Ch 4: Monitoring and Detecting Security Breaches

Updated 9-7-23

Monitoring

- Four useful types of data
  - Log data
  - Network flow data
  - Packet data
  - Application level metadata

Log data

Types of Log Data

- Format errors in queries
- Lame delegations
  - Referral from a parent zone to an invalid name server for the child zone
- Queries for nonexistent domains

BIND's Logging in *named.conf*

```
logging {
    [ channel channel_name {
      ( file path name
          [ versions ( number | unlimited ) ]
          [ size size spec ]
        | syslog syslog_facility
        | stderr
        | null );
      [ severity (critical | error | warning | notice |
                  info | debug [ level ] | dynamic ); ]
      [ print-category yes or no; ]
      [ print-severity yes or no; ]
      [ print-time yes or no; ]
    }; ]
    [ category category_name {
      channel_name ; [ channel_name ; ... ]
    }; ]
    ...
};
```

Clauses

- Channel
  - Defines output medium, such as files, syslog, stderr, or null to eliminate output
- Versions
  - Max. number of files that can be used
  - Files are rolled when "size" is reached
- Severity
  - "critical" logs only critical events
  - "info" stores much more
- Print
  - print-time, print-severity, print-category
  - Controls what is printed (link Ch 4a)

Categories

- queries
  - Logs client IP & port, question name, type and class of query
  - Useful to record which hosts are querying for what domains
  - + indicates recursive query
  - S indicates signed query
  - E indicates Extended DNS (EDNS)

Example:

```
12-Sep- 15:45:49:053 queries: info: client
192.168.0.100#1876: query: www.example.com IN A +SE
```

Categories

- security
  - Requests that were denied
  - Rejected by access control lists (ACLS) that define which hosts are allowed to send queries, zone transfers, etc.
  - ACLs are set using these **options** statements
    - allow-query
    - allow-recursion
    - allow-transfer

```
14-Sep- 22:06:38.524 security: debug 3: client 127.0.0.1#58896: recursion not available
14-Sep- 22:06:38.524 security: debug 3: client 127.0.0.1#58896: query (cache)
'example.com/A/IN' approved
```

Categories

- update-security
  - Denied requests to update DNS zone data dynamically, because of ACLs or policies
  - ACLs and policies defined with
    - **allow-update**
    - **allow-update-forwarding**
    - **update-policy**
  - BIND tool "nsupdate" generates dynamic updates

```
20-Sep  21:21:11.499  update-security:  info:  client
127.0.0.1#42445: update 'ppdev.net/IN' denied
```

Categories

- dnssec
  - Only works if DNS server supports DNSSEC and is configured to perform record validation
  - DNSSEC statements
    - **dnssec-enable**
    - **dnssec-validation**

DNSSEC Example

- Line prefix omitted in figure below
  - Date dnssec: debug 3:

```
validating @0xb904ace8: nist.gov A: starting
validating @0xb904ace8: nist.gov A: attempting positive response validation
validating @0xb904c510: nist.gov DNSKEY: starting
validating @0xb904c510: nist.gov DNSKEY: attempting positive response validation
validating @0xb904c510: nist.gov DNSKEY: verify rdataset (keyid=41227): success
validating @0xb904c510: nist.gov DNSKEY: signed by trusted key; marking as secure
validator @0xb904c510: dns_validator_destroy
validating @0xb904ace8: nist.gov A: in fetch_callback_validator
validating @0xb904ace8: nist.gov A: keyset with trust 7
validating @0xb904ace8: nist.gov A: resuming validate
validating @0xb904ace8: nist.gov A: verify rdataset (keyid=63462): success
validating @0xb904ace8: nist.gov A: marking as secure
validator @0xb904ace8: dns_validator_destroy
```

Categories

- xfer-in
- xfer-out
  - Report zone transfers

```
25-Sep 14:12:12.179 xfer-out: info: client
127.0.0.1#38077: transfer of 'ppdev.net/IN': AXFR
started
25-Sep 14:12:12.186 xfer-out: info: client
127.0.0.1#38077: transfer of 'ppdev.net/IN': AXFR ended
```

Packet Data

SPAN Port

- Capture packets with *tcpdump* or *Wireshark*
- From a SPAN port on a router or switch
  - Provides a copy of every packet
- Or use an optical or electronic splitter
  - Or a hub
- Data sent to a server that captures and stores all the packets
- Usually uses *libpcap* or *WinPcap* with standard **pcap** format

Network Flow Data

Flow Data

- Summarized record of a network traffic session
- Packets with common characteristics
  - Source and destination IP, Port, and Protocol
- Each flow typically goes in only one direction
- NetFlow
  - Originally developed by Cisco
  - Standardized by IETF as IP Flow Information Export (IPFIX)

Packet Grouping

- TCP sessions
  - Export flow as soon as session ends with FIN or RST
- UDP traffic
  - Must guess when flow ends
  - Activity timer expiration exports after a period of time, even if flow is still in progress
  - Inactivity times generates a flow record when there is inactivity for a period of time

Flow Records

- Don't contain a complete summary of a session between two hosts
- Very long sessions, or sessions with periods of inactivity, may appear in multiple flow records

```
Router1,10.173.163.76,10.246.128.147,171,8313,
1255112063,1255233063,64126,41450,26,6
```

where the fields correspond to: Router name, Source IP address, Destination IP address, number of packets transferred, number of bytes transferred, UTC start time of flow in seconds since 1/1/1970, UTC end time, source port, destination port, cumulative TCP flags (in decimal representation), and protocol number.

Application-Level Metadata

Metadata

- Flow records provide very little information
- Packet data are overwhelming, containing too much data
  - Also raise privacy concerns
- Application layer metadata
  - Keeps some packet fields from application and other layers

```
Domain, A_record, first_time, last_time, number_of_responses
www.example.com,10.20.30.40, Jan 1 2009, June 30 2010, 15288
```


Kahoot!

Detection

Cache Poisoning Attack Detection

- Brute force attempts to guess Transaction ID and Source Port
  - Of a query from a recursive DNS server to an authoritative server
- First, attacker makes a request for a record that is not cached
  - Then blasts server with spoofed responses with many Transaction ID and Source Port values

Flow Records

- Keep flows with source or destination port 53 (TCP or UDP) and source or destination IP of the DNS server

Table 5: Example of a sequence of flow records indicating a possible cache poisoning attack.

Sip	Dip	Sport	Dport	Stime	Etime	Pkts	Bytes	Proto
10.10.5.100	10.10.1.1	1024	53	0.000	0.000	1	70	17
192.168.0.50	10.10.1.1	53	1024	0.001	0.001	1	90	17
192.168.0.50	10.10.1.1	53	1024	0.002	0.002	1	90	17
192.168.0.50	10.10.1.1	53	1024	0.003	0.003	1	90	17
192.168.0.50	10.10.1.1	53	1024	0.004	0.004	1	90	17
192.168.0.50	10.10.1.1	53	1024	0.005	0.005	1	90	17
192.168.0.50	10.10.1.1	53	1024	0.006	0.006	1	90	17

Limitations of Flow Records

- No Layer 7 data
  - Such as the DNS request
- Cannot pinpoint the domains being targeted
- Or the addresses being injected

Selecting Relevant Data

- DNS requests are irrelevant
- Poisoning is performed by replies
- Data needed
  - Source & destination IP
  - Domain name in the question section
  - Answer, authority, and additional sections
  - Transaction ID
  - Timestamp
  - Only include authoritative replies (AA set)

Transient Domains

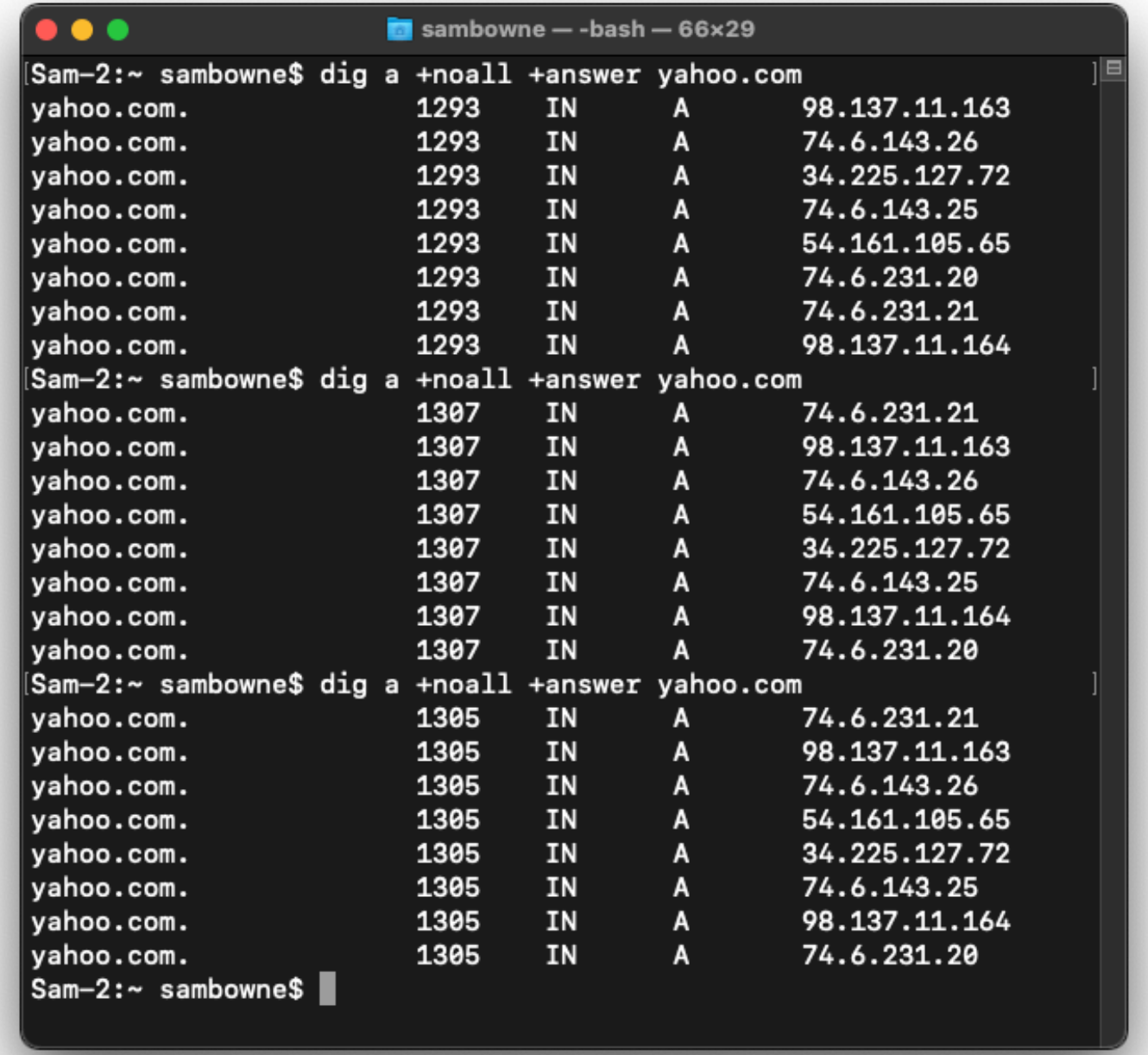
- Resolve to a small number of IP addresses
- Change over hours or days
- IP addresses are not owned by the same autonomous system (AS)
- Typically they are botnet controllers, malware downloads, or file drop sites
- Could be an innocent software bug, or a security research site

Identifying Transient Domains

- Collect DNS traffic with
  - Small TTLs
  - Collect at peering links to other AS networks
- Record
  - Domain that was queried
  - Answer given
  - Timestamp
  - Exclude client IP address for privacy

Round-Robin DNS

- If there's more than one A record
  - The order changes for each request
    - Link Ch 4b
- This is the default for most DNS servers
- Demo:
  - dig a +noall +answer yahoo.com
  - Repeat a few times


sambowne — -bash — 66×29
Sam-2:~ sambowne$ dig a +noall +answer yahoo.com
yahoo.com. 1293 IN A 98.137.11.163
yahoo.com. 1293 IN A 74.6.143.26
yahoo.com. 1293 IN A 34.225.127.72
yahoo.com. 1293 IN A 74.6.143.25
yahoo.com. 1293 IN A 54.161.105.65
yahoo.com. 1293 IN A 74.6.231.20
yahoo.com. 1293 IN A 74.6.231.21
yahoo.com. 1293 IN A 98.137.11.164
Sam-2:~ sambowne$ dig a +noall +answer yahoo.com
yahoo.com. 1307 IN A 74.6.231.21
yahoo.com. 1307 IN A 98.137.11.163
yahoo.com. 1307 IN A 74.6.143.26
yahoo.com. 1307 IN A 54.161.105.65
yahoo.com. 1307 IN A 34.225.127.72
yahoo.com. 1307 IN A 74.6.143.25
yahoo.com. 1307 IN A 98.137.11.164
yahoo.com. 1307 IN A 74.6.231.20
Sam-2:~ sambowne$ dig a +noall +answer yahoo.com
yahoo.com. 1305 IN A 74.6.231.21
yahoo.com. 1305 IN A 98.137.11.163
yahoo.com. 1305 IN A 74.6.143.26
yahoo.com. 1305 IN A 54.161.105.65
yahoo.com. 1305 IN A 34.225.127.72
yahoo.com. 1305 IN A 74.6.143.25
yahoo.com. 1305 IN A 98.137.11.164
yahoo.com. 1305 IN A 74.6.231.20
Sam-2:~ sambowne$

Fast Fluxing Domains

- TTLs set to a few seconds
- IP changes rapidly
- Purposes
  - Evade detection
  - Resilience: maintain control of a botnet despite attempts to block malicious traffic

Example from Conficker

Answer at time 0

- `www.refaourma.info. 60 IN A 65.54.40.75`
- `www.refaourma.info. 60 IN A 65.118.223.203`
- `www.refaourma.info. 60 IN A 65.130.228.46`

Answer 28 sec. later

- `www.refaourma.info. 32 IN A 65.130.228.46`
- `www.refaourma.info. 32 IN A 65.54.40.75`
- `www.refaourma.info. 32 IN A 65.118.223.203`

Example from Conficker

Answer at 56 sec.

- `www.refaourma.info. 4 IN A 65.118.223.203`
- `www.refaourma.info. 4 IN A 65.130.228.46`
- `www.refaourma.info. 4 IN A 65.54.40.75`

Answer at 83 sec.

- `www.refaourma.info. 32 IN A 209.17.184.203`
- `www.refaourma.info. 32 IN A 209.228.250.75`
- `www.refaourma.info. 32 IN A 209.229.142.35`

- When cache expires, IP addresses are all new

Detecting Fast-Flux Domains

```
Domain|IP|Last_activity|
       IP_registration|Country_code
www.refaourma.info|10.5.172.203|10-25@16:01:03|
       10.5.160.0|19|ISP1|US
www.refaourma.info|20.203.221.67|10-25@15:01:05|
       20.203.221.64|27|ISP2|JP
www.refaourma.info|30.135.46.203|10-25@15:00:59|
       30.135.0.0|16|ISP3|CN
www.refaourma.info|40.54.159.203|10-25@14:05:12|
       40.52.0.0|14|Company1|US|
```

Phantom Domains

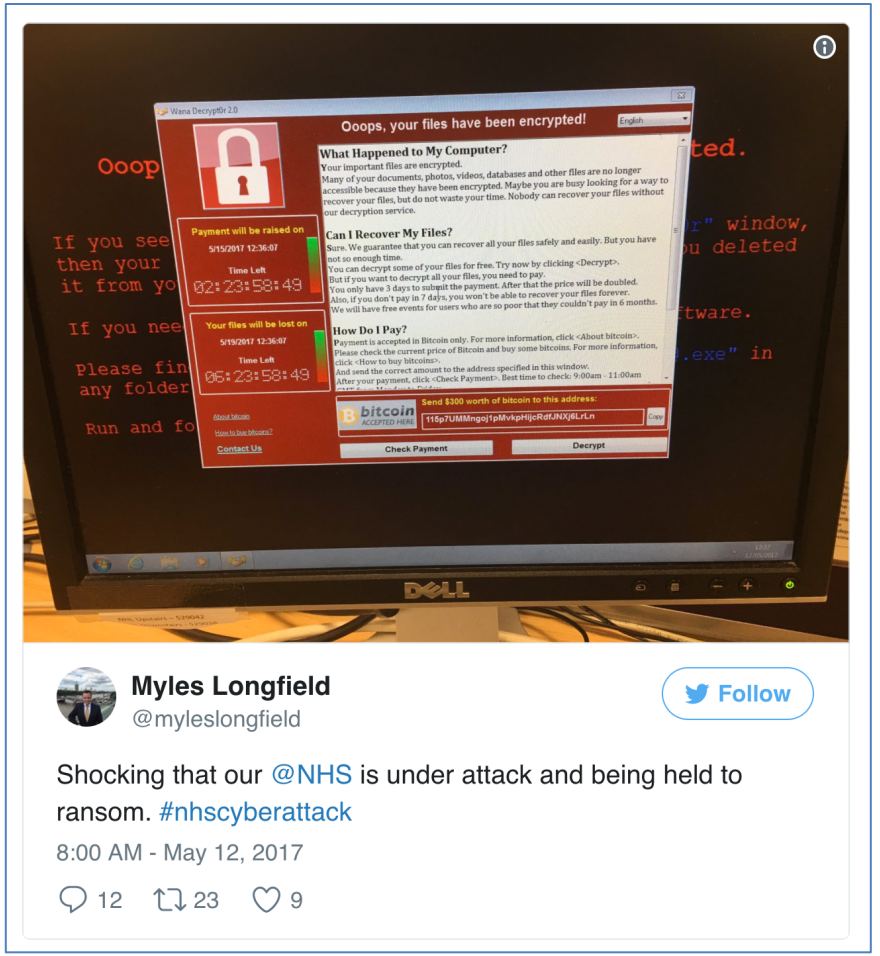
- Register a domain
- Use it for only a few hours or days
- Defends malware against *sinkholing*
  - Resolving to an address that offers no service
- Works best with domain registrars who offer a free trial period

Detecting Phantom Domains

- Find domains that have been active recently
- Find current addresses
- Find domains with no matching historical IP addresses
- Find records with very different IP addresses for the same domain

Wannacry Ransomware

- Caused hospitals across England to divert emergency patients in May 2017
- Used NSA-developed attacks leaked by "Shadow Brokers" (Russians)
- Microsoft released a patch but hospital systems didn't install it in time
  - Link Ch 1y



How to Accidentally Stop a Global Cyber Attacks

May 13, 2017 MalwareTech ms17-010, ransowmare, worm 442

have to be propagated using another method). I was quickly able to get a sample of the malware with the help of Kafeine, a good friend and fellow researcher. Upon running the sample in my analysis environment I instantly noticed it queried an unregistered domain, which i promptly registered.

Darien Huss
@darienhuss

Follow

#WannaCry propagation payload contains previously unregistered domain, execution fails now that domain has been sinkholed

10:29 AM - May 12, 2017

65 1,458 2,186

- Link Ch 1z1

Conficker Worm Domains

- Algorithm made 50,000 new domains per day
- Registrars tried to block them all
  - Links Ch 1u, 1v

```
Variant, Date, Index, Hostname
A, 02/12/2009, 0, puxqy.net
A, 02/12/2009, 1, elvyodjjtao.net
A, 02/12/2009, 2, ltxbshpv.net
A, 02/12/2009, 3, ykjzaluthux.net
A, 02/12/2009, 4, lpiishmjlb.net
A, 02/12/2009, 5, arpsyp.com
A, 02/12/2009, 6, txkjngucnth.org
A, 02/12/2009, 7, vhslzulwn.org
A, 02/12/2009, 8, jcqavkkhg.net
A, 02/12/2009, 9, dmszsyfp.info
. . .

B, 02/12/2009, 0, tvxwoajfwad.info
B, 02/12/2009, 1, blojvbcbrwx.biz
B, 02/12/2009, 2, wimmugmq.biz
B, 02/12/2009, 3, fwnvlja.org
B, 02/12/2009, 4, umgrzaybbf.ws
B, 02/12/2009, 5, btgoyr.cc
B, 02/12/2009, 6, zboycplmkhc.cc
B, 02/12/2009, 7, qsqzphbn.biz
B, 02/12/2009, 8, xqdvmavs.cn
B, 02/12/2009, 9, wgrrrr.biz
```

Corrupted Local DNS Server Settings (DNS Changer)

- Redirect victims to evil DNS server
- Most resolutions are correct
- Some lead to fake websites
  - Such as banking sites, antivirus sites, etc.

Detecting DNS Changers

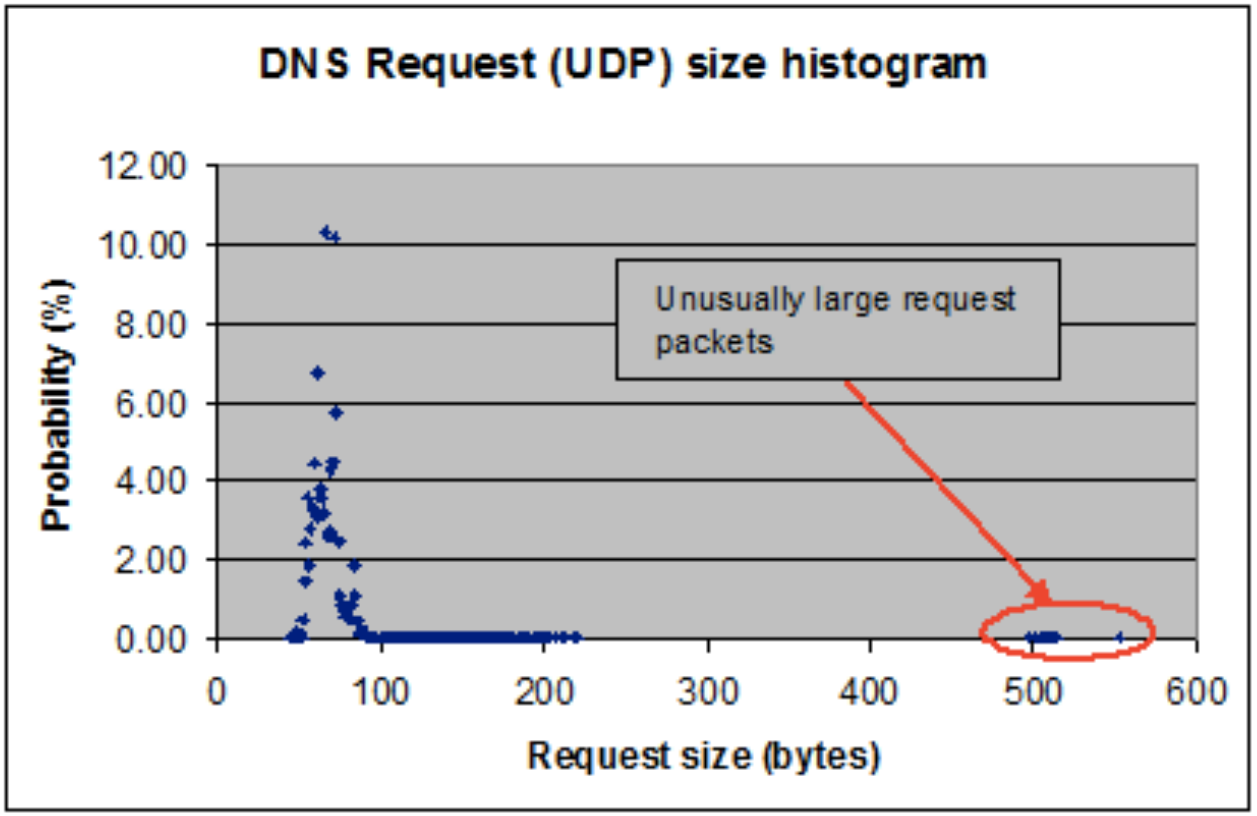
- Recursive DNS requests to suspicious remote addresses
  - Not in ISP's address range
  - Not a known public DNS server
  - Are in an IP address blacklist
  - Associated with transient, fast-flux, phantom, sinkholed or blacklisted domain
  - Located more than 1000 miles away
  - Have no forward DNS domains

Tunneling

- Firewalls allow port 53 through
- Malware can phone home via port 53
- Covert channels via DNS traffic
  - Even embedded in fields of legitimate-looking DNS packets, such as DNSSEC keys or signatures

Detecting Tunneling

- Large UDP Request packets (>300bytes)



DoS Attacks

- Attacks against the DNS server
  - TCP or UDP flood
  - SYN flood
  - Spoofed source addresses or botnets

DoS Attack Detection

- Watch for these to be different from baseline
  - Incoming bits/sec and outgoing bits/sec
    - Imbalance indicates an attack
  - DNS requests/sec (TCP and UDP)
  - TCP SYN/sec
  - Incoming TCP and UDP packets/sec
  - ICMP incoming and outgoing packets/sec and bits/sec


Kahoot!