



SSL and Browsers: The Pillars of Broken Security

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Session ID: TECH-403

Session Classification: Intermediate

RSACONFERENCE2012

SSL, TLS, And PKI

- SSL (or TLS, if you prefer) is the technology that secures the Internet
 - Designed with aim to secure credit card transactions
 - Ended up as a generic encryption protocol for the transport layer
 - Design based on the old threat model shows cracks in use today



Overview Of Major Attacks

- Identity/account compromise:
 - Financial loss (theft)
 - Data leakage
 - Spam
 - Embarrassment
- Eavesdropping
- Mass surveillance

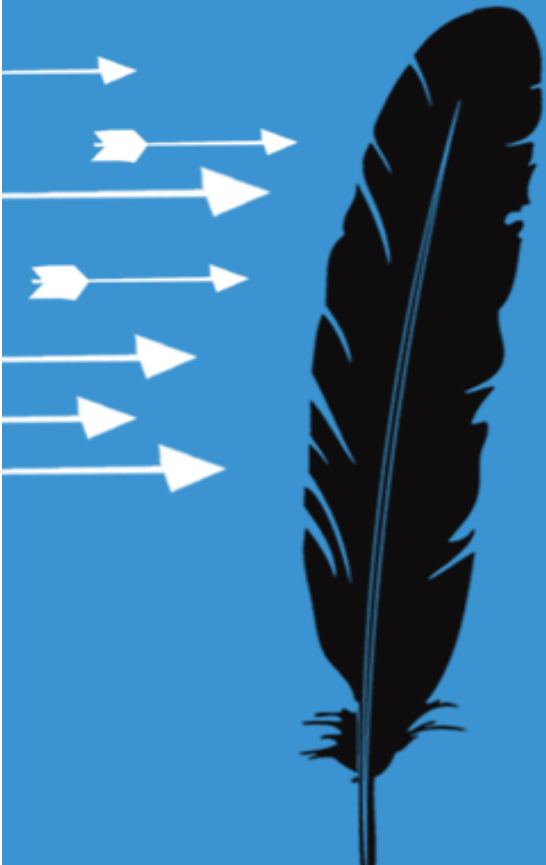


SSL Ecosystem

- Protocol designers (IETF TLS Working Group)
- Library developers (Microsoft, OpenSSL, NSS, ...)
- Vendors
 - Server vendors
 - Browser vendors
- Certificate authorities and resellers
- System administrators
- Consumers

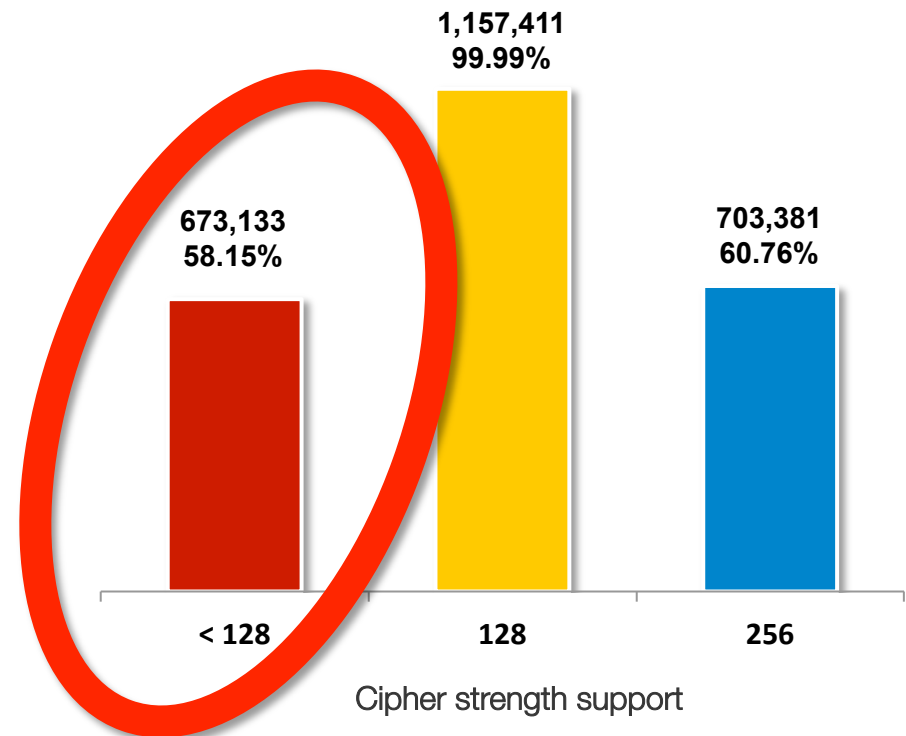


SSL/TLS Server Configuration Issues



Weak Encryption Still Common

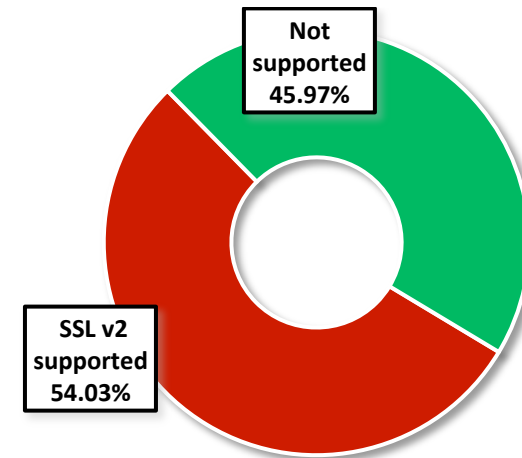
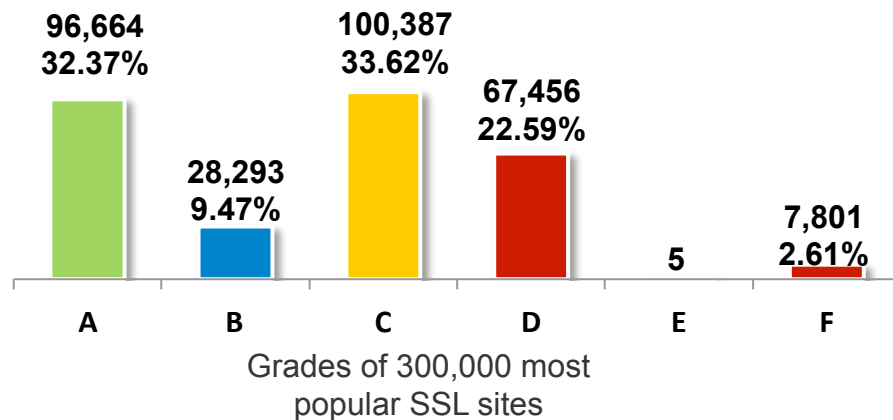
- Private keys under 1024 bits are easy to break
 - Few public servers vulnerable, but issues likely in internal legacy systems
 - Digicert Sdn. Bhd. (not related to DigiCert, Inc.), was recently caught issuing 512-bit certs
- Ciphers below 128 bits equally weak



SSLv2 Insecure, Yet Widely Supported

More than half of all servers tested support the insecure SSL v2 protocol

- **SSL v2 can be easily broken**
- An active MITM can force browsers to fall back to SSL v2, if supported in both client and server
- Modern browsers do not support SSLv2, but old do



Protocol	Support	Best protocol
SSL v2.0	625,484	-
SSL v3.0	1,156,033	13,471
TLS v1.0	1,143,673	1,141,458
TLS v1.1	2,191	2,007
TLS v1.2	211	211



Reasons

- Hard to configure ?



In the Wild...

The screenshot shows the AWS Management Console interface for Amazon EC2. The main content area displays a list of Amazon Machine Images (AMIs) filtered by the search term "wordpress". The table below shows the details of these AMIs.

Name	AMI ID	Source	Owner	Visibility	Status
empty	ami-000af969	bitnami-cloud/wordpress/bitnami-wordpress-3.1.0-linux-ubuntu-10.04.ma	979382823631	Public	Available
empty	ami-04cd326d	979382823631/bitnami-wordpress-3.1.2-0-linux-ubuntu-10.04-eps	979382823631	Public	Available
empty	ami-07b1626e	979382823631/bitnami-wordpress-3.3.1-1-multisite-linux-x64-ubuntu-10.	979382823631	Public	Available
empty	ami-07ca1d6e	264011160664/HFMHHRGA-ubuntu11_10/apache-bench/AWS_API_toc	264011160664	Public	Available
empty	ami-0ce61065	979382823631/bitnami-wordpress-3.0.2-0-linux-ubuntu-10.04-eps	979382823631	Public	Available
empty	ami-115b9078	turnkeylinux-us-east-1/turnkey-wordpress-11.3-lucid-x86.s3.manifest.xr	096457495696	Public	Available
empty	ami-11bc7478	979382823631/bitnami-wordpress-3.2.1-5-linux-ubuntu-10.04-eps	979382823631	Public	Available
empty	ami-1216e07b	bitnami-cloud/wordpress/bitnami-wordpress-3.0.3-0-linux-ubuntu-10.04.r	979382823631	Public	Available
empty	ami-127d8c7b	bitnami-cloud/wordpress/bitnami-wordpress-3.0.4-0-linux-ubuntu-10.04.r	979382823631	Public	Available
empty	ami-17f6217e	264011160664/zMkGTGBH-ubuntu11_10/apache-bench/AWS_API_toc	264011160664	Public	Available
empty	ami-1a4ead73	bitnami-cloud/wordpress/bitnami-wordpress-2.8.5-1-linux.manifest.xml	979382823631	Public	Available

0 EC2 Amazon Machine Images selected
Select an image above

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In the Wild...



In the Wild...

BitNami WordPress Stack - Mozilla Firefox

BitNami WordPress Stack

amazonaws.com https://ec2-107-22-13-224.

BITNAMI

Welcome!

The BitNami WordPress Stack greatly simplifies the installation of WordPress and runtime dependencies on Amazon EC2. It includes ready-to-run versions of Apache, MySQL and PHP. BitNami WordPress Stack is distributed for free under the Apache 2.0 license.

WordPress

You can learn more about BitNami at <http://bitnami.org>

WordPress is an open source, standards-compliant, fast, light and free personal publishing platform. The project was started in 2003 as a personal publishing platform, with a set of features designed to make the internet publishing experience easy. WordPress blogs now reach a combined 70 million global visitors and 300 million pageviews each month.

You can learn more about WordPress at <http://www.wordpress.org>

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In the Wild...

Qualys SSL Labs - Projects / SSL Server Test / cert.kandek.com - Mozilla Firefox

Qualys SSL Labs - Projects / SS...

sslabs.com https://www.ssllabs.com

Home Qualys.com Projects Cont

QUALYS[®] SSL LABS

You are here: [Home](#) > [Projects](#) > [SSL Server Test](#) > [cert.kandek.com](#) > 107.22.13.224

SSL Report: [cert.kandek.com](#) (107.22.13.224)

Assessed on: Wed Feb 01 23:32:55 UTC 2012 | [Clear cache](#) [Scan Another](#)

Summary

Overall Rating

C

52

Certificate	100
Protocol Support	55
Key Exchange	40
Cipher Strength	60

The scores are explained in the [SSL Server Rating Guide 2009](#)

This server is vulnerable to the BEAST attack ([more info](#))



In the Wild...

Qualys SSL Labs - Projects / SSL Server Test / cert.kandek.com - Mozilla Firefox

Qualys SSL Labs - Projects / SS... +

sslabs.com https://www.ssllabs.com Google

Protocols

TLS 1.2	No
TLS 1.1	No
TLS 1.0	Yes
SSL 3.0	Yes
SSL 2.0+ upgrade support	Yes
SSL 2.0 INSECURE	Yes

Cipher Suites (sorted by strength; we could not determine if server has a preference)

SSL_RC4_128_EXPORT40_WITH_MD5 (0x20080) WEAK	40
SSL_RC2_128_CBC_EXPORT40_WITH_MD5 (0x40080) WEAK	40
TLS_RSA_EXPORT_WITH_RC4_40_MD5 (0x3) WEAK	40
TLS_RSA_EXPORT_WITH_RC2_CBC_40_MD5 (0x6) WEAK	40
TLS_RSA_EXPORT_WITH_DES40_CBC_SHA (0x8) WEAK	40
TLS_DHE_RSA_EXPORT_WITH_DES40_CBC_SHA (0x14) DH 512 bits (p: 64, g: 1, Ys: 64) WEAK	40
SSL_DES_64_CBC_WITH_MD5 (0x60040) WEAK	56
TLS_RSA_WITH_DES_CBC_SHA (0x9) WEAK	56
TLS_DHE_RSA_WITH_DES_CBC_SHA (0x15) DH 1024 bits (p: 128, g: 1, Ys: 128) WEAK	56



In the Wild... - the Fix



The screenshot shows a web browser window with the address bar displaying `https://community.qualys.com/message/12495#12495`. The page header features the Qualys logo and the text "QUALYS® COMMUNITY". Below the header is a navigation menu with "HOME", "NEW", "YOUR STUFF", "HISTORY", and "BROWSE". A breadcrumb trail reads "You are here: Qualys Community > SSL Labs > Discussions". The post itself has "539 Views" and "1 Reply". The latest reply is from Ivan Ristic on Dec 22, 2011 at 3:26 AM. The post content includes a list of SSL configuration directives and a note about an upcoming document.

ssllabs.com's own Apache SSL Config Directives

Here are the relevant directives:

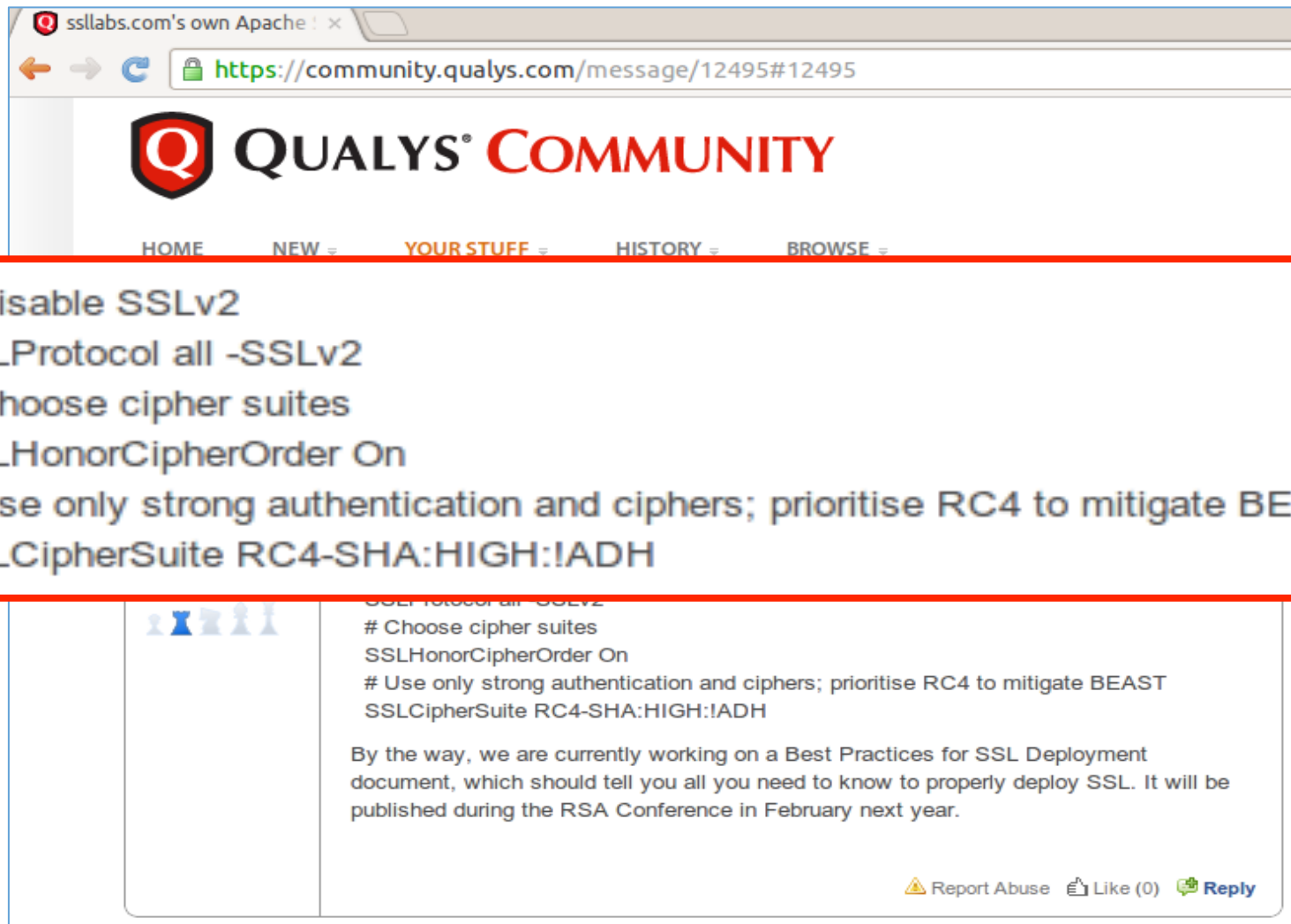
- # Disable SSLv2
SSLProtocol all -SSLv2
- # Choose cipher suites
SSLHonorCipherOrder On
- # Use only strong authentication and ciphers; prioritise RC4 to mitigate BEAST
SSLCipherSuite RC4-SHA:HIGH:!ADH

By the way, we are currently working on a Best Practices for SSL Deployment document, which should tell you all you need to know to properly deploy SSL. It will be published during the RSA Conference in February next year.

Report Abuse Like (0) Reply



In the Wild... - the Fix



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```
# Disable SSLv2
SSLProtocol all -SSLv2
# Choose cipher suites
SSLHonorCipherOrder On
# Use only strong authentication and ciphers; prioritise RC4 to mitigate BEAST
SSLCipherSuite RC4-SHA:HIGH:!ADH
```

Below the code block, there is a smaller version of the same code block and a paragraph of text: "By the way, we are currently working on a Best Practices for SSL Deployment document, which should tell you all you need to know to properly deploy SSL. It will be published during the RSA Conference in February next year." At the bottom right of the message, there are three icons: a warning triangle for "Report Abuse", a thumbs up for "Like (0)", and a speech bubble for "Reply".



In the Wild... - the Fix

```
root@ip-10-98-5-207: /opt/bitnami/apache2/conf/extra
SSLEngine on

# SSL Cipher Suite:
# List the ciphers that the client is permitted to negotiate.
# See the mod_ssl documentation for a complete list.
SSLCipherSuite ALL:!ADH:!EXPORT56:RC4+RSA:+HIGH:+MEDIUM:+LOW:+SSLv2:+EXP:+eNULL

# Server Certificate:
# Point SSLCertificateFile at a PEM encoded certificate.  If
# the certificate is encrypted, then you will be prompted for a
# pass phrase.  Note that a kill -HUP will prompt again.  Keep
# in mind that if you have both an RSA and a DSA certificate you
# can configure both in parallel (to also allow the use of DSA
# ciphers, etc.)
SSLCertificateFile "/opt/bitnami/apache2/conf/server.crt"
#SSLCertificateFile "/opt/bitnami/apache2/conf/server-dsa.crt"

# Server Private Key:
# If the key is not combined with the certificate, use this
# directive to point at the key file.  Keep in mind that if
# you've both a RSA and a DSA private key you can configure
# both in parallel (to also allow the use of DSA ciphers, etc.)
SSLCertificateKeyFile "/opt/bitnami/apache2/conf/server.key"

90,1 40%
```



In the Wild... - the Fix

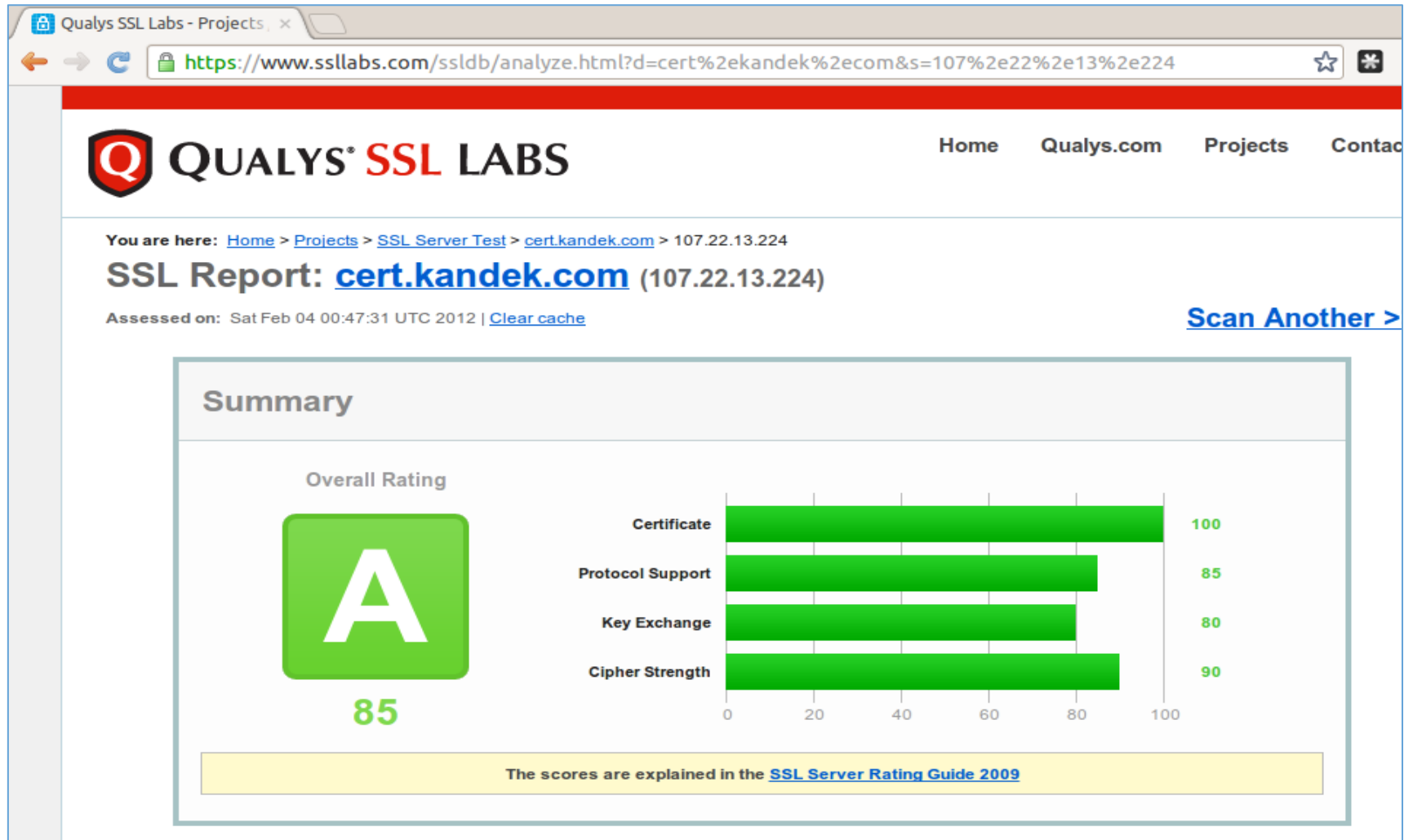
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SSLProtocol all -SSLv2
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SSLCipherSuite RC4-SHA:HIGH:!ADH
█
# Server Certificate:
# Point SSLCertificateFile at a PEM encoded certificate. If
# the certificate is encrypted, then you will be prompted for a
# pass phrase. Note that a kill -HUP will prompt again. Keep
# in mind that if you have both an RSA and a DSA certificate you
# can configure both in parallel (to also allow the use of DSA
# ciphers, etc.)
SSLCertificateFile "/opt/bitnami/apache2/conf/server.crt"
#SSLCertificateFile "/opt/bitnami/apache2/conf/server-dsa.crt"

97,0-1 39%
```



In the Wild... - the Fix



In the Wild... - the Fix

sslabs.com's own Apache ! x

https://community.qualys.com/message/12495#12495

QUALYS® COMMUNITY

HOME NEW ▾ YOUR STUFF ▾ HISTORY ▾ BROWSE ▾

You are here: Qualys Community > SSL Labs > Discussions

By the way, we are currently working on a Best Practices for SSL Deployment document, which should tell you all you need to know to properly deploy SSL. It will be published during the RSA Conference in February next year.

55 posts since Jul 23, 2010

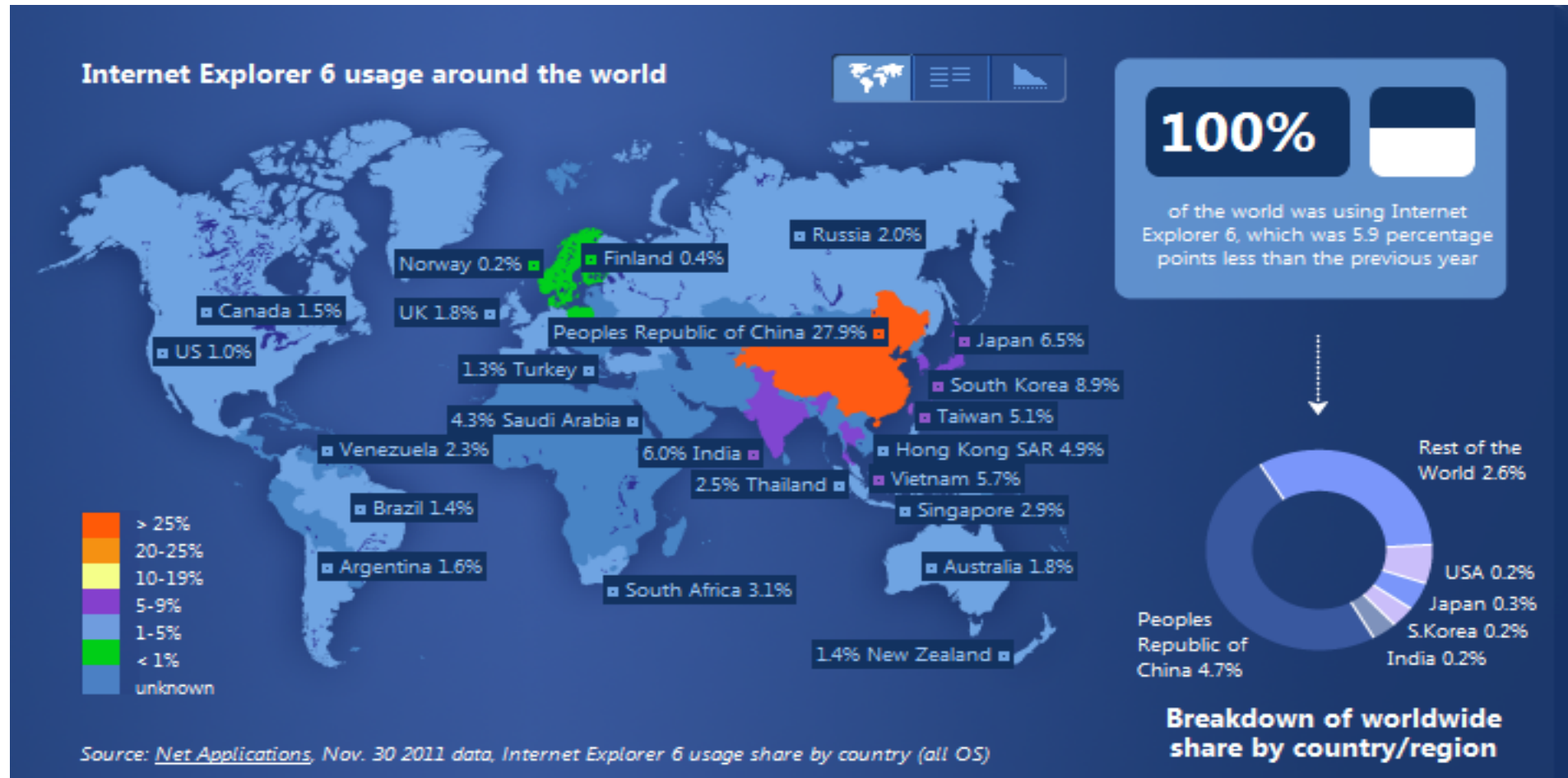
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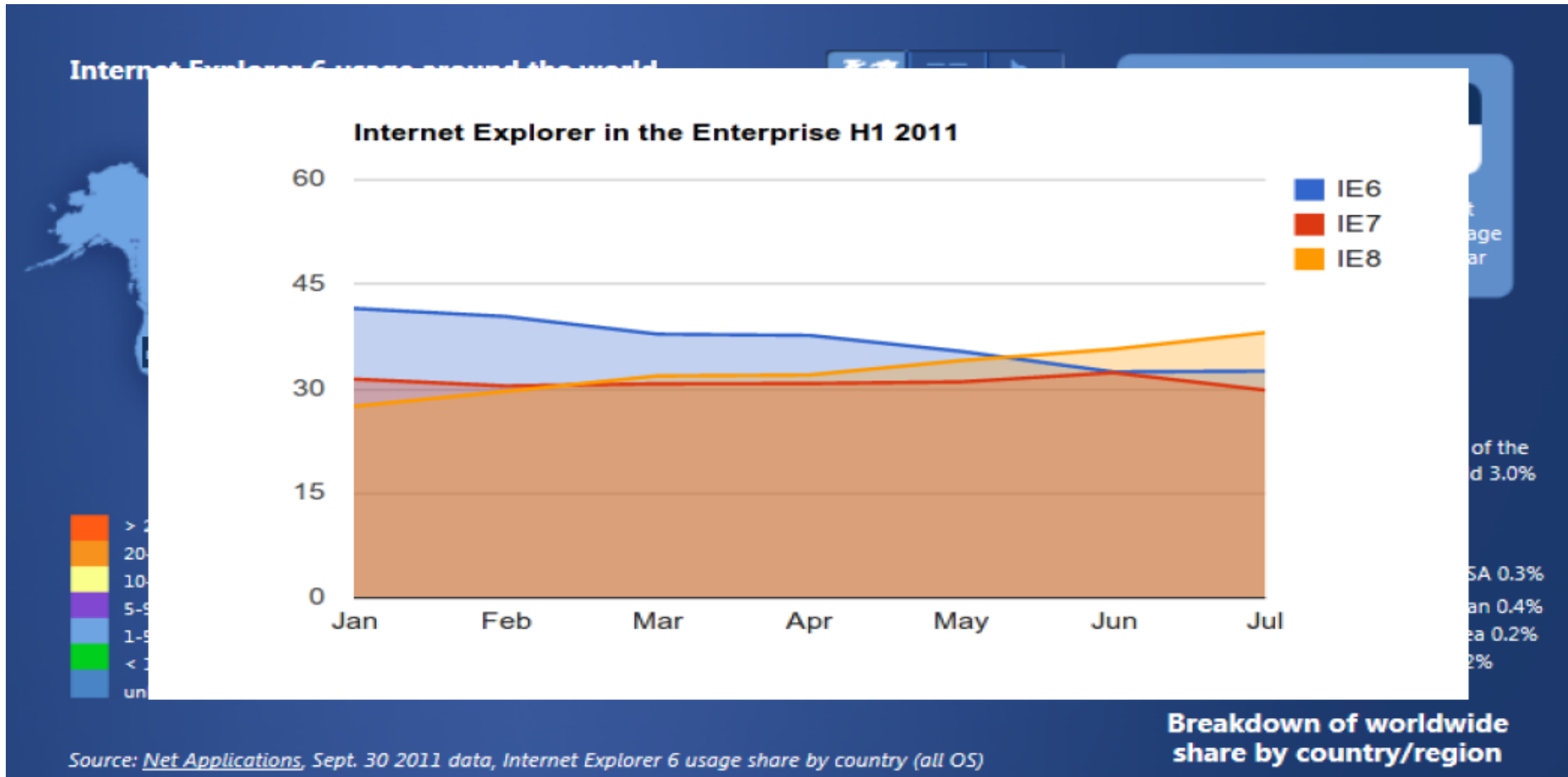
Report Abuse Like (0) Reply



Is Internet Explorer 6 a Problem? No?



Actually, yes. IE6 Still In Wide Use



Configure Apache to Monitor SSL Usage

```
# this only for browsers where you know that their SSL implementation
# works correctly.
# Notice: Most problems of broken clients are also related to the HTTP
# keep-alive facility, so you usually additionally want to disable
# keep-alive for those clients, too. Use variable "nokeepalive" for th
# Similarly, one has to force some clients to use HTTP/1.0 to workarou
# their broken HTTP/1.1 implementation. Use variables "downgrade-1.0"
# "force-response-1.0" for this.
BrowserMatch ".*MSIE.*" \
    nokeepalive ssl-unclean-shutdown \
    downgrade-1.0 force-response-1.0

# Per-Server Logging:
# The home of a custom SSL log file. Use this when you want a
# compact non-error SSL logfile on a virtual host basis.
CustomLog "/opt/bitnami/apache2/logs/ssl_request_log" \
    "%t %h %{SSL_PROTOCOL}x %{SSL_CIPHER}x \"%r\" %b"

</VirtualHost>
```

222,38



Protocol and cipher suite log

```
[01/Feb/2012:23:32:15 +0000] 173.203.79.216 - - "HEAD / HTTP/1.0" -
[01/Feb/2012:23:32:16 +0000] 173.203.79.216 SSLv2 DES-CBC3-MD5 "GET / HTTP/1.0" 2706
[01/Feb/2012:23:32:44 +0000] 173.203.79.216 TLSv1 EXP-RC4-MD5 "GET / HTTP/1.0" 2706
[01/Feb/2012:23:32:44 +0000] 173.203.79.216 TLSv1 EXP-DES-CBC-SHA "GET / HTTP/1.0" 2706
[01/Feb/2012:23:32:44 +0000] 173.203.79.216 TLSv1 DES-CBC-SHA "GET / HTTP/1.0" 2706
[01/Feb/2012:23:32:44 +0000] 173.203.79.216 TLSv1 EXP-EDH-RSA-DES-CBC-SHA "GET / HTTP/1.0" 2706
[01/Feb/2012:23:32:44 +0000] 173.203.79.216 TLSv1 EDH-RSA-DES-CBC-SHA "GET / HTTP/1.0" 2706
[02/Feb/2012:01:24:17 +0000] 94.236.127.132 TLSv1 DHE-RSA-AES256-SHA "HEAD / HTTP/1.0" -
[03/Feb/2012:12:57:52 +0000] 222.175.207.206 TLSv1 DHE-RSA-AES256-SHA "GET / HTTP/1.1" 219
[04/Feb/2012:00:46:50 +0000] 173.203.79.216 TLSv1 RC4-SHA "GET / HTTP/1.0" -
```

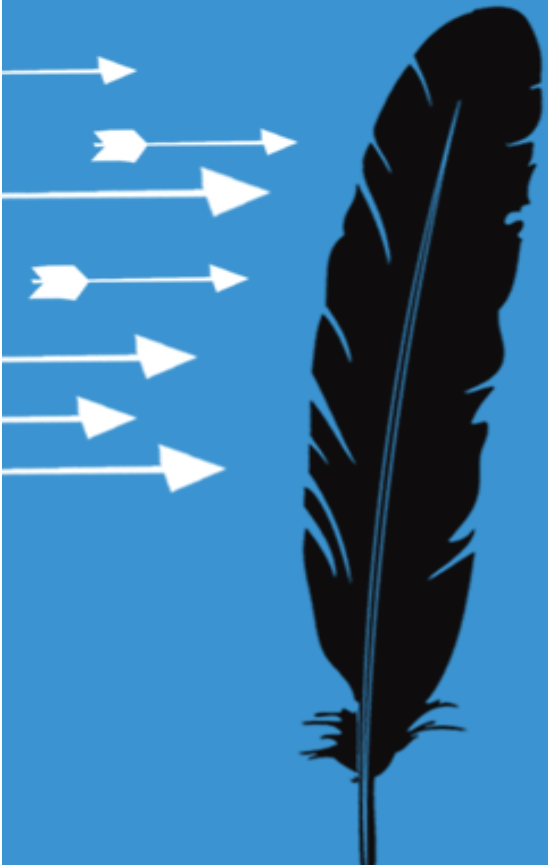


Lessons Learned

- If a system allows for an insecure configuration, the majority of the installations will be insecure
 - Vendors must actively prune libraries and products to remove obsolete features
 - Ship secure by default
 - Bug fix-only maintenance not good enough
- End-user products have a very long life, and will not be replaced even if insecure

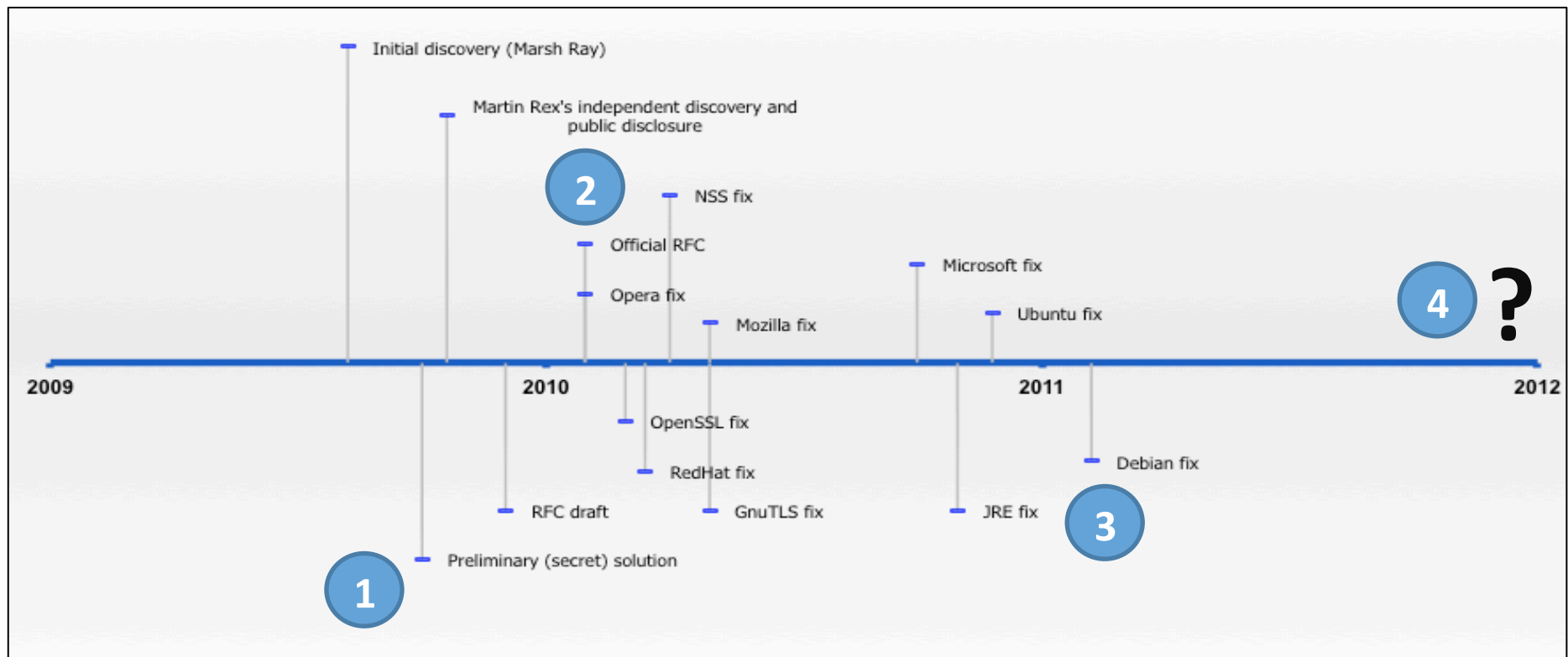


Protocol Attacks



SSL/TLS Authentication Gap Timeline

- Flaw in the protocol that allowed one TCP connection to carry multiple independent SSL/TLS streams
- A rare example that allows us to follow the fix timeline:



Lessons Learned

- Fixing flaws in protocols takes time:
 1. Allow 6 months to fix the protocol itself
 2. Further 12 months to fix implementations
 3. Further 24 months for “everyone” to patch



BEAST Attack Against CBC Suites

- Vulnerability in SSL 3.0 and TLS 1.0
- Decrypts small parts of traffic (e.g., cookies)
- Fixed a long time ago in TLS 1.1 (2006)
- But TLS 1.1+ ignored by majority (“Attack not practical”)

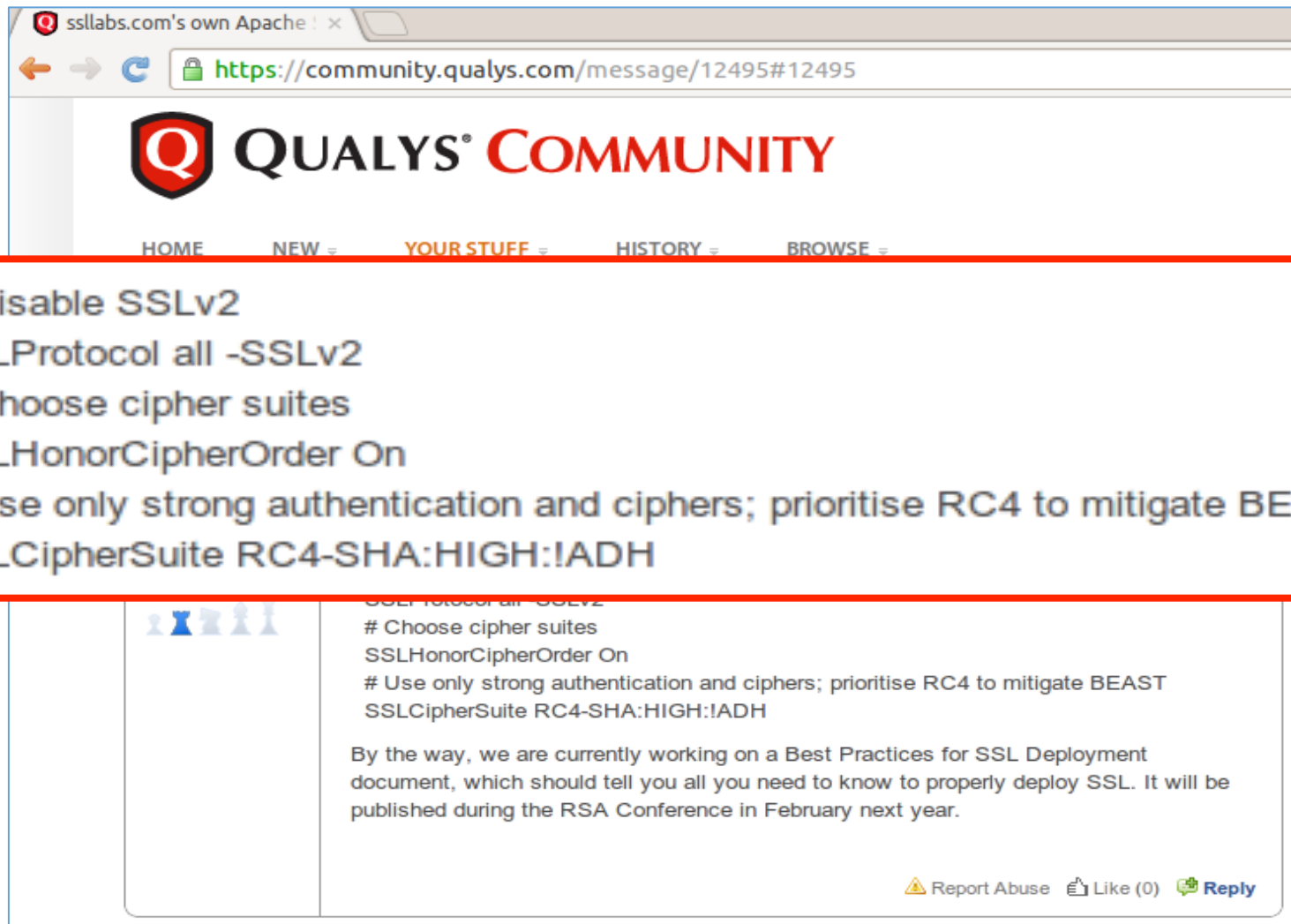
The screenshot displays a security tool interface with a sidebar on the left and a main content area. The sidebar includes a 'Miscellaneous' section with links for 'Test date', 'Test duration', 'Server signature', and 'Server hostname'. The main content area features a 'Cipher Suites (SSLv3+ suites in server-preferred order, then SSLv2 suites where used)' section. This section lists several cipher suites: 'TLS_RSA_WITH_RC4_128_MD5 (0x4)', 'TLS_RSA_WITH_RC4_128_SHA (0x5)', 'TLS_RSA_WITH_3DES_EDE_CBC_SHA (0xa)', 'TLS_RSA_WITH_AES_256_CBC_SHA (0x35)', and 'TLS_RSA_WITH_AES_128_CBC_SHA (0x2f)'. The first two suites are highlighted with a green box. Below this, a table shows the status of various security features: 'BEAST attack' is 'Vulnerable INSECURE (more info)', 'Insecure Renegotiation' is 'Supported INSECURE (more info)', and 'Strict Transport Security' is 'No'.

Cipher Suite	Status	Info
TLS_RSA_WITH_RC4_128_MD5 (0x4)	Vulnerable	INSECURE (more info)
TLS_RSA_WITH_RC4_128_SHA (0x5)	Vulnerable	INSECURE (more info)
TLS_RSA_WITH_3DES_EDE_CBC_SHA (0xa)	Supported	INSECURE (more info)
TLS_RSA_WITH_AES_256_CBC_SHA (0x35)	Supported	INSECURE (more info)
TLS_RSA_WITH_AES_128_CBC_SHA (0x2f)	Supported	INSECURE (more info)

Feature	Status	Info
BEAST attack	Vulnerable	INSECURE (more info)
Insecure Renegotiation	Supported	INSECURE (more info)
Strict Transport Security	No	



BEAST Mitigation using RC4



The screenshot shows a web browser window with the address bar displaying `https://community.qualys.com/message/12495#12495`. The page header features the Qualys logo and the text "QUALYS COMMUNITY". Below the header is a navigation menu with links for "HOME", "NEW", "YOUR STUFF", "HISTORY", and "BROWSE". The main content area displays a forum post with the following text:

```
# Disable SSLv2
SSLProtocol all -SSLv2
# Choose cipher suites
SSLHonorCipherOrder On
# Use only strong authentication and ciphers; prioritise RC4 to mitigate BEAST
SSLCipherSuite RC4-SHA:HIGH:!ADH
```

Below the code, there is a paragraph of text: "By the way, we are currently working on a Best Practices for SSL Deployment document, which should tell you all you need to know to properly deploy SSL. It will be published during the RSA Conference in February next year." At the bottom right of the post, there are three icons: a warning triangle for "Report Abuse", a thumbs-up for "Like (0)", and a speech bubble for "Reply".

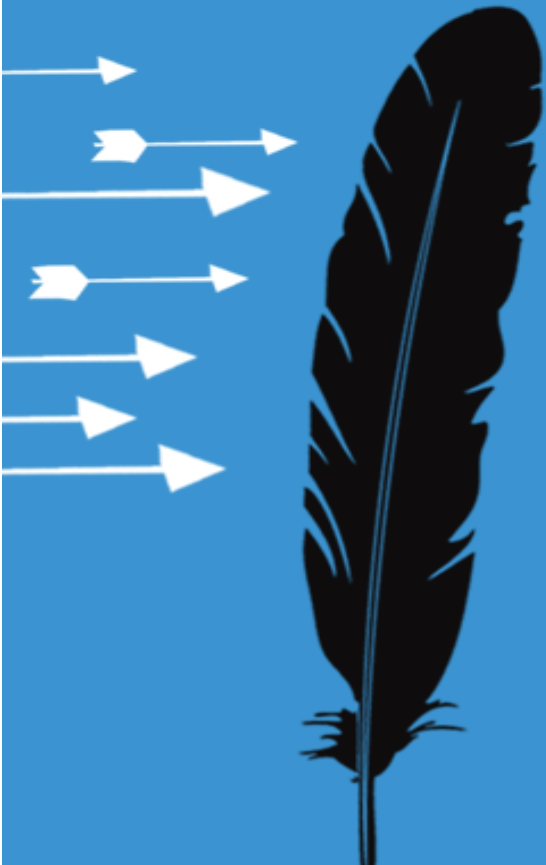


Lessons Learned

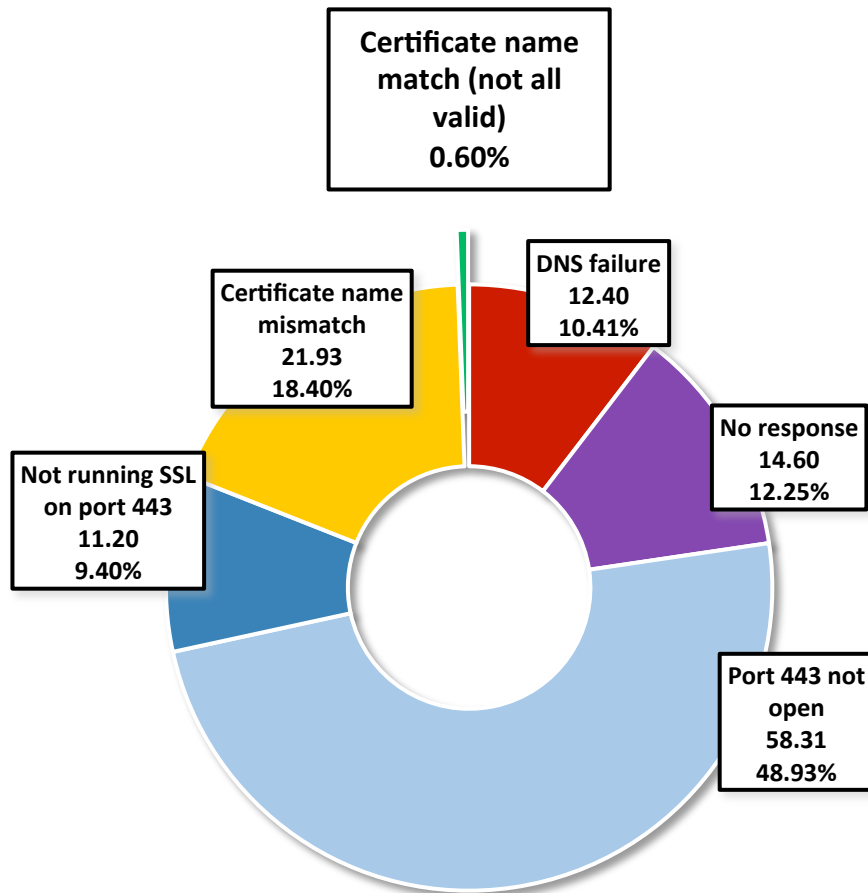
- Attacks get only better over time
 - Do not leave obvious flaws without a fix, even if an exploit is not currently available
 - Someone will find a way to exploit the flaw, if it is important or interesting enough



SSL/TLS Application Issues



Very Few Sites Actually Use SSL



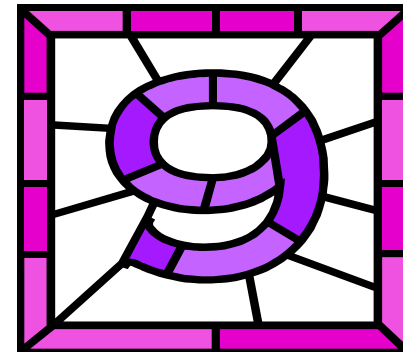
- The pie chart on the left represents a scan of about 120 million domain name registrations
- SSL is not very common, across all registrations
- Today, we are at **0.4%** across registered domains and **1%** across active sites
- However, about **10%** of the Alexa's Top 1M sites support SSL



Sites With SSL Use It Incorrectly

Virtually all sites are a mix of HTTP and HTTPS.

- User's first request to a site is virtually always unprotected, which means it can be hijacked
- Over **67%** not well configured
- Nearly **54%** support SSLv2
- About **20%** mix content within the same page
- About **54%** do not use SSL to protect authentication
- About **15%** use session cookies that are not secure

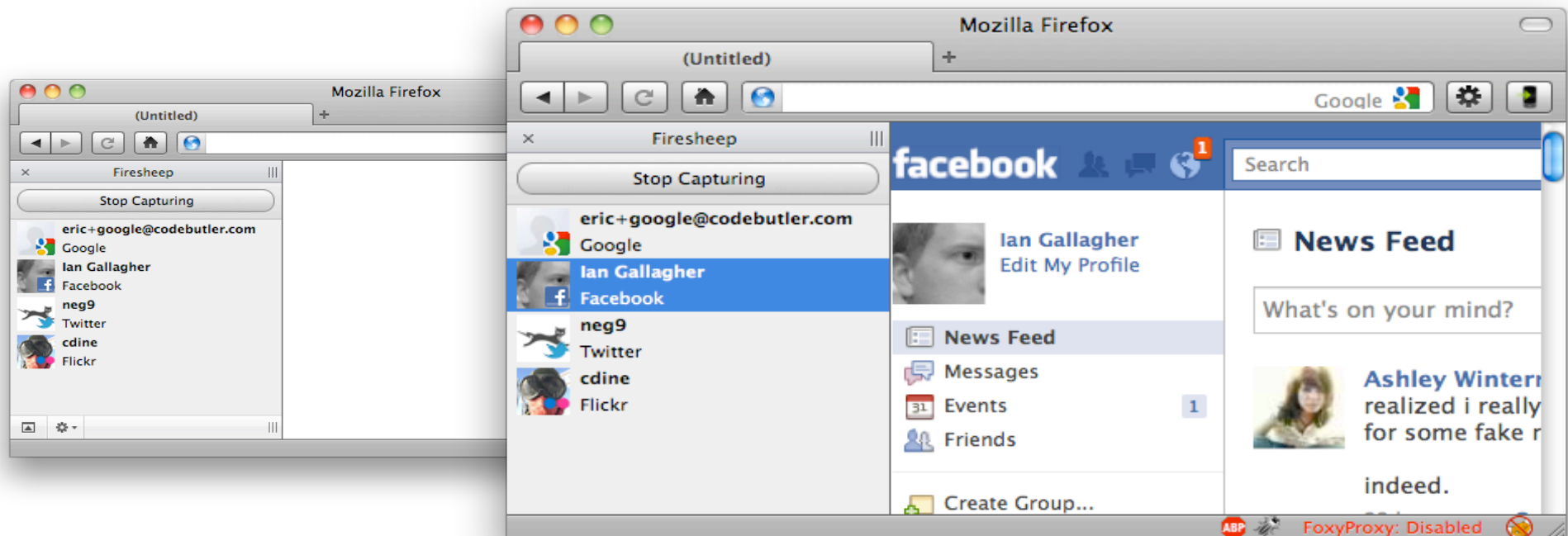


We found only 9 properly secured SSL sites among Alexa's top 1 million



Firesheep: Account Hijacking Made Easy

1. Install Firefox plug-in
2. Press “Start Capturing”
3. Choose account to hijack



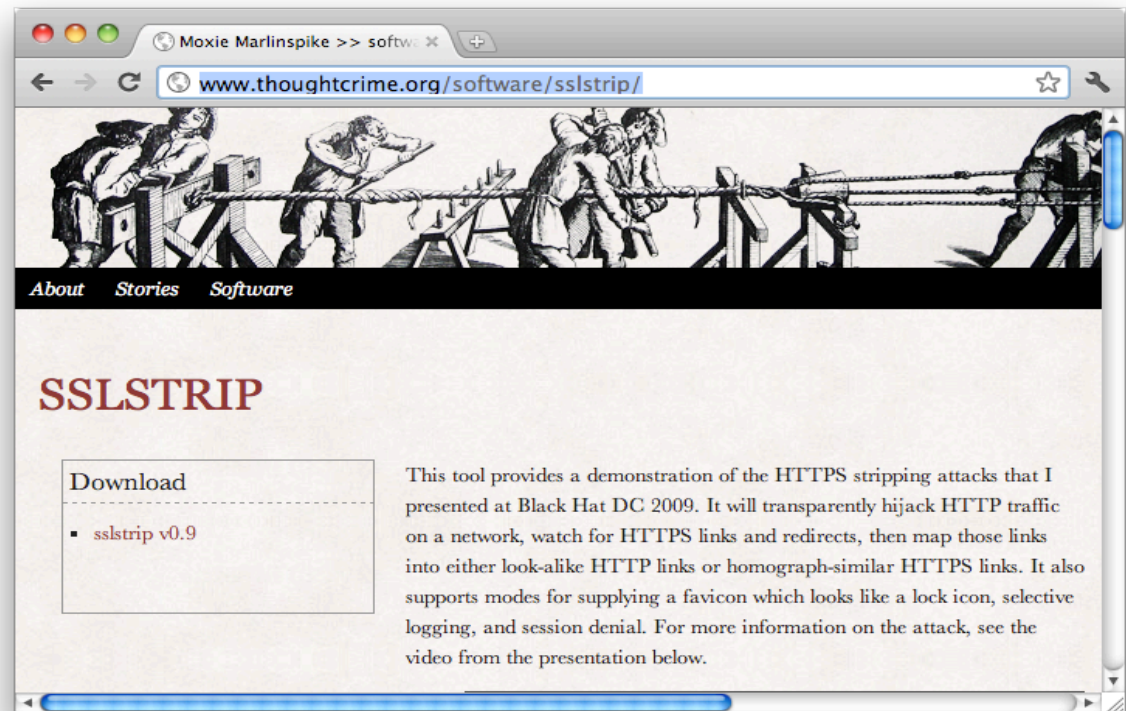
Screen captures retrieved from Firesheep's web site:
<http://codebutler.com/firesheep>



SSLStrip: HTTP Users Stay With HTTP

1. Victim's traffic re-routed through attacker's machine
2. Links to HTTPS are stripped
3. Victim stays in HTTP, under full control of attacker

The attack can be fully automated



Lessons Learned

- Developers are too busy adding features to do the right thing when it comes to security
- The path of least resistance always wins



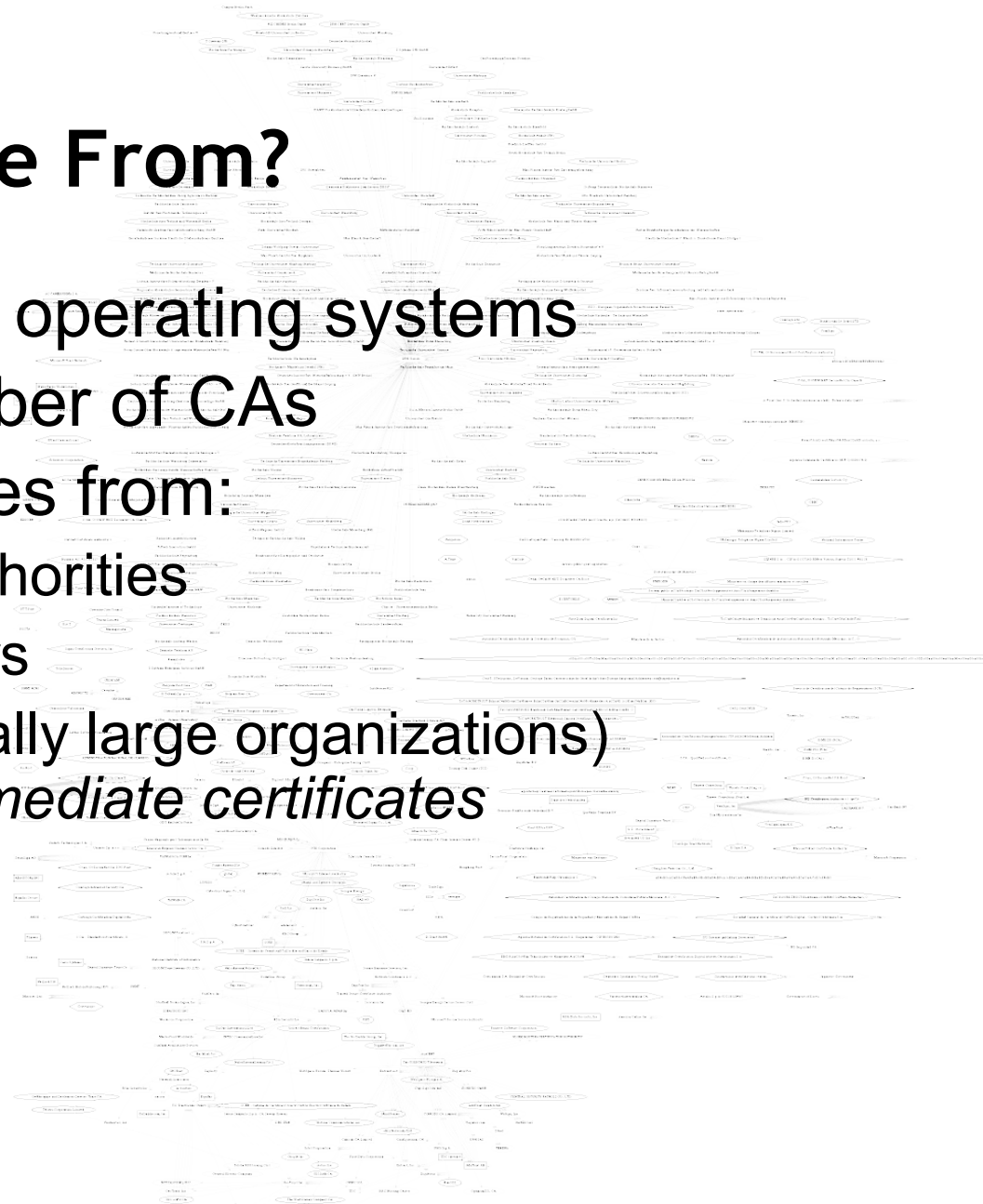


PKI Trust Issues



RSA CONFERENCE 2012

Where Does Trust Come From?

- Users trust browsers and operating systems
- They, in turn, trust a number of CAs
- In practice, the trust comes from:
 - Hundreds of certificate authorities
 - Their resellers and partners
 - Other organizations (typically large organizations) that have purchased *intermediate certificates*
- **Any one of these can sign any domain name**



Recent Attacks Against PKI

- Comodo (March 2011) 
 - One successful attack and at least one unsuccessful one that we know of
 - Reseller compromise lead to issuance of certificates for 7 high-profile domain names
 - No reports of successful use of the rogue certificates
- DigiNotar (July-August 2011) 
 - Full CA compromise (and without a timely notification)
 - Over 500 rogue certificates issued; some used
 - *DigiNotar blacklisted by all major vendors*



Mitigation: Certificate Authority Pinning

- CA pinning: require specific CA for domain name
- The DigiNotar compromise was detected by the CA-pinning feature in Chrome
 - There is no standard way to do that
 - Google used it for themselves because they could
- You *may* be able use the same mechanism:
 - Adam Langley (Google): *“If you run a large, high security site and want Chrome to include pins, let me know.”*
- RFC: Public Key Pinning Extension for HTTP
<http://tools.ietf.org/html/draft-ietf-websec-key-pinning-01>



Possible Future: DANE (DNSSEC)

- DNSSEC is a secure version of the DNS protocol
- DANE* leans on DNSSEC to add support for *out-of-bound certificate validation*
- It provides support for:
 - Certificate Authority pinning
 - Certificate pinning (has to be signed by valid CA)
 - Self-signed certificates
- Problems to overcome:
 - No support for DNSSEC in clients
 - DNS registrar hack can hijack your domain name

(*) DNS-based Authentication of Named Entities



PKI Alternative: Convergence

- Introduced by Moxie Marlinspike* in August 2011
- Not a replacement for PKI, but a method of *abstracting trust decisions on the client side*
 - Client asks remote notaries to make trust decisions
 - Notaries are free to implement own decision logic
 - Clients are free to choose what notaries they trust
- Problems to overcome:
 - Needs reliable infrastructure, which may be very expensive



(*) Author of sslsniff and sslstrip

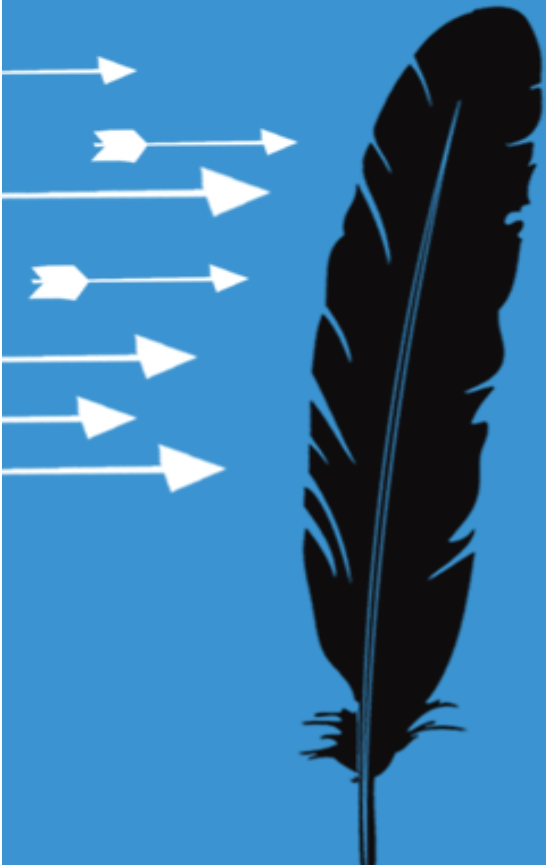


Lessons Learned

- Embedded trusted certificate stores are a liability for everyone: users, browser vendors, and certificate authorities
- At present, there are few incentives for CAs to improve the security of the current system
 - CAs do not compete on security
 - If you're large enough, no one can touch you
 - Little guys will burn

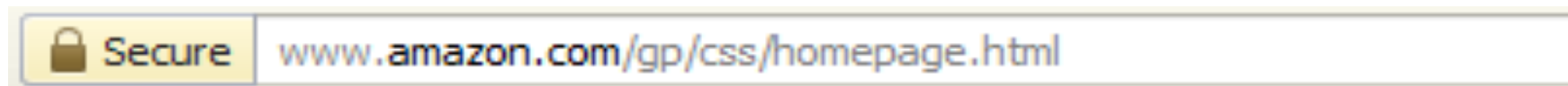
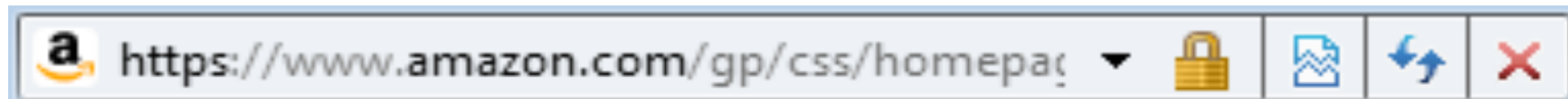
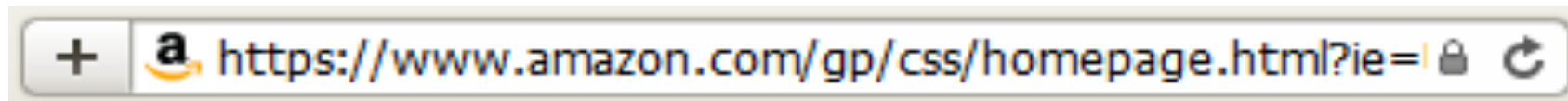
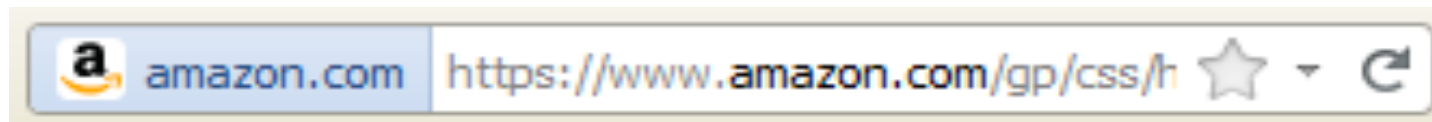


Browser Problems



SSL Indicators

- The padlock changes location with every new browser version
- Firefox does not use it any more

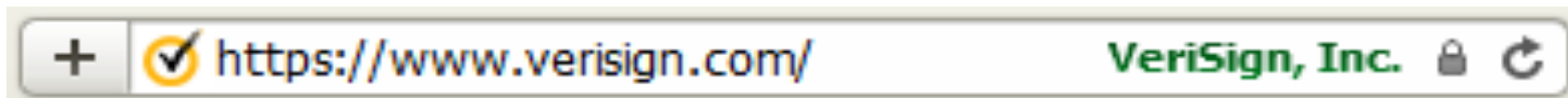
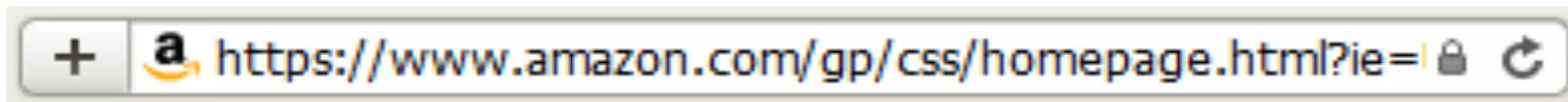


Extended Validation Certificate Indicators

- EV certificates want to be “the new padlock”
- Some browsers try to differentiate



- Others, not so much



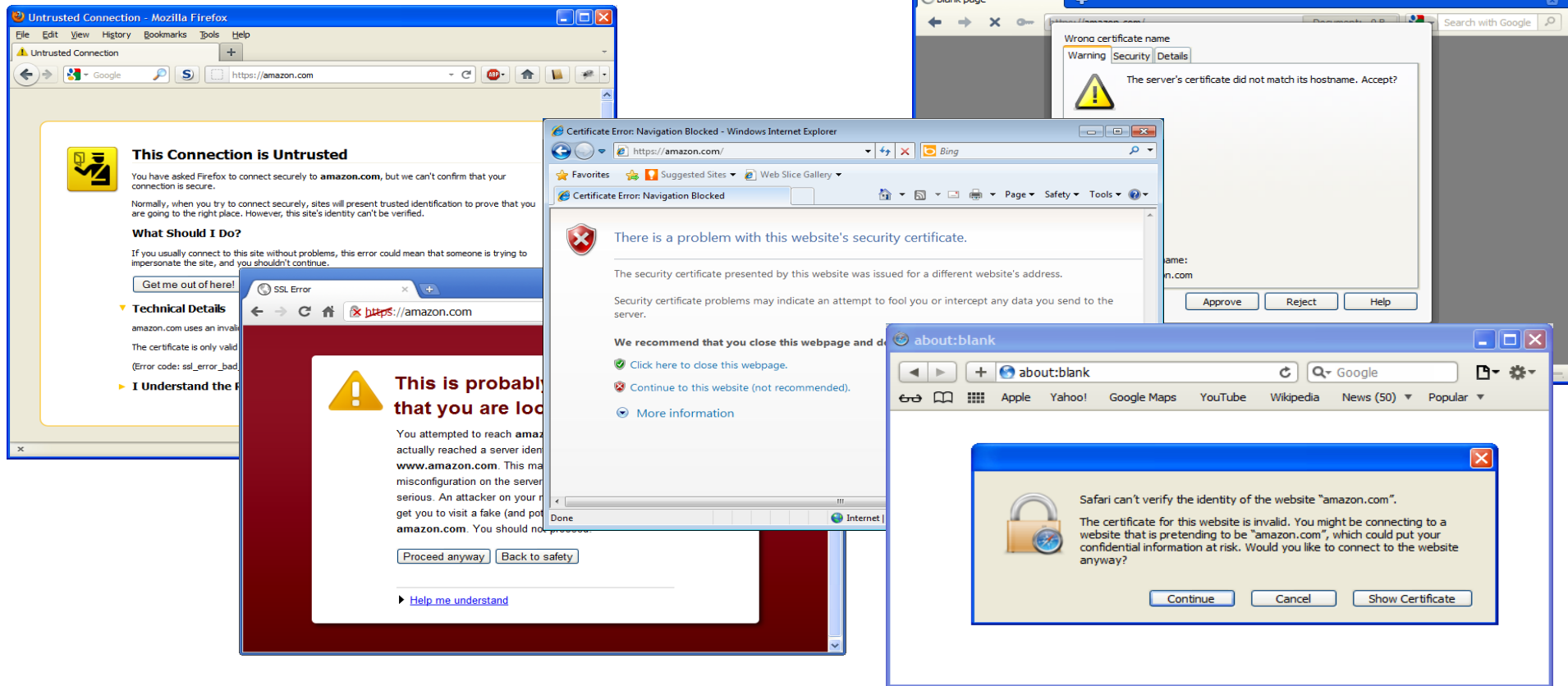
- No one cares, anyway



SSL Certificate Warnings

All browsers will accept invalid certificates, most with one click; Firefox requires that you do a little dance

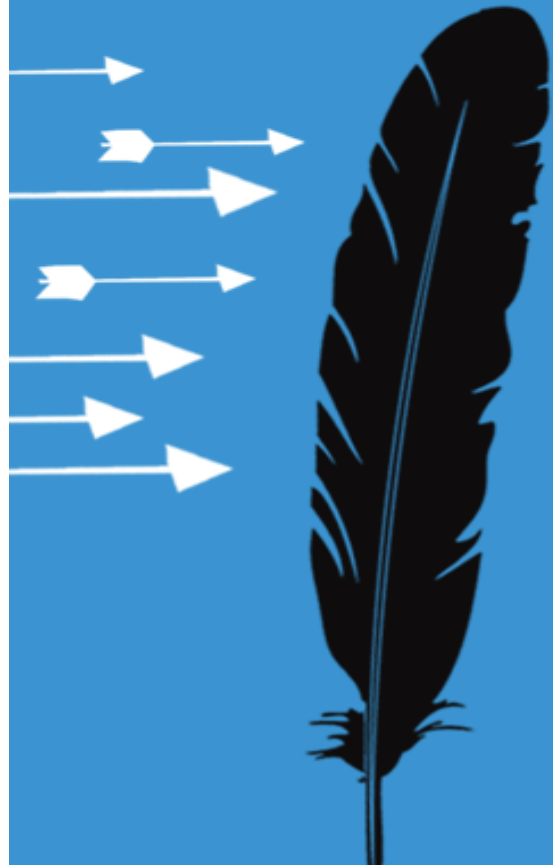
- Everyone ignores these



Lessons Learned

- Vendors of consumer products cannot afford to be strict when it comes to security
- They tend to be conservative, in order to preserve product usability and their market share





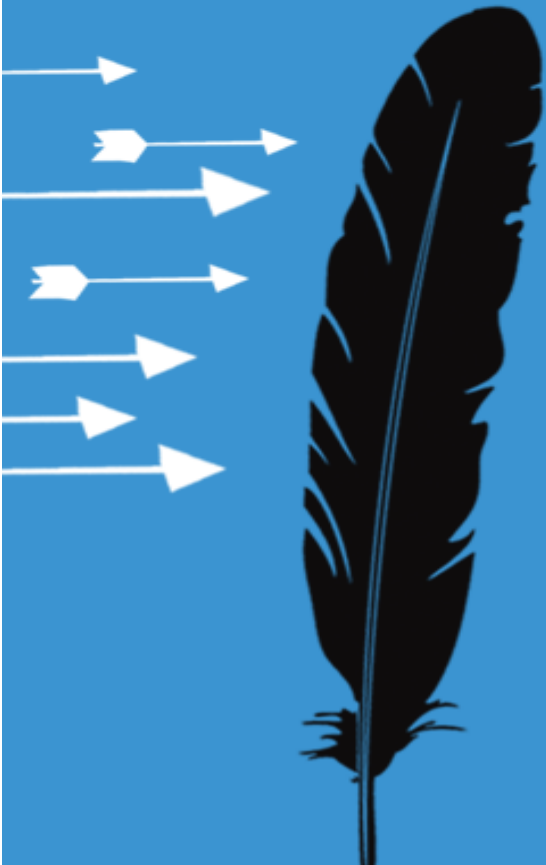
Lessons Learned

Summary of Lessons Learned

- Security must be **invisible** and **always enabled**, as well as **resilient** to configuration and programming errors, and consumer bypasses
- Complex security systems need constant supervision and guidance
 - We need independent bodies, free of financial conflict, that can **focus on security**
 - The ecosystem must be designed so that every participant has an **incentive to do better** when it comes to security



How to Apply What You Have Learned?

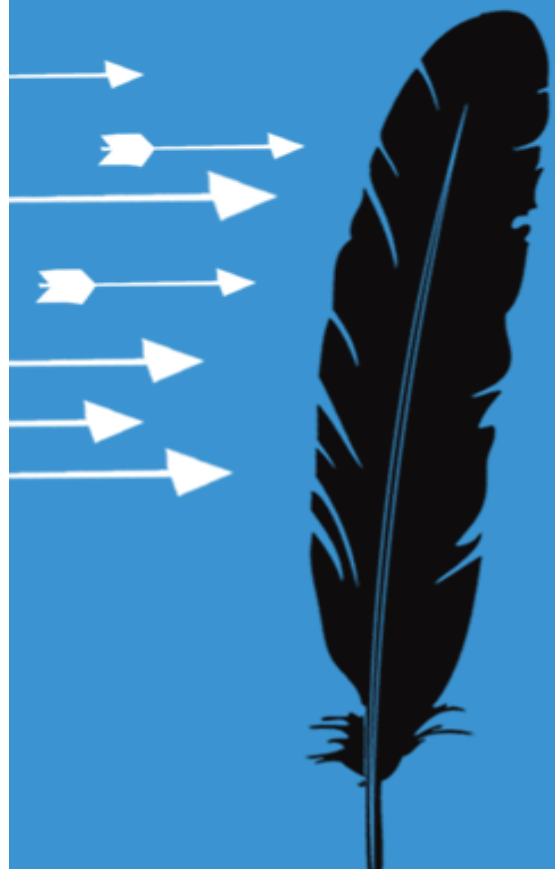


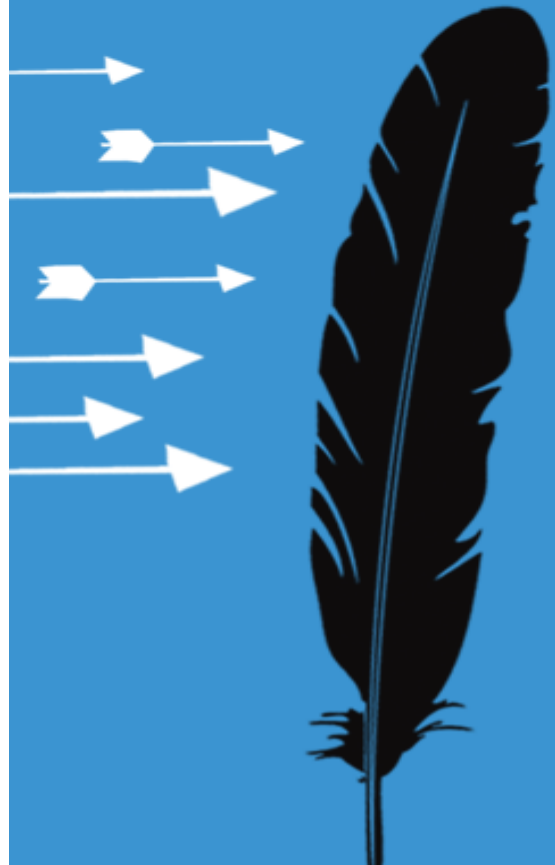
How To Apply What You Have Learned

- In the first 3 months following this presentation you should:
 - Identify business-critical public-facing web sites
 - Test each site for common certificate and configuration issues, as well as the renegotiation vulnerability
 - Instrument change to fix discovered weaknesses
- Within 6 months, you should:
 - Publish a checklist for secure SSL web deployment
 - Initiate a HSTS adoption program





Questions?





Bonus slides

Sources of SSL/TLS and PKI Data

- **SSL Labs**  **QUALYS[®] SSL LABS**
 - Tested nearly all public SSL servers, checking certs, configuration and application-level flaws
 - Reports and raw data available
- **SSL Observatory**  **ELECTRONIC FRONTIER FOUNDATION**
 - Scanned entire IPv4 space looking for certificates
 - Reports and raw data available
- **Opera Security Group**
 - Weekly large-scale assessments
 - Findings on their blog

