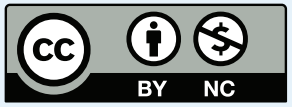
Web Security



Web Security

- Crypto (SSL)
- Client security
- Server security

SSL

SSL

- Mostly covered last time
- Crypto is insufficient for Web security
- One issue: linkage between crypto layer and applications

Trusting SSL

- What does the server *really* know about the client?
- What does the client *really* know about the server?

The Server's Knowledge of the Client

- What has SSL told the server?
- Unless client-side certificates are used, *absolutely nothing*
- SSL provides a secure pipe. *Someone* is at the other end; you don't know whom
- No linkage to transactions

SET

- In theory, we could have had digitally-signed purchase orders linked to credit card accounts
- Visa and Mastercard (and eventually Amex) tried, after the Web became popular
- They developed a protocol called SET (Secure Electronic Transactions)
- It provided client-side certificates linked to credit cards
- In theory, merchants wouldn't need to know (and store) credit card numbers
- Virtually no one used it
- The reasons were both technical and financial

The Failure of SET

- It required client-side software

⇒ Very few people install extra software

- Client-side certificates are hard to use — what if you use several computers?
- There was too little financial incentive for merchants, so they couldn't give customers a discount for using SET
- It *still* permitted merchants to store credit card numbers; in fact, they were present, albeit encrypted, in the certificate

⇒ Merchants use credit card numbers as customer tracking keys for databases

- Good crypto alone isn't sufficient!

Aside: The SET Root Certificate

- Who should control the SET root certificate, used to sign the Visa, Mastercard, etc., top-level certificates?
- (SET certified Visa et al.; they certified banks, who in turn issued customer certificates)
- It would be catastrophic if the root's private key were compromised
- Visa didn't trust Mastercard, or vice-versa
- Solution: a sacrificial PC signed all of the second-level certificates, at which point it was physically *smashed*. Different organizations took home different pieces...

The Client's Knowledge of the Server

- The client receives the server's certificate. Does that help?
- A certificate means that *someone* has attested to the binding of *some* name to a public key.
- Who has done the certification? Is it the right name?

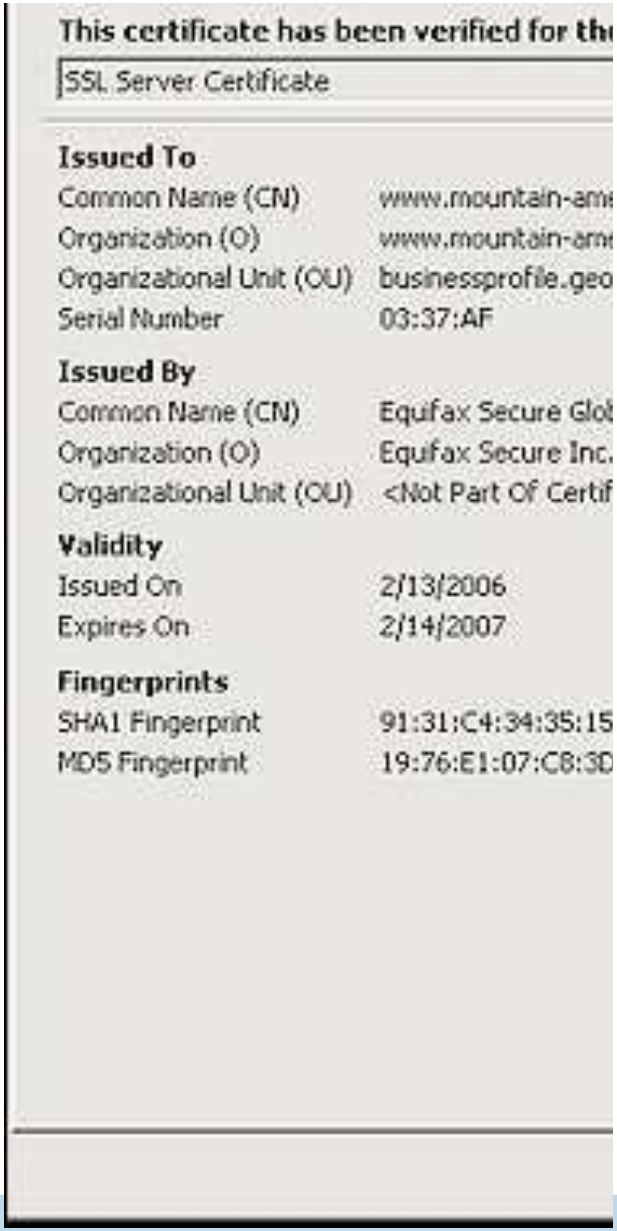
Who Issues Web Certificates?

- Every browser has a list of built-in certificate authorities
- The latest version of Firefox has about 180 certificate authorities!
- Do you trust them all to be honest and competent?
- Do you even know them all?
- (One CA has a 512-bit RSA key.)
- (Baltimore Cybertrust is listed. It *sold* its PKI business in 2003. Are the new owners trustworthy?)

Mountain America Credit Union

- In 2006, someone persuaded a reputable CA to issue them a certificate for Mountain America, a credit union
- The DNS name was `www.mountain-america.net`
- It looks legitimate, but the *real* credit union site is at `www.mtnamerica.org`.
- (There's also `www.mountainamerica.com`, a Las Vegas travel site)
- Which site was *intended* by the user?

A Fake Certificate



A Technical Attack

- Usually, you shop via unencrypted pages
- You click "Checkout" (or "Login" on a bank web site)
- The *next page* — downloaded without SSL protection — has the login link, which will use SSL
- What if an attacker tampers with that page, and changes the link to something different? Will you notice?
- Note that some small sites outsource payment processing. . .

Conclusions on SSL

- The cryptography itself seems correct
- The human factors are dubious
- Most users don't know what a certificate is, or how to verify one
- Even when they do know, it's hard to know what it should say in any given situation
- There is no rational basis for deciding whether or not to trust a given CA

Recent Changes in TLS

Recent Changes in TLS

- Client host name
- Client CA list
- More standard PRFs; those are specified in the cipher suites
- Changes to cipher suites

Client Host Name

- In hosting centers, many web sites (with different DNS names) sometimes share the same IP address
- Distinguished in HTTP by a `Host:` header
- But — with TLS (or SSL), the server sends its certificate *before* the `Host:` header is sent. Which certificate should be offered by the server?
- New extension: include the host name in the ClientHello message

Hash Function Support

- TLS uses hash functions for several things: certificates, MACs, PRFs
- What hash functions are supported?
- For the entire life of SSL and TLS, we've had MD5 and SHA-1 — but MD5 has been cracked and SHA-1 is falling
- Which functions are supported by the client?
- MACs are easy; that's part of the cipher suite
- New extension: ClientHello announces hash function support
- Should have been done originally — but *no* protocol designer anticipated the hash function problem

Protecting the Client

Web Browser Security

- User interface
- Buggy code
- Active content

The Attackers' Goals

- Steal personal information, especially financial site passwords
- Turn computers into "bots"
- Bots can be used for denial of service attacks, sending spam, hosting phishing web sites, etc.

Buggy Code

- *All* browsers are vulnerable, and getting worse
- Browser bugs (Symantec):

Brower	1H2005	2H2005	1H2006
IE	25	25	38
Firefox	32	17	47
Opera	7	9	7
Safari	4	6	12

- Exposure period (Symantec):

Browser	2H2005	1H2006
IE	25	9
Firefox	-2	1
Safari		5
Opera	18	2

Why Are Browsers So Insecure?

- Their task is complex
- They are dealing with many untrusted sites
- By definition, browser inputs cross *protection domains*
- It is likely that no browser is signficantly better than any other in this regard — they're *all* bad

Active Content

CS @CU

Active Content

- There's worse yet for web users: active content
- Typical active content: JavaScript, Java, Flash, ActiveX
- Web pages can contain more-or-less arbitrary programs or references to programs
- To view certain web pages, users are told "please install this plug-in", i.e., a program
- "Given a choice between dancing pigs and security, users will pick dancing pigs every time." (Ed Felten)

JavaScript

- No relationship to Java — originally called LiveScript (EvilScript?)
- Source of most recent security holes, in Firefox and IE
- No clear security model
- Crucial link in *cross-site scripting* attacks

AJAX

- AJAX — Asynchronous JavaScript and XHTML
- Permits highly interactive web pages, i.e., Google Maps
- Security implications for client and server are still quite unclear (but are likely to be bad. . .)

ActiveX

- *The* biggest active content design error
- Over 1,000 ActiveX controls on a typical new, out-of-the box, machine
- Translation: over 1,000 different pieces of code that can be run by almost any web page
- But wait, there's more!

Downloading ActiveX Controls

- Any web page can download other controls
- Translation: any web page can download an arbitrary piece of code to run on a user's machine
- The only protection is a digital signature on the downloaded code
- But at best that identifies the author — see the previous discussion of certificates!
- There is *no* restriction on what the code can do

Why ActiveX?

- It can be used for some very beneficial things, such as Windows Update
- It can be used to "enhance" the user's web experience, i.e., provide dancing pigs
- Business reasons? Tie web sites to Windows and IE?
- Only IE has ActiveX. This is the single biggest security difference between IE and Firefox

Web Authentication

Web Authentication

- Three options: client-side certificates, HTTP authentication, site-specific
- Client-side certificate uses SSL
- Storing and protecting the private key is hard
- Where does the key live? How is it moved from machine to machine?
- Site-specific — a login screen — is by far the most common

HTTP Authentication

- Transaction between the web browser and the web server
- Two types, Basic and Digest
- Generally used together with SSL
- Often seen as unaesthetic

How They Work

- Client sends an HTTP request
- Server replies with a `WWW-Authenticate:` challenge
- Client prompts user for credentials
- Client retries request with `Authorization:` header included
- Can be used to authenticate to proxies, but that's rare

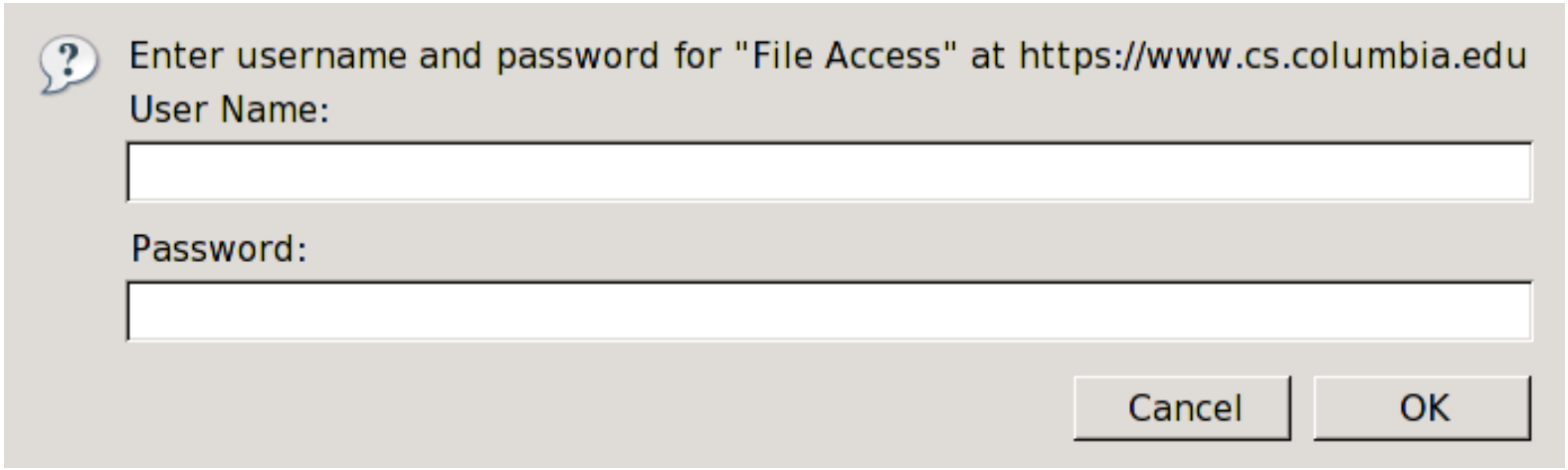
Basic Authentication

- Server send a challenge with a `realm`
- Realm is displayed to the user (but not tied to a certificate)
- Client replies with base-64 encoded (but not encrypted) password
- For userid `Aladdin` and password `open sesame`, client sends

  Authorization: Basic QWxhZGRpbjpvcGVuIHNlc2FtZQ==

  which is `Aladdin:open sesame` in base 64

User Prompt



Digest Authentication

- Uses challenge/response authentication
- Server sends a nonce in the `WWW-Authenticate:` message
- Client reply includes MD5 hash of username, password, nonce, HTTP method, and requested URL
- Can't replay, because the nonce will be different each time
- Password not sent in the clear
- (Actually somewhat more complex than this)

Password Storage

- With Basic authentication, Unix-style hashed passwords can be stored
- Digest (and most forms of challenge/response) require plaintext passwords
- That file can be stolen — and people often reuse their passwords for other web sites
- Note that this applies to web page-based authentication, too; it's not a limitation of HTTP authentication

Limitations of HTTP Authentication

- No fancy login screen
- No "Forgot your password?" link
- No easy recovery from authentication failure; just a 401 error
- Generally used only by low-end web sites
- Not very friendly for token-based authentication (though Digest is better)