Netflow in Daily Information Security Operations

Mike Pochan

Software Engineering Institute
Carnegie Mellon University
Pittsburgh, PA 15213

DM-0003173

Agenda

- Types of netflow tools being used
- Sensor architecture
- Sensor and endpoint configurations
- Use cases
  - Malicious domain lookup detection
  - Beacon detection
  - Outbound SSH anomalies
  - Augmenting IDS coverage with pDNS

Why use netflow tools?

- Free
- Lightweight in terms of:
  - Processing, since it’s not dealing with whole data streams
  - Storage. 3T can store up to a year’s worth of flow data
  - Analysis. Queries run extremely quickly
- Great for strengthening existing security posture

Two types of toolsets

1. Collection and metering tools
    1. YAF (Yet Another Flowmeter) – flow collector
    2. Super_mediator – flow importer/exporter

2. Analysis Tools
    1. SiLK – flow data repository
    2. Orcus – passive DNS database
    3. Analysis Pipeline (AP) – real-time alerting on flows

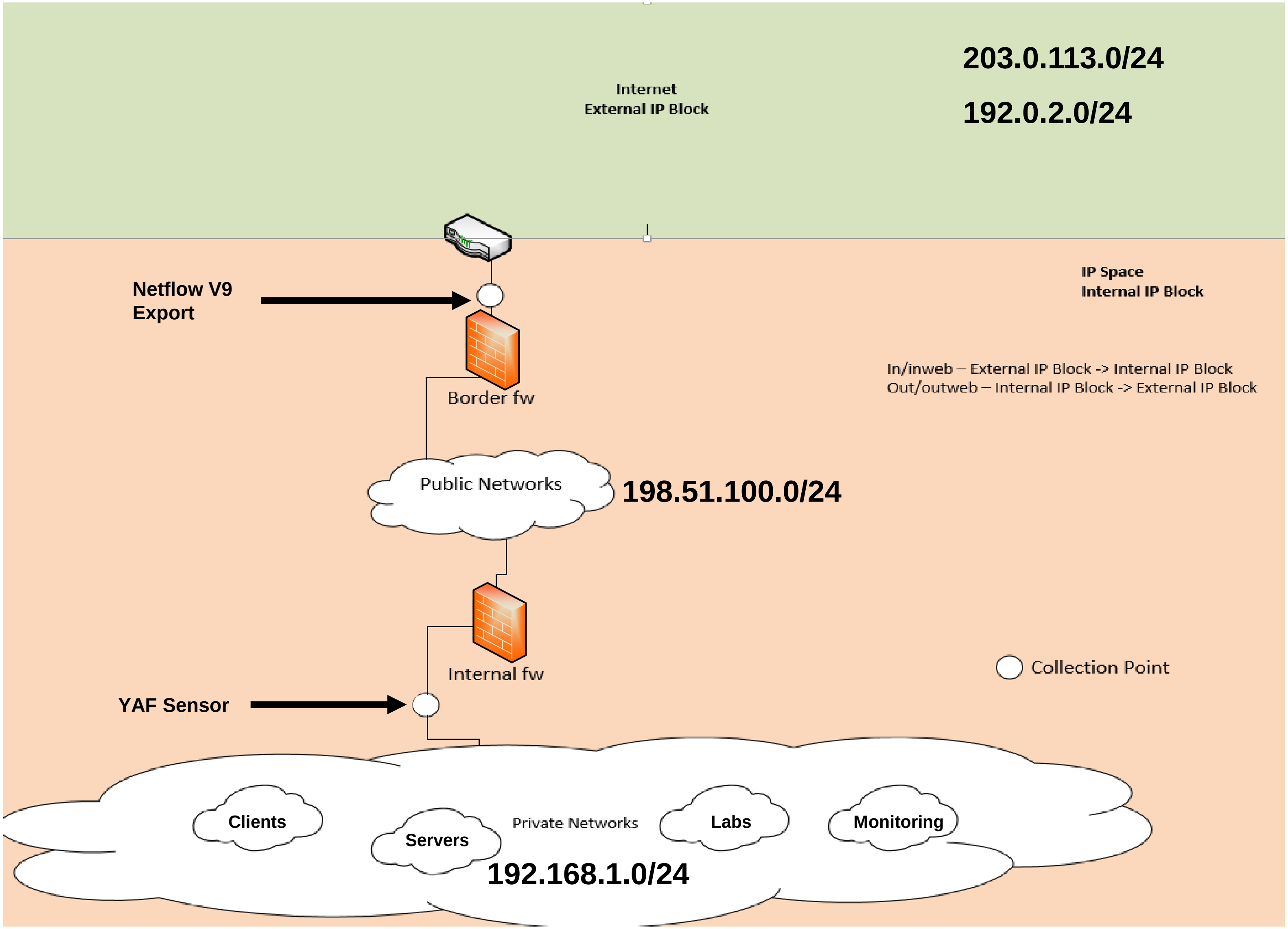
Analysis Tools – Common Processes/Commands

- SiLK
  - Rwflowpack – collection process
  - Rwfilter – primary query command

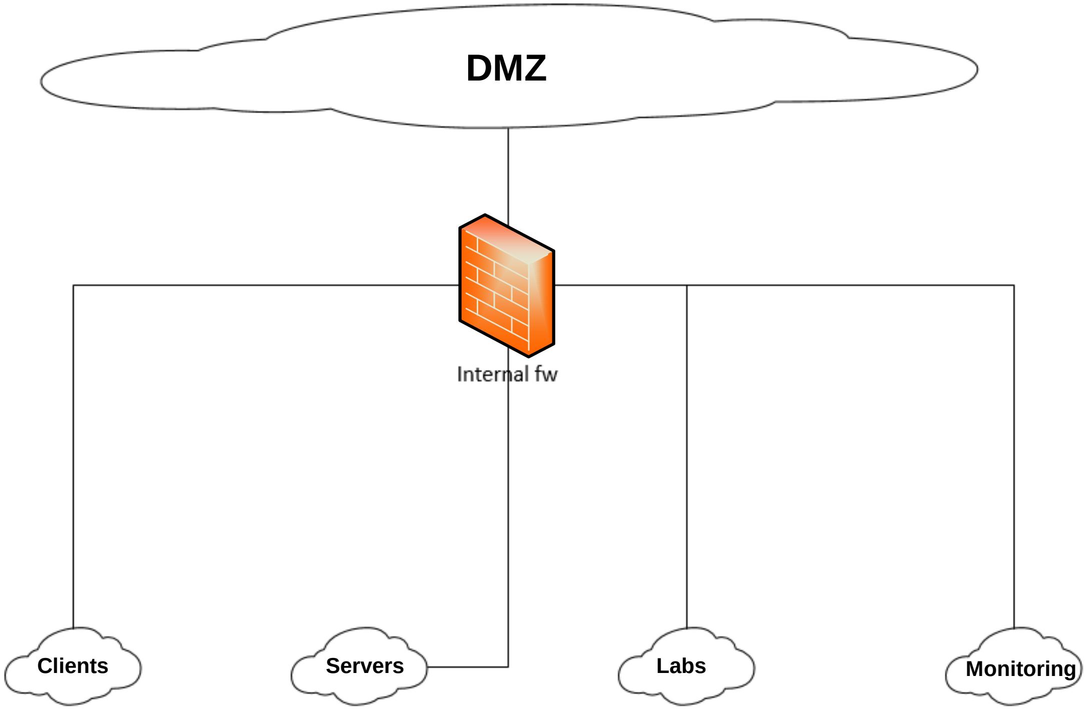
- Orcus
  - Orlookup – query to map between IPs and domain names
  - Orquery – query to access DNS records from database

- Analysis Pipeline
  - Filter – similar to rwfilter, but preconfigured
  - Evaluations – series of checks that are performed on flows that pass the filters

Sensor Architecture



YAF flow distribution (internal network)



YAF sensor connected to SPAN port that mirrors all ingress/egress traffic through firewall

SPAN port → YAF sensor interface → Super mediator listening port → SiLK Server (Incident Response)

→ Orcus Server (Incident Response)

→ Analysis Pipeline Server (Intrusion Detection)

SPAN to YAF to Super Mediator

```
/usr/bin/yaf --silk --in=p1p1 --live=pcap --ipfix=tcp --out=127.0.0.1 --ipfix-
port=18004 --become-user tcpdump --become-group tcpdump --mac --plugin-
name=/usr/lib64/yaf/dpacketplugin.la --applabel --applabel-
rules=/etc/yafApplabelRules.conf --plugin-conf=/etc/yafDPIRules.conf --max-
payload=5000 --udp-uniflow=53 --verbose --log=/var/log/messages --plugin-opts 53
```

--in=p1p1 – YAF server interface connected to SPAN sport

--ipfix-port=18004 – listening Super Mediator port on same host

--plugin-opts 53 – DPI on DNS data (important for later)

SM to Analysis Endpoints (SiLK)

Super Mediator Server

```
# Collect from YAF
COLLECTOR TCP
        HOST "127.0.0.1"
        PORT 18004
COLLECTOR END
```

↓

```
# Export to  SiLK server
EXPORTER TCP
        HOST “silk.server.ip"
        PORT 9934
        FLOW_ONLY
EXPORTER END
```

→

SiLK Server (rwflowpack)

```
# Collect flow data from SM
probe Internalfw ipfix
        listen-on-port 9934
        protocol tcp
end probe
sensor Internalfw0
        ipfix-probes Internalfw
        internal-ipblock
@internal-networks
        external-ipblock
remainder
end sensor
```

SM to Analysis Endpoints (Orcus)

Super Mediator Server

```
# Export to Orcus Server
EXPORTER TCP
    PORT 18009
    HOST “orcus.host.ip"
    APPLICATION == 53
    DPI_ONLY
EXPORTER END
```

Orcus Server (SM again)

```
# Collect DPI DNS from SM
COLLECTOR TCP
        PORT 18009
COLLECTOR END

EXPORTER FILEHANDLER
        PATH "/var/orcus/fw0"
        ROTATE 300
        LOCK
EXPORTER END
```

SM to Analysis Endpoints (Analysis Pipeline)

Super Mediator Server

```
# Export to AP
EXPORTER TCP
    PORT 9970
    HOST "AP.host.ip" →
EXPORTER END
```

Analysis Pipeline

```
#Collect flow and DPI DNS from SM
PRIMARY DATA SOURCE flow_dpi_data
        YAF BUILDER
        TCP PORT 9970
        BREAK ON RECS 5000
        TIMING FIELD NAME flowEndMilliseconds
END DATA SOURCE
```

What about the V9 border flows?

- Only sent to SiLK and Analysis Pipeline since DPI is not an option.

Silk Server (rwflowpack)

```
probe Border netflow-v9
        listen-on-port 9920
        protocol udp
end probe
sensor Border0
        netflow-v9-probes Border
        internal-ipblock @internal-networks
        external-ipblock remainder
end sensor
```

Analysis Pipeline Server

```
SECONDARY DATA SOURCE silk
  SILK BUILDER
  INCOMING DIRECTORY "/AP/incoming"
  ERROR DIRECTORY "/AP/error"
END DATA SOURCE
```

Analysis Pipeline

What traffic do we detect with it?

- Malicious domain lookups on internal resolvers
- Beaconing
- Traffic to/from IP blacklists
- Lateral movement
- Anomalous outbound ssh/rdp traffic
- Traffic to/from foreign nations

Analysis Pipeline – Malicious Domain Queries

- Need a list of malicious domains to start out with
  - ~35,000 unique ones
- File name - pipeline_domain_blacklist.txt
  - Format

```
##format:dns
baddomain.com
notaRAT.com
givemePII.net
asdlkfjsadfsad.org
qowenzie.com
```

Analysis Pipeline – Malicious Domain Queries

```
FILTER bad_domains
    destinationTransportPort==53
    sourceIPv4Address IN_LIST "/etc/lookup_list.set"
    sourceIPv4Address NOT_IN_LIST "/etc/mx_list.set"
    destinationIPv4Address IN_LIST "/etc/lookup_list_dest.set"
    dnsQName IN_LIST "/etc/pipeline_domain_blacklist.txt"
END FILER
```

Translation

- Destination port is 53
- Lookup source IP is in our home network
- Lookup source IP is not one of our MX servers (noisy)
- Lookup destination is one of our internal resolvers
- Domain in the query is in our malicious domain file

Analysis Pipeline – Malicious Domain Queries

```
EVALUATION malicious_domain_lookup
    FILTER bad_domains
    CHECK EVERYTHING PASSES
    END CHECK
    ALERT ALWAYS
    ALERT EVERYTHING
    EXTRA ALERT FIELD dnsQName
END EVALUATION
```

Domain Looked up

Source IP (client)

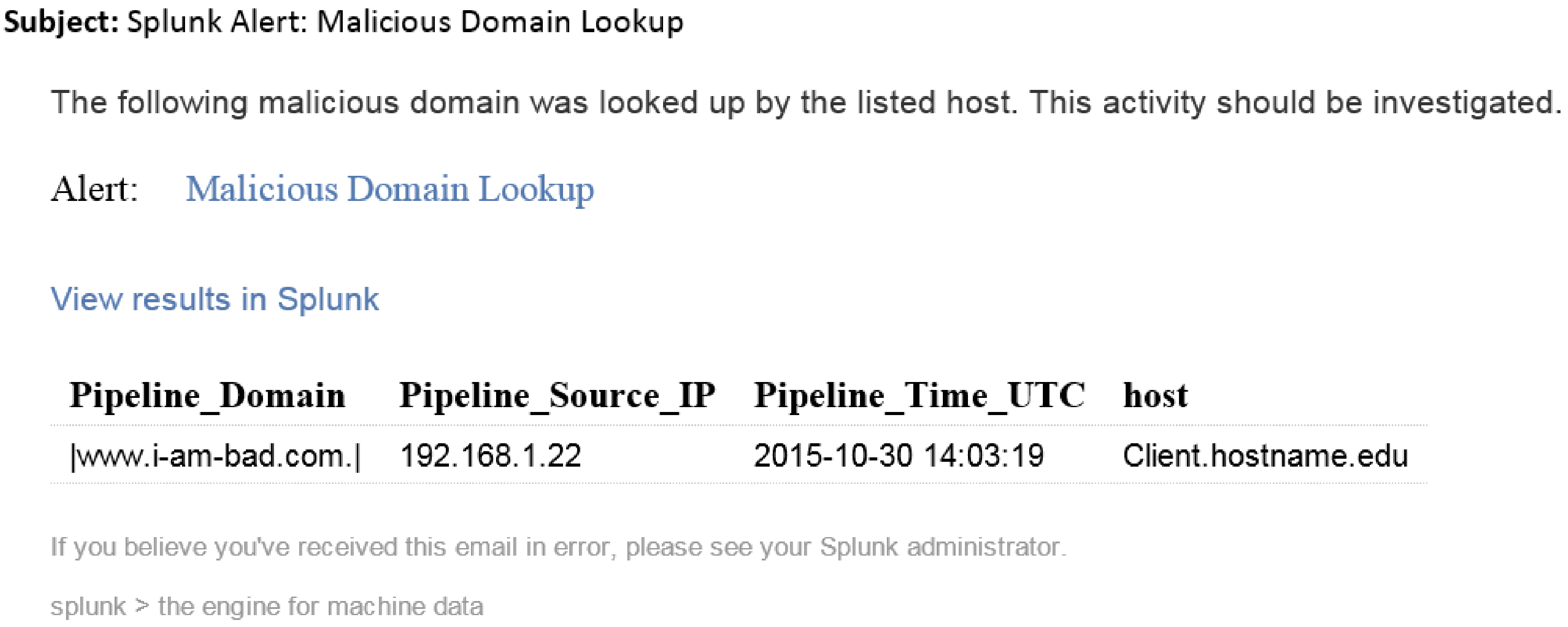
Destination IP (internal resolver address)

From alert.log

```
2015-10-30
14:03:19|Evaluation|malicious_domain_lookup|1|2015-10-30
14:03:19|2015-10-30
14:03:19|62|1|192.168.1.22|192.168.1.7|57112|53|0|17|31|53|
107|0|0|d9d40f7f|www.i-am-bad.com.|
```

Analysis Pipeline – Malicious Domain Queries

- Utilize Splunk to send out real-time email alerts



Subject: Splunk Alert: Malicious Domain Lookup

The following malicious domain was looked up by the listed host. This activity should be investigated.

Alert: Malicious Domain Lookup

View results in Splunk

Pipeline_Domain	Pipeline_Source_IP	Pipeline_Time_UTC	host
|www.i-am-bad.com.|	192.168.1.22	2015-10-30 14:03:19	Client.hostname.edu

If you believe you've received this email in error, please see your Splunk administrator.

splunk > the engine for machine data

Orcus – Malicious Domain Lookup Pivot

- What does the domain resolve to?

```
$ orlookup --start-date=2015/10/29 --end-date=2015/10/31 --
name=com.i-am-bad.www
date|name|address|source
2015-10-29|com.i-am-bad.www|203.0.113.200|A
2015-10-30|com.i-am-bad.www|203.0.113.55|A
2015-10-31|com.i-am-bad.www|203.0.113.200|A
```

- Now we know the IP this domain resolves to on the day of the alert
  - Use SiLK to find source IPs
  - What type of traffic do we see to this IP?

SiLK – Malicious Domain Lookup Pivot

```
$ rwfilter --type=out,outweb --start-date=2015/10/30
--end-date=2015/10/30 --daddress=203.0.113.55 --
pass=stdout | rwstats --fields=sIP,dPort --packets --
top --count=10
```

```
            sIP|          dPort|           Packets|   %Packets|    cumul_%|
 198.51.100.101|             80|               225|  60.483871|  60.483871|
 198.51.100.105|             25|               147|  39.516129| 100.000000|
```

Web proxy IP – search proxy logs for client IP (hopefully matches our AP alert's source IP). Proxy logs and full pcap will show if anything malicious was downloaded. Also can look for redirects to other sites based on time stamps.

MX server IP – most likely harmless

Analysis Pipeline – Beacon Detection

```
FILTER beacon
    sourceIPv4Address NOT_IN_LIST "/etc/dns.set"
    sourceIPv4Address IN_LIST "/etc/internal.set"
    sourceTransportPort>=1024
    destinationIPv4Address NOT_IN_LIST "/etc/whitelist.set"
    destinationTransportPort NOT_IN_LIST [25,1935,993,5223,5222,161,119,587,110,53]
END FILTER
```

- **EVERYTHING** beacons.
- Tune by:
    - Source Address
    - Destination Address
    - Destination Port
        - This takes time
        - DNS and SMTP should be whitelisted from the beginning

Analysis Pipeline – Beacon Detection

```
EVALUATION beacon_eval
    FILTER beacon
     CHECK BEACON
      COUNT 20 CHECK_TOLERANCE 5 PERCENT
      TIME_WINDOW 5 MINUTES
     END CHECK
    CLEAR NEVER
    SEVERITY 3
    OUTPUT TIMEOUT 1 DAY
    ALERT EACH_ONLY_ONCE
    ALERT 2 TIMES 1 HOURS
END EVALUATION
```

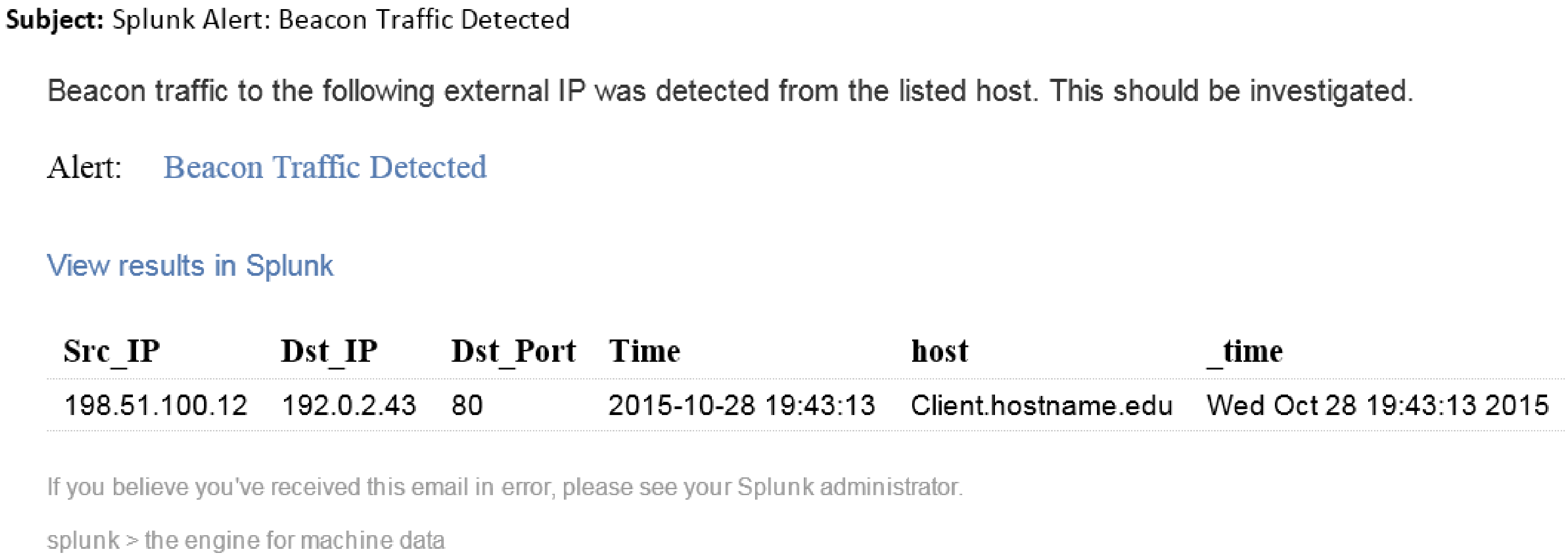
- At least 20 beacons with a minimum 5 minute intervals
- 5% error for the intervals

Analysis Pipeline – Beacon Detection

```
2015-10-28
19:43:13|Evaluation|beacon_eval|3|sourceIPv4Addre
ss,destinationIPv4Address,destinationTransportPor
t,protocolIdentifier|198.51.100.12,192.0.2.43,80,
6|BEACON|20,330|
```

- Source Address
- Destination Address
- Destination Port
- Beacon Interval (in seconds)

Analysis Pipeline – Beacon Detection



Subject: Splunk Alert: Beacon Traffic Detected

Beacon traffic to the following external IP was detected from the listed host. This should be investigated.

Alert: Beacon Traffic Detected

View results in Splunk

Src_IP	Dst_IP	Dst_Port	Time	host	_time
198.51.100.12	192.0.2.43	80	2015-10-28 19:43:13	Client.hostname.edu	Wed Oct 28 19:43:13 2015

If you believe you've received this email in error, please see your Splunk administrator.

splunk > the engine for machine data

Orcus – Beacon Pivot

- What does this IP resolve to?

```
$ orlookup --start-date=2015/10/27 --end-date=2015/10/29 --
address=192.0.2.43

date|name|address|source
2015-10-27|org.fedoraproject.mail|192.0.2.43|A
2015-10-28|org.fedoraproject|192.0.2.43|A
2015-10-29|org.fedoraproject|192.0.2.43|A
```

- False positive
  - Add address to “/etc/whitelist.set”

Analysis Pipeline – Outbound SSH Anomalies

```
FILTER outbound_SSH
    sourceIPv4Address IN_LIST "/etc/home.set"
    destinationIPv4Address NOT_IN_LIST "/etc/home.set"
    destinationIPv4Address NOT_IN_LIST "/etc/ssh_whitelist.set"
    destinationTransportPort==22
END FILTER
```

Translation

- SSH traffic from our network to external IPs
- External IPs are not in an SSH whitelist

Analysis Pipeline – Outbound SSH Anomalies

```
EVALUATION outbound_ssh_tracking
    FILTER outbound_SSH
    FOREACH sourceIPv4Address destinationIPv4Address
    CHECK THRESHOLD
      SUM PACKETS>4
      TIME WINDOW 1 MINUTES
    END CHECK
    OUTPUT TIMEOUT 12 HOURS
    ALERT 1 TIMES 5 MINUTES
    ALERT EACH_ONLY_ONCE
    CLEAR ALWAYS
END EVALUATION
```

Analysis Pipeline – Outbound SSH Anomalies

- From aux.log

```
2015-10-31
22:17:23|Evaluation|outbound_ssh_tracking|1|SIP,DIP|198.51.100.222
,192.0.2.77|SUM PACKETS|1762634|
```

- Source IP – NAT’d IP from our public network. Need to check the firewall logs to get private IP of client.
- Destination IP – unknown external SSH server
  - Obviously not in our ssh whitelist
  - HIGH volume of traffic (1,762,634 packets in one day)
  - Need DNS information

Orcus – Outbound SSH Anomalies Pivot

- What does the external IP resolve to?

```
$ orlookup --start-date=2015/10/31 --end-
date=2015/10/31 --address=192.0.2.77

date|name|address|source
2015-10-21|net.akamaiedge.ce.e0000|192.0.2.77|A
```

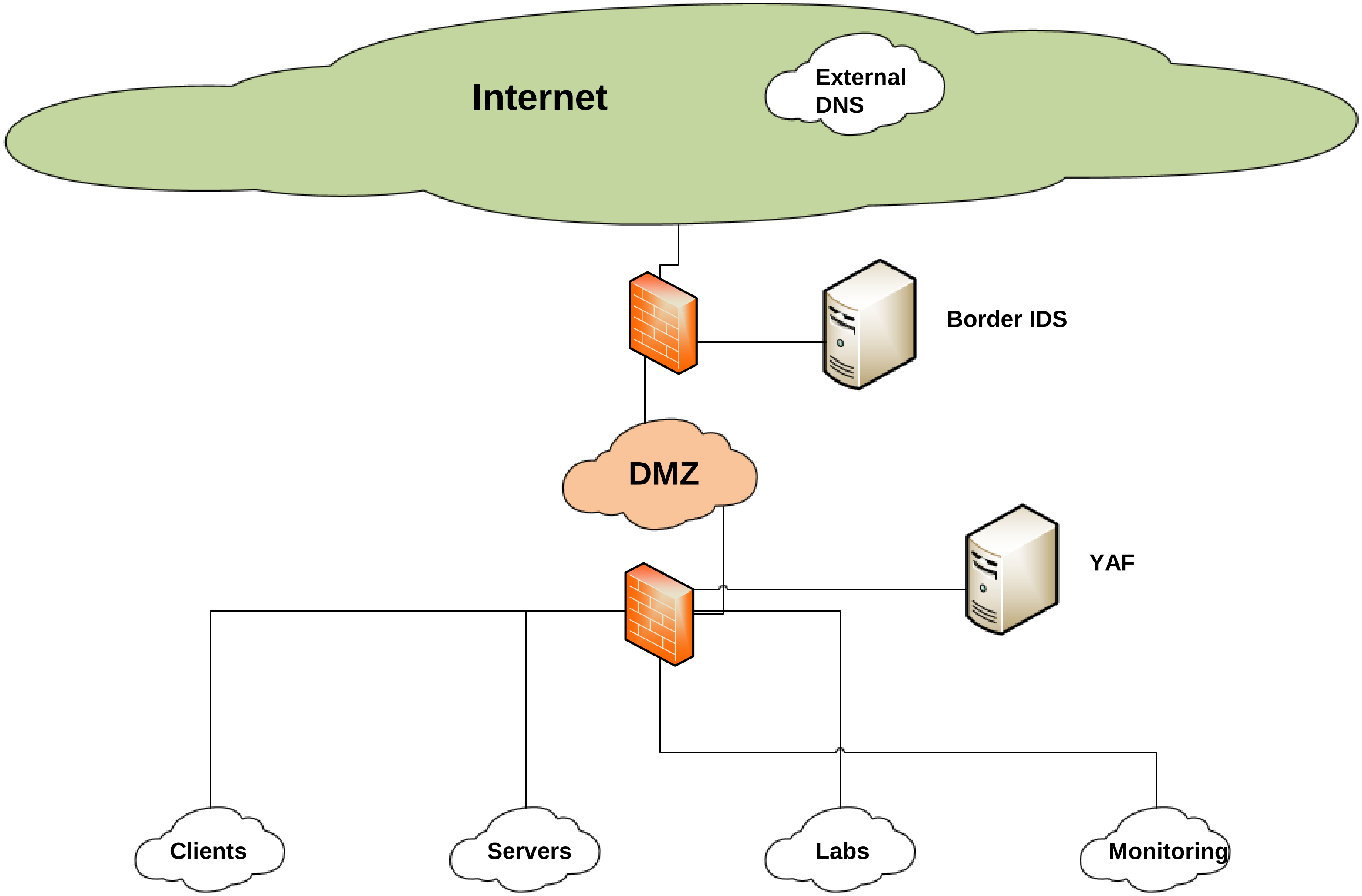
- Doesn't tell us much. Need to find out the internal of the machine generating this traffic. From firewall logs:

```
2015-10-31T00:12:43-05:00 fw.host : Built dynamic TCP
translation from inside:192.168.1.34/61077 to
border:198.51.100.222/61077
```

AD – Outbound SSH Anomalies Pivot

- 192.168.1.34 – search in SIEM for Windows Security Logs
  - User is st_smith
  - Confront user about traffic
  - Learn it’s the user’s private site being hosted via Akamai
    - Discipline + policy adjustments if necessary

Orcus – Augments IDS Coverage



Orcus – Finding source of malicious lookups

IDS Alert for Malicious Domain Lookup

```
11/10/15-05:02:44 [1:111:1] <eth2> Malicious Domain
Lookup: www.i-am-bad-also.com {UDP}
198.51.100.20:62943 -> 192.0.2.79:53
```

- Source IP – Public NAT address of our resolver
- Destination IP – Some unknown public DNS server

- Who actually queried our resolver in the first place?
  - IDS only monitors border
  - Doesn’t capture internal client to server query
  - YAF saw it

Orcus - Orquery

- Who wanted to know what www.i-am-bad-also.com resolved to?

```
$ orquery --start-date=2015/11/10 --end-
date=2015/11/10 --rr-name=com.i-am-bad-also.www
```

```
2015/11/10T05:02:44.043|internalfw0|int|A|192.168.1.7
2015/11/10T05:02:44.043|internalfw0|int|A|192.168.1.75
```

- Internal IP of resolver
- Client that initiated lookup

- Investigate client for signs of compromise

Conclusion

- Netflow can be a great tool to help strengthen your security posture and intrusion detections monitoring techniques
- Cannot function solely as replacement for existing security solutions, but can help make intrusion detection and analysis more efficient
- Other tools are still needed:
  - IDS/IPS
  - PCAPs
  - Web, Server, VPN, and Firewall logs
  - Proxy Logs

Questions…?

Mike Pochan

Software Engineering Institute

Carnegie Mellon

mjpochan@sei.cmu.edu

412-268-6293