



SSL and Browser Security: Why is it Such an Uphill Battle?

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Qualys, Inc.

Session ID: HTA-209

Session Classification: Advanced

RSACONFERENCE
EUROPE 2012

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
- 

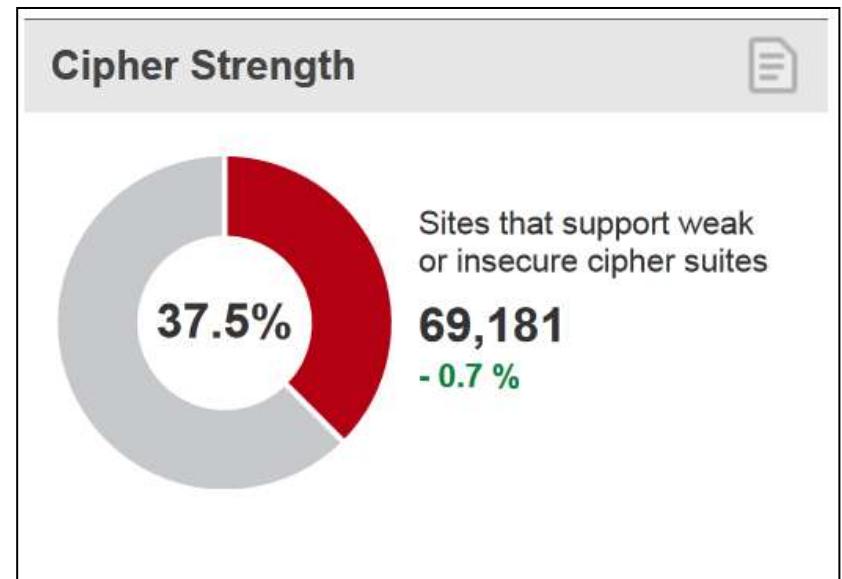


SSL/TLS Server Configuration Issues



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



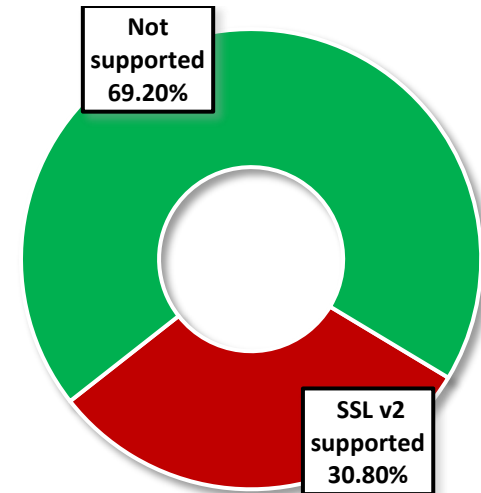
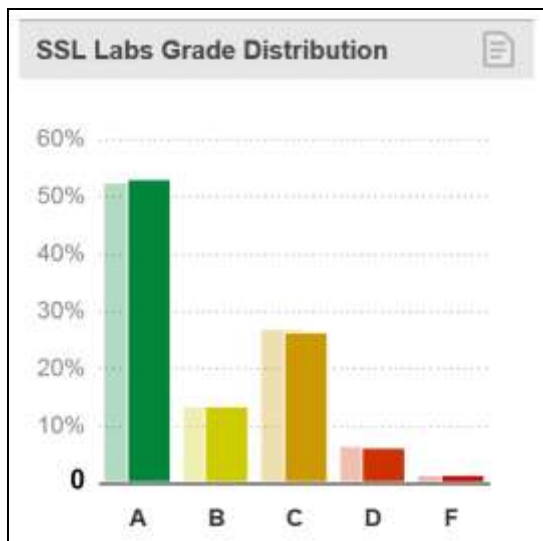
Cipher strength support
SSL Pulse, August 2012



SSLv2 Insecure, Yet Widely Supported

About one third of popular web sites still support the insecure SSL v2 protocol (*SSL Pulse, August 2012*)

- **SSL v2 can be easily broken**
- An active MITM can force some browsers to fall back to SSL v2, if supported in both client and server



Protocol	Support
SSL v2.0	56,839
SSL v3.0	184,040
TLS v1.0	183,305
TLS v1.1	5,387
TLS v1.2	8,349

Reasons

- Hard to configure ?



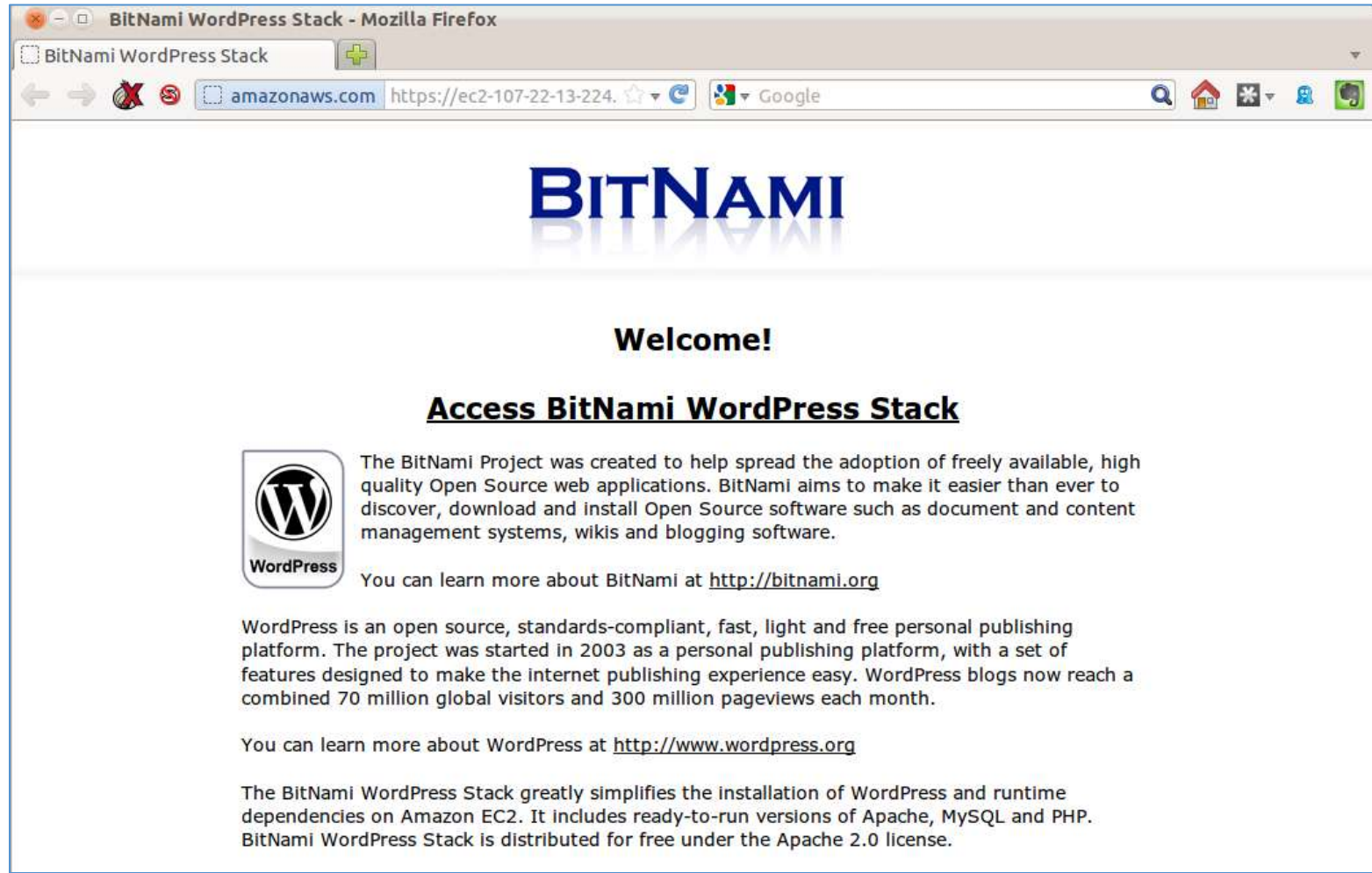
In the Wild...

The screenshot shows the AWS Management Console interface. The main content area displays a list of Amazon Machine Images (AMIs) filtered by the keyword '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.m	979382823631	Public	Active
empty	ami-04cd326d	979382823631/bitnami-wordpress-3.1.2-0-linux-ubuntu-10.04-ebs	979382823631	Public	Active
empty	ami-07b1626e	979382823631/bitnami-wordpress-3.3.1-1-multisite-linux-x64-ubuntu-10.	979382823631	Public	Active
empty	ami-07ca1d6e	264011160664/HFMHHRGA-ubuntu11_10/apache-bench/AWS_API_too	264011160664	Public	Active
empty	ami-0ce61065	979382823631/bitnami-wordpress-3.0.2-0-linux-ubuntu-10.04-ebs	979382823631	Public	Active
empty	ami-115b9078	turnkeylinux-us-east-1/turnkey-wordpress-11.3-lucid-x86.s3.manifest.xr	096457495696	Public	Active
empty	ami-11bc7478	979382823631/bitnami-wordpress-3.2.1-5-linux-ubuntu-10.04-ebs	979382823631	Public	Active
empty	ami-1216e07b	bitnami-cloud/wordpress/bitnami-wordpress-3.0.3-0-linux-ubuntu-10.04.r	979382823631	Public	Active
empty	ami-127d8c7b	bitnami-cloud/wordpress/bitnami-wordpress-3.0.4-0-linux-ubuntu-10.04.r	979382823631	Public	Active
empty	ami-17f6217e	264011160664/zMkGTGBH-ubuntu11_10/apache-bench/AWS_API_too	264011160664	Public	Active
empty	ami-1a4ead73	bitnami-cloud/wordpress/bitnami-wordpress-2.8.5-1-linux.manifest.xml	979382823631	Public	Active

0 EC2 Amazon Machine Images selected
Select an image above

In the Wild...



BitNami WordPress Stack - Mozilla Firefox


BitNami WordPress Stack

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

BITNAMI

Welcome!

Access BitNami WordPress Stack

 The BitNami Project was created to help spread the adoption of freely available, high quality Open Source web applications. BitNami aims to make it easier than ever to discover, download and install Open Source software such as document and content management systems, wikis and blogging software.

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>

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.



In the Wild...

BitNami WordPress Stack - Mozilla Firefox

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

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In the Wild...

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

Qualys SSL Labs - Projects / SS... [ssllabs.com](https://www.ssllabs.com) <https://www.ssllabs.com> Google

QUALYS[®] SSL LABS Home Qualys.com Projects Cont...

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

Category	Score
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... <https://www.ssllabs.com> Google

Protocols

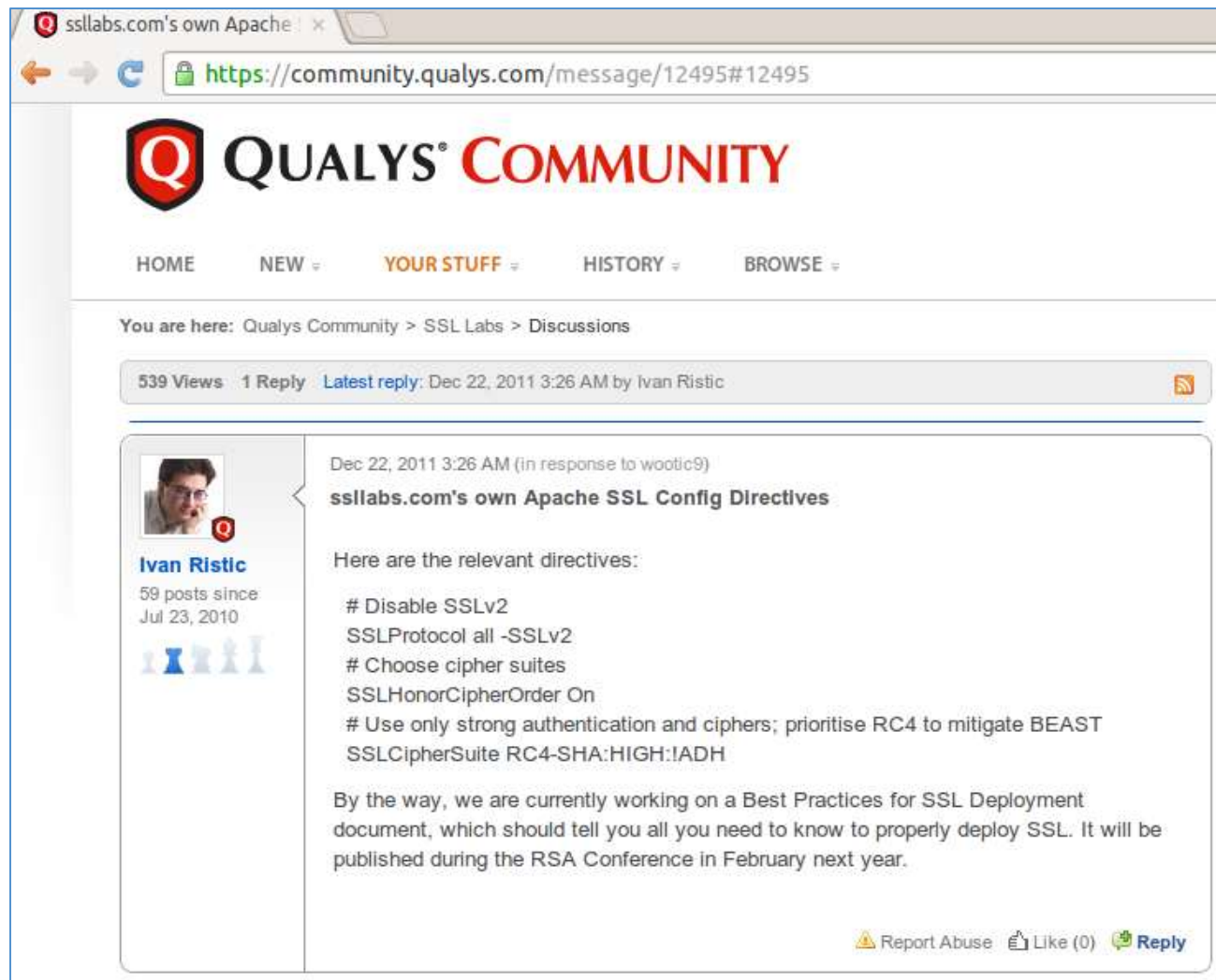
TLS 1.2	No
TLS 1.1	No
TLS 1.0	Yes
SSL 3.0	Yes
SSL 2.0+ upgrade support	Yes
SSL 2.0 INSECURE	Yes

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 Community logo and navigation links: HOME, NEW, YOUR STUFF, HISTORY, and BROWSE. Below the header, a breadcrumb trail reads "You are here: Qualys Community > SSL Labs > Discussions". A summary bar indicates "539 Views", "1 Reply", and "Latest reply: Dec 22, 2011 3:26 AM by Ivan Ristic".

The main content area shows a post by Ivan Ristic, dated Dec 22, 2011 3:26 AM, in response to a user named wootic9. The post title is "ssllabs.com's own Apache SSL Config Directives". The post text reads:

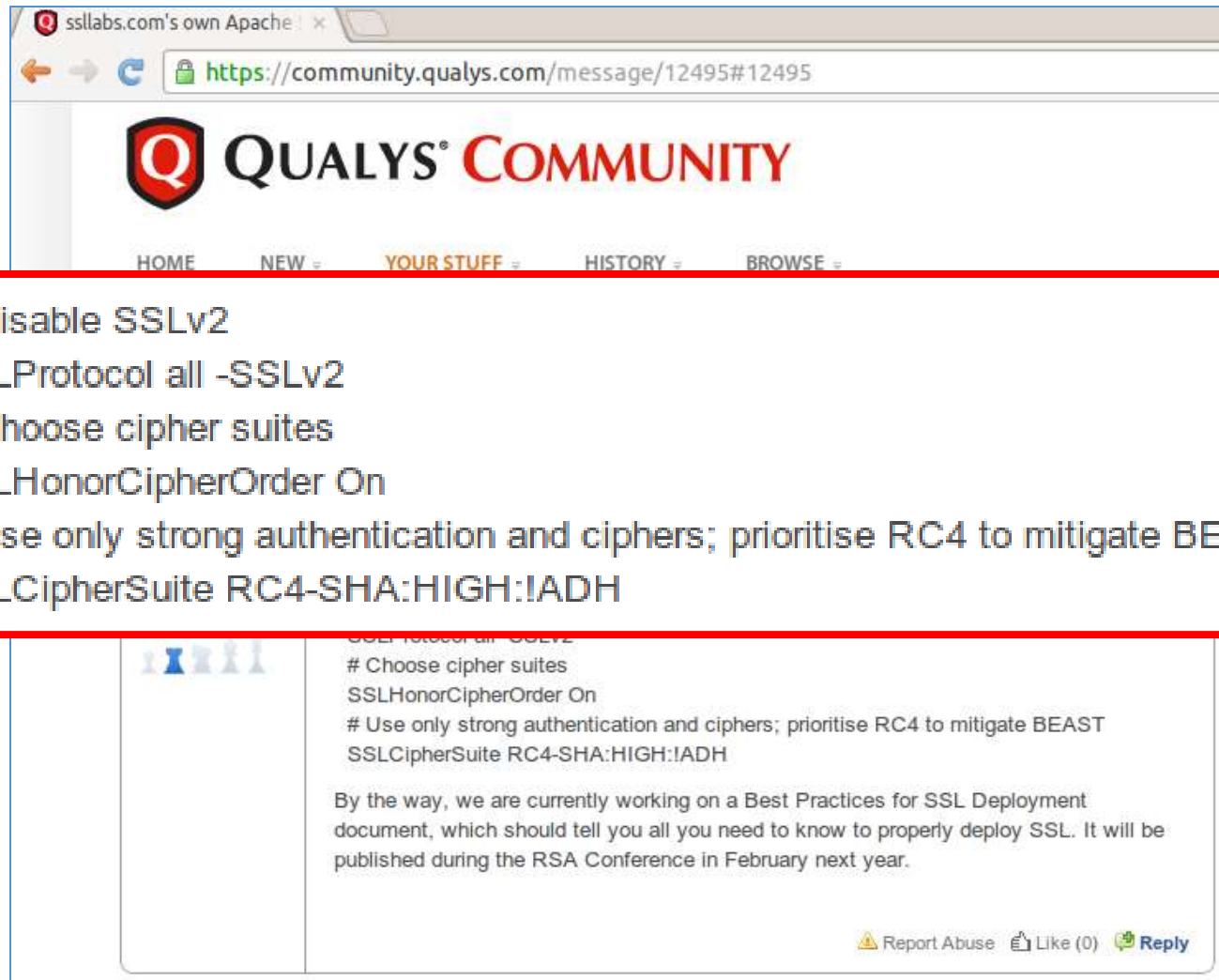
Here are the relevant directives:

- # 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.

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".

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 are navigation links: HOME, NEW, YOUR STUFF, HISTORY, and BROWSE. A red rectangular box highlights a code block containing the following text:

```
# Disable SSLv2
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SSLCipherSuite RC4-SHA:HIGH:!ADH
```

Below the code block, the same text is repeated in a smaller font. At the bottom of the message, there are interaction options: "Report Abuse", "Like (0)", and "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

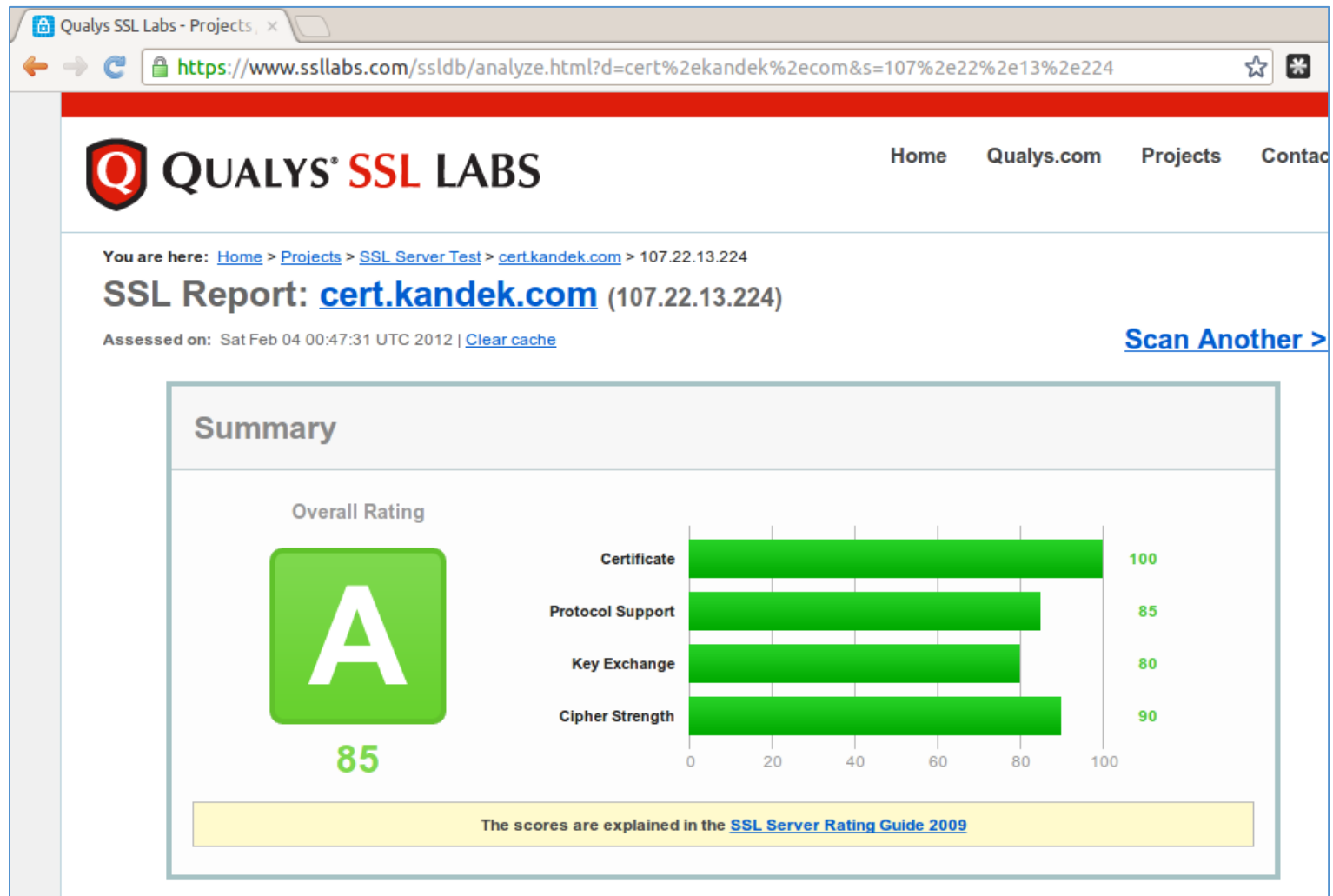
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# ciphers, etc.)
SSLCertificateFile "/opt/bitnami/apache2/conf/server.crt"
#SSLCertificateFile "/opt/bitnami/apache2/conf/server-dsa.crt"

97,0-1 39%
```

In the Wild... - the Fix



Qualys SSL Labs - Projects

https://www.ssllabs.com/ssldb/analyze.html?d=cert%2ekandek%2ecom&s=107%2e22%2e13%2e224

QUALYS[®] SSL LABS Home Qualys.com Projects Contact

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: Sat Feb 04 00:47:31 UTC 2012 | [Clear cache](#) [Scan Another >](#)

Summary

Overall Rating

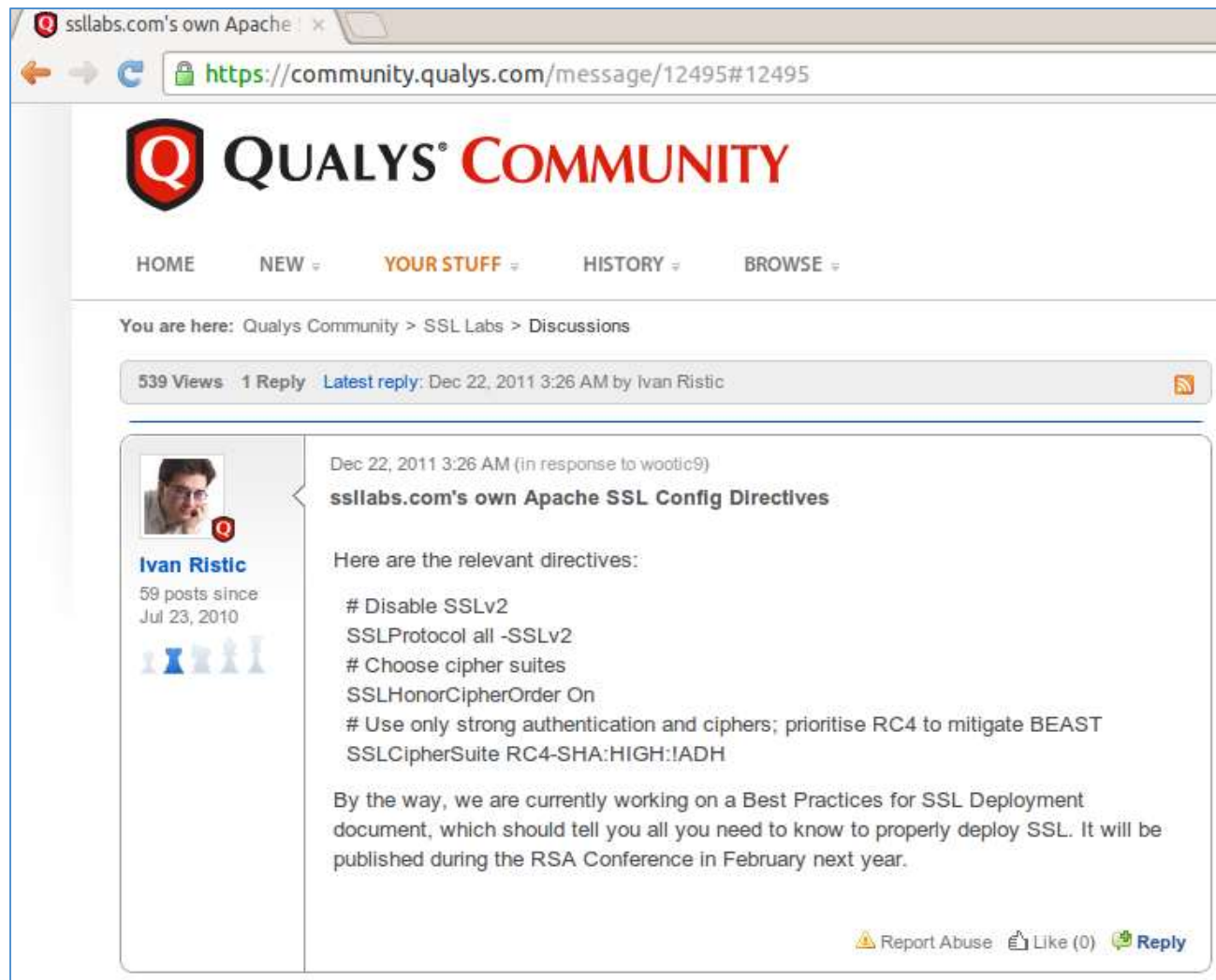
A

85

Category	Score
Certificate	100
Protocol Support	85
Key Exchange	80
Cipher Strength	90

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

In the Wild... - the Fix



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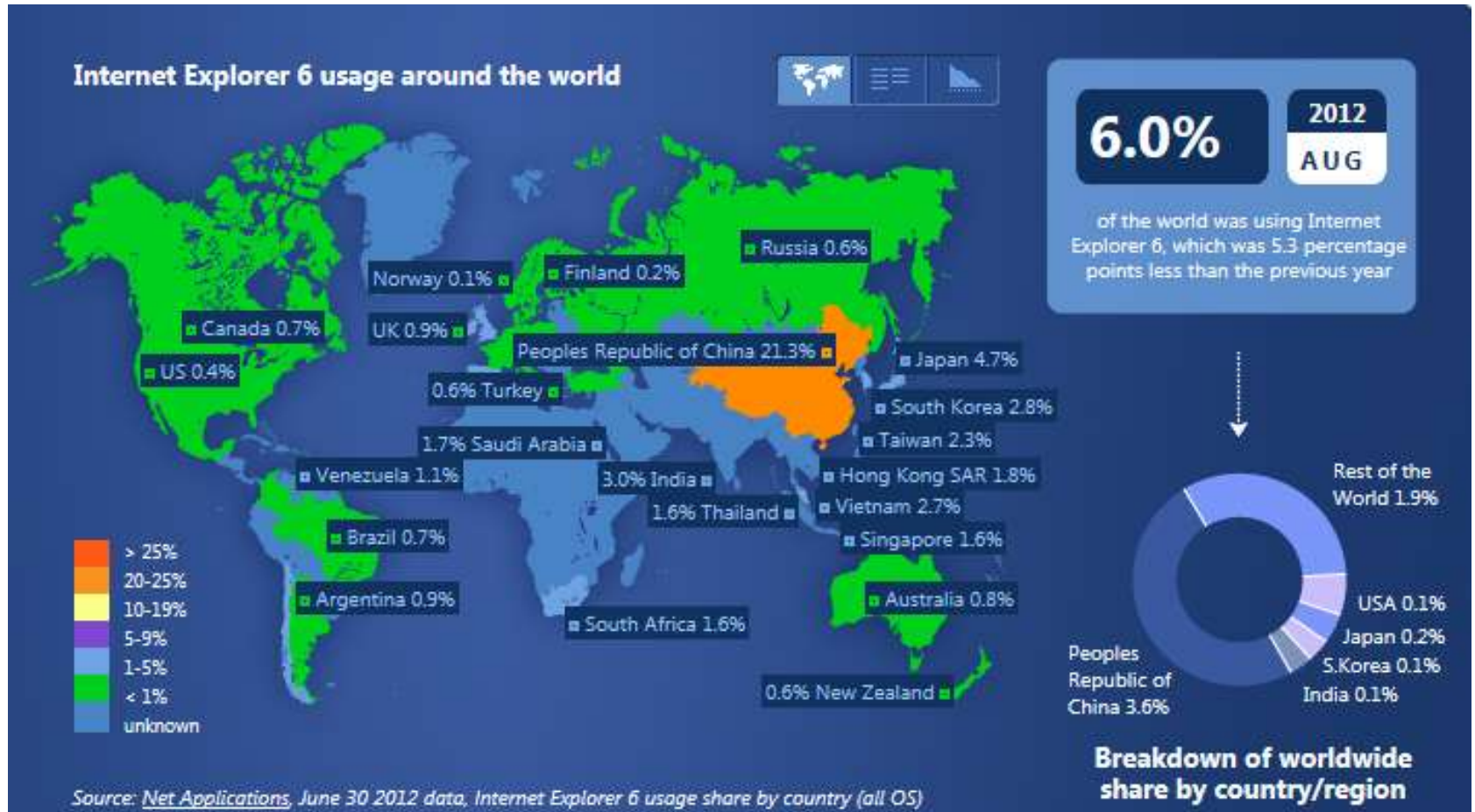
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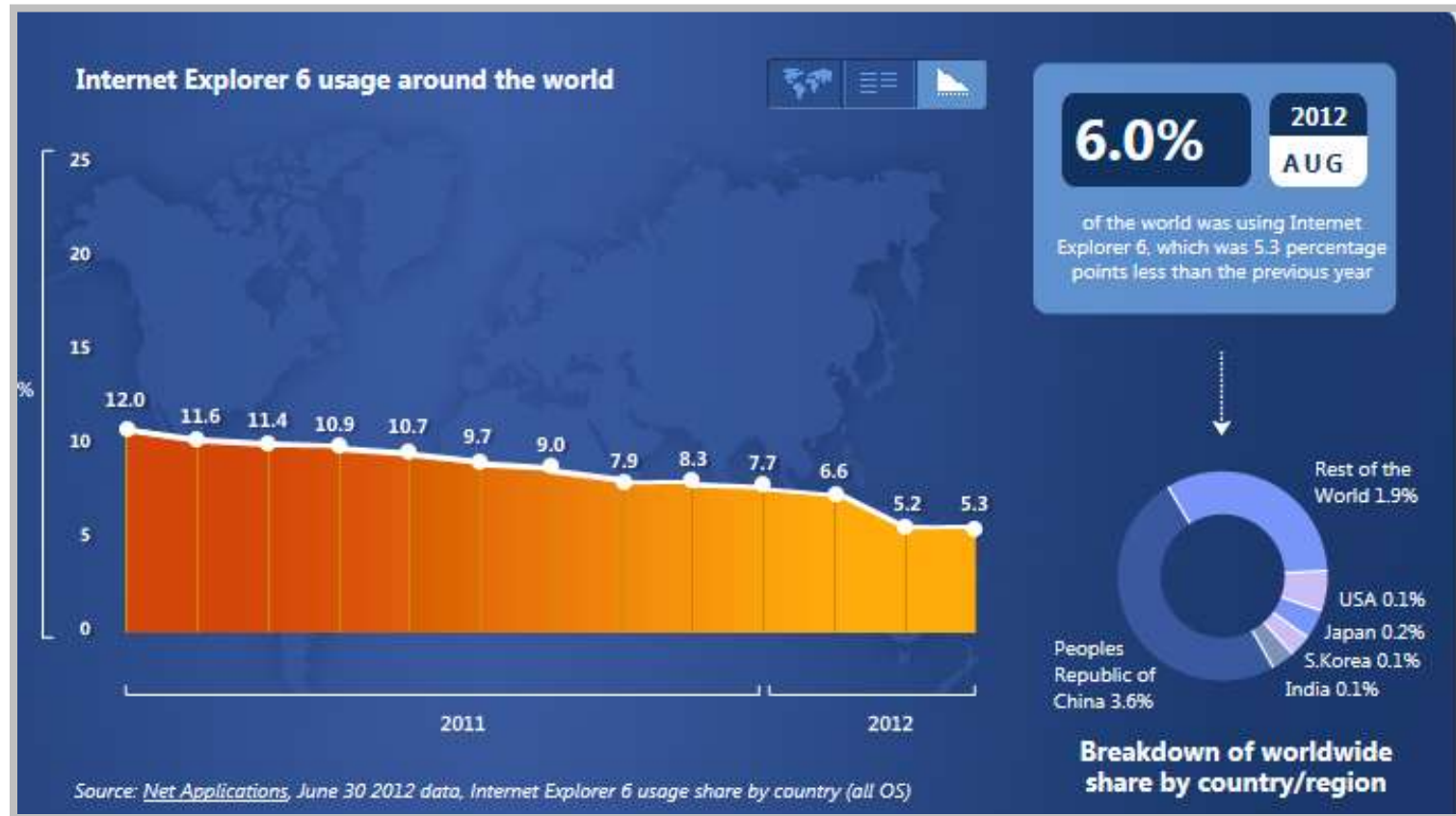
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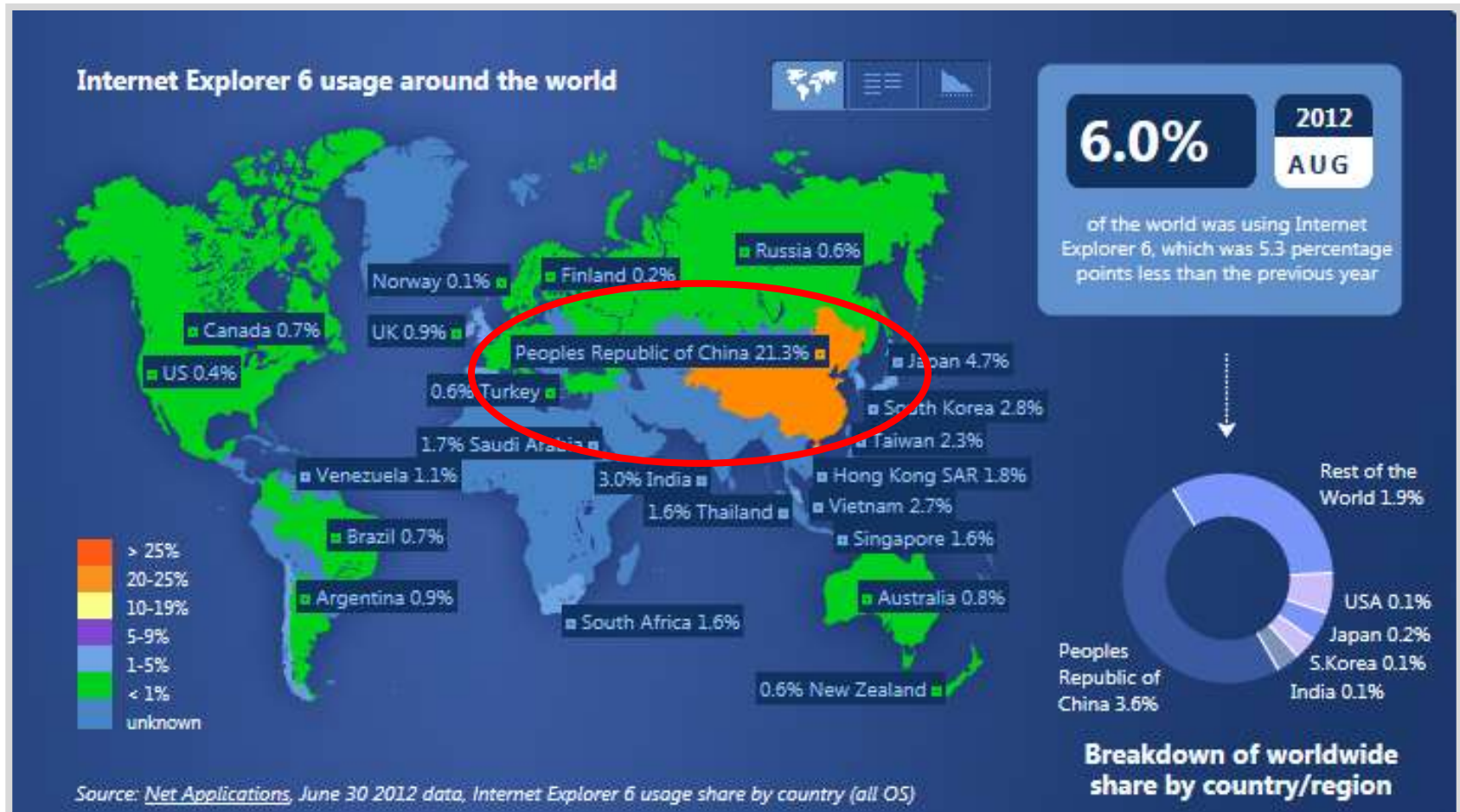
Is Internet Explorer 6 a Problem? No?



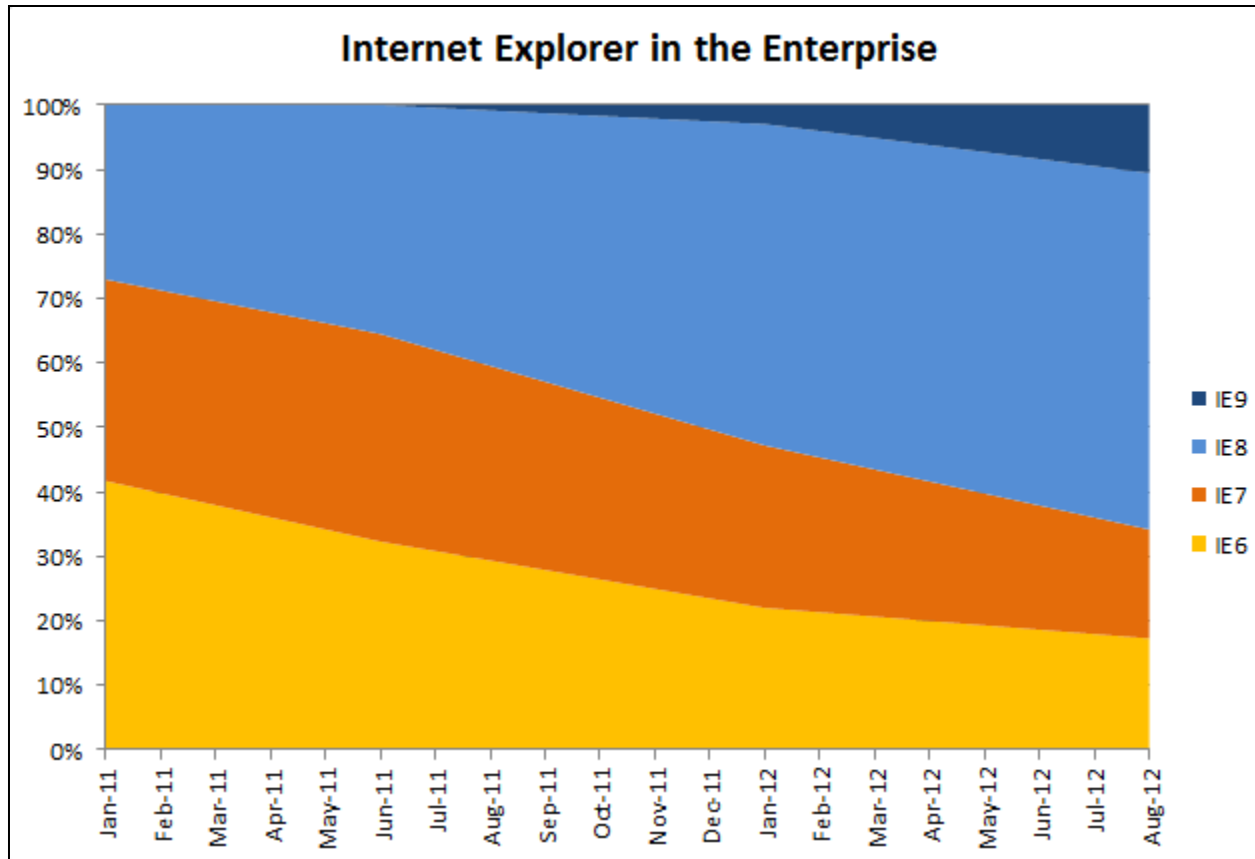
Is Internet Explorer 6 a Problem? No?



Is Internet Explorer 6 a Problem? No?



Actually, yes. IE6 Still In 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/  
2706  
[01/Feb/2012:23:32:44 +0000] 173.203.79.216 TLSv1 EXP-RC4-MD5 "GET / HTTP/  
706  
[01/Feb/2012:23:32:44 +0000] 173.203.79.216 TLSv1 EXP-DES-CBC-SHA "GET / H  
0" 2706  
[01/Feb/2012:23:32:44 +0000] 173.203.79.216 TLSv1 DES-CBC-SHA "GET / HTTP/  
706  
[01/Feb/2012:23:32:44 +0000] 173.203.79.216 TLSv1 EXP-EDH-RSA-DES-CBC-SHA  
HTTP/1.0" 2706  
[01/Feb/2012:23:32:44 +0000] 173.203.79.216 TLSv1 EDH-RSA-DES-CBC-SHA "GET  
P/1.0" 2706  
[02/Feb/2012:01:24:17 +0000] 94.236.127.132 TLSv1 DHE-RSA-AES256-SHA "HEAD  
P/1.0" -  
[03/Feb/2012:12:57:52 +0000] 222.175.207.206 TLSv1 DHE-RSA-AES256-SHA "GET  
n/cdr/counter.txt 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

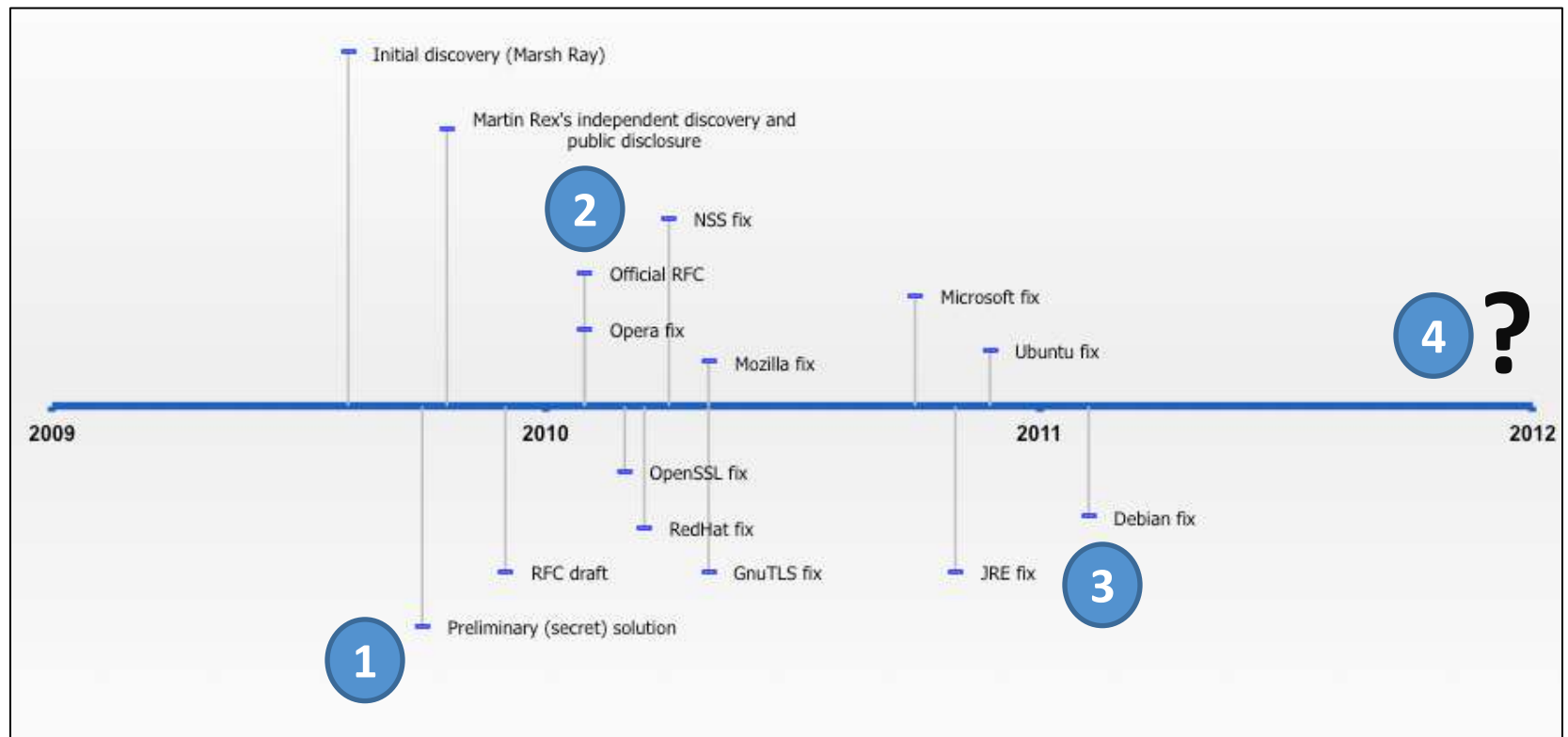


Protocol Attacks



SSL/TLS Authentication Gap (2009)

- 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 (2011)

- Vulnerability in SSL 3.0 and TLS 1.0, exploited by Rizzo/Duong
- 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”)**
- Mitigated by enforcing RC4 ciphers server-side

The screenshot shows a security tool interface with a sidebar on the left containing a 'Miscellaneous' section with links for 'Test date', 'Test duration', 'Server signature', and 'Server hostname'. The main content area is titled 'Cipher Suites (SSLv3+ suites in server-preferred order, then SSLv2 suites where used)' and 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 RC4-based suites are highlighted with a green box. Below this list, a table shows the status of various attacks: 'BEAST attack' is 'Vulnerable INSECURE (more info)', 'Insecure Renegotiation' is 'Supported INSECURE (more info)', and 'Strict Transport Security' is 'No'.

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



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



CRIME Attack Against Compression (2012)

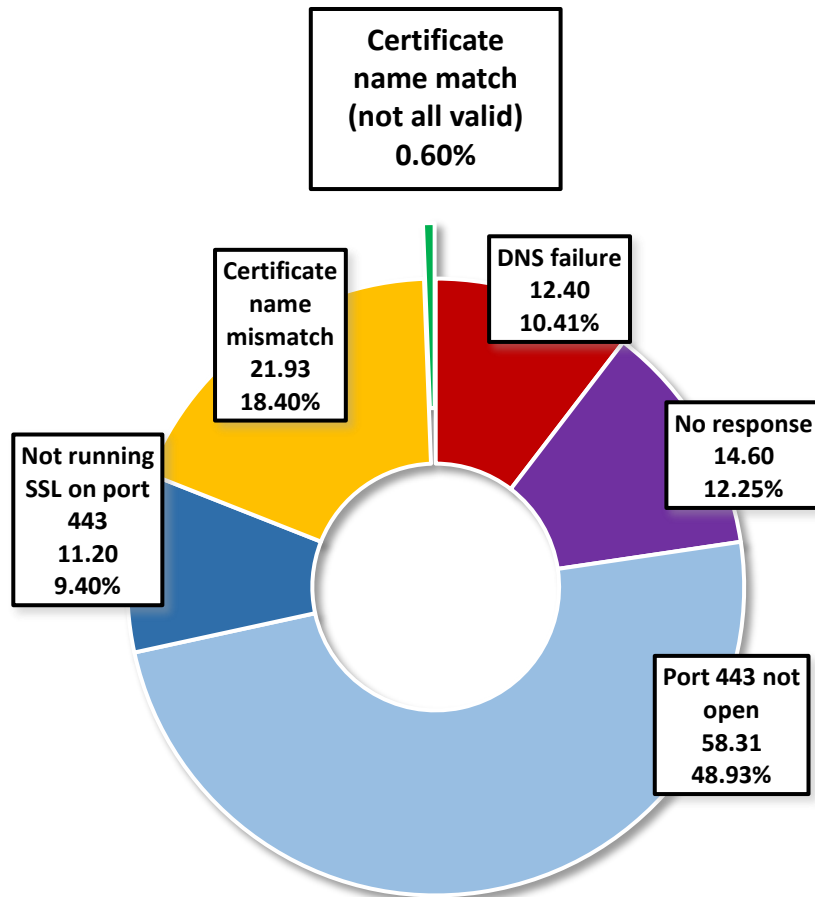
- Information leakage stemming from *compression before encryption*, exploited by Rizzo/Duong
- Decrypts small parts of traffic (e.g., cookies, credentials)
- **Affects TLS compression and SPDY header compression**
- Impact:
 - TLS compression support at 40% (SSL Pulse, October 2012)
 - SPDY support at 2% (SSL Pulse, October 2012)
 - However, TLS compression not widely used before the discovery (Chrome only); now disabled
 - SPDY header compression was also disabled in Chrome and Firefox
 - **All vulnerable browsers use auto-updates**



SSL/TLS Application Issues



Very Few Sites Actually Use SSL



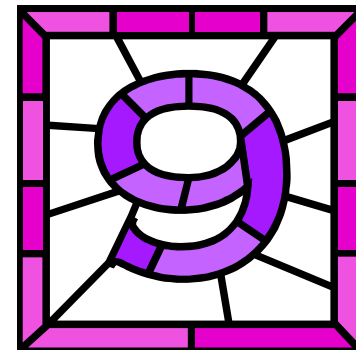
- The pie chart on the left represents a scan of about 120 million domain name registrations (*SSL Labs 2010 Survey*)
- SSL is not very common, across all registrations
- Today, we are at **0.4%** across registered domains and **1%** across active sites
- However, about **10%** of the Alexa's Top 1M sites support SSL (*SSL Pulse, 2012*)



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 (*SSL Labs Survey, 2011*)



Firesheep: Account Hijacking Made Easy

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

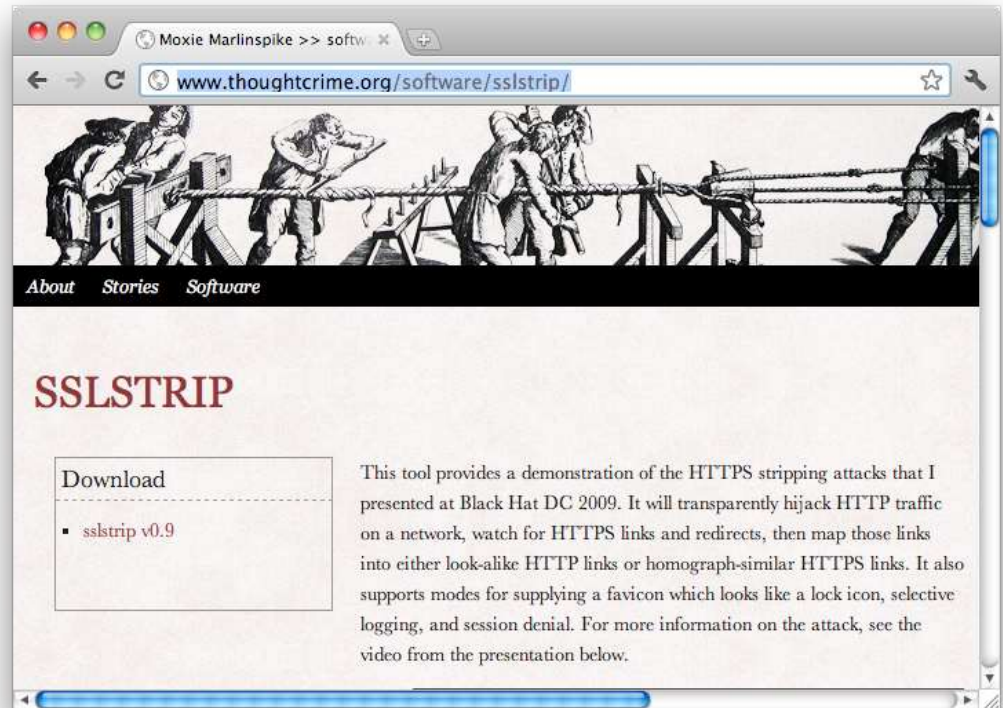


Screen captures retrieved from Firesheep's web site:
<http://codebutler.com/firesheep>

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

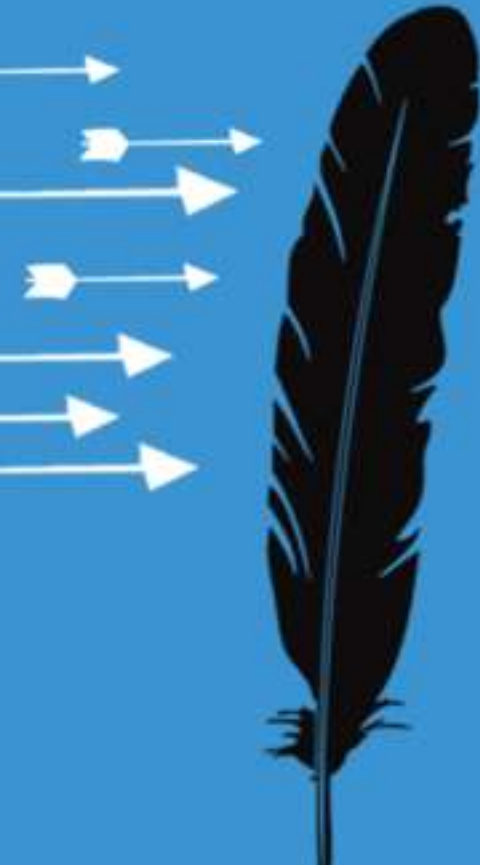


Lessons Learned

- 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




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) **COMODO**
 - 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  chrome
 - 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

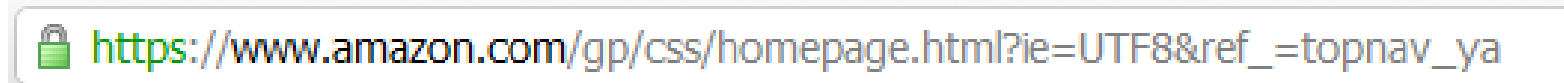
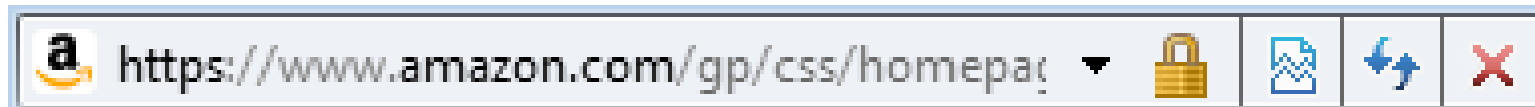
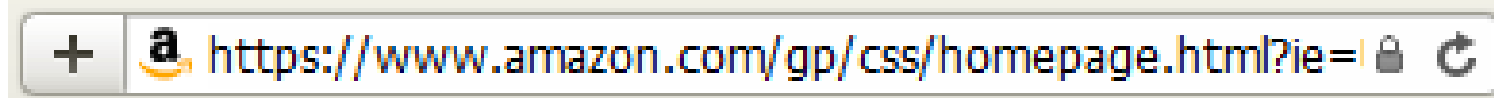
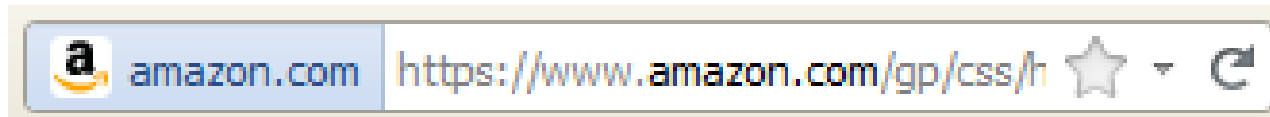


Browser Problems



SSL Indicators

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

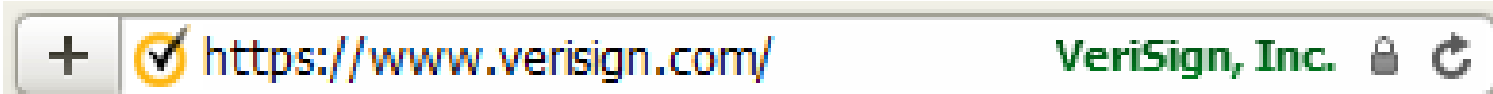
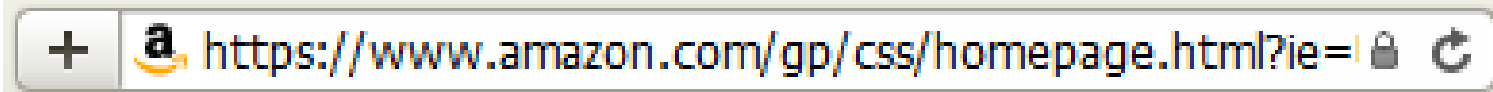


Extended Validation Certificate Indicators

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



- Others, not so much



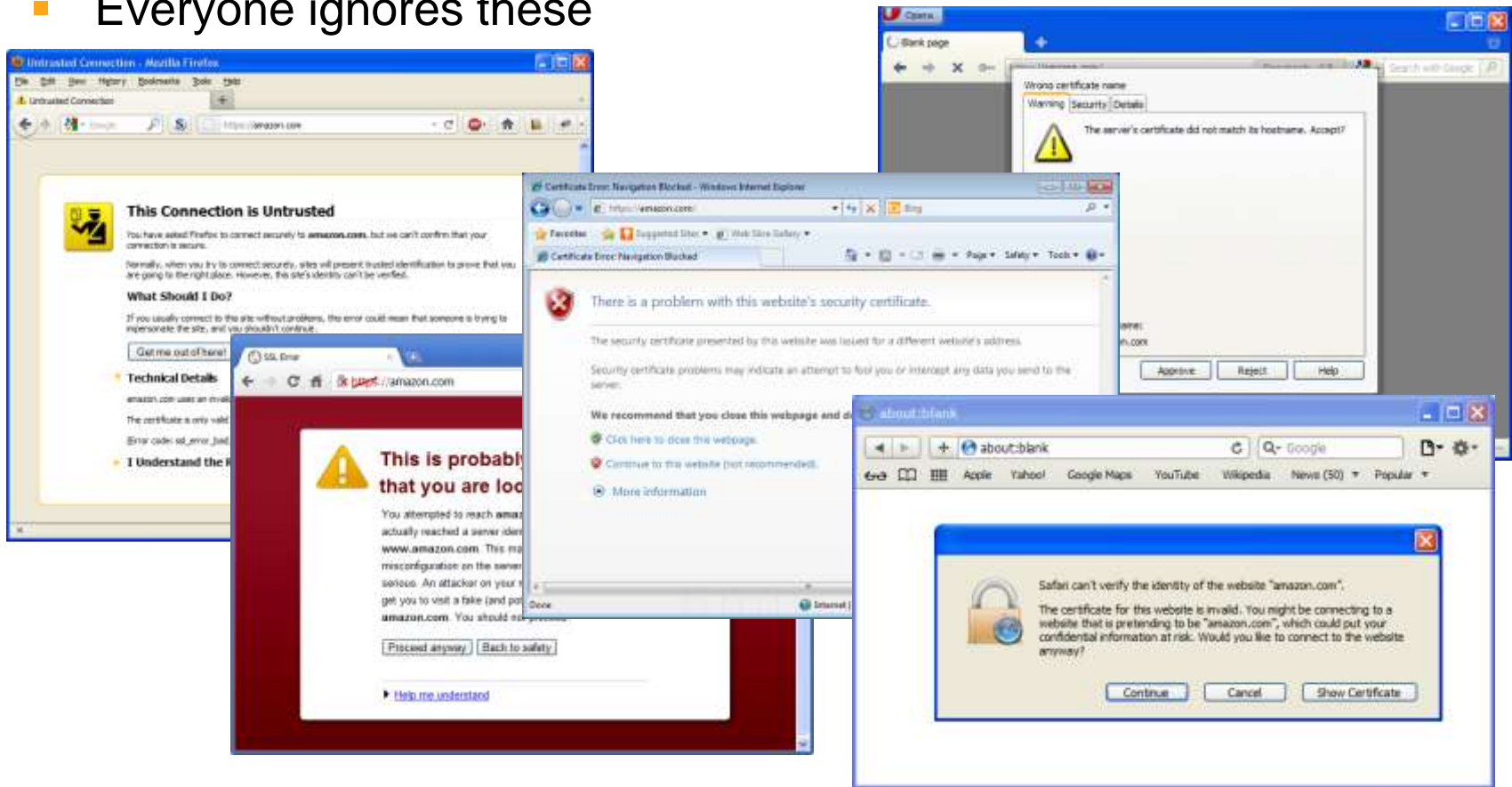
- No one cares, anyway



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 the renegotiation, BEAST, and CRIME vulnerabilities
 - 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

- TIM SSL Pulse 
 - Monthly scan of SSL servers among Alexa's Top 1m sites
- SSL Labs 
 - Tested nearly all public SSL servers, checking certs, configuration and application-level flaws
 - Reports and raw data available
- SSL Observatory 
 - Scanned entire IPv4 space looking for certificates
 - Reports and raw data available
- Opera Security Group 
 - Weekly large-scale assessments
 - Findings on their blog

