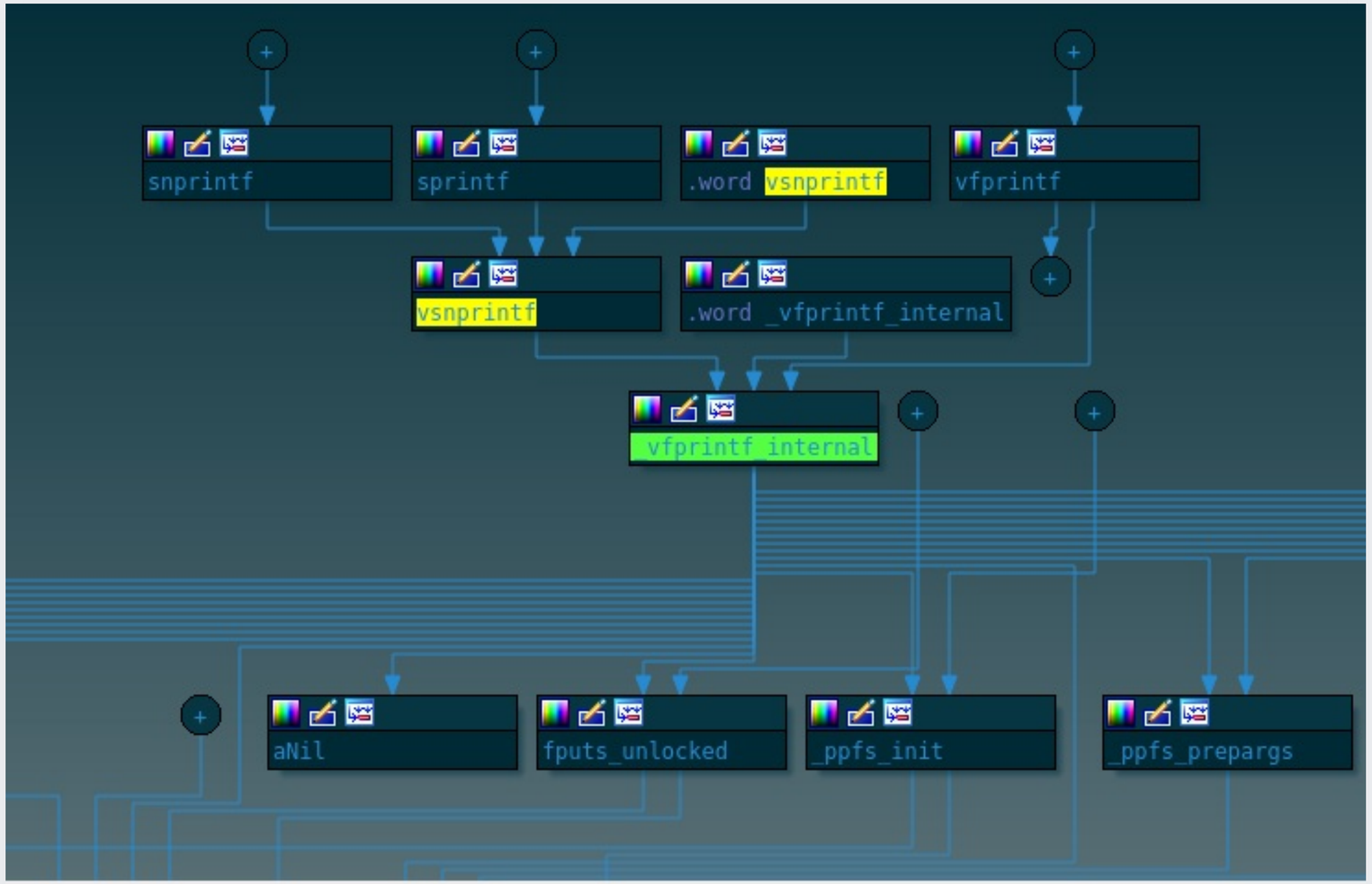
Static/stripped ELF primer

- No imports (library calls) present
- All the code bundled together down to kernel syscall
- Disassembler (if available for arch) doesn't help much

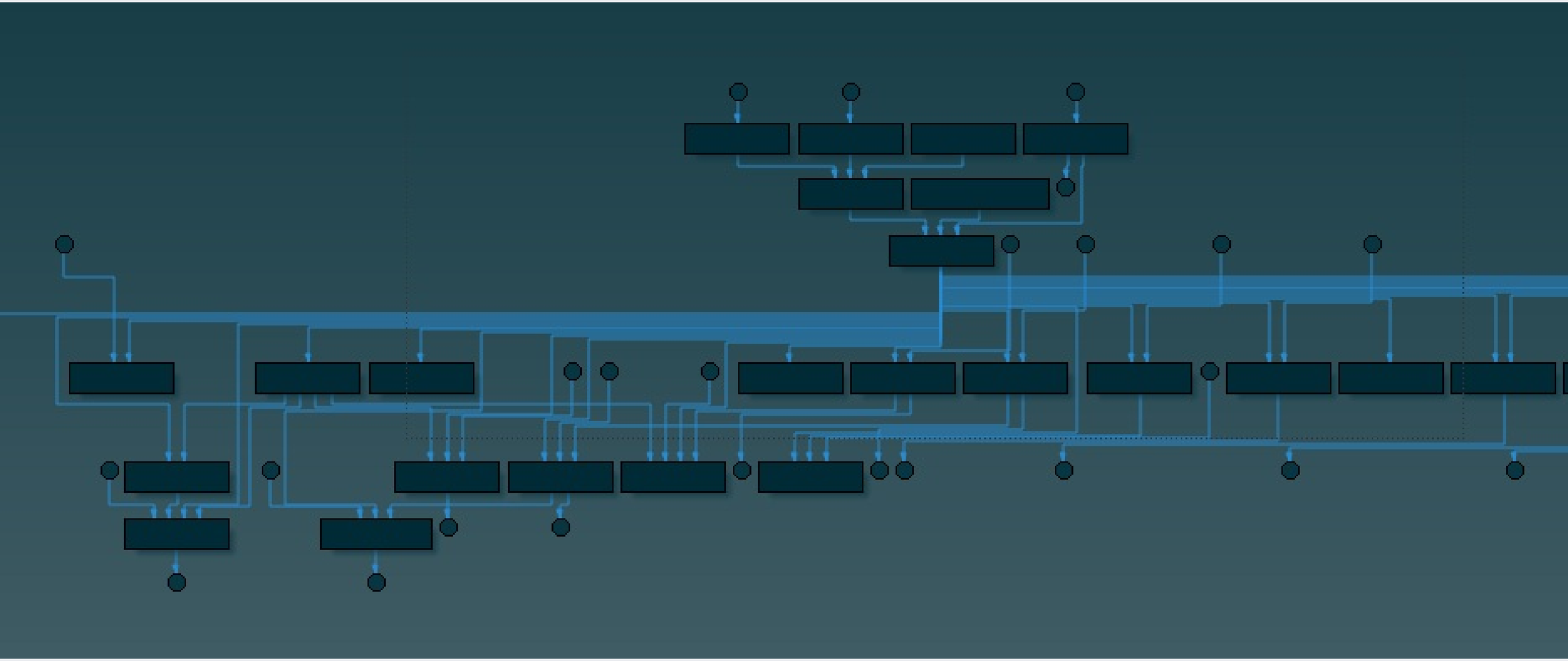
Linux/Moose binary in IDA



printf family

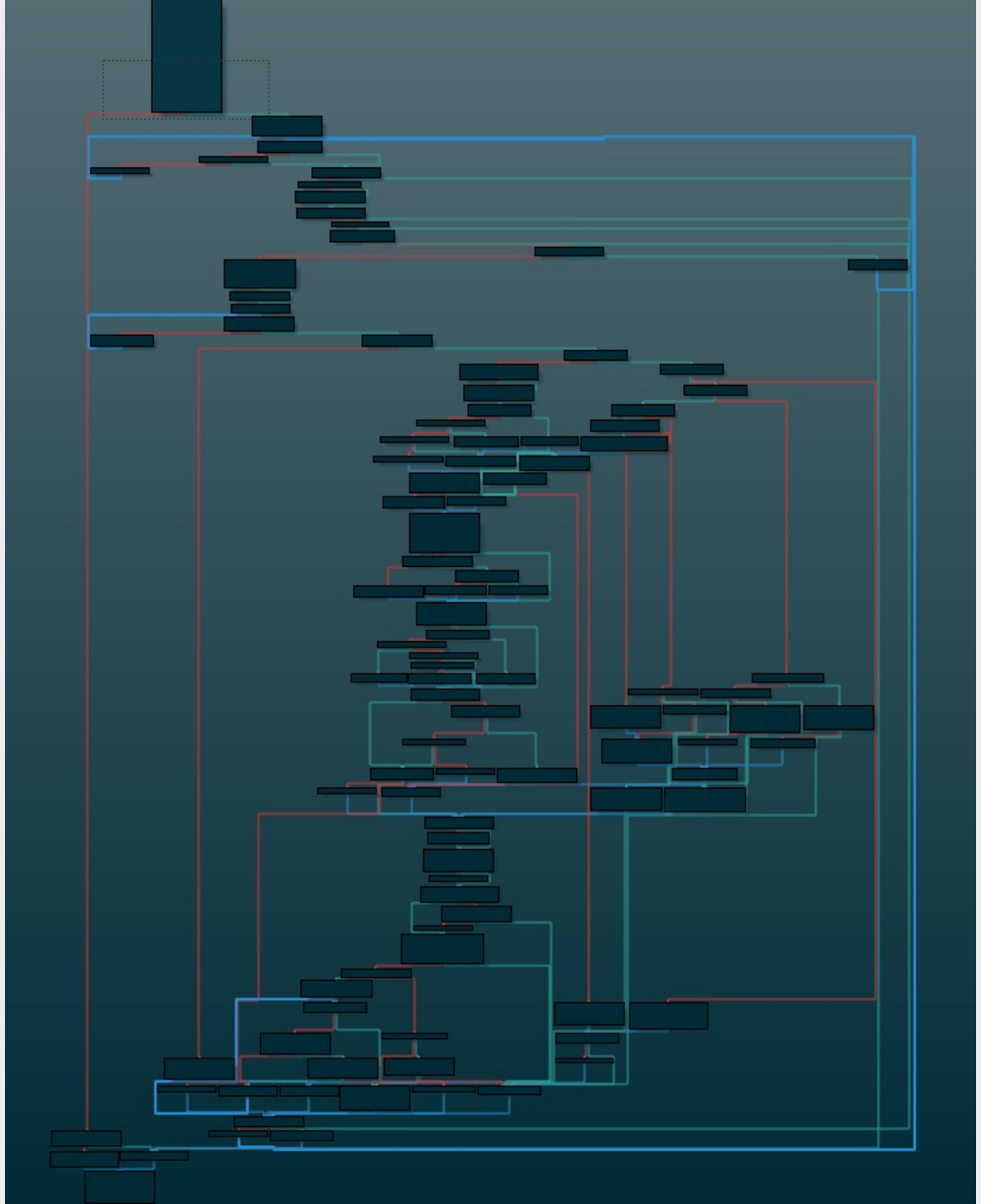


B60 00417B60: vsnprintf



ENJOY SAFER TECHNOLOGY™


WE HAVE TO GO
DEEPER!
DIYLOL.COM



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Ecosystem makes it worst [for reversers]

- GCC and GNU libc is always changing so compiled binaries always change
- Little IDA FLIRT signatures available (if any)
- µClibc, eglibc, glibc, musl, …

A Failed Attempt

- Map syscalls with IDA script
- But libc is too big it is still too much

Better Solution

- Reproduce environment (arch, libc/compiler versions)
- Build libraries w/ symbols under same conditions
- Use bindiff to map library functions
- Focus on malware code

similarity	confider	change	EA primary	name primary	EA secondary	name secondary	con	algorithm	matched ba
0.99	0.99	-I--E--	00419BE0	sub_419BE0_282	00037E60	strncmp		MD index matching (flowg...	21
0.99	0.99	-I--E--	00423F20	sub_423F20_444	00034C20	fgets		edges flowgraph MD index	18
0.99	0.99	-I--E--	004228D0	sub_4228D0_435	0002D650	__stdio_WRITE		edges flowgraph MD index	17
0.99	0.99	-I--E--	0041B634	sub_41B634_308	0003E7A4	inet_pton4		edges flowgraph MD index	21
0.99	0.99	-I--E--	004261A0	sub_4261A0_471	0002D790	__stdio_adjust_position		edges flowgraph MD index	21
0.99	0.99	-I--E--	00423010	sub_423010_438	0002E1B0	__stdio_trans2w_o		edges flowgraph MD index	17
0.99	0.99	-I--E--	004277D0	sub_4277D0_485	0003F2E0	__encode_dotted		edges flowgraph MD index	17
0.99	0.99	-I--E--	00424790	sub_424790_448	000362F0	fgets_unlocked		edges flowgraph MD index	19
0.99	0.99	-I--E--	00424050	sub_424050_445	00035BB0	_stdio_openlist_dec_use		edges flowgraph MD index	44
0.99	0.99	-I--E--	0041B734	sub_41B734_310	0003E89C	inet_ntop		edges flowgraph MD index	63
0.99	0.99	-I-----	004176FC	sub_4176FC_237	000107E4	opendir		edges flowgraph MD index	11
0.99	0.99	-I--E--	00424FF0	sub_424FF0_456	0003EE60	inet_aton		edges flowgraph MD index	17
0.99	0.99	-I--E--	004189B0	sub_4189B0_260	00030540	_ppfs_init		edges flowgraph MD index	16
0.99	0.99	-I--E--	00419670	sub_419670_268	00036810	fwrite_unlocked		edges flowgraph MD index	15
0.99	0.99	-I--E--	00418218	sub_418218_259	0002FDA8	_vfprintf_internal		edges flowgraph MD index	136
0.99	0.99	-I--E--	00419318	sub_419318_265	000354F0	putchar		address sequence	50
0.99	0.99	-I--E--	00425F00	sub_425F00_469	0002CF30	fseeko64		edges flowgraph MD index	32
0.99	0.99	-I--E--	0041FD70	sub_41FD70_384	0004E960	raise		edges flowgraph MD index	15
0.99	0.99	-I--E--	004224C0	sub_4224C0_431	00024690	wcsnrtombs		edges flowgraph MD index	19
0.99	0.99	-I--E--	00423DC0	sub_423DC0_443	00034AC0	getc		instruction count	48
0.99	0.99	-I--E--	0041B4D0	sub_41B4D0_307	0003E640	inet_ntop4		edges flowgraph MD index	11
0.99	0.99	-I--E--	004285E0	sub_4285E0_495	00051DD0	__fixdfsi		edges flowgraph MD index	13

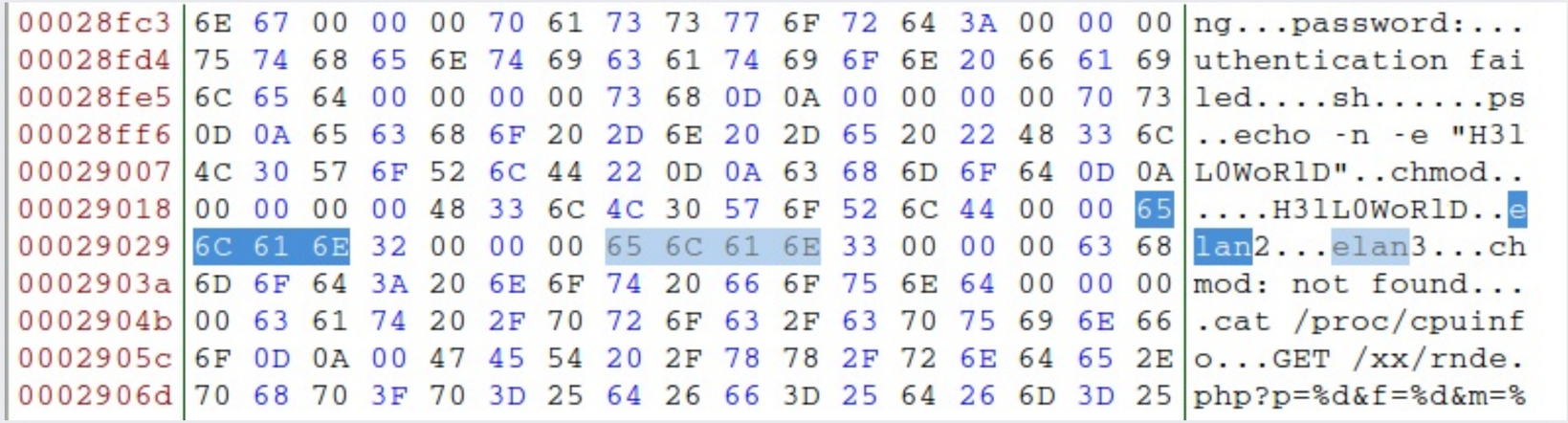
Moose DNA

aka Malware description

Hang tight, this is a recap

Linux/Moose...

Named after the string "elan" present in the malware executable



```
00028fc3 6E 67 00 00 00 70 61 73 73 77 6F 72 64 3A 00 00 00 ng...password:...
00028fd4 75 74 68 65 6E 74 69 63 61 74 69 6F 6E 20 66 61 69 uthentication fai
00028fe5 6C 65 64 00 00 00 00 73 68 0D 0A 00 00 00 00 70 73 led....sh......ps
00028ff6 0D 0A 65 63 68 6F 20 2D 6E 20 2D 65 20 22 48 33 6C ..echo -n -e "H3l
00029007 4C 30 57 6F 52 6C 44 22 0D 0A 63 68 6D 6F 64 0D 0A L0WoRlD"..chmod..
00029018 00 00 00 00 48 33 6C 4C 30 57 6F 52 6C 44 00 00 65 ....H3lL0WoRlD..e
00029029 6C 61 6E 32 00 00 00 65 6C 61 6E 33 00 00 00 63 68 lan2...elan3...ch
0002903a 6D 6F 64 3A 20 6E 6F 74 20 66 6F 75 6E 64 00 00 00 mod: not found...
0002904b 00 63 61 74 20 2F 70 72 6F 63 2F 63 70 75 69 6E 66 .cat /proc/cpuinf
0002905c 6F 0D 0A 00 47 45 54 20 2F 78 78 2F 72 6E 64 65 2E o...GET /xx/rnde.
0002906d 70 68 70 3F 70 3D 25 64 26 66 3D 25 64 26 6D 3D 25 php?p=%d&f=%d&m=%
```

Elan is French for

The Lotus Elan

Elán

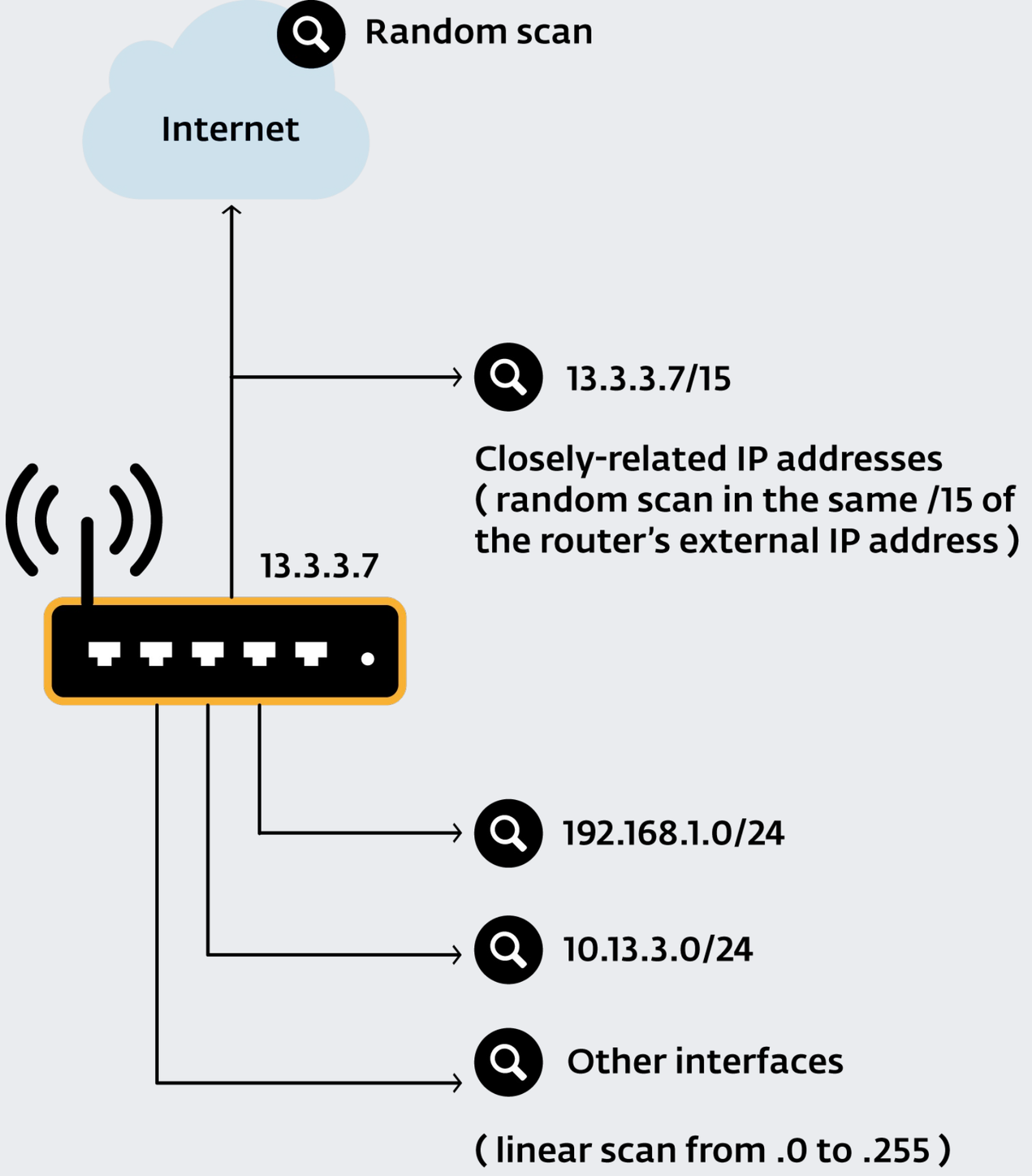
The Slovak rock band (from 1969 and still active)

Network capabilities

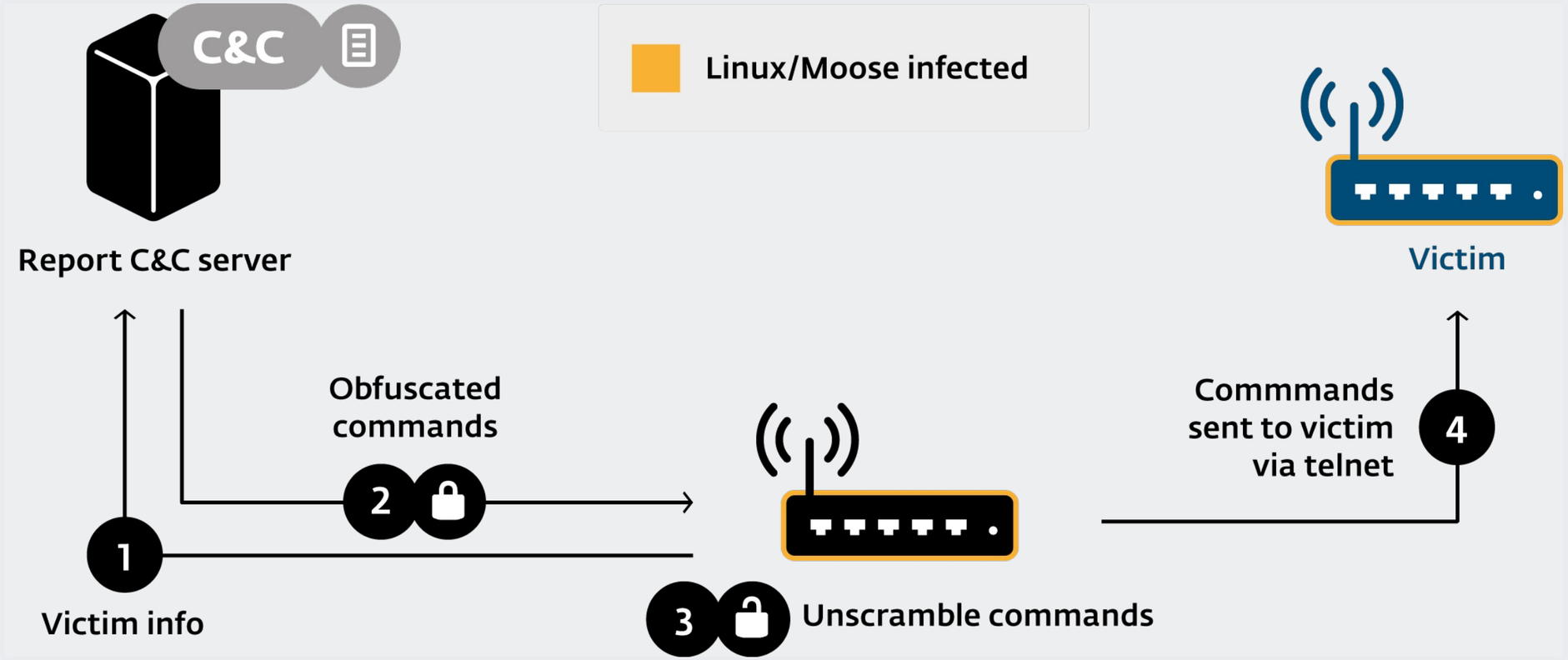
- Pivot through firewalls
- Home-made NAT traversal
- Custom-made Proxy service
  - only available to a set of whitelisted IP addresses
- Remotely configured generic network sniffer
- DNS Hijacking

Worm-like behavior

- Tries to replicate via aggressive scanning
- Will dedicate more resources to scan near current external IP
- Will also scan on LAN interfaces
- Will not reinfect an infected device
- Can replicate across architectures
- C&C is made aware of new compromises

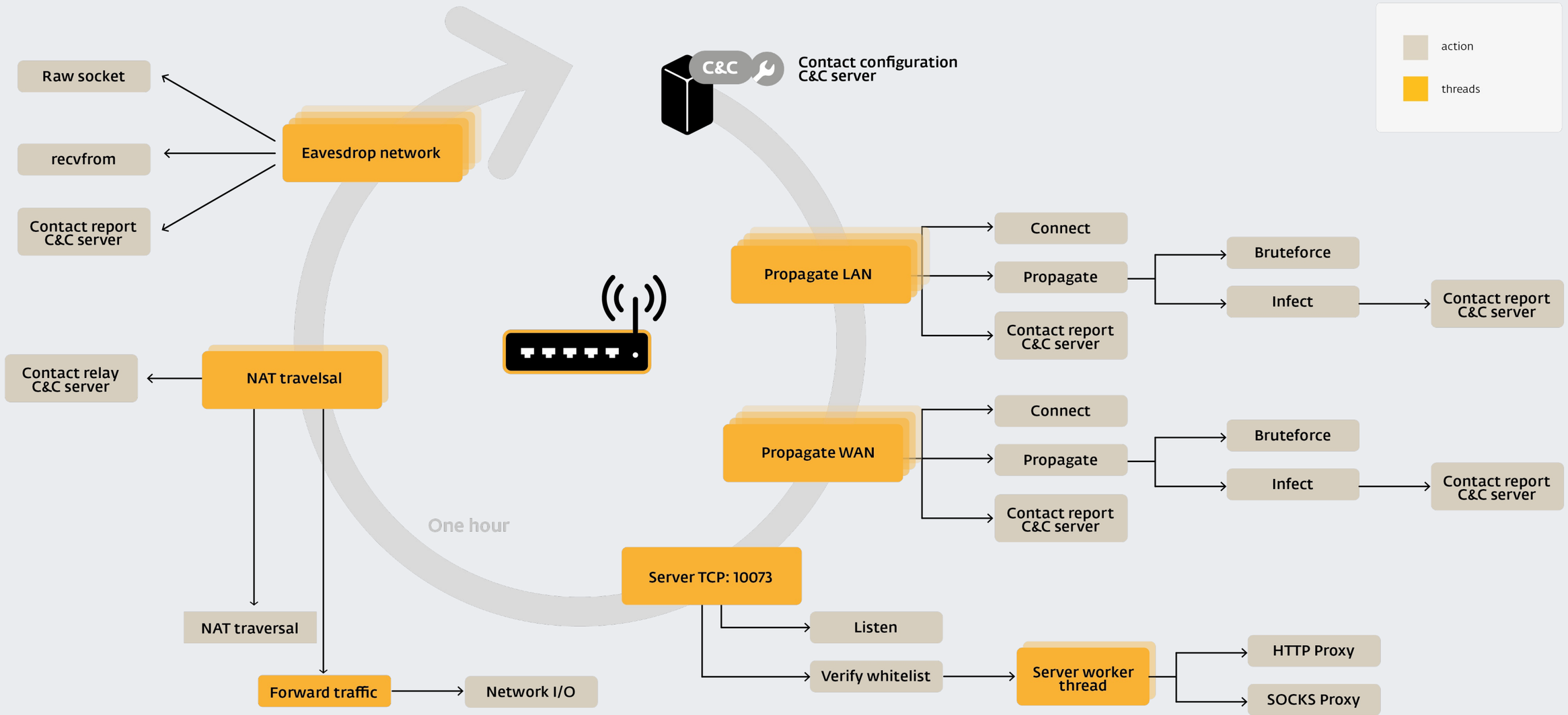


Compromise Protocol



Anti-Analysis

- Statically linked binary stripped of its debugging symbols
- Hard to reproduce environment required for malware to operate
- Misleading strings (getcool.com)



Moose Herding

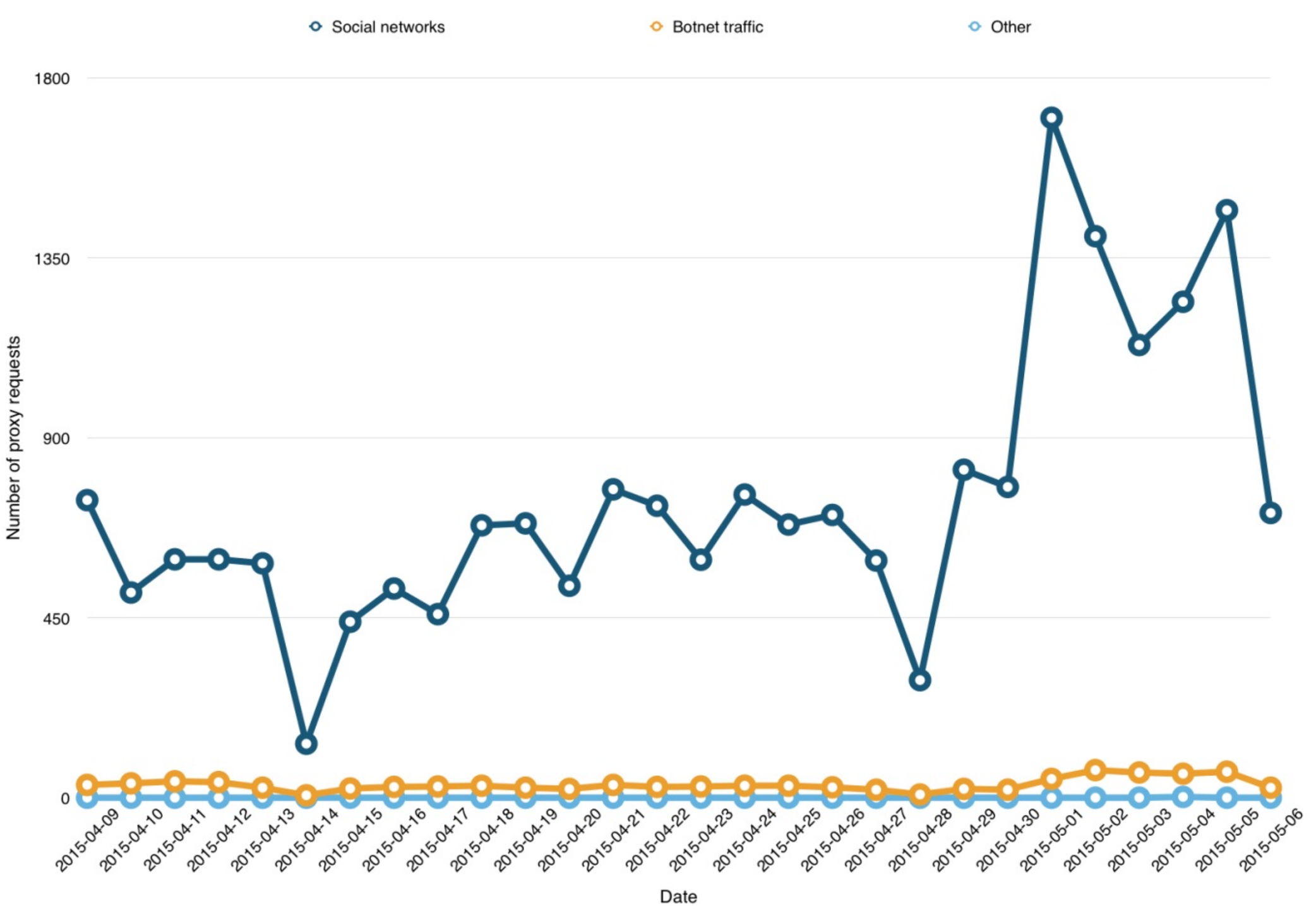
The Malware Operation

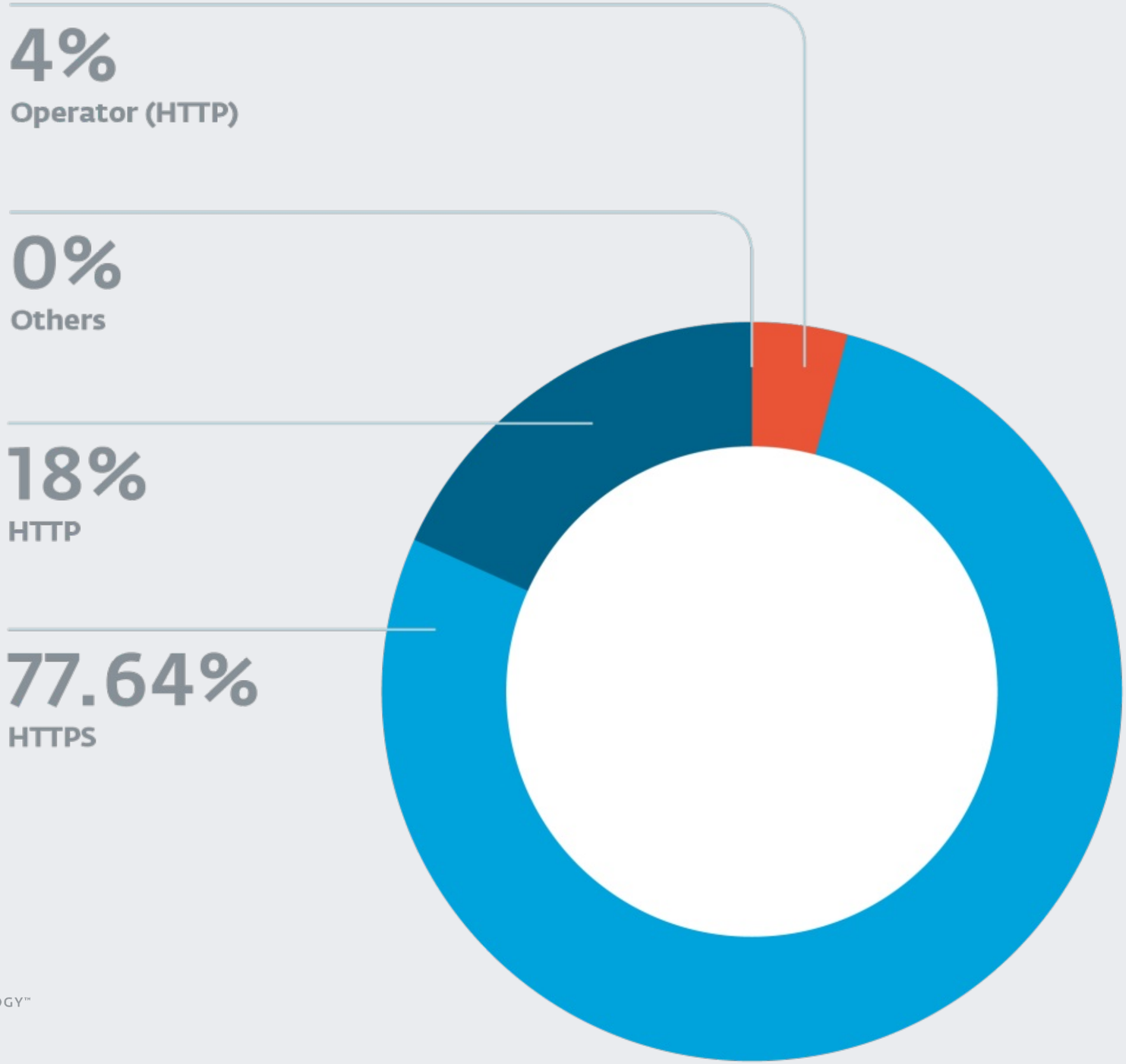
Via C&C Configuration

- Network sniffer was used to steal HTTP Cookies
  - Twitter: `twll`, `twid`
  - Facebook: `c_user`
  - Instagram: `ds_user_id`
  - Google: `SAPISID`, `APISID`
  - Google Play / Android: `LAY_ACTIVE_ACCOUNT`
  - Youtube: `LOGIN_INFO`

Via Proxy Usage Analysis

- Nature of traffic
- Protocol
- Targeted social networks


Social networks
Botnet traffic
Other
1800
1350
900
450
0
Number of proxy requests
2015-04-09
2015-04-10
2015-04-11
2015-04-12
2015-04-13
2015-04-14
2015-04-15
2015-04-16
2015-04-17
2015-04-18
2015-04-19
2015-04-20
2015-04-21
2015-04-22
2015-04-23
2015-04-24
2015-04-25
2015-04-26
2015-04-27
2015-04-28
2015-04-29
2015-04-30
2015-05-01
2015-05-02
2015-05-03
2015-05-04
2015-05-05
2015-05-06
Date

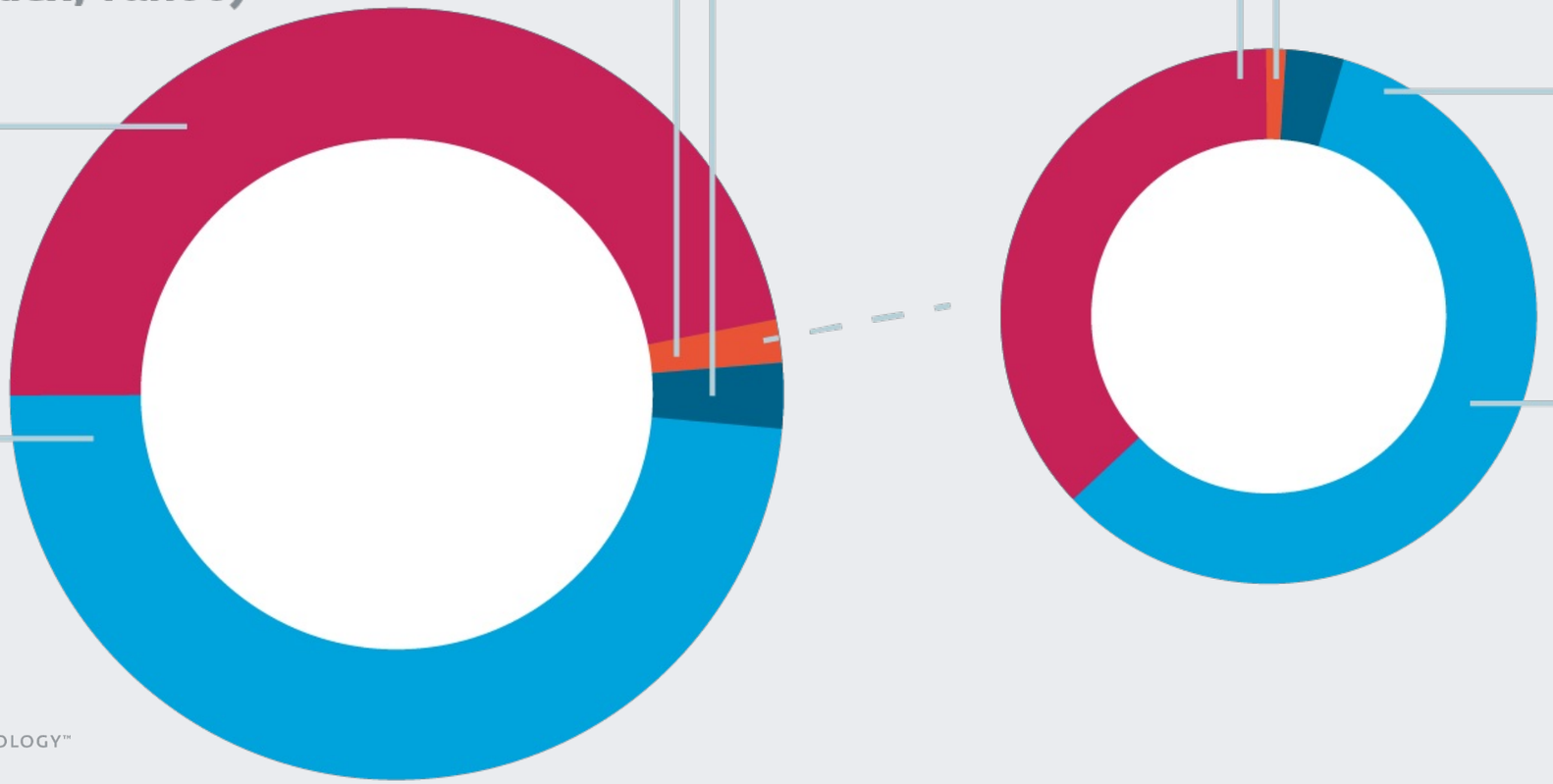

4%
Operator (HTTP)
0%
Others
18%
HTTP
77.64%
HTTPS

2%
Soundcloud

3%
Others (Youtube, Yandex, Yahoo)

47%
Instagram

49%
Twitter / Vine



59%
Yandex

4%
Yahoo

1%
Amazon Cloud

37%
Youtube

ESET ENJOY SAFER TECHNOLOGY™

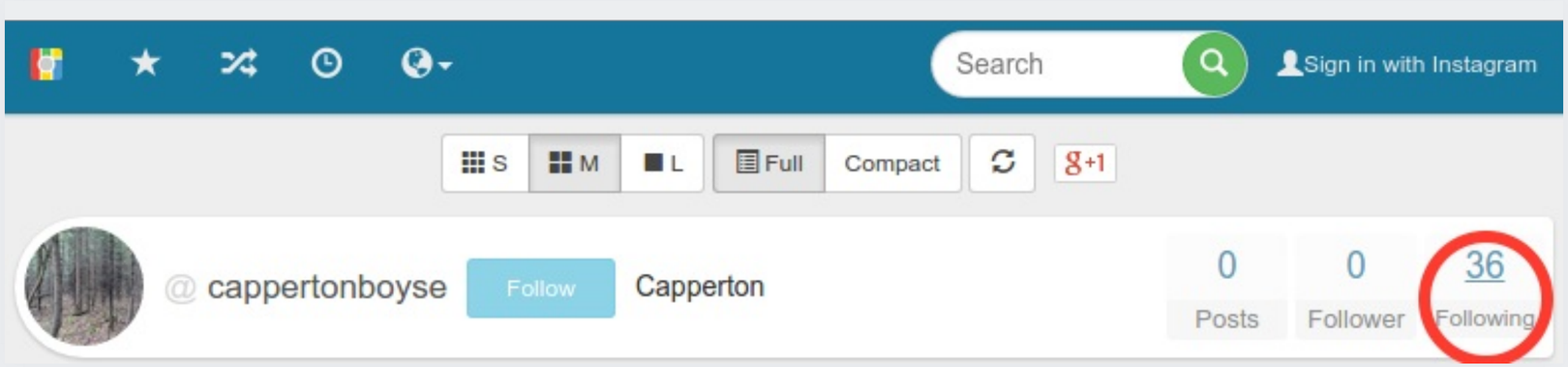
75%+ HTTPS but...

Follow TCP Stream (tcp.stream eq 10698)

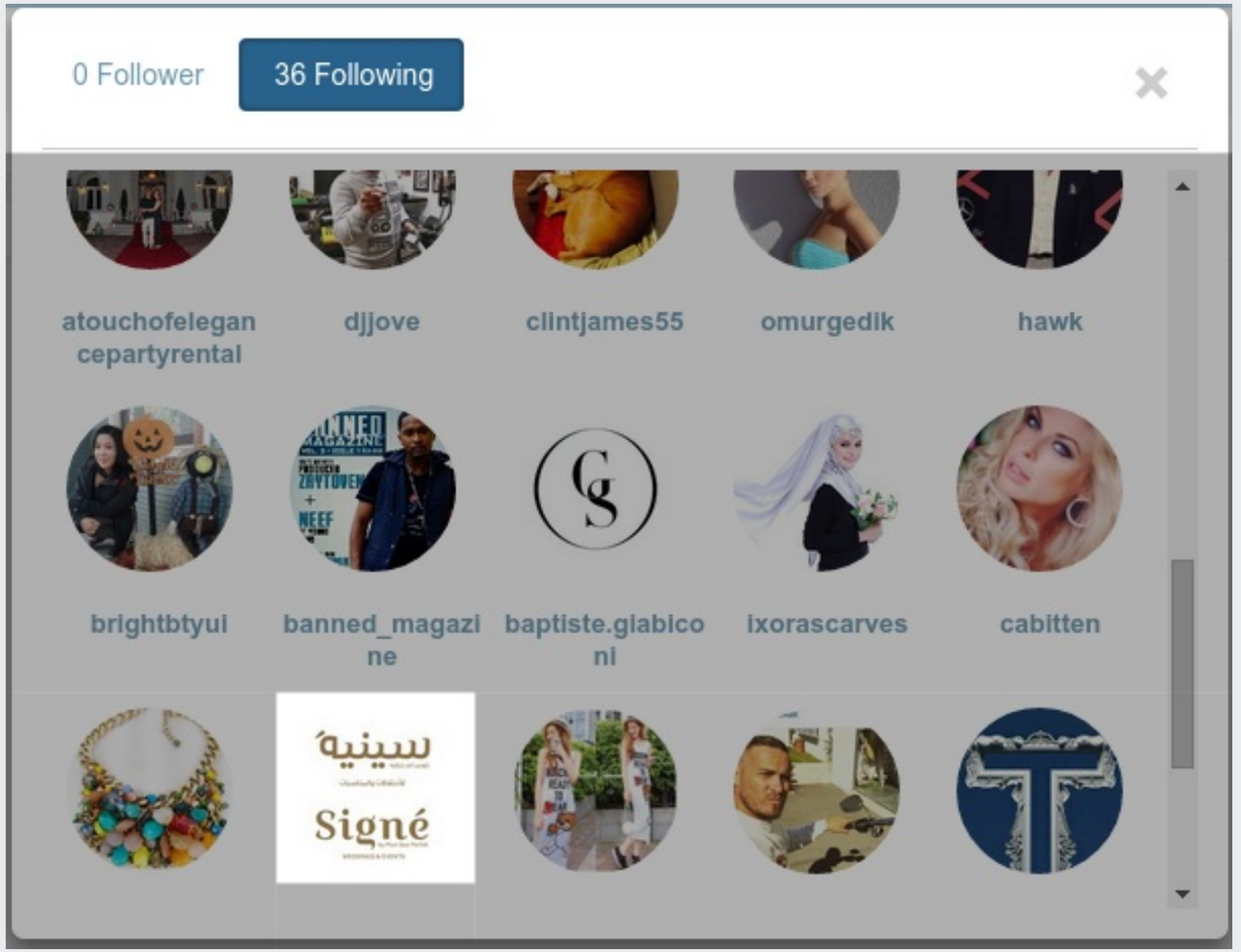
Stream Content (1)

```
...P6.X.778swan5e..Z.P6.X.GET /hookahleague HTTP/1.1
Host: instagram.com
User-Agent: Mozilla/5.0 (Windows NT 5.1; rv:17.0) Gecko/20100101 Firefox/17.0
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,*/*;q=0.8
Accept-Language: en-US,en;q=0.5
Accept-Encoding: gzip, deflate
Connection: keep-alive

HTTP/1.1 301 Moved Permanently
Content-Type: text/html
Date:
Location: https://instagram.com/hookahleague/ (2)
Server: nginx
Content-Length: 178
Connection: keep-alive

<html>
<head><title>301 Moved Permanently</title></head>
<body bgcolor="white">
<center><h1>301 Moved Permanently</h1></center>
<hr><center>nginx</center>
</body>
```

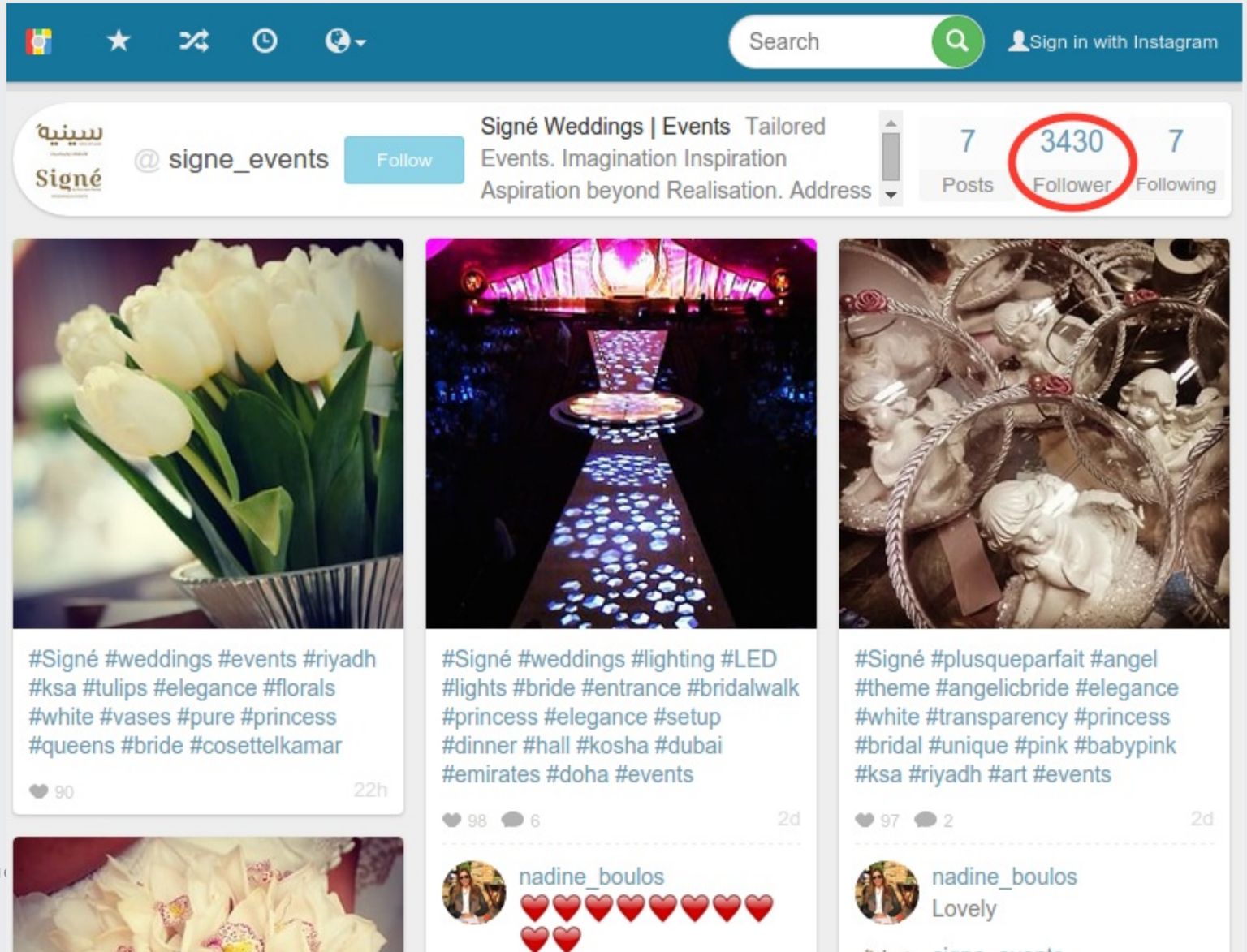
An Example


Search
Sign in with Instagram
S
M
L
Full
Compact
g+1
@ cappertonboyse
Follow
Capperton
0
Posts
0
Follower
36
Following

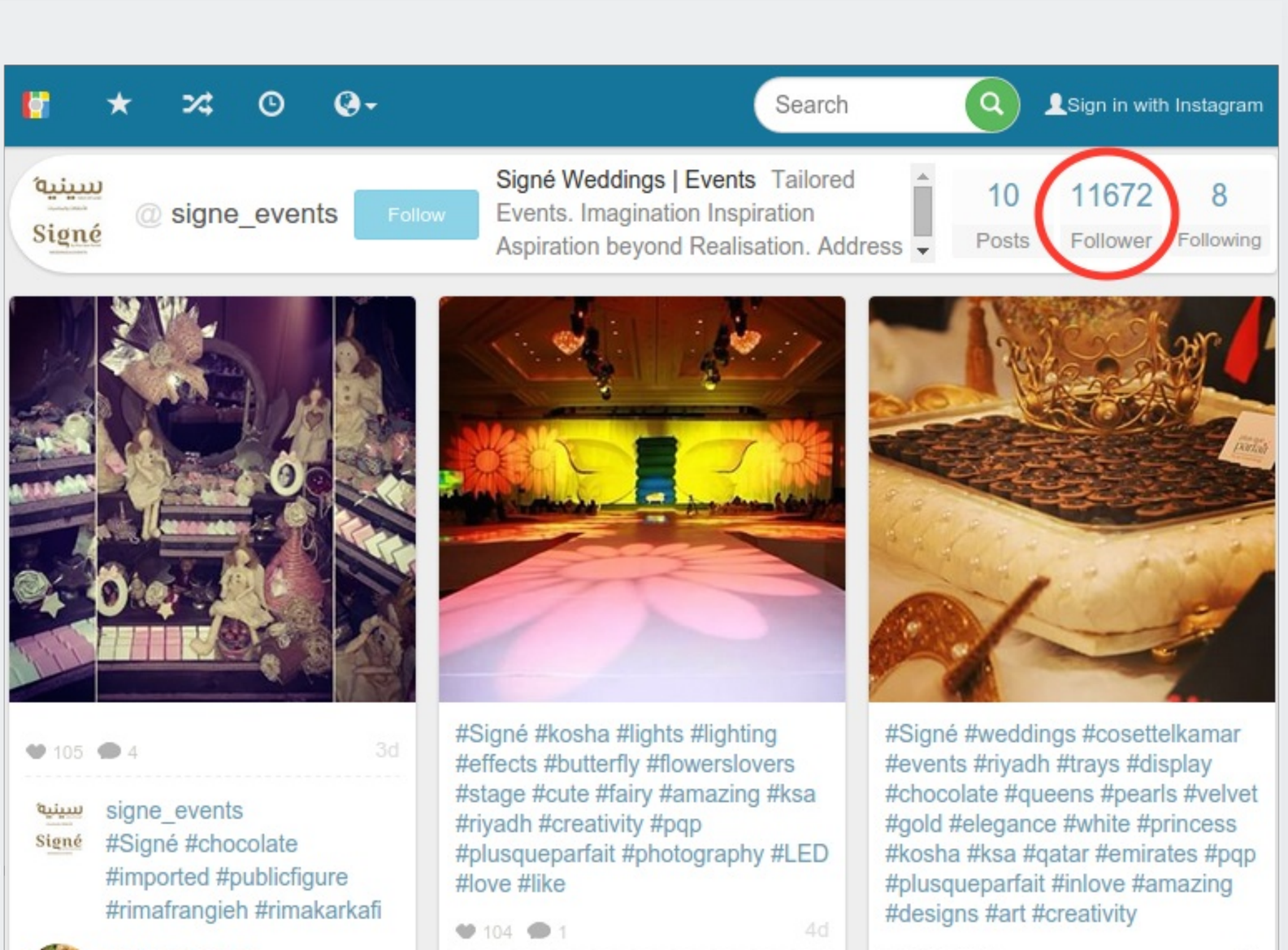
An Example (cont.)



An Example (cont.)

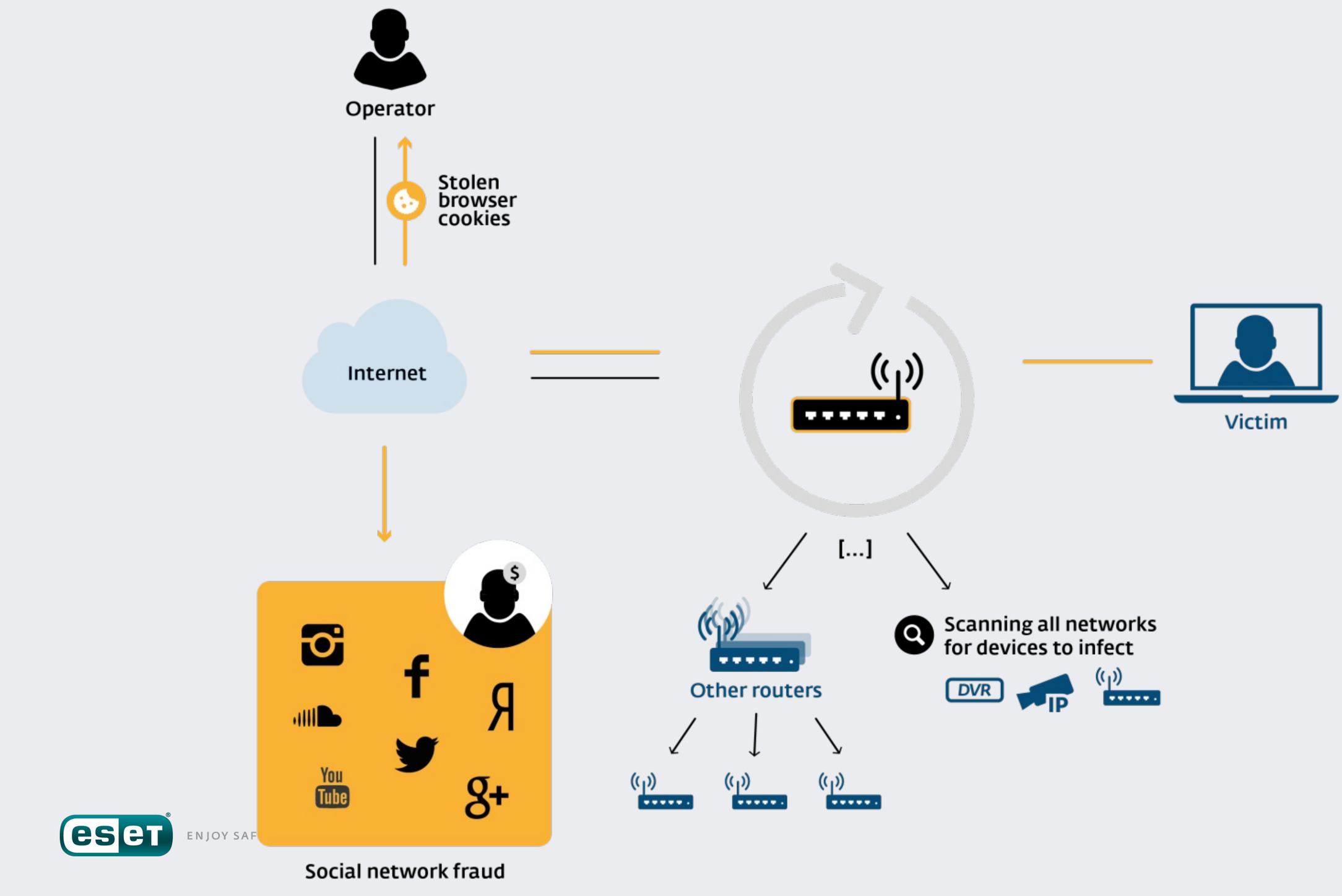


An Example (cont.)



Anti-Tracking

- Whitelist means we can’t use the proxy service to evaluate malware population
- Blind because of HTTPS enforced on social networks
- DNS Hijacking’s Rogue DNS servers never revealed


Operator
Stolen browser cookies
Internet
Victim
[...]
Other routers
Scanning all networks for devices to infect
DVR
IP
Social network fraud

A Strange Animal

Different focus

- not in the DDoS or bitcoin mining business
- no x86 variant found
- controlled by a single group of actors

Missing "features"

- No persistence mechanism
- No shell access for operators

Thought big, realized little?

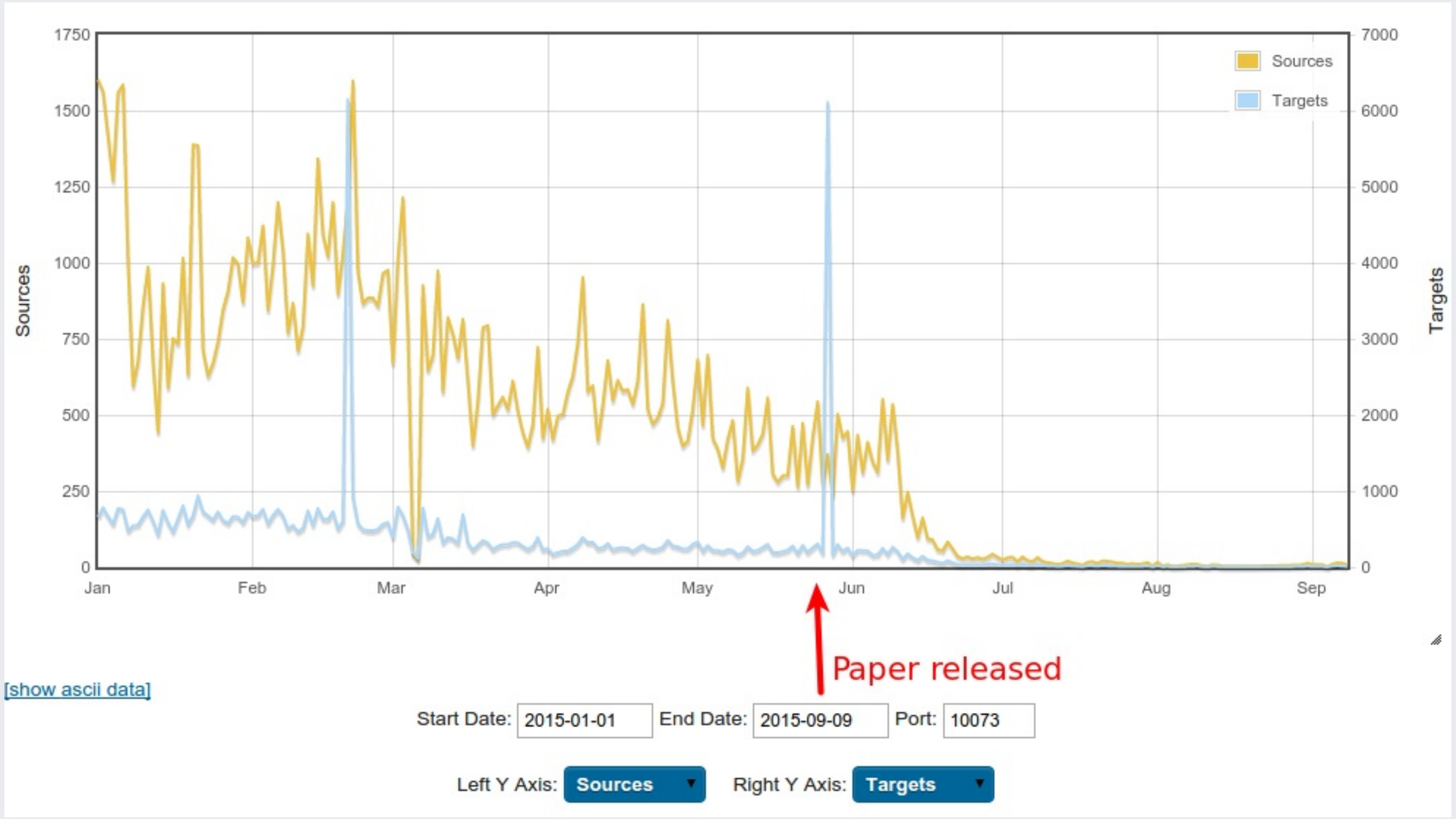
- In social network fraud, network sniffer irrelevant
- DNS Hijacking possible but only for few devices
- No ad fraud, spam, DDoS, etc.

Latest Developments

Whitepaper Impact

- Few weeks after the publication the C&C servers went dark
  - After a reboot, all affected devices should be cleaned
  - But victims compromised via weak credentials, so they can always reinfect

Alive or dead?



Alive or dead? (cont.)

- On the lookout for Moose v2
- Looked at over 150 new samples targeting embedded Linux platforms
- Linux/Aidra, Linux/Dofloo (AES.DDoS), Linux/DNSAmp (Mr.Black), Linux.Gafgyt and Linux/Tsunami
- Still no Moose update…

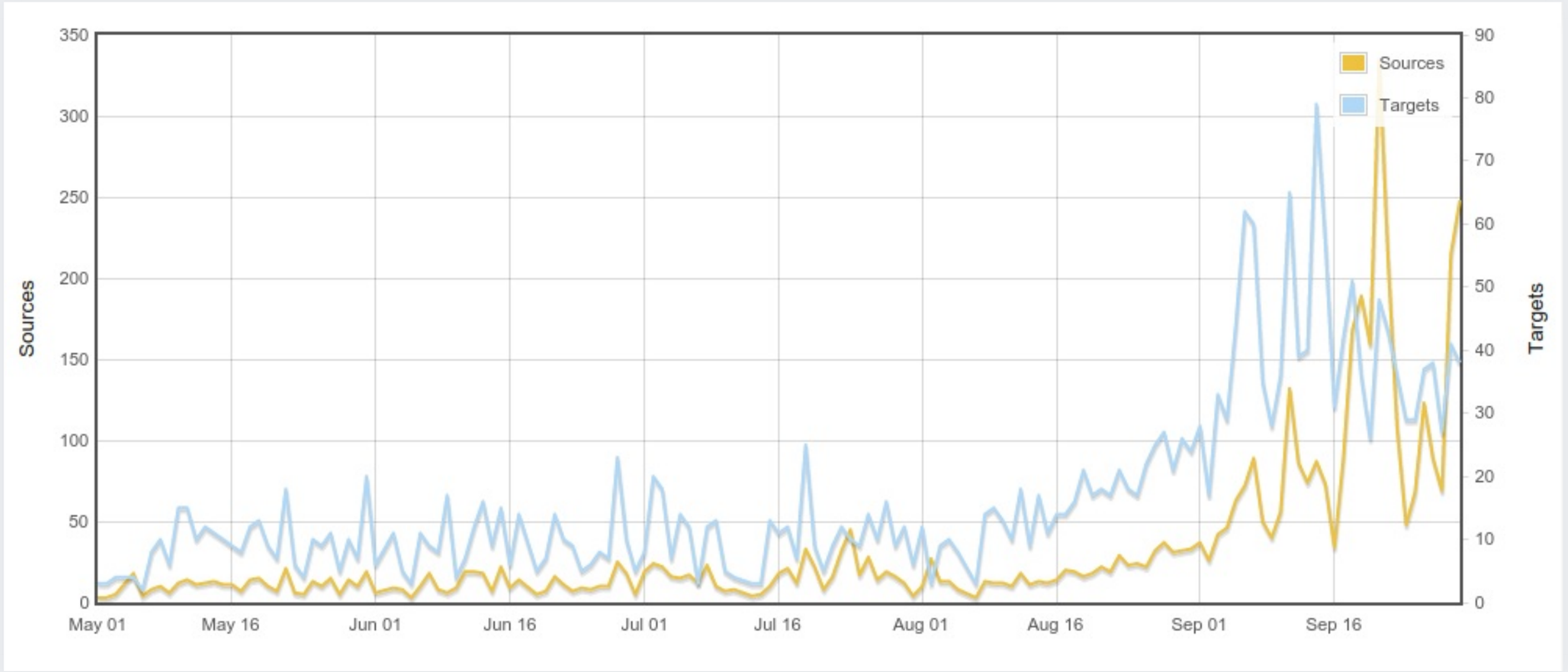
Yay! except…

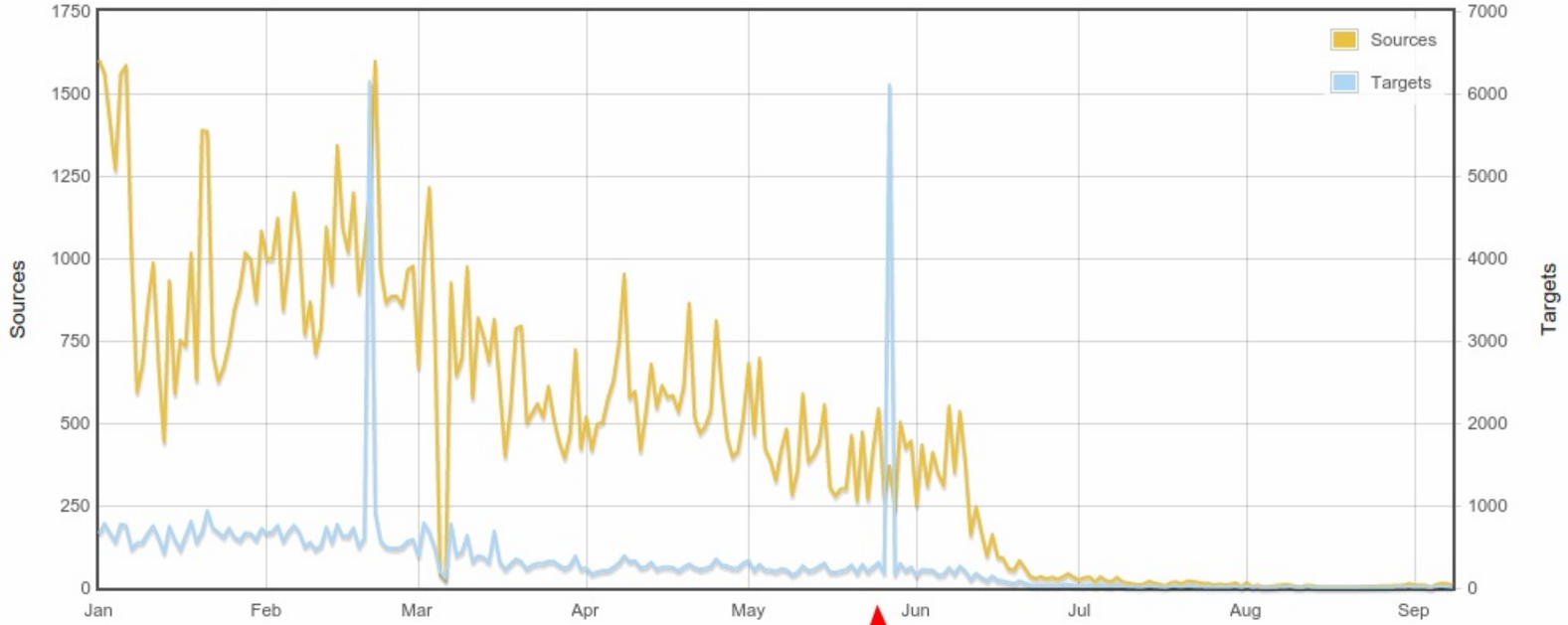
Moose level-up

Update

New sample this Saturday

- New proxy service port (20012)
- New C&C selection algorithm
- Lots of differences
- Still under scrutiny


Sources
Targets
350
300
250
200
150
100
50
0
90
80
70
60
50
40
30
20
10
0
May 01
May 16
Jun 01
Jun 16
Jul 01
Jul 16
Aug 01
Aug 16
Sep 01
Sep 16

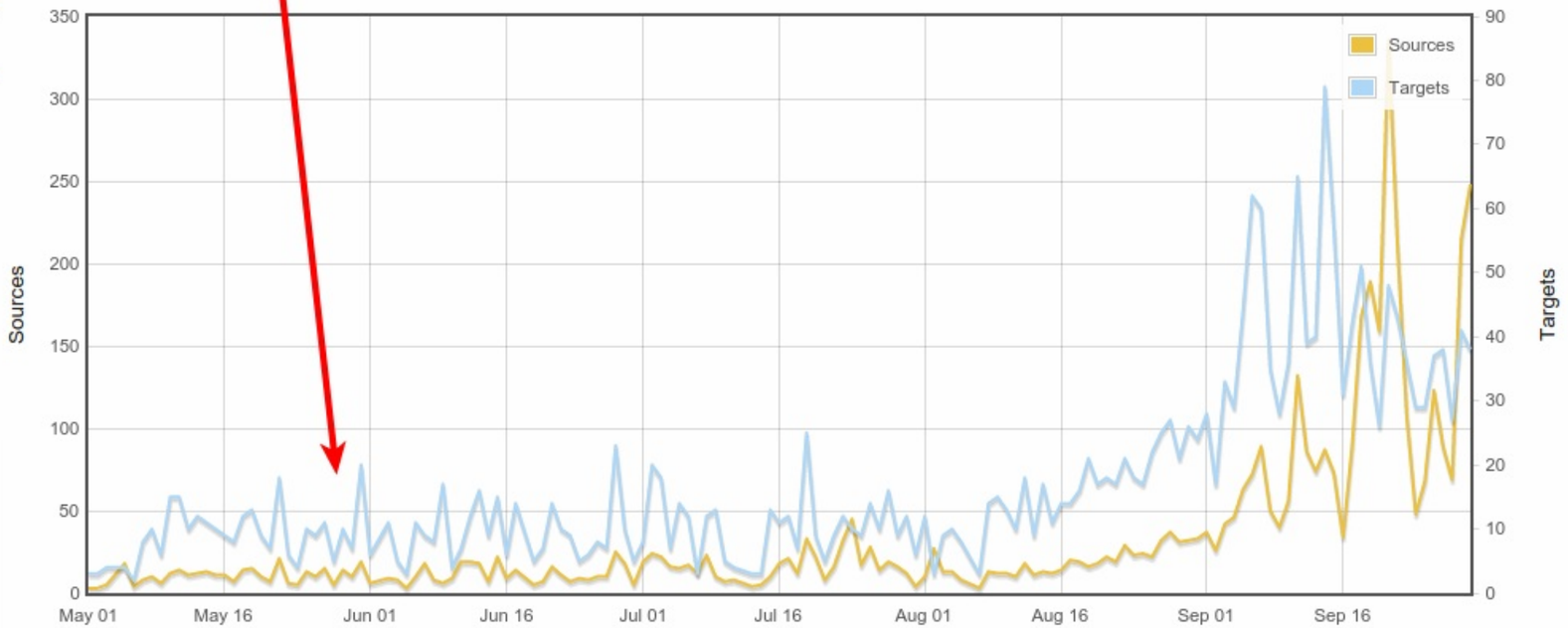


[show ascii data]

Start Date: 201

Left Y Axis:

Paper released



Conclusion

Embedded malware

- Not yet complex
- Tools and processes need to catch up
- a low hanging fruit
- Prevention simple

Questions?

Thank you!

- @obilodeau
- and special thanks to Thomas Dupuy (@nyx__o)