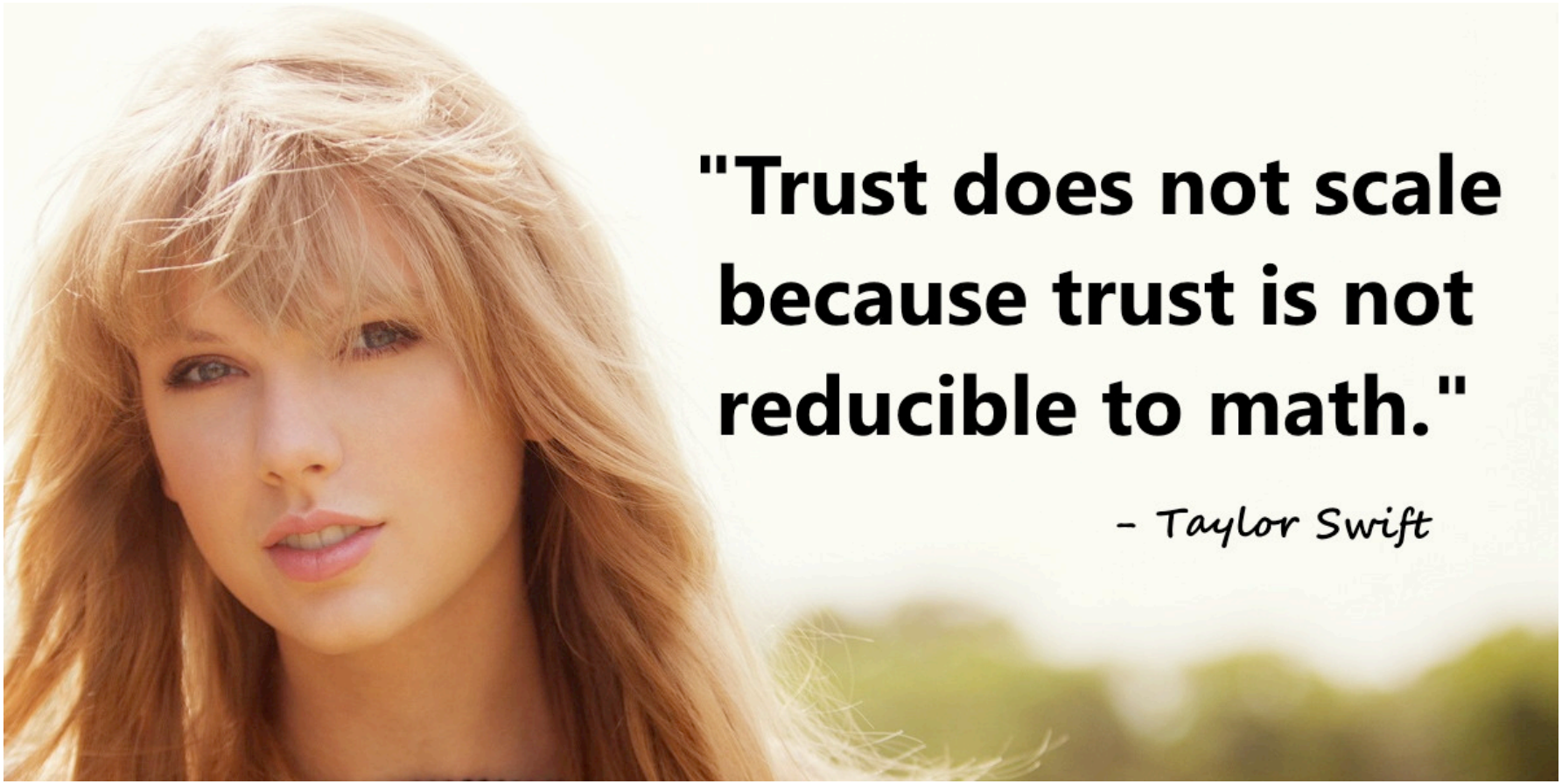
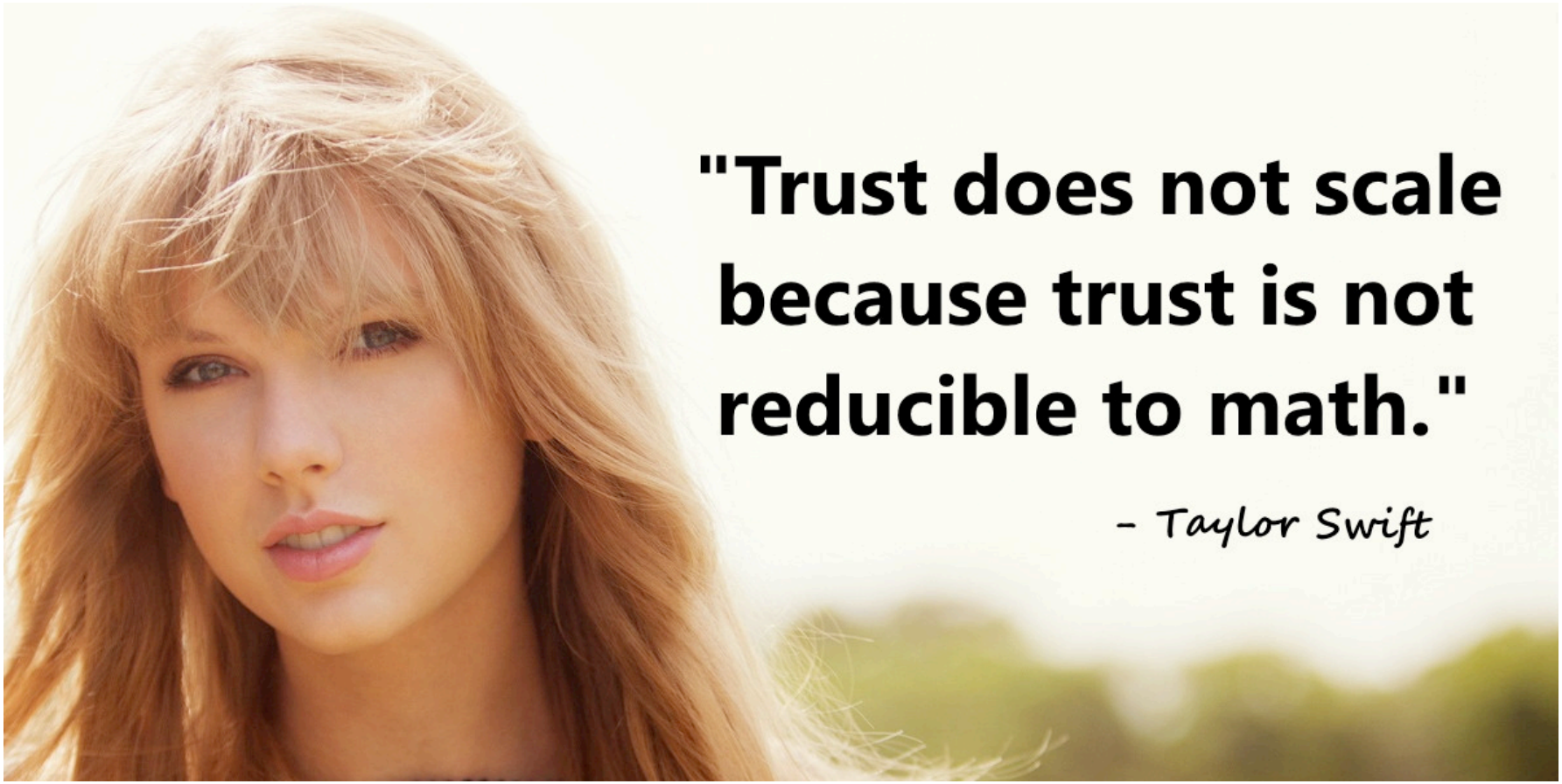
Network #4: Transport Layer Security (Most Slides stolen from Dave Wagner)

Theme of This Lecture



But Trust Can Be Delegated…



Today's Lecture

- Applying crypto technology in practice
- Two simple abstractions cover 80% of the use cases for crypto:
  - "Sealed blob": Data that is encrypted and authenticated under a particular key
  - Secure channel: Communication channel that can't be eavesdropped on or tampered with
- Today: TLS – a secure channel
  - In network parlance, this is an "application layer" protocol but…
  - designed to have any application over it, so really "layer 6.5" is a better description

Building Secure End-to-End Channels

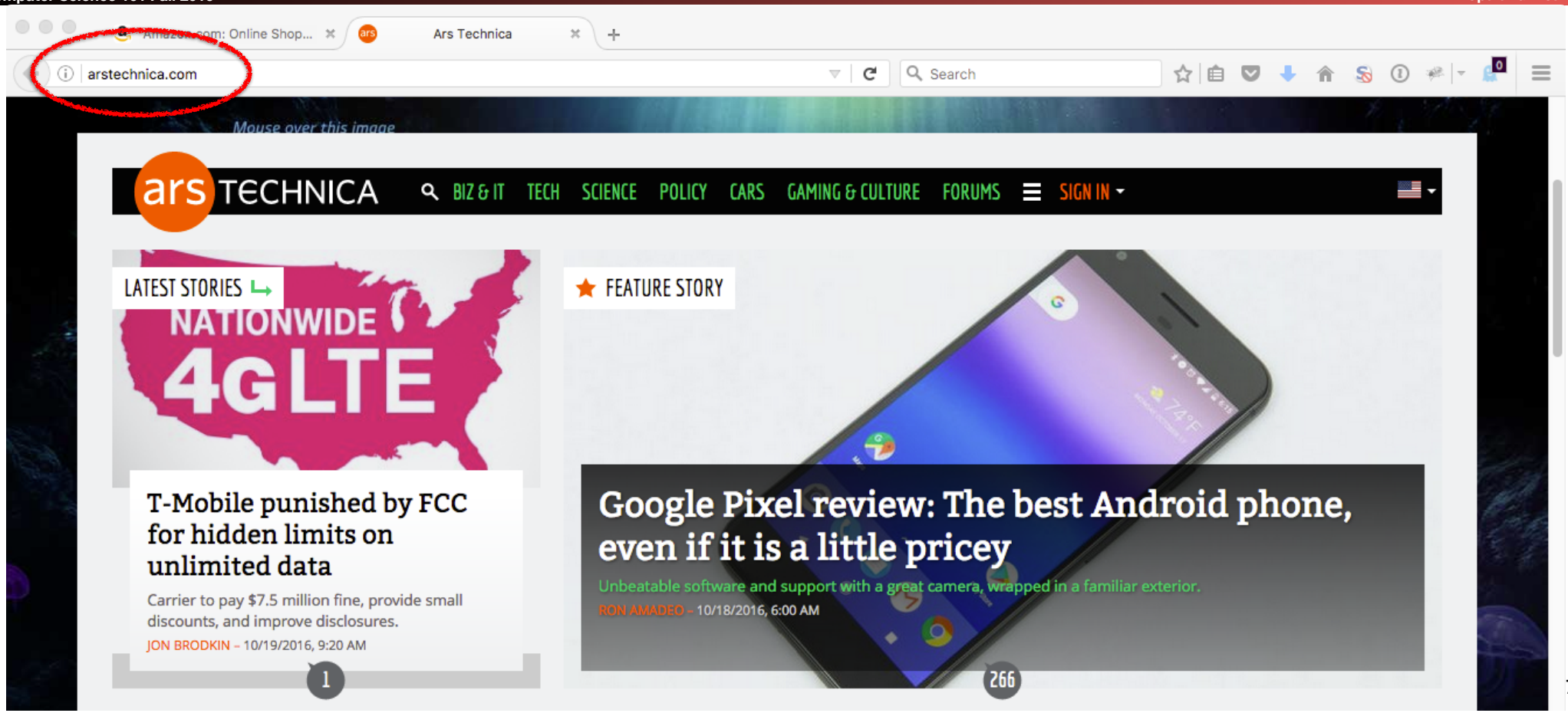
- End-to-end = communication protections achieved all the way from originating client to intended server
  - With no need to trust intermediaries
- Dealing with threats:
  - Eavesdropping?
    - Encryption (including session keys)
  - Manipulation (injection, MITM)?
    - Integrity (use of a MAC); replay protection
  - Impersonation?
    - Signatures

(What's missing? *Availability …*)

Building A Secure End-to-End Channel: SSL/TLS

- SSL = Secure Sockets Layer (predecessor)
- TLS = Transport Layer Security (standard)
  - Both terms used interchangeably
- Security for any application that uses TCP
  - Secure = encryption/confidentiality + integrity + authentication (of server, but not of client)
- Multiple uses
  - Puts the ‘s’ in “https”
  - Secures mail sent between servers (STARTTLS)
  - Virtual Private Networks

An “Insecure” Web Page



A “Secure” Web Page

Lock Icon means:

“Your communication betw your computer and the site is encrypted and authenticated”

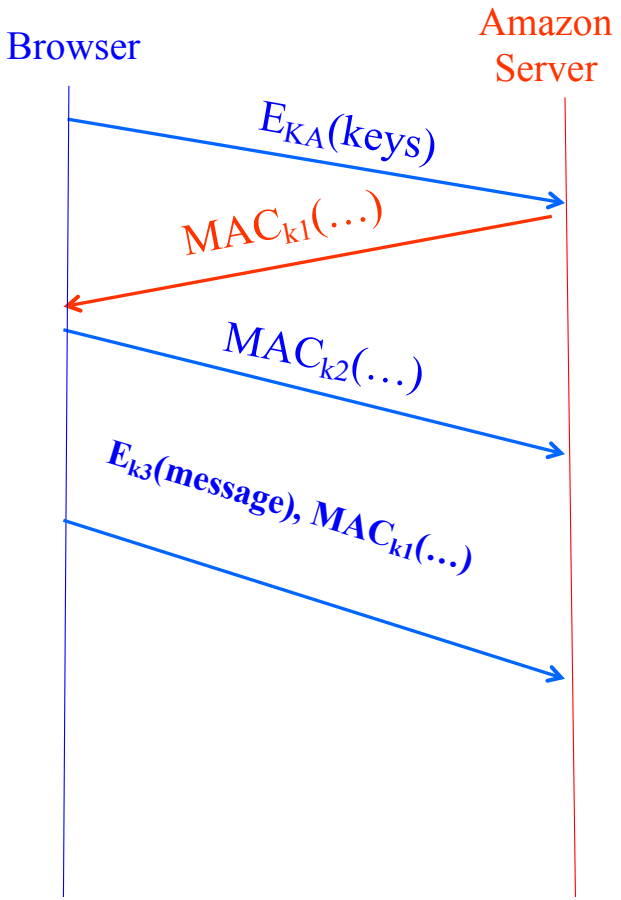
“Some other third party attests that this site belongs to Amazon”

“These properties hold not just for the main page, but any image or script is also fetched from a site with attestation and encryption”

People *think* lock icon means “Hey, I can trust this site” (no matter where the lock icon itself actually appears).

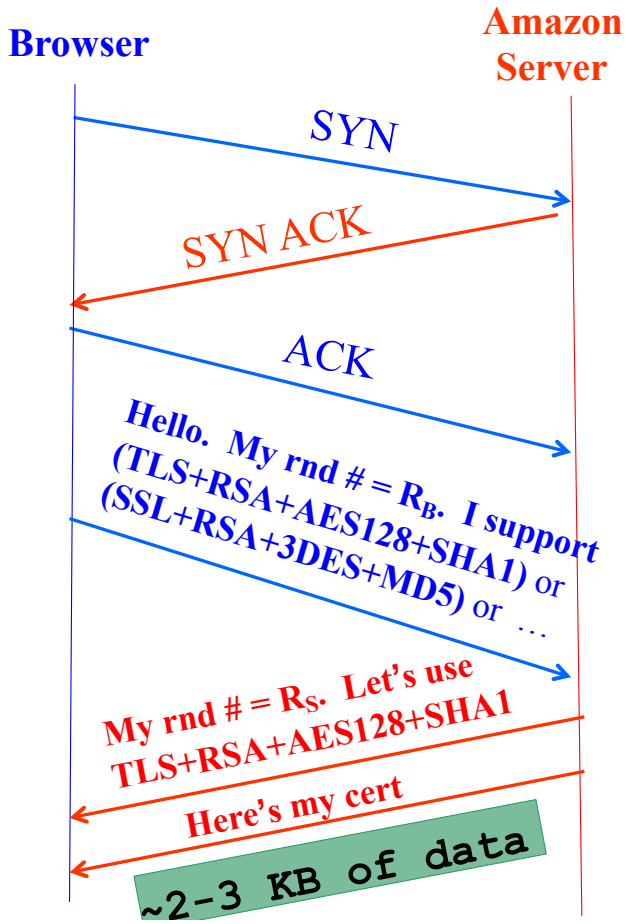
Basic idea

- Browser (client) picks some symmetric keys for encryption + authentication
- Client sends them to server, encrypted using RSA public-key encryption
- Both sides send MACs
- Now they use these keys to encrypt and authenticate all subsequent messages, using symmetric-key crypto



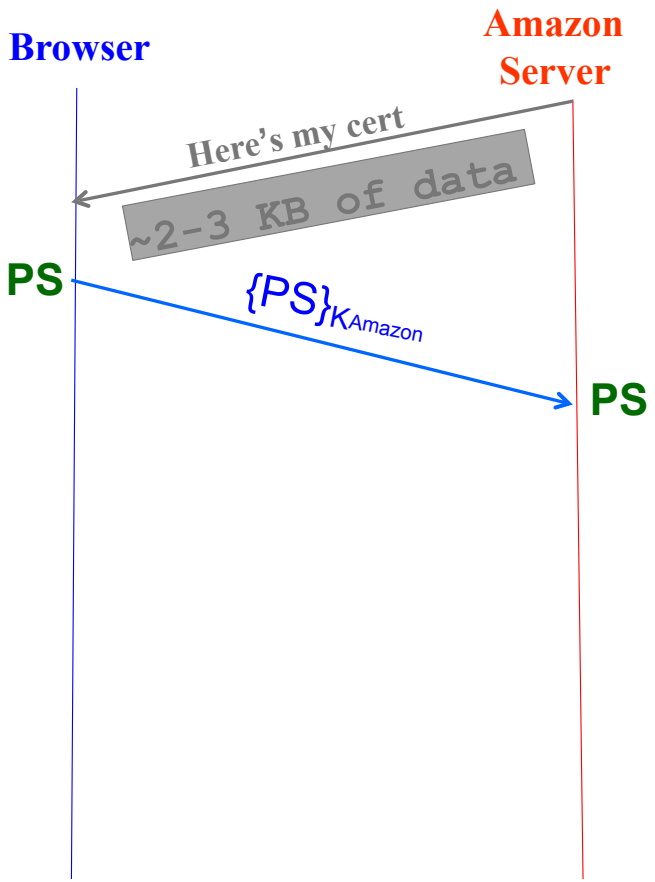
HTTPS Connection (SSL / TLS)

- Browser (client) connects via TCP to Amazon's HTTPS server
- Client picks 256-bit random number R_B, sends over list of crypto protocols it supports
- Server picks 256-bit random number R_S, selects protocols to use for this session
- Server sends over its certificate
  - (all of this is in the clear)
- Client now ***validates*** cert



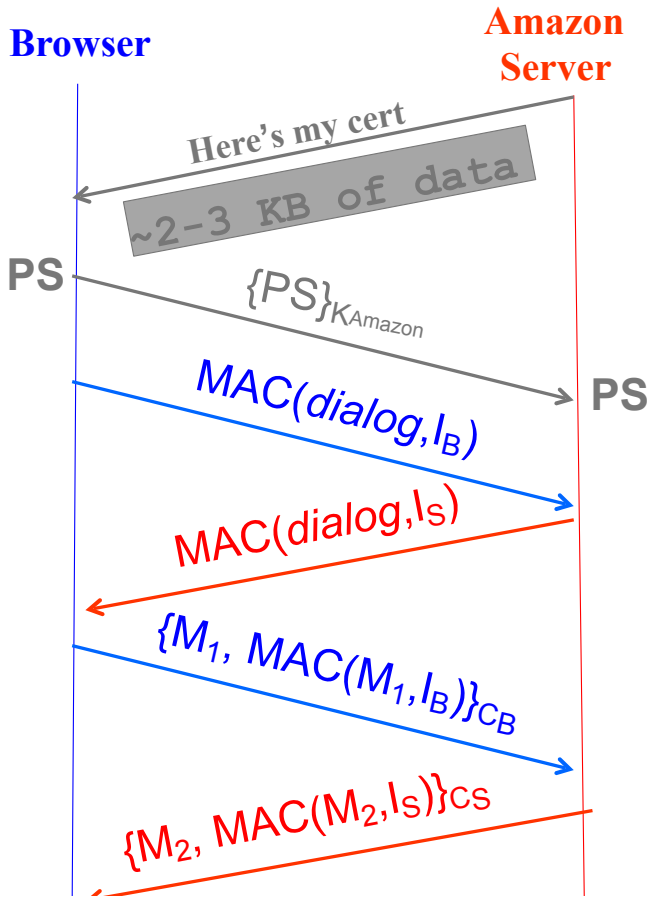
HTTPS Connection (SSL / TLS), cont.

- For RSA, browser constructs "Premaster Secret" PS
- Browser sends PS encrypted using Amazon's public RSA key K_{Amazon}
- Using PS, R_B, and R_S, browser & server derive symettric cipher keys (C_B, C_S) & MAC integrity keys (I_B, I_S)
  - One pair to use in each direction
  - Done by seeding a pRNG in common between the browser and the server:
    Repeated calls to the pRNG then create the common keys



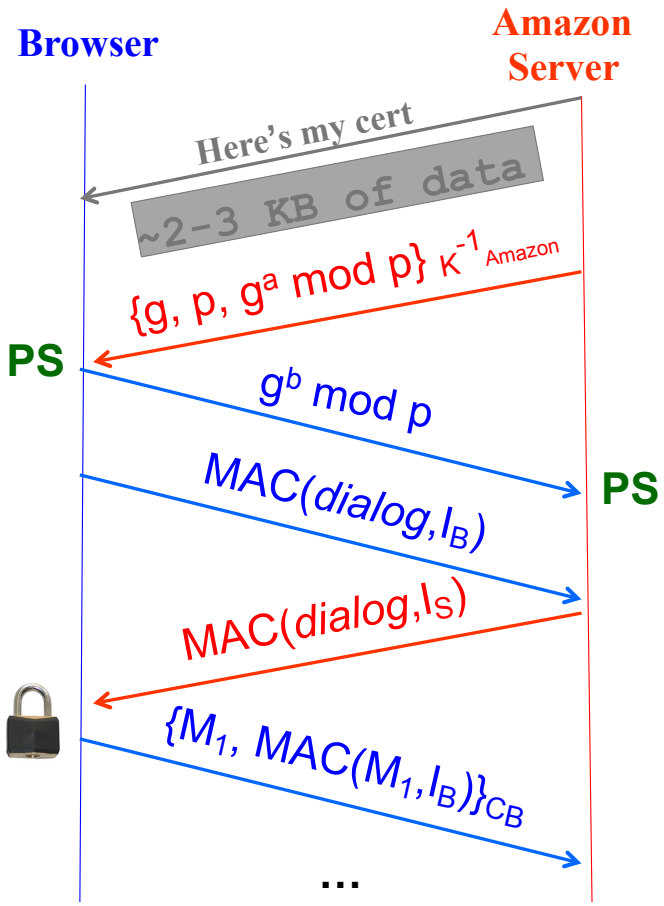
HTTPS Connection (SSL / TLS), cont.

- For RSA, browser constructs "Premaster Secret" PS
- Browser sends PS encrypted using Amazon's public RSA key KAmazon
- Using PS, R_B, and R_S, browser & server derive symm. cipher keys (C_B, C_S) & MAC integrity keys (I_B, I_S)
  - One pair to use in each direction
- Browser & server exchange MACs computed over entire dialog so far
- If good MAC, Browser displays 
- All subsequent communication encrypted w/ symmetric cipher (e.g., AES128) cipher keys, MACs
  - Sequence #'s thwart replay attacks



Alternative: Key Exchange via Diffie-Hellman

- For Diffie-Hellman, server generates random a, sends public parameters and g^a mod p
  - Signed with server's private key
- Browser verifies signature
- Browser generates random b, computes PS = g^{ab} mod p, sends g^b mod p to server
- Server also computes PS = g^{ab} mod p
- Remainder is as before: from PS, R_B, and R_S, browser & server derive symm. cipher keys (C_B, C_S) and MAC integrity keys (I_B, I_S), etc…

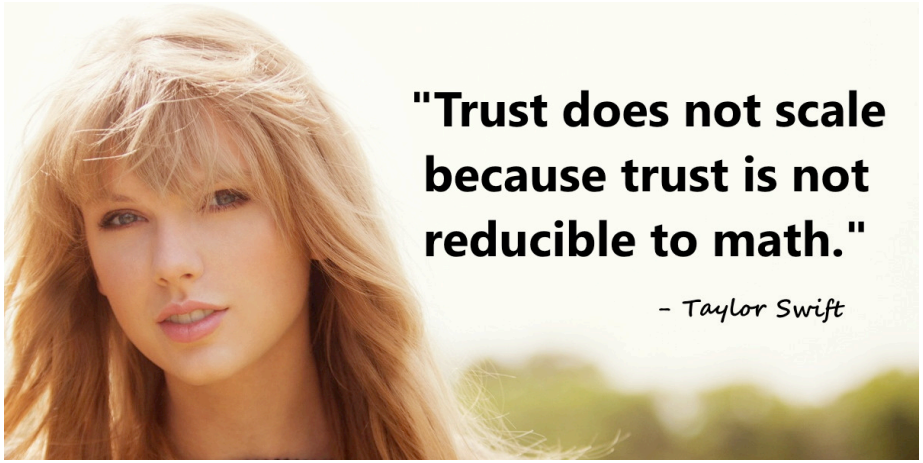


Big Changes for TLS 1.3
Diffie/Hellman and ECDHE only

- The RSA key exchange has a substantial vulnerability
  - If the attacker is ever able to compromise the server and obtain its RSA key… the attacker can decrypt any traffic captured
  - RSA lacks ***forward secrecy***
- So TLS 1.3 uses DHE/ECDHE only
- TLS 1.3 also speeds things up:
  - In the client hello, the client includes $\{g^b \bmod p\}$ for preferred parameters
    - If the server finds it suitable, the server returns $\{g^a \bmod p\}$
  - Saves a round-trip time

But What About that "Certificate Validation"

- Certificate validation is used to establish a chain of "trust"
  - It actually is an ***attempt*** to build a scalable trust framework
- This is commonly known as a Public Key Infrastructure (PKI)
  - Your browser is trusting the "Certificate Authority" to be responsible…



Certificates

- Cert = signed statement about someone's public key
  - Note that a cert does not say anything about the identity of who gives you the cert
  - It simply states a given public key K_{Bob} belongs to Bob …
    - … and backs up this statement with a digital signature made using a different public/private key pair, say from Verisign (a "Certificate Authority")
- Bob then can prove his identity to you by you sending him something encrypted with K_{Bob} …
  - … which he then demonstrates he can read
- … or by signing something he demonstrably uses
- Works provided you trust that you have a valid copy of Verisign's public key …
  - … and you trust Verisign to use prudence when she signs other people's keys

Validating Amazon's Identity

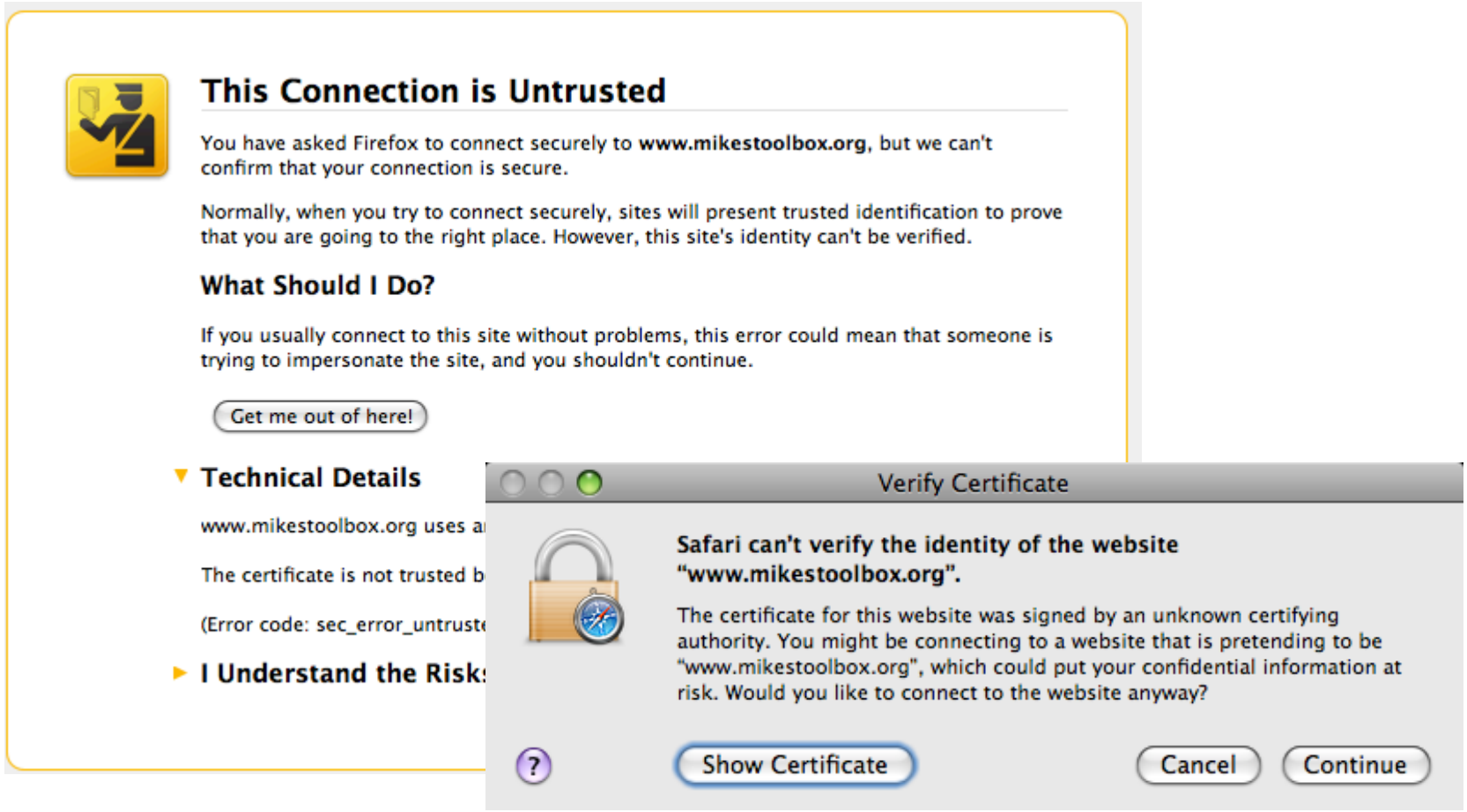
- Browser compares domain name in cert w/ URL
  - Note: this provides an ***end-to-end*** property
    (as opposed to say a cert associated with an IP address)
- Browser accesses separate cert belonging to issuer
  - These are hardwired into the browser – ***and trusted***!
  - There could be a chain of these …
- Browser applies issuer's public key to verify signature **S**, obtaining the hash of what the issuer signed
  - Compares with its own SHA-1 hash of Amazon's cert
- Assuming hashes match, now have high confidence it's indeed Amazon's public key …
  - assuming signatory is trustworthy, didn't lose private key, wasn't tricked into signing someone else's certificate, and that Amazon didn't lose their key either…

End-to-End ⇒ Powerful Protections

- Attacker runs a sniffer to capture our WiFi session?
  - But: encrypted communication is unreadable
    - No problem!
- DNS cache poisoning?
  - Client goes to wrong server
  - But: detects impersonation
    - No problem!
- Attacker hijacks our connection, injects new traffic
  - But: data receiver rejects it due to failed integrity check since all communication has a mac on it
    - No problem!
- Only thing a ***full man-in-the-middle*** attacker can do is inject RSTs, inject invalid packets, or drop packets: limited to a ***denial of service***

Validating Amazon's Identity, cont.

- Browser retrieves cert belonging to the issuer
  - These are hardwired into the browser – and trusted!
- But what if the browser can't find a cert for the issuer?


This Connection is Untrusted
You have asked Firefox to connect securely to www.mikestoolbox.org, but we can't confirm that your connection is secure.
Normally, when you try to connect securely, sites will present trusted identification to prove that you are going to the right place. However, this site's identity can't be verified.
What Should I Do?
If you usually connect to this site without problems, this error could mean that someone is trying to impersonate the site, and you shouldn't continue.
Get me out of here!
Technical Details
www.mikestoolbox.org uses a
The certificate is not trusted b
(Error code: sec_error_untruste
I Understand the Risk
Verify Certificate
Safari can't verify the identity of the website "www.mikestoolbox.org".
The certificate for this website was signed by an unknown certifying authority. You might be connecting to a website that is pretending to be "www.mikestoolbox.org", which could put your confidential information at risk. Would you like to connect to the website anyway?
Show Certificate
Cancel
Continue

Validating Amazon's Identity, cont.

- Browser retrieves cert belonging to the issuer
  - These are hardwired into the browser – and trusted!
- What if browser can't find a cert for the issuer?
- If it can't find the cert, then warns the user that site has not been verified
  - Can still proceed, just without authentication
- Q: Which end-to-end security properties do we lose if we incorrectly trust that the site is whom we think?
- A: All of them!
  - Goodbye confidentiality, integrity, authentication
  - Active attacker can read everything, modify, impersonate

SSL / TLS Limitations

- Properly used, SSL / TLS provides powerful end-to-end protections
- So why not use it for everything??
- Issues:
  - Cost of public-key crypto (fairly minor)
    - Takes non-trivial CPU processing (but today a minor issue)
    - Note: symmetric key crypto on modern hardware is effectively free
  - Hassle of buying/maintaining certs (fairly minor)
  - Integrating with other sites that don't use HTTPS
    - Namely, you can't: Non-HTTPS content won't load!
  - Latency: extra round trips ⇒ 1st page slower to load

SSL / TLS Limitations, cont.

- Problems that SSL / TLS does not take care of ?
- Censorship:
  - The censor sees the certificate in the clear, so knows who the client is talking to
  - Optional Server Name Identification (SNI) is also sent in the clear
  - The censor can then inject RSTs or block the communication
- SQL injection / XSS / server-side coding/logic flaws
- Vulnerabilities introduced by server inconsistencies

SSL/TLS Problem: Revocation

- A site screws up and an attacker steals the private key associated with a certificate, what now?
  - Certificates have a timestamp and are only good for a specified time
    - But this time is measured in years!?!?
- Two mitigations:
  - Certificate revocation lists
    - Your browser occasionally calls back to get a list of "no longer accepted" certificates
  - OSCP
    - Online Certificate Status Protocol: https://en.wikipedia.org/wiki/Online_Certificate_Status_Protocol

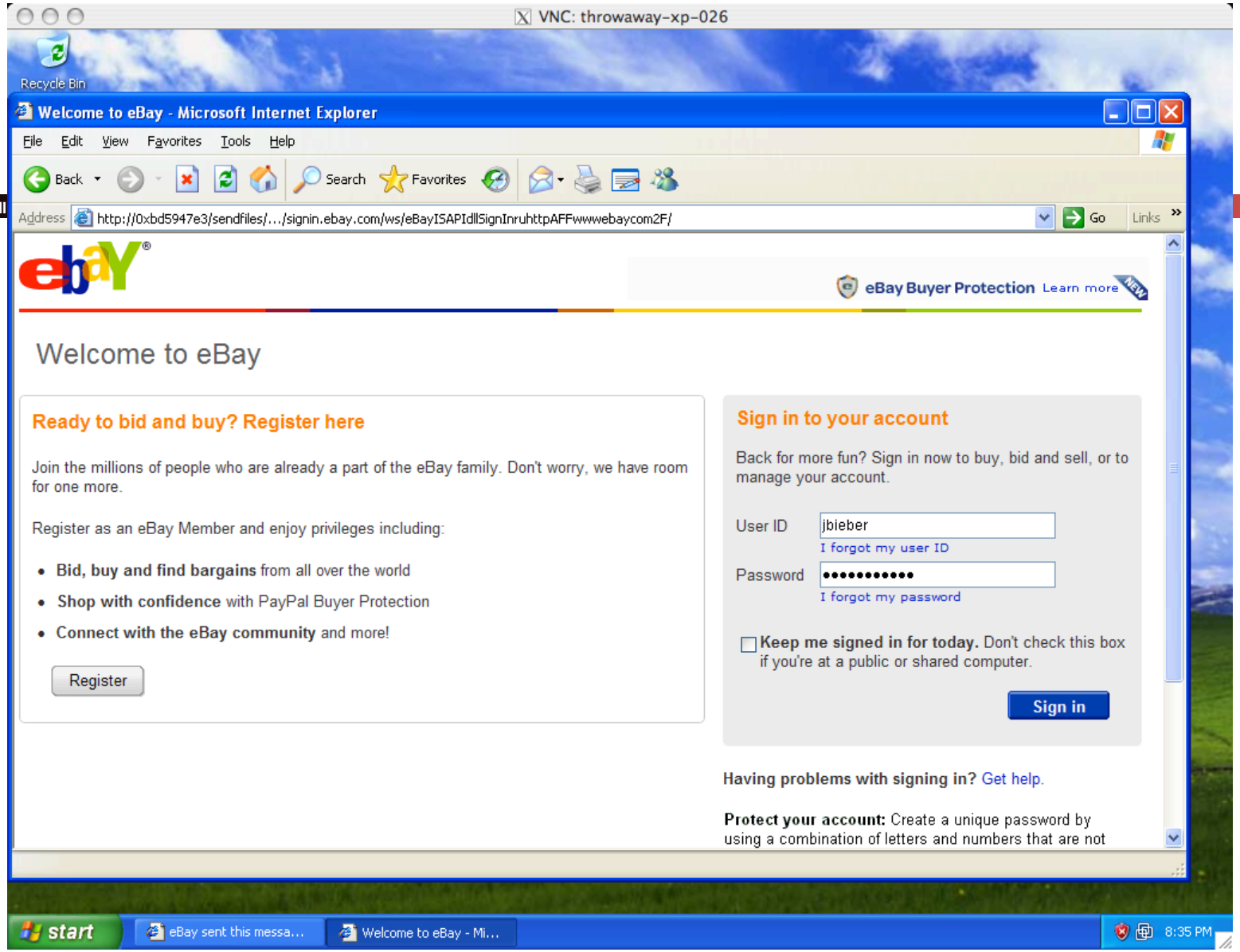
“sslstrip”
(Amazon FINALLY fixed this recently)

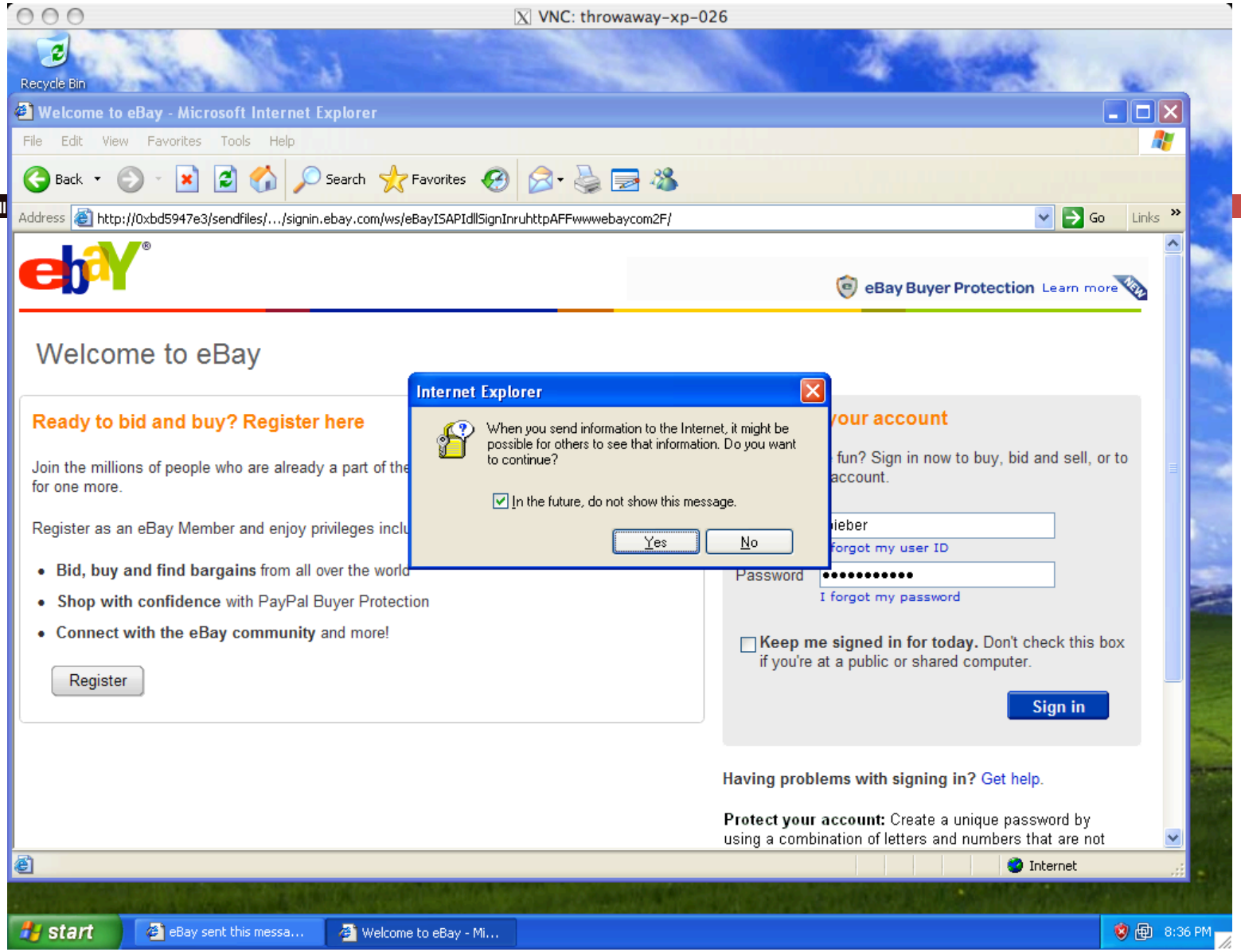
SSL / TLS Limitations, cont.

- Problems that SSL / TLS does not take care of ?
- Censorship
- SQL injection / XSS / server-side coding/logic flaws
- Vulnerabilities introduced by server inconsistencies
- Browser and server bugs
- Bad passwords
- What about the trust?

TLS/SSL Trust Issues

- User has to make correct trust decisions …


VNC: throwaway-xp-026
Recycle Bin
Welcome to eBay - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites
Address http://0xbd5947e3/sendfiles/.../signin.ebay.com/ws/eBayISAPIdllSignInruhttpAFFwwwebaycom2F/
Go Links
eBay Buyer Protection Learn more
Welcome to eBay
Ready to bid and buy? Register here
Join the millions of people who are already a part of the eBay family. Don't worry, we have room for one more.
Register as an eBay Member and enjoy privileges including:
Bid, buy and find bargains from all over the world
Shop with confidence with PayPal Buyer Protection
Connect with the eBay community and more!
Register
Sign in to your account
Back for more fun? Sign in now to buy, bid and sell, or to manage your account.
User ID jbieber
I forgot my user ID
Password
I forgot my password
Keep me signed in for today. Don't check this box if you're at a public or shared computer.
Sign in
Having problems with signing in? Get help.
Protect your account: Create a unique password by using a combination of letters and numbers that are not
start
eBay sent this messa...
Welcome to eBay - Mi...
8:35 PM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Go Links
eBay Buyer Protection Learn more
Welcome to eBay
Ready to bid and buy? Register here
Join the millions of people who are already a part of the
for one more.
Register as an eBay Member and enjoy privileges inclu
Bid, buy and find bargains from all over the world
Shop with confidence with PayPal Buyer Protection
Connect with the eBay community and more!
Register
Internet Explorer
When you send information to the Internet, it might be possible for others to see that information. Do you want to continue?
In the future, do not show this message.
Yes
No
your account
fun? Sign in now to buy, bid and sell, or to
account.
ieber
forgot my user ID
Password
I forgot my password
Keep me signed in for today. Don't check this box if you're at a public or shared computer.
Sign in
Having problems with signing in? Get help.
Protect your account: Create a unique password by using a combination of letters and numbers that are not
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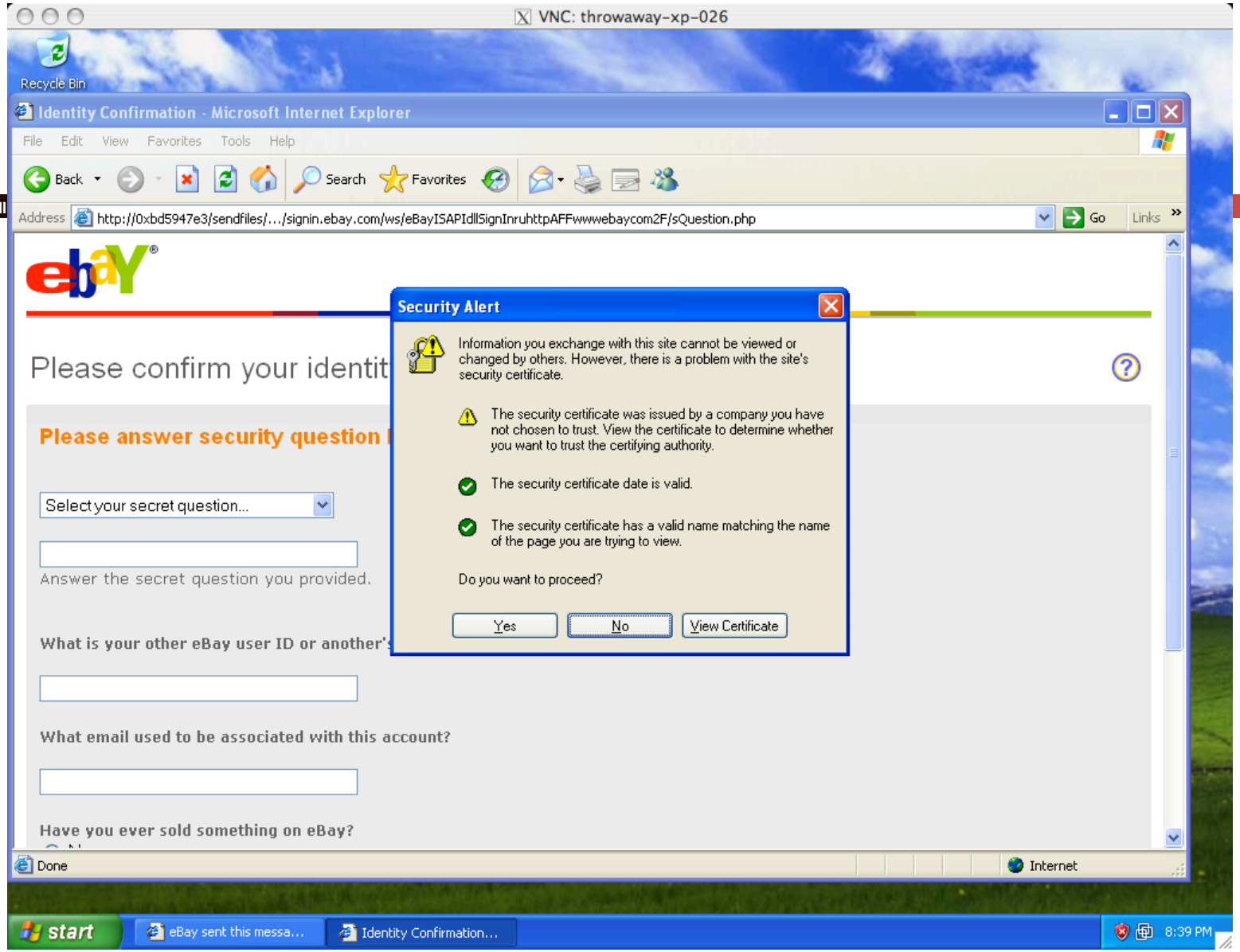
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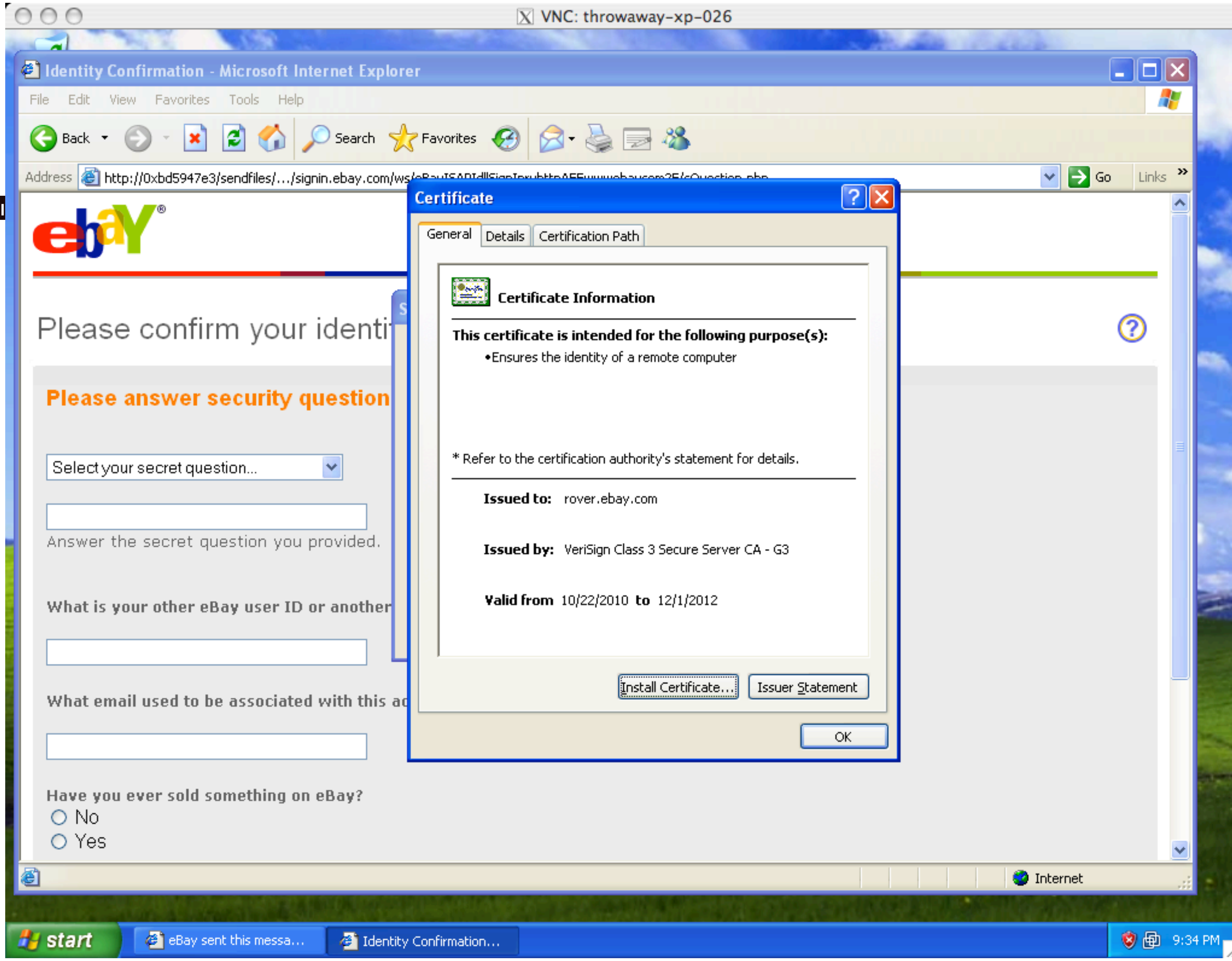
Address http://0xbd5947e3/sendfiles/.../signin.ebay.com/ws/eBayISAPIdllSignInruhttpAFFwwwebaycom2F/sQuestion.php
Go Links
Please confirm your identit
Please answer security question
Select your secret question...
Answer the secret question you provided.
What is your other eBay user ID or another's
What email used to be associated with this account?
Have you ever sold something on eBay?
Security Alert
Information you exchange with this site cannot be viewed or changed by others. However, there is a problem with the site's security certificate.
The security certificate was issued by a company you have not chosen to trust. View the certificate to determine whether you want to trust the certifying authority.
The security certificate date is valid.
The security certificate has a valid name matching the name of the page you are trying to view.
Do you want to proceed?
Yes
No
View Certificate
Done
Internet
start
eBay sent this messa...
Identity Confirmation...
8:39 PM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Identity Confirmation - Microsoft Internet Explorer
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Address
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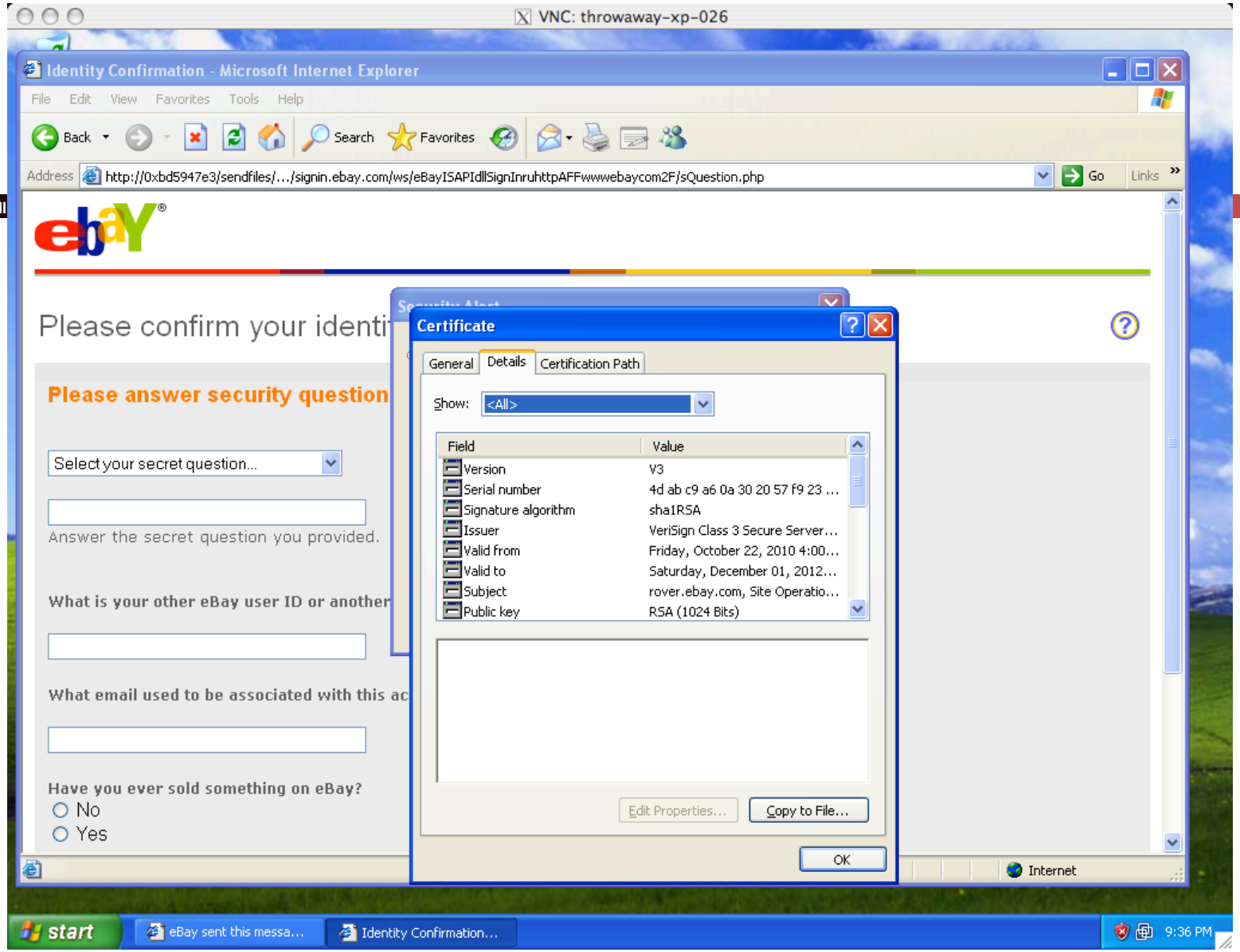
Links
Please confirm your identi
Please answer security question
Select your secret question...
Answer the secret question you provided.
What is your other eBay user ID or another
What email used to be associated with this ac
Have you ever sold something on eBay?
No
Yes
Certificate
General
Details
Certification Path
Certificate Information
This certificate is intended for the following purpose(s):
•Ensures the identity of a remote computer
* Refer to the certification authority's statement for details.
Issued to: rover.ebay.com
Issued by: VeriSign Class 3 Secure Server CA - G3
Valid from 10/22/2010 to 12/1/2012
Install Certificate...
Issuer Statement
OK
Internet
start
eBay sent this messa...
Identity Confirmation...
9:34 PM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Please confirm your identi
Please answer security question
Select your secret question...
Answer the secret question you provided.
What is your other eBay user ID or another
What email used to be associated with this ac
Have you ever sold something on eBay?
No
Yes
Certificate
General Details Certification Path
Show: <All>
Field Value
Version V3
Serial number 4d ab c9 a6 0a 30 20 57 f9 23 ...
Signature algorithm sha1RSA
Issuer VeriSign Class 3 Secure Server...
Valid from Friday, October 22, 2010 4:00...
Valid to Saturday, December 01, 2012...
Subject rover.ebay.com, Site Operatio...
Public key RSA (1024 Bits)
Edit Properties... Copy to File...
OK
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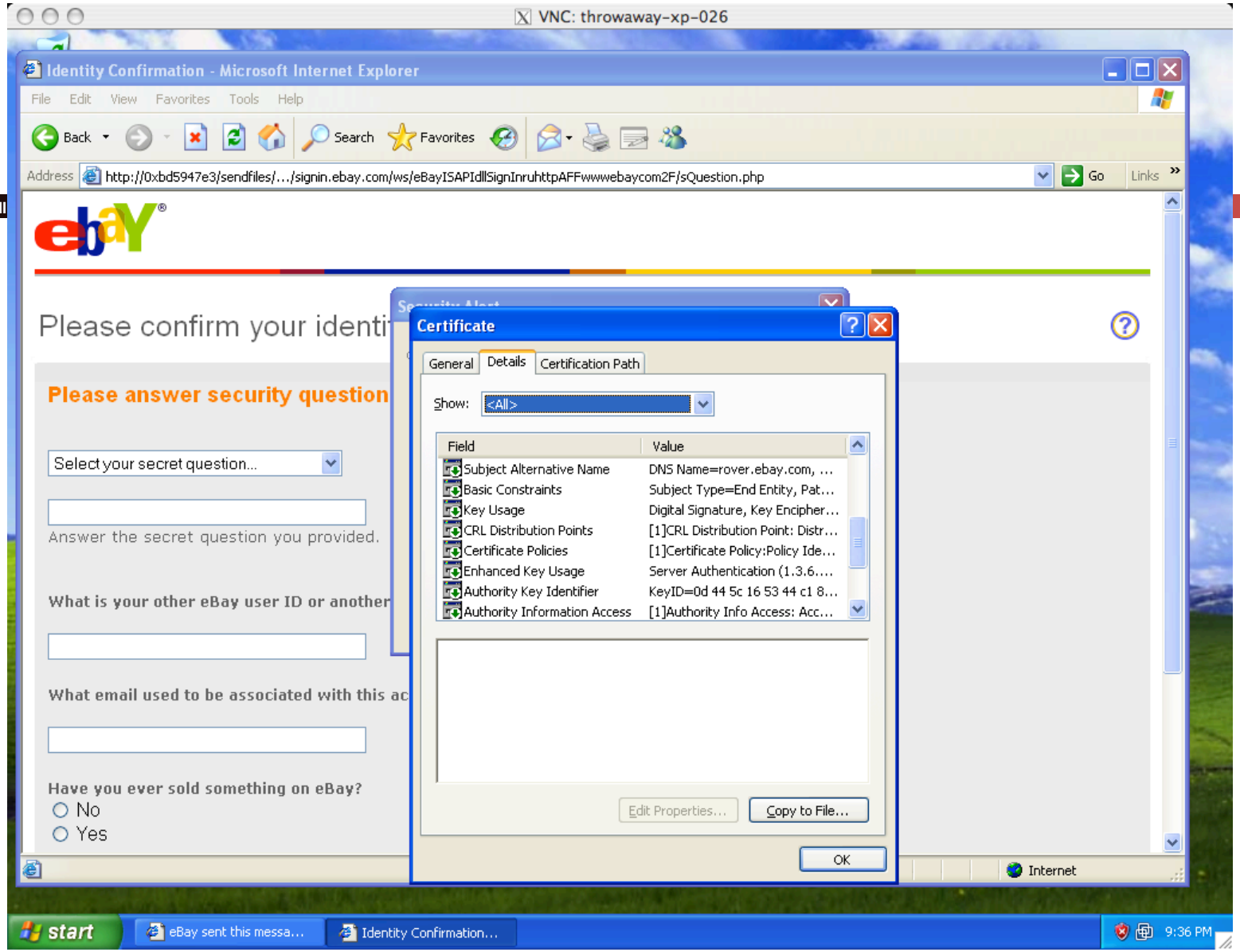
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Please confirm your identi
Please answer security question
Select your secret question...
Answer the secret question you provided.
What is your other eBay user ID or another
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Have you ever sold something on eBay?
No
Yes
Certificate
General Details Certification Path
Show: <All>
Field Value
Subject Alternative Name DNS Name=rover.ebay.com, ...
Basic Constraints Subject Type=End Entity, Pat...
Key Usage Digital Signature, Key Encipher...
CRL Distribution Points [1]CRL Distribution Point: Distr...
Certificate Policies [1]Certificate Policy:Policy Ide...
Enhanced Key Usage Server Authentication (1.3.6....
Authority Key Identifier KeyID=0d 44 5c 16 53 44 c1 8...
Authority Information Access [1]Authority Info Access: Acc...
Edit Properties... Copy to File...
OK
Internet
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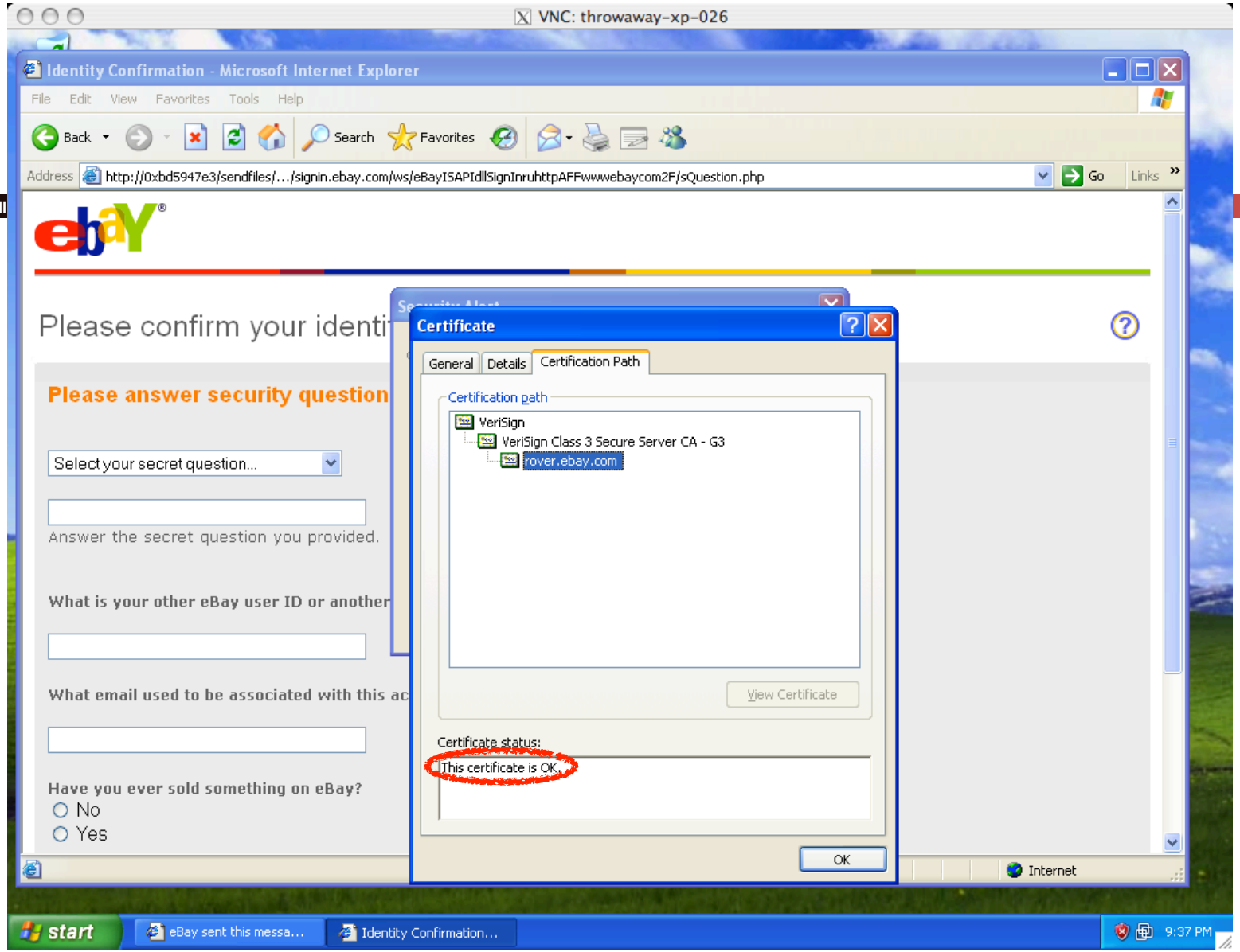
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Please confirm your identi
Please answer security question
Select your secret question...
Answer the secret question you provided.
What is your other eBay user ID or another
What email used to be associated with this ac
Have you ever sold something on eBay?
No
Yes
Certificate
General Details Certification Path
Certification path
VeriSign
VeriSign Class 3 Secure Server CA - G3
rover.ebay.com
View Certificate
Certificate status:
This certificate is OK.
OK
Internet
start
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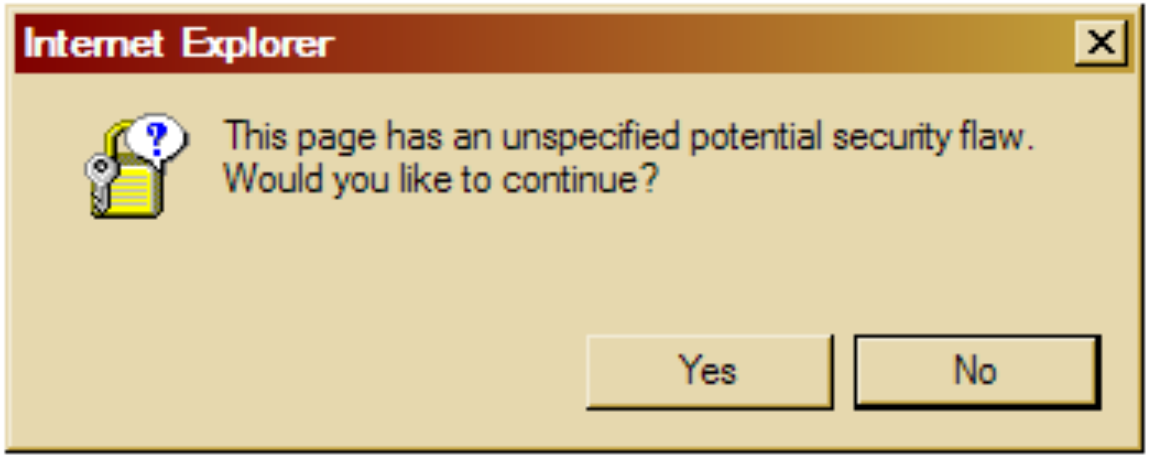
Identity Confirmation...
9:37 PM

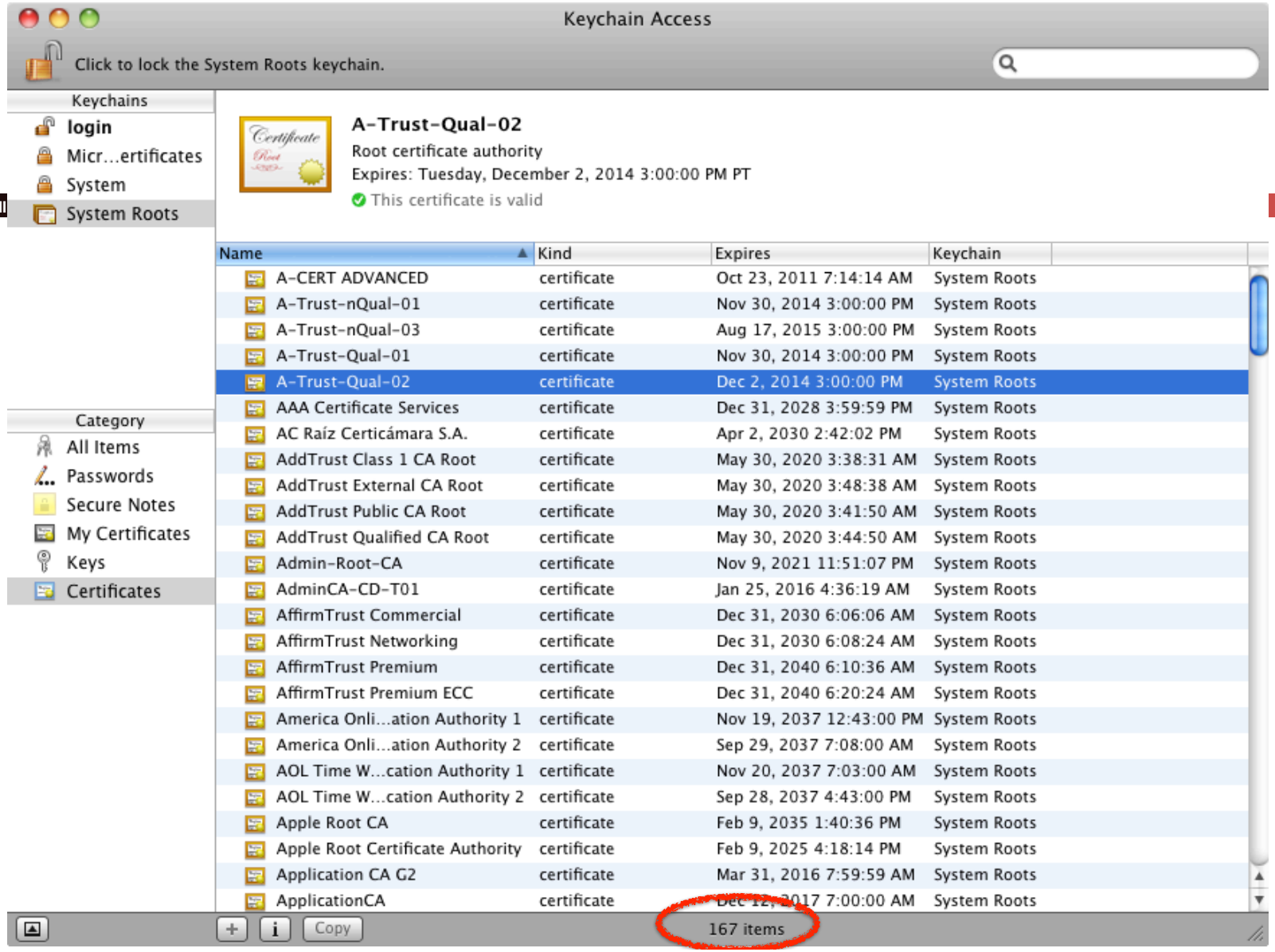
The equivalent as seen by most Internet users:



(note: an actual Windows error message!)

TLS/SSL Trust Issues, cont.

- "*Commercial certificate authorities protect you from anyone from whom they are unwilling to take money*."
  - Matt Blaze, circa 2001
- So how many CAs do we have to worry about, anyway?


Keychain Access
Click to lock the System Roots keychain.
Keychains
login
Micr...ertificates
System
System Roots
Category
All Items
Passwords
Secure Notes
My Certificates
Keys
Certificates
A-Trust-Qual-02
Root certificate authority
Expires: Tuesday, December 2, 2014 3:00:00 PM PT
This certificate is valid
Name
Kind
Expires
Keychain
A-CERT ADVANCED certificate Oct 23, 2011 7:14:14 AM System Roots
A-Trust-nQual-01 certificate Nov 30, 2014 3:00:00 PM System Roots
A-Trust-nQual-03 certificate Aug 17, 2015 3:00:00 PM System Roots
A-Trust-Qual-01 certificate Nov 30, 2014 3:00:00 PM System Roots
A-Trust-Qual-02 certificate Dec 2, 2014 3:00:00 PM System Roots
AAA Certificate Services certificate Dec 31, 2028 3:59:59 PM System Roots
AC Raíz Certicámara S.A. certificate Apr 2, 2030 2:42:02 PM System Roots
AddTrust Class 1 CA Root certificate May 30, 2020 3:38:31 AM System Roots
AddTrust External CA Root certificate May 30, 2020 3:48:38 AM System Roots
AddTrust Public CA Root certificate May 30, 2020 3:41:50 AM System Roots
AddTrust Qualified CA Root certificate May 30, 2020 3:44:50 AM System Roots
Admin-Root-CA certificate Nov 9, 2021 11:51:07 PM System Roots
AdminCA-CD-T01 certificate Jan 25, 2016 4:36:19 AM System Roots
AffirmTrust Commercial certificate Dec 31, 2030 6:06:06 AM System Roots
AffirmTrust Networking certificate Dec 31, 2030 6:08:24 AM System Roots
AffirmTrust Premium certificate Dec 31, 2040 6:10:36 AM System Roots
AffirmTrust Premium ECC certificate Dec 31, 2040 6:20:24 AM System Roots
America Onli...ation Authority 1 certificate Nov 19, 2037 12:43:00 PM System Roots
America Onli...ation Authority 2 certificate Sep 29, 2037 7:08:00 AM System Roots
AOL Time W...cation Authority 1 certificate Nov 20, 2037 7:03:00 AM System Roots
AOL Time W...cation Authority 2 certificate Sep 28, 2037 4:43:00 PM System Roots
Apple Root CA certificate Feb 9, 2035 1:40:36 PM System Roots
Apple Root Certificate Authority certificate Feb 9, 2025 4:18:14 PM System Roots
Application CA G2 certificate Mar 31, 2016 7:59:59 AM System Roots
ApplicationCA certificate Dec 12, 2017 7:00:00 AM System Roots
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TLS/SSL Trust Issues

- "*Commercial certificate authorities protect you from anyone from whom they are unwilling to take money*."
  - Matt Blaze, circa 2001
- So how many CAs do we have to worry about, anyway?
- Of course, it's not just their greed that matters …

News

Solo Iranian hacker takes credit for Comodo certificate attack

Security researchers split on whether 'ComodoHacker' is the real deal

By Gregg Keizer

March 27, 2011 08:39 PM ET

Computerworld - A solo Iranian hacker on Saturday claimed responsibility for stealing multiple SSL certificates belonging to some of the Web's biggest sites, including Google, Microsoft, Skype and Yahoo.

Early reaction from security experts was mixed, with some believing the hacker's claim, while others were dubious.

CNET › News › InSecurity Complex › Fraudulent Google certificate points to Internet attack

Fraudulent Google certificate points to Internet attack

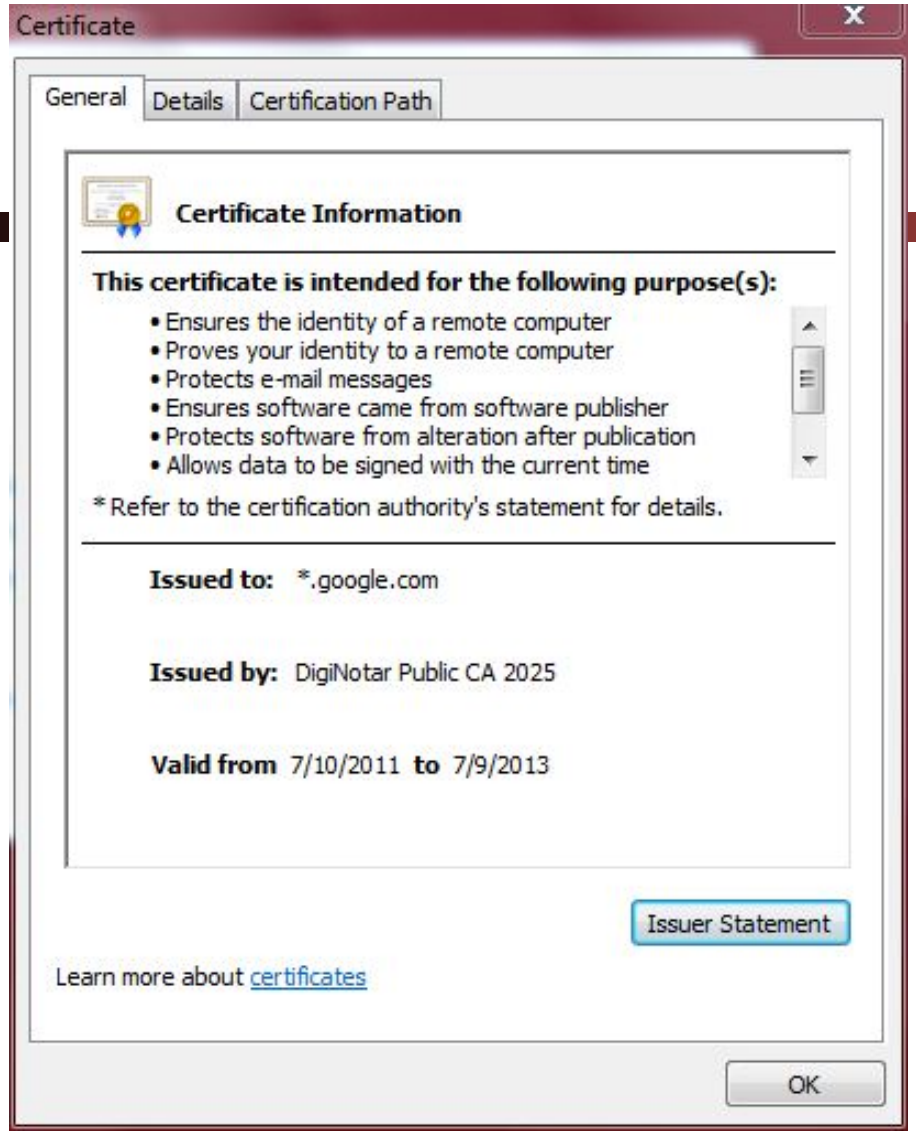
nd Weaver

Is Iran behind a fraudulent Google.com digital certificate? The situation is similar to one that happened in March in which spoofed certificates were traced back to Iran.

by Elinor Mills | August 29, 2011 1:22 PM PDT

A Dutch company appears to have issued a digital certificate for Google.com to someone other than Google, who may be using it to try to re-direct traffic of users based in Iran.

Yesterday, someone reported on a Google support site that when attempting to log in to Gmail the browser issued a warning for the digital certificate used as proof that the site is legitimate, according to this thread on a Google support forum site.



This appears to be a fully valid cert using normal browser validation rules.

Only detected by Chrome due to its recent introduction of cert "pinning" – requiring that certs for certain domains must be signed by specific CAs rather than any generally trusted CA

October 31, 2012, 10:49AM

Final Report on DigiNotar Hack Shows Total Compromise of CA Servers

The attacker who penetrated the Dutch CA DigiNotar last year had complete control of all eight of the company's certificate-issuing servers during the operation and he may also have issued some rogue certificates that have not yet been identified. The final report from a

Evidence Suggests DigiNotar, Who Issued Fraudulent Google Certificate, Was Hacked *Years* Ago

from the *diginot* dept

The big news in the security world, obviously, is the fact that a **fraudulent Google certificate made its way out into the wild**, apparently targeting internet users in Iran. The Dutch company DigiNotar has put out a statement saying that **it discovered a breach** back on July 19th during a security audit, and that fraudulent certificates were generated for "several dozen" websites. The only one known to have gotten out into the wild is the Google one.

The DigiNotar Fallout

- The result was the “CA Death Sentence”:
  - Web browsers removed it from the trusted root certificate store
- This has just happened again with “WoSign”
  - A Chinese CA
- WoSign would allow an interesting attack
  - If I controlled nweaver.github.com…
  - WoSign would allow me to create a certificate for *.github.com!?!?
  - And a bunch of other shady shenanigans

TLS/SSL Trust Issues

- "Commercial certificate authorities protect you from anyone from whom they are unwilling to take money."
  - Matt Blaze, circa 2001
- So how many CAs do we have to worry about, anyway?
- Of course, it's not just their greed that matters …
- … and it's not just their diligence & security that matters …
  - "*A decade ago, I observed that commercial certificate authorities protect you from anyone from whom they are unwilling to take money. That turns out to be wrong; they don't even do that much*." - Matt Blaze, circa 2010

So the Modern Solution:
Invoke Ronald Reagan, “Trust, but Verify”

- Static Certificate Pinning:
  The chrome browser has a list of certificates or certificate authorities that it trusts for given sites
  - Now creating a fake certificate requires attacking a particular CA
- HPKP Certificate Pinning:
  The web server provides hashes of certificates that should be trusted
  - This is “Leap of Faith”: The first time you assume it is honest but you will catch future changes
- Transparency mechanisms:
  - Public logs provided by certificate authorities
  - Browser extensions (EFF’s TLS observatory)
  - Backbone monitors (ICSI’s TLS notary)

Bonus slides

Law Enforcement Appliance Subverts SSL

By Ryan Singel ✉ March 24, 2010 | 1:55 pm | Categories: Surveillance, Threats

That little lock on your browser window indicating you are communicating securely with your bank or e-mail account may not always mean what you think its means.

Normally when a user visits a secure website, such as Bank of America, Gmail, PayPal or eBay, the browser examines the website's certificate to verify its authenticity.

At a recent wiretapping convention, however, security researcher Chris Soghoian discovered that a small company was marketing internet spying boxes to the feds. The boxes were designed to intercept those communications — without breaking the encryption — by using forged security certificates, instead of the real ones that websites use to verify secure connections. To use the appliance, the government would need to acquire a forged certificate from any one of more than 100 trusted Certificate Authorities.

Law Enforcement Appliance Subverts SSL

By Ryan Singel ✉ March 24, 2010 | 1:55 pm | Categories: Surveillance, Threats

Note: the cert is "forged" in the sense that it doesn't really belong to Gmail, PayPal, or whomever. But it does not appear forged because it includes a legitimate signature from a trusted CA.

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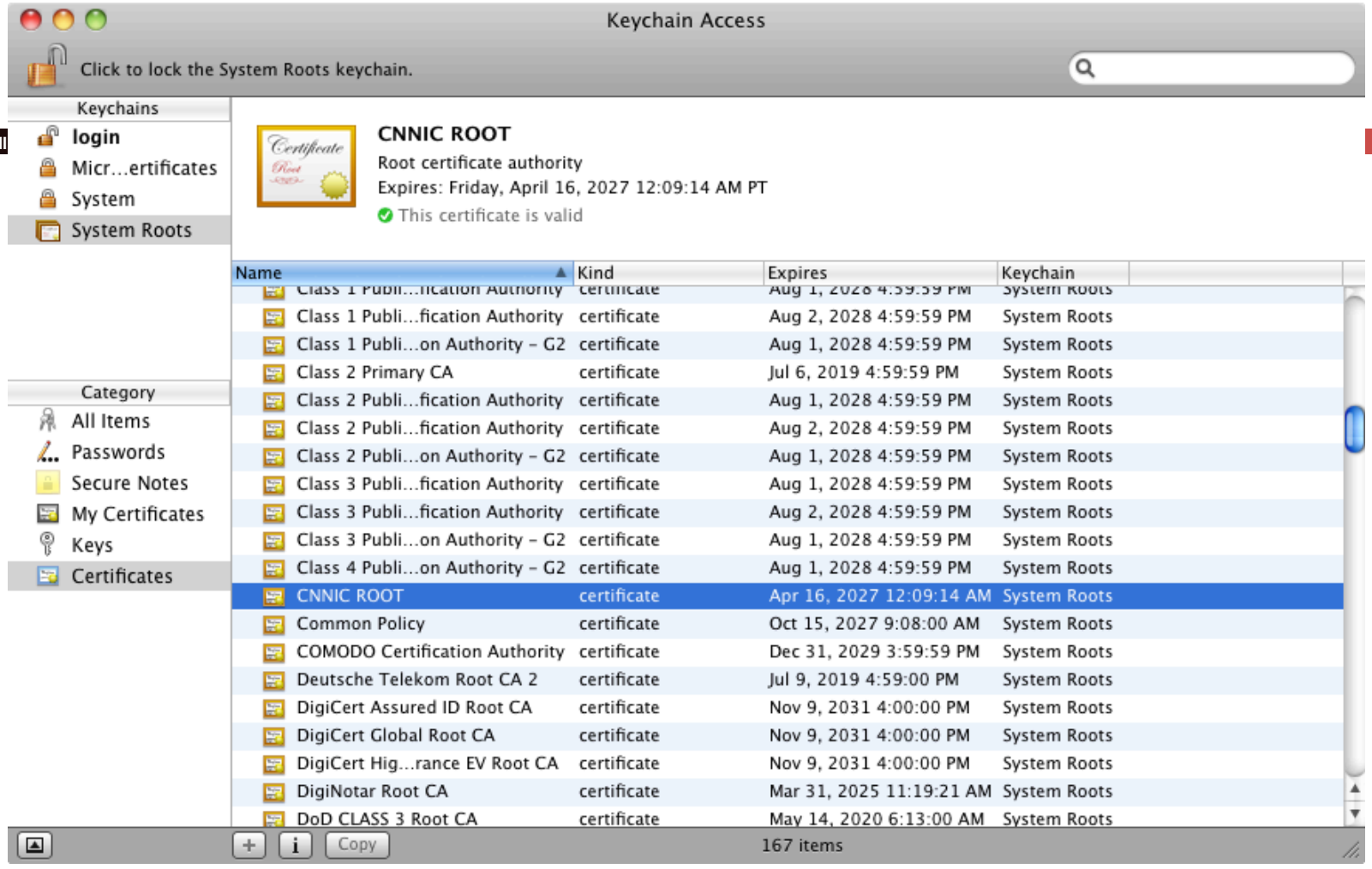
Security Warning: Do you trust the Russian government?
Firefox has detected that your connection to this website is probably not secure. If you are attempting to access or transmit sensitive data, you should stop this task, and try again using a different Internet connection.
Firefox has detected a potential security problem while trying to access www.bankofamerica.com, a website visited at least 131 times in the past by persons using this computer.
In these previous browsing sessions, www.bankofamerica.com provided a security certificiate verified by a company in the United States.
However, this website is now presenting a different security certificate verified by a company based in Russia.
If you do not trust the government of Russia with your private data, or think it unlikely that Bank of America would obtain a security certificate from a company based there, this could be a sign that someone is attempting to intercept your secure communications.
Click here to learn more about security certificiates and this potentially risky situation.
If you trust the government of Russia and companies located there to protect your privacy and security, click here to accept this new certificate and continue with your visit to the site.
Get me out of here!


Keychain Access
Click to lock the System Roots keychain.
Keychains
login
Micr...ertificates
System
System Roots
Category
All Items
Passwords
Secure Notes
My Certificates
Keys
Certificates
CNNIC ROOT
Root certificate authority
Expires: Friday, April 16, 2027 12:09:14 AM PT
This certificate is valid
Name
Kind
Expires
Keychain
Class 1 Publi...fication Authority certificate Aug 2, 2028 4:59:59 PM System Roots
Class 1 Publi...on Authority - G2 certificate Aug 1, 2028 4:59:59 PM System Roots
Class 2 Primary CA certificate Jul 6, 2019 4:59:59 PM System Roots
Class 2 Publi...fication Authority certificate Aug 1, 2028 4:59:59 PM System Roots
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Class 4 Publi...on Authority - G2 certificate Aug 1, 2028 4:59:59 PM System Roots
CNNIC ROOT certificate Apr 16, 2027 12:09:14 AM System Roots
Common Policy certificate Oct 15, 2027 9:08:00 AM System Roots
COMODO Certification Authority certificate Dec 31, 2029 3:59:59 PM System Roots
Deutsche Telekom Root CA 2 certificate Jul 9, 2019 4:59:00 PM System Roots
DigiCert Assured ID Root CA certificate Nov 9, 2031 4:00:00 PM System Roots
DigiCert Global Root CA certificate Nov 9, 2031 4:00:00 PM System Roots
DigiCert Hig...rance EV Root CA certificate Nov 9, 2031 4:00:00 PM System Roots
DigiNotar Root CA certificate Mar 31, 2025 11:19:21 AM System Roots
DoD CLASS 3 Root CA certificate May 14, 2020 6:13:00 AM System Roots
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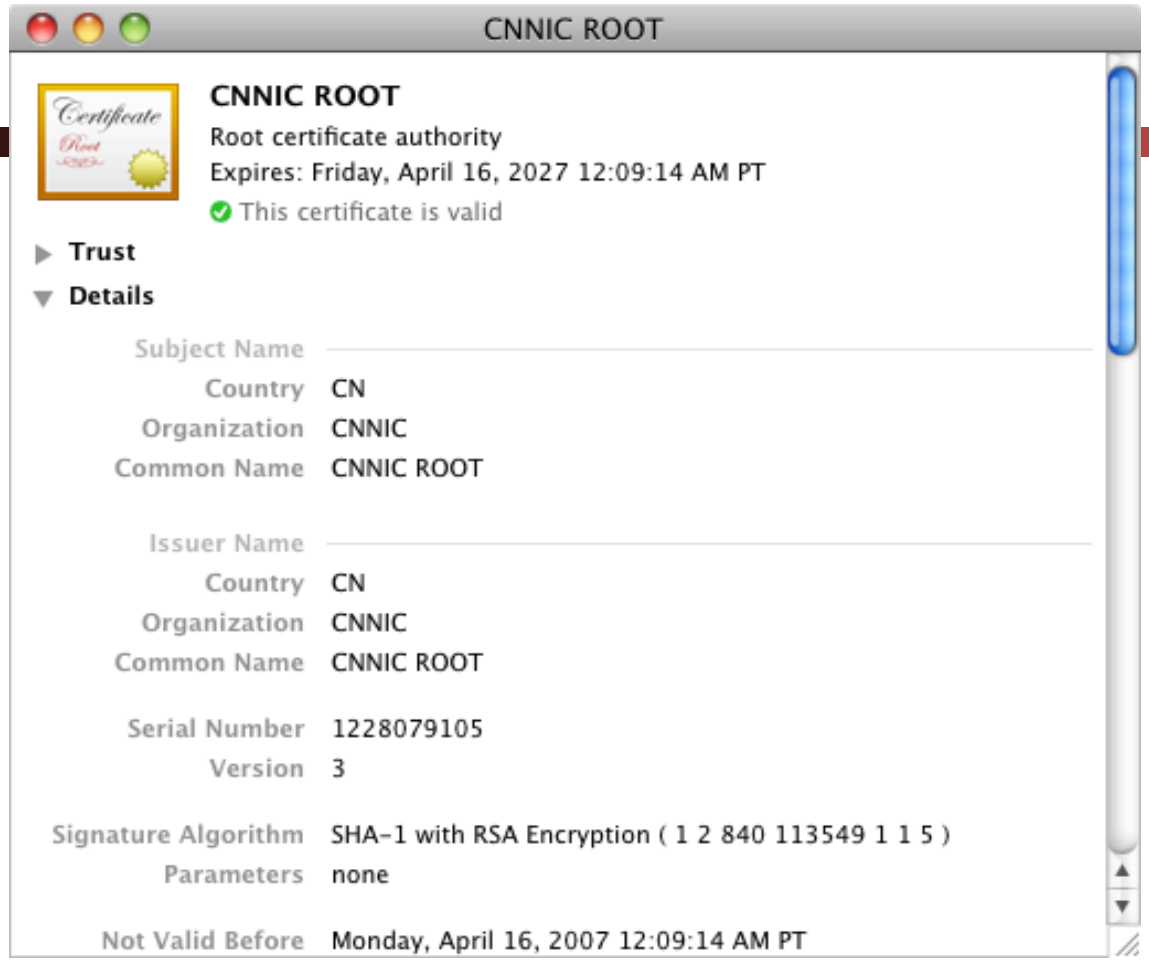
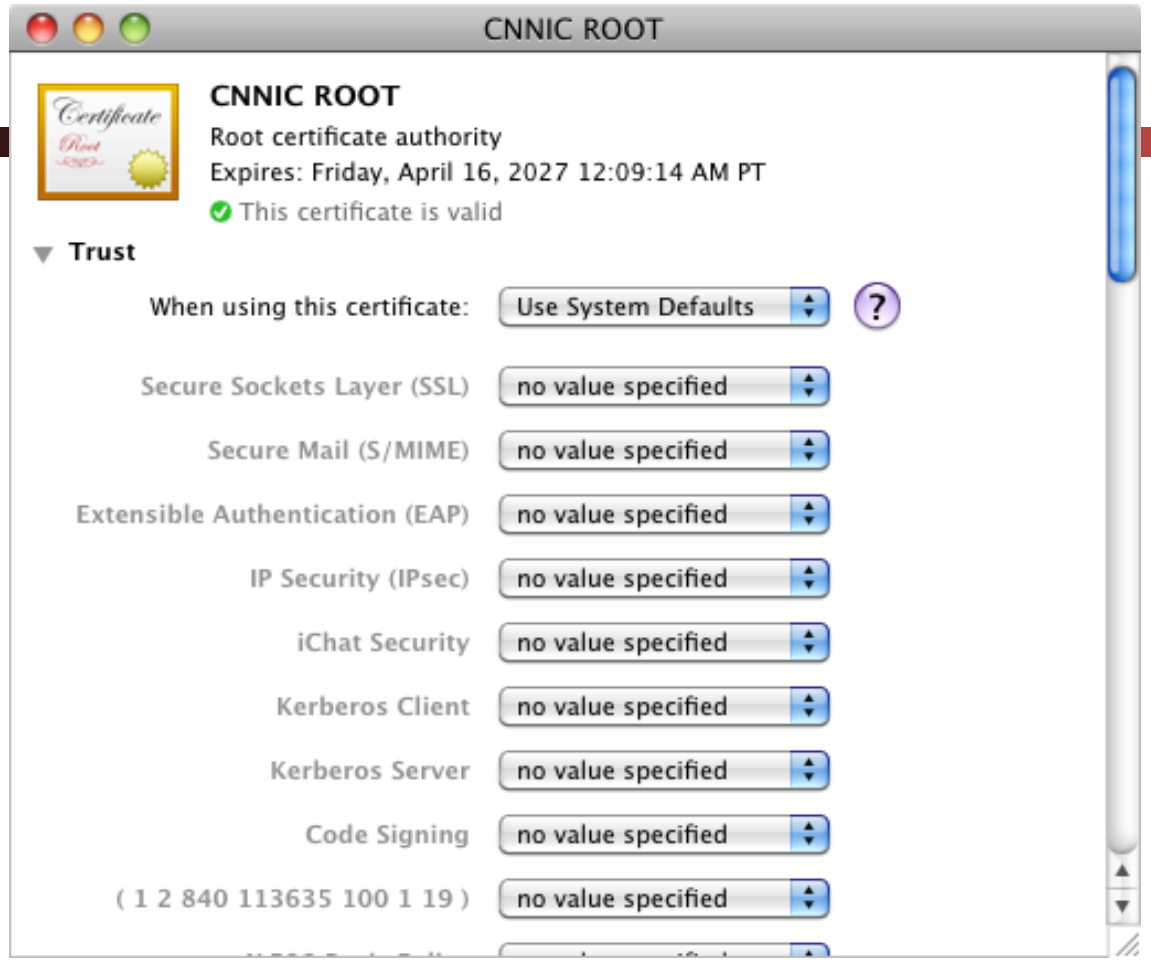
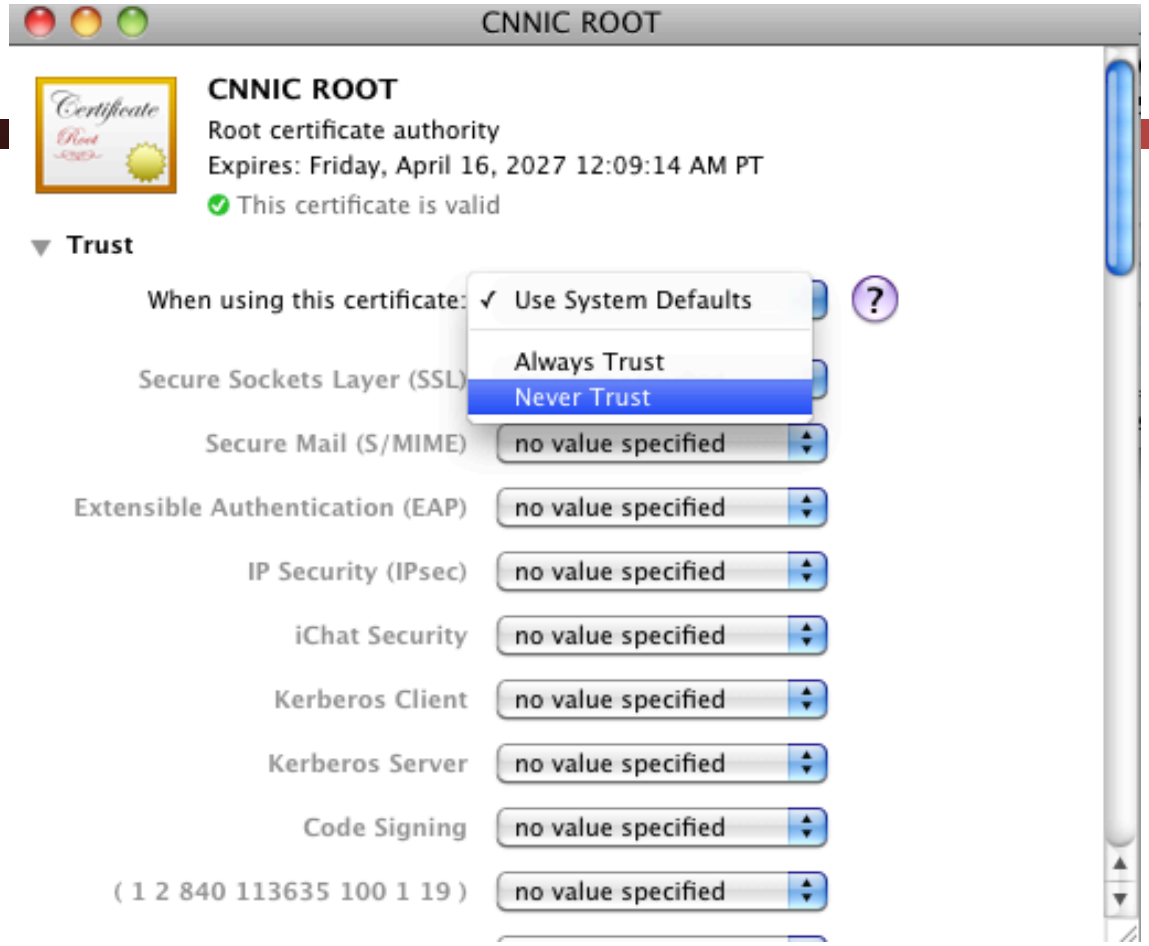
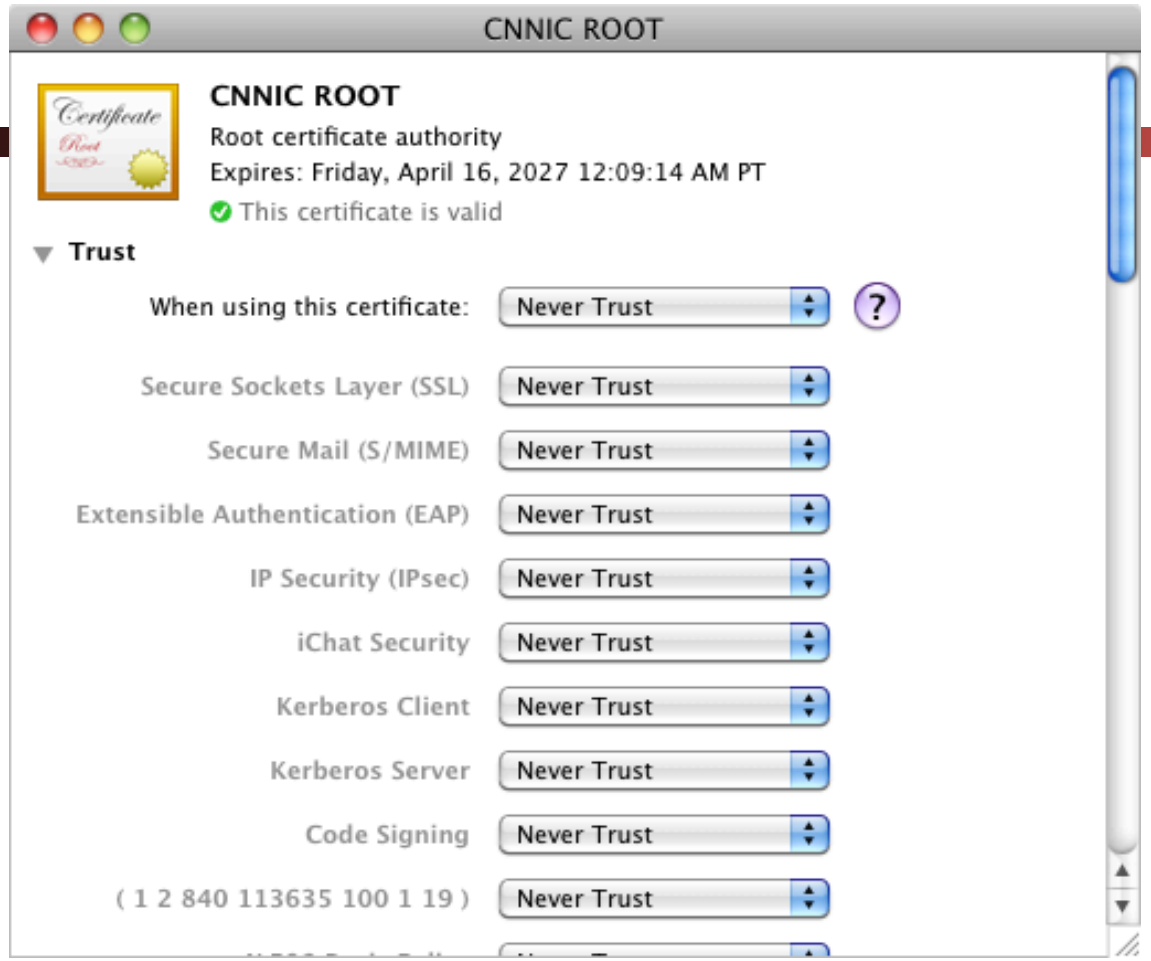

CNNIC ROOT
CNNIC ROOT
Root certificate authority
Expires: Friday, April 16, 2027 12:09:14 AM PT
This certificate is valid
Trust
Details
Subject Name
Country CN
Organization CNNIC
Common Name CNNIC ROOT
Issuer Name
Country CN
Organization CNNIC
Common Name CNNIC ROOT
Serial Number 1228079105
Version 3
Signature Algorithm SHA-1 with RSA Encryption (1 2 840 113549 1 1 5)
Parameters none
Not Valid Before Monday, April 16, 2007 12:09:14 AM PT


CNNIC ROOT
CNNIC ROOT
Root certificate authority
Expires: Friday, April 16, 2027 12:09:14 AM PT
This certificate is valid
Trust
When using this certificate:
Use System Defaults
Secure Sockets Layer (SSL)
no value specified
Secure Mail (S/MIME)
no value specified
Extensible Authentication (EAP)
no value specified
IP Security (IPsec)
no value specified
iChat Security
no value specified
Kerberos Client
no value specified
Kerberos Server
no value specified
Code Signing
no value specified
(1 2 840 113635 100 1 19)
no value specified


CNNIC ROOT
CNNIC ROOT
Root certificate authority
Expires: Friday, April 16, 2027 12:09:14 AM PT
This certificate is valid
Trust
When using this certificate:
Use System Defaults
Always Trust
Never Trust
Secure Sockets Layer (SSL)
Secure Mail (S/MIME)
Extensible Authentication (EAP)
IP Security (IPsec)
iChat Security
Kerberos Client
Kerberos Server
Code Signing
(1 2 840 113635 100 1 19)
no value specified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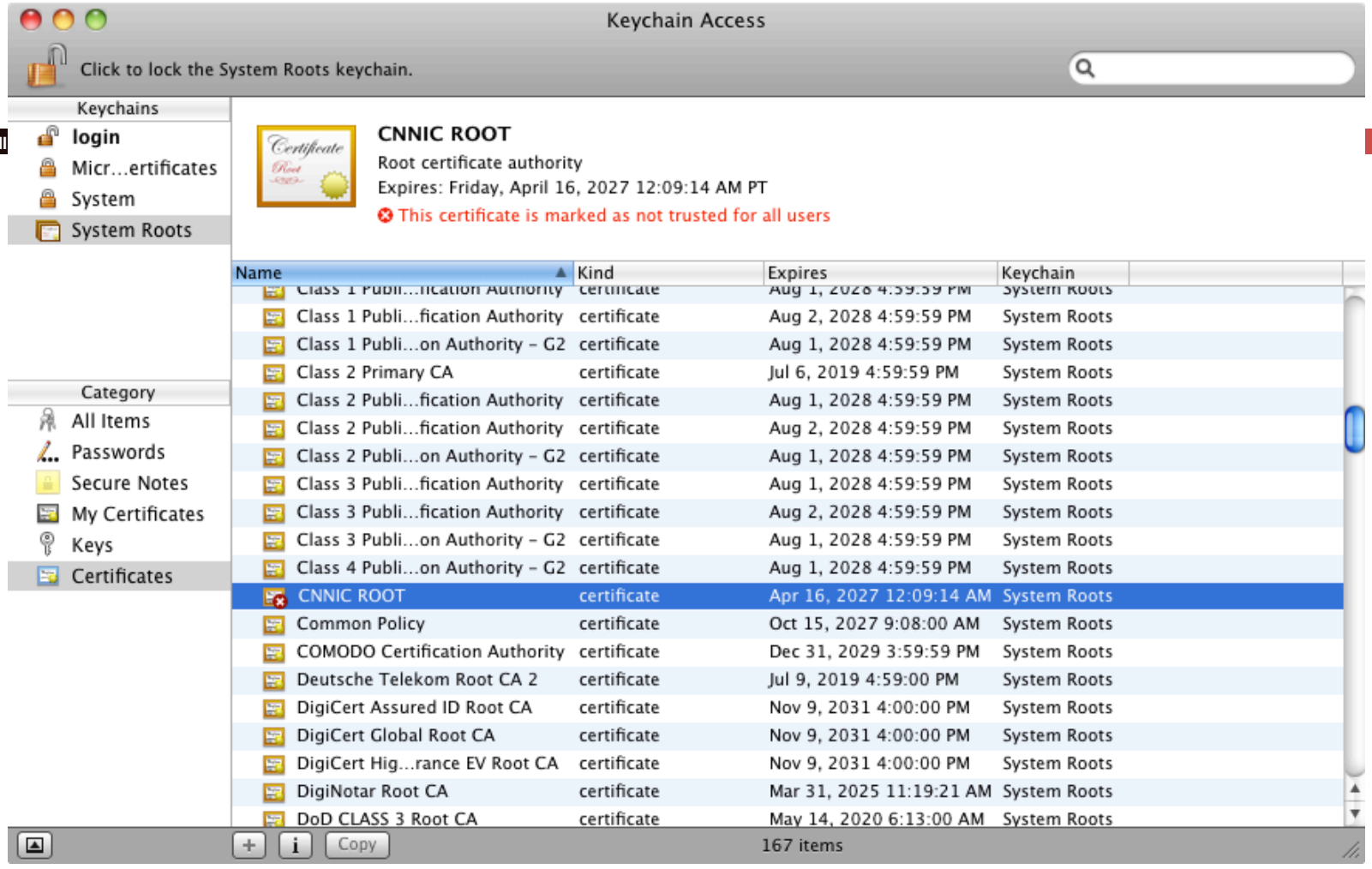
Never Trust
IP Security (IPsec)
Never Trust
iChat Security
Never Trust
Kerberos Client
Never Trust
Kerberos Server
Never Trust
Code Signing
Never Trust
(1 2 840 113635 100 1 19)
Never Trust


Keychain Access
Click to lock the System Roots keychain.
Keychains
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Micr...ertificates
System
System Roots
Category
All Items
Passwords
Secure Notes
My Certificates
Keys
Certificates
CNNIC ROOT
Root certificate authority
Expires: Friday, April 16, 2027 12:09:14 AM PT
This certificate is marked as not trusted for all users
Name
Kind
Expires
Keychain
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