Baseline the Network with Zeek

Who am I?

- Network defender, analyst and integrator
- Working with Bro/Zeek for about 10 years
- Experience deploying, operating and leveraging Zeek in many environments, large and small
- Always looking for novel ways to use Zeek to solve network monitoring problems

Agenda

- The Problem
- What are baselines?
- Discuss a new Zeek module for creating them
- Instrument traffic analysis techniques
- Using baselines
- Other considerations

~~The~~ A Problem

- Network Defenders Dilemma – you must understand normal in order to identify *abnormal*

- This is profoundly difficult, especially for new analysts

- Is what is happening now normal compared what happened 10 minutes ago? yesterday? last week?

- Given all the data available, where do you start?

More about the data

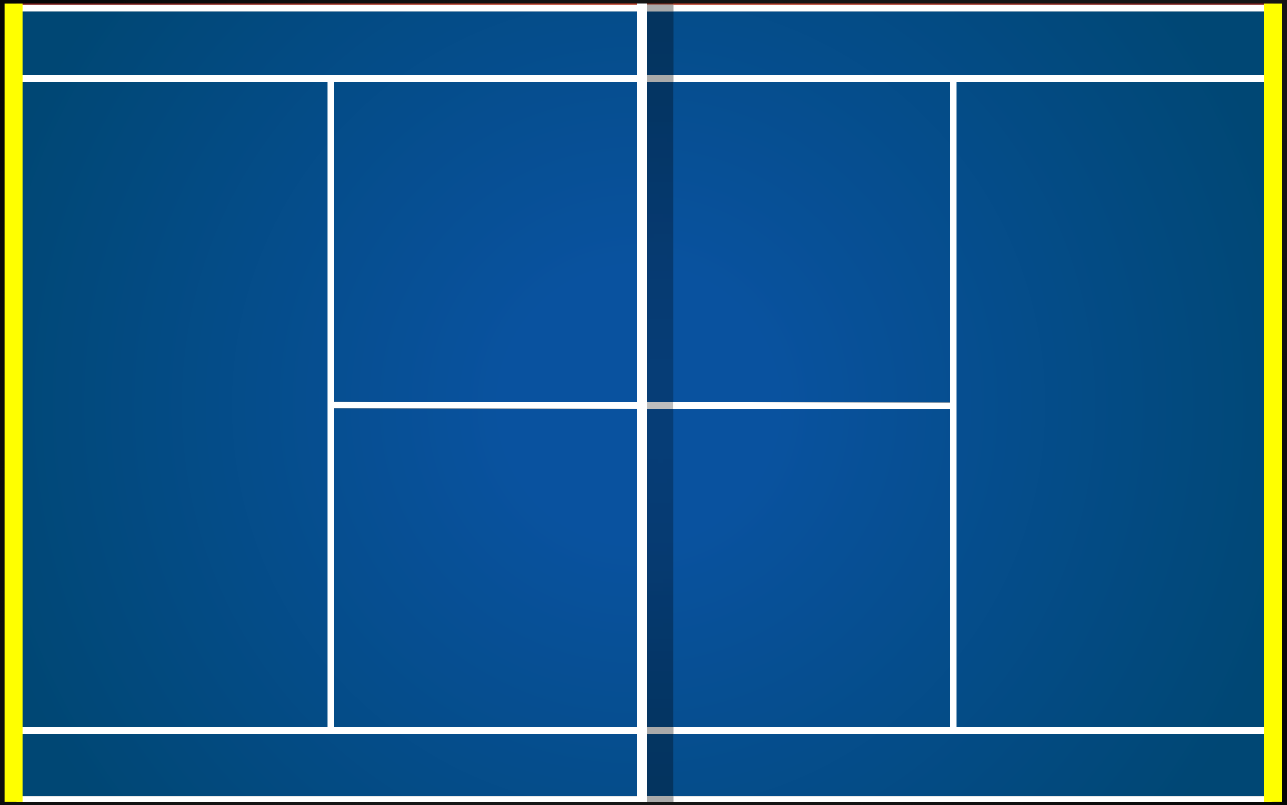
- Most protocol metadata is qualitative
    - IP address, User Agent, URL, Domain, Port Numbers

- Byte and Packet counters are quantitative

- Other quantitative measures:
    - Duration, interval, rate

- Without additional context still difficult to use to gain an understanding of *normal*

What are baselines?



What are baselines? really…

A minimum or starting point used for comparisons

How can we create and use one?

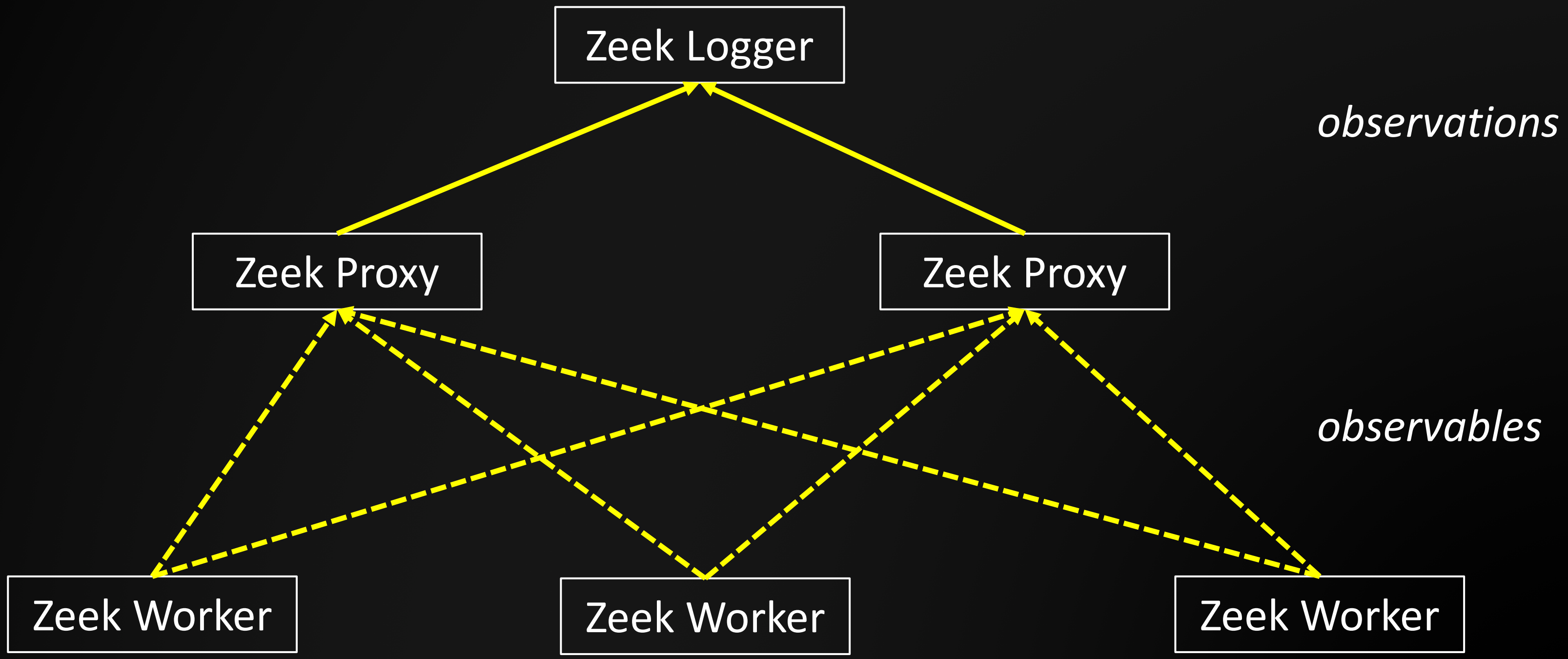
- Make quantitative observations that describe host behavior
- Record those observations in a standard, easily consumed format
- Analyze the data, look for patterns and deviations

NetBase
(Network Baseliner)

Netbase at a high level

- For each *monitored* IP address record observations that describe attributes and behaviors - ***observables***
- Accrue these observations for a set period of time – *5 mins*
- At the end of the interval, log a summary of the observations

Netbase Structure



Zeek Logger

observations

Zeek Proxy

Zeek Proxy

observables

Zeek Worker

Zeek Worker

Zeek Worker

the *observation* record

```
type observation: record {
      address: addr &log &optional;
      starttime: time &log &optional;
      endtime: time &log &optional;
   } &redef;
```

the *observations* table

```
{
    [192.168.10.9] = [address=192.168.10.9,
                      starttime=1570474522.835633,
                      endtime=<uninitialized>,
                      observables…],
    [192.168.10.15] = [address=192.168.10.15,
                       starttime=1570474493.419398,
                       endtime=<uninitialized>,
                       observables…]
}
```

the *observable* record

```
type observable: record {
      name: string;
      val: string &optional;
   };
```

Name corresponds to new fields added to observations record

the *SEND* function

```
function SEND(ip: addr, obs: set[observable])
    {
    Cluster::publish_hrw(Cluster::proxy_pool,
                         ip,
                         add_observables,
                         ip,
                         obs);
    event Netbase::add_observables(ip, obs);
    }
```

the netbase log stream

```
{
    "address": "192.168.10.3",
    “starttime": "2019-10-07T19:10:06.652734Z”,
    "endtime": "2019-10-07T19:15:09.413167Z",
    "ext_client_cnt": 0,
    "ext_host_cnt": 1,
    "ext_port_cnt": 1,
    "ftp_auth_failures": 0,
    "ftp_failed_auth_attempts": 0,
    …
```

the netbase stats log stream

```
{
    "ts":"2019-10-07T18:59:18.476335Z",
    ”node_id":"proxy-2",
    "addr_cnt":6,
    "table_size":54624
}
```

protocol-specific modules

Lets talk observables

Observable types

- Currently using two types:
  - Counters of occurrences
  - Distinct value counts

- Every time an IP’s comms meet a condition, increment a counter

- Distinct counts record the number of instances of some thing

- Plan to add others like: mean, max and min

Conn *observables*

int_port_cnt

int_host_cnt

ext_port_cnt

ext_host_cnt

out_orig_conns

out_succ_conns

out_rej_conns

out_to_port#

int_orig_conns

int_succ_conns

int_rej_conns

int_resp_conns

DNS *observables*

dns_as_server

dns_as_client

dns_auth_answers

dns_recur_answers

dns_ext_rr_cnt

dns_int_rr_cnt

dns_nxdomain_sent

dns_nxdomain_rcvd

HTTP *observables*

http_as_server

http_as_client

http_post_sent

http_post_recvd

http_get_sent

http_get_recvd

http_400_recvd

http_400_sent

Back to the Baselines

- By creating a running record of these observations, per IP, you are in effect creating a baseline

- Point in time observations that can be compared manually, visually or statistically

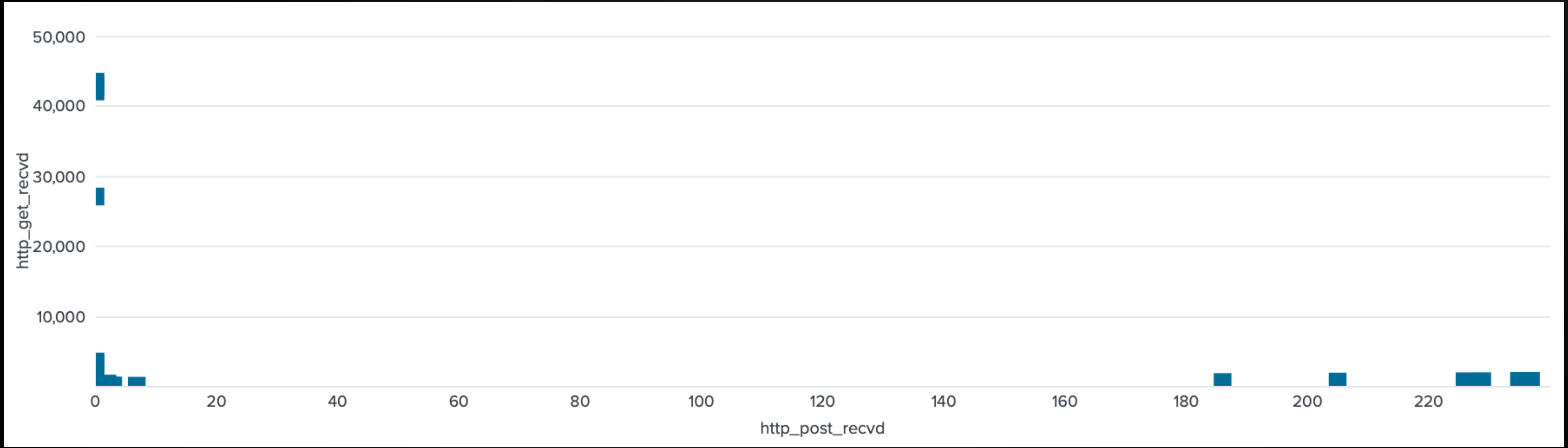
- Compare observations for a given IP to previous observations

- Compare observations for multiple IP's at once

- Compare across other dimensions using asset information

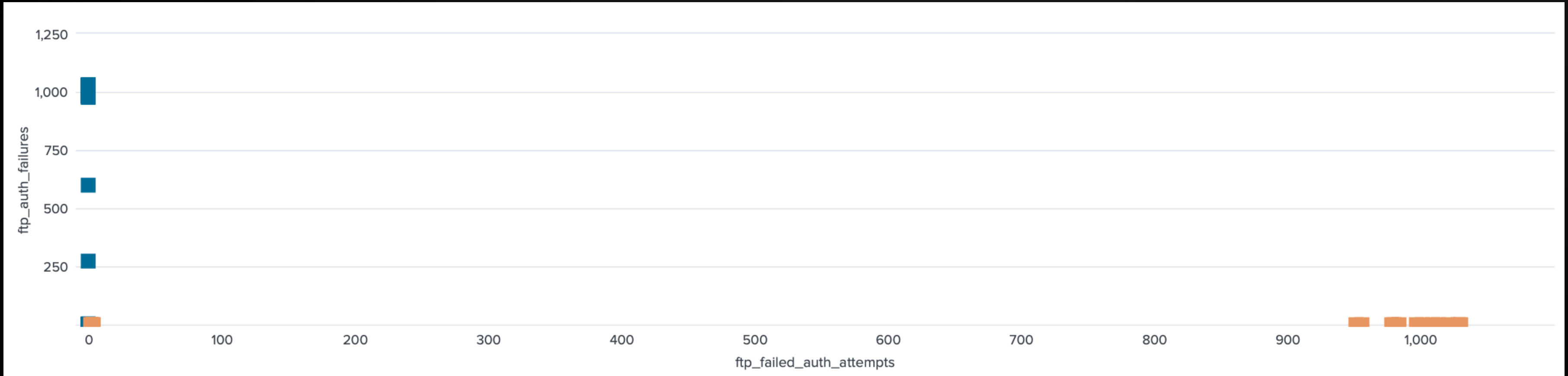
Lets see it!

HTTP DoS



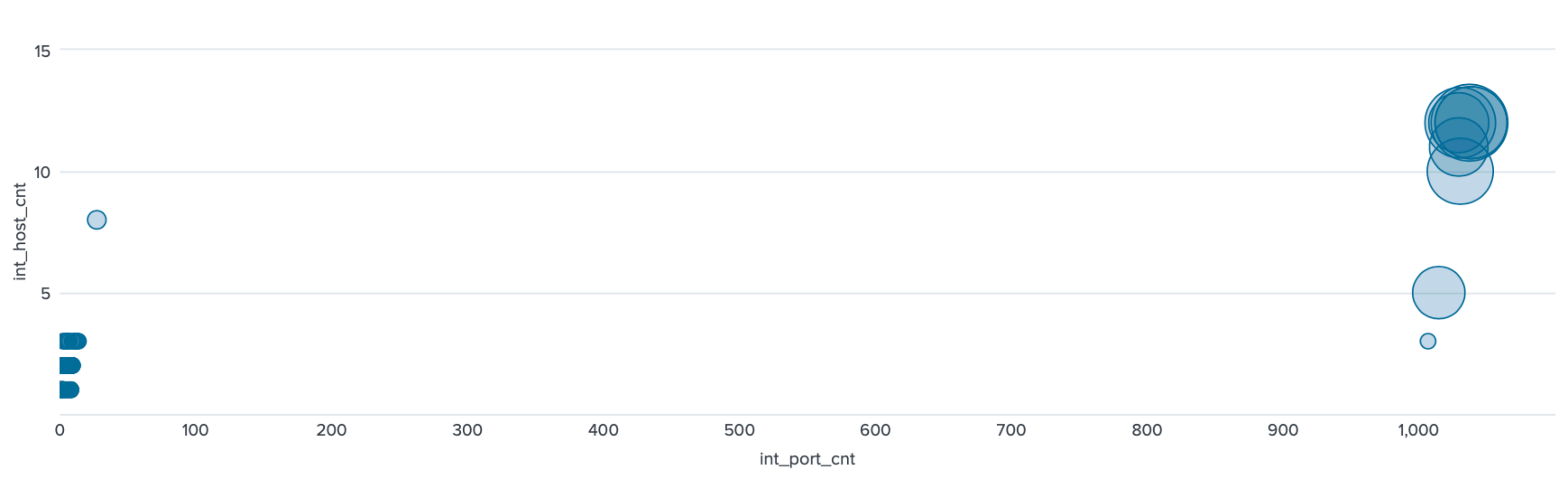
Y Axis = HTTP GET Received, X Axis = HTTP POST Received
All observations are for a single web server

FTP Bruteforce



Y Axis = FTP Client Failed to Authenticate, X Axis = FTP Server Responded with Auth Failure

Port Scanning



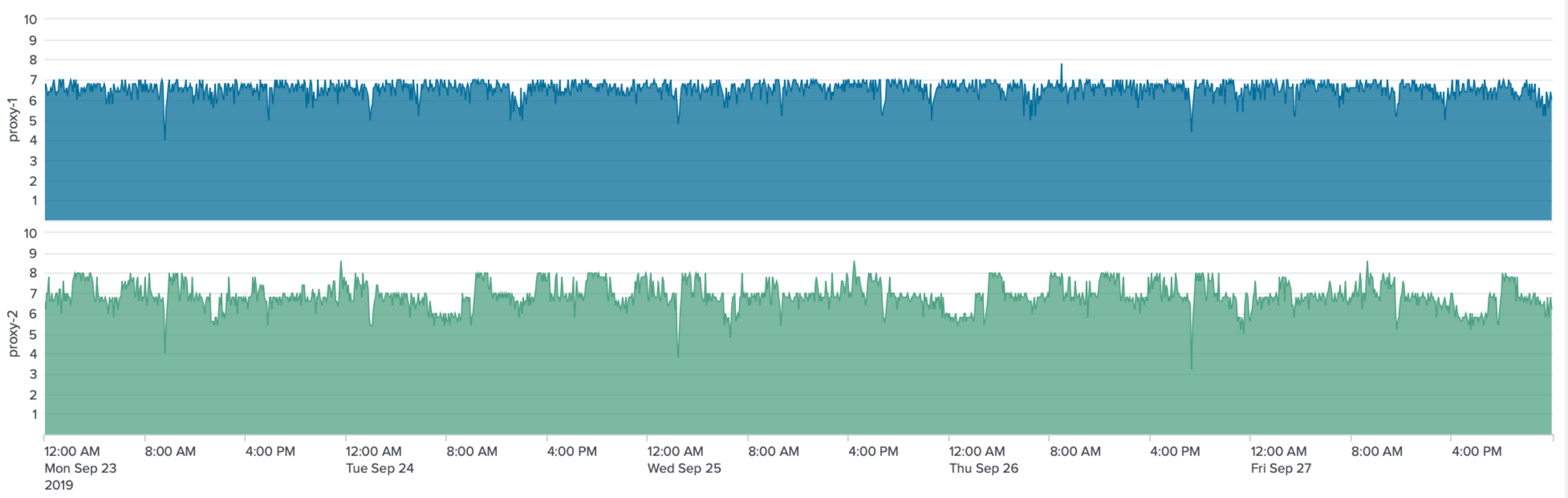
Y Axis = Internal Host Count, X Axis = Internal Port Count, Bubble Size = Rejected Conn count

Gotchas and limitations

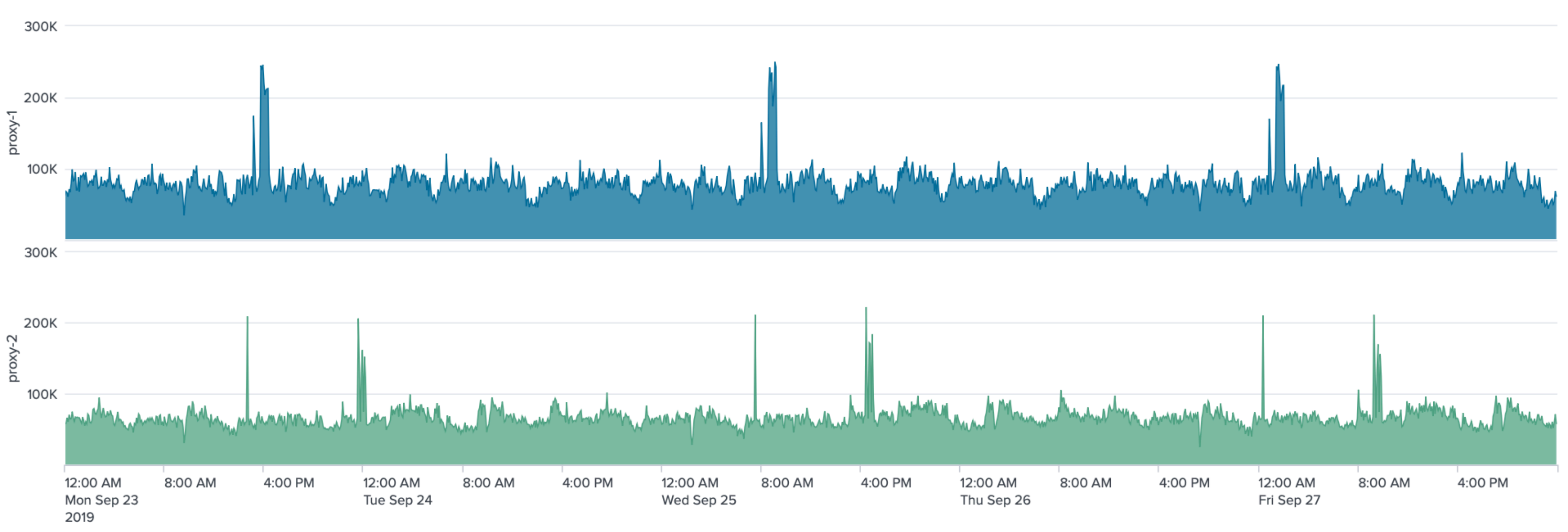
- Transient hosts, devices that aren’t always connected
- DHCP - IP addresses may move around
- Large networks, lots of IP addresses in use
- May not be suitable for every host in the environment

Does it scale?

IP's Tracked by Proxy



Observations Table Size by Proxy



Future Work

- Get it cleaned up and released as a Zeek 3.0 package
- Add new observable types: mean, max, min
- Add more protocol-specific observables
- Analytics

Conclusion

- Network baselines are a real thing with practical application in cyber network defense
- Many ways to categorize host network behavior
- Zeek is a great tool for turning behavioral observations into quantitative data

Thank You!

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