CSci 5271
Introduction to Computer Security
Usability and Voting combined slides

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Outline

Tor experiences and challenges (cont'd)
Usability and security
Announcements intermission
Usable security example areas
Elections and their security
System security of electronic voting
End-to-end verification

Intersection attacks

- Suppose you use Tor to update a pseudonymous blog, reveal you live in Minneapolis
- Comcast can tell who in the city was sending to Tor at the moment you post an entry
  - Anonymity set of 1000 $\rightarrow$ reasonable protection
- But if you keep posting, adversary can keep narrowing down the set

Exit sniffing

- Easy mistake to make: log in to an HTTP web site over Tor
- A malicious exit node could now steal your password
- Another reason to always use HTTPS for logins

Browser bundle JS attack

- Tor's Browser Bundle disables many features try to stop tracking
- But, JavaScript defaults to on
  - Usability for non-expert users
  - Fingerprinting via NoScript settings
- Was incompatible with Firefox auto-updating
- Many Tor users de-anonymized in August 2013 by JS vulnerability patched in June

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Users are not 'ideal components'

- Frustrates engineers: cannot give users instructions like a computer
  - Closest approximation: military
- Unrealistic expectations are bad for security

Most users are benign and sensible

- On the other hand, you can't just treat users as adversaries
  - Some level of trust is inevitable
  - Your institution is not a prison
- Also need to take advantage of user common sense and expertise
  - A resource you can't afford to pass up

Don't blame users

- "User error" can be the end of a discussion
- This is a poor excuse
- Almost any "user error" could be avoidable with better systems and procedures

Users as rational

- Economic perspective: users have goals and pursue them
  - They're just not necessarily aligned with security
- Ignoring a security practice can be rational if the rewards is greater than the risk

Perspectives from psychology

- Users become habituated to experiences and processes
  - Learn "skill" of clicking OK in dialog boxes
- Heuristic factors affect perception of risk
  - Level of control, salience of examples
- Social pressures can override security rules
  - "Social engineering" attacks

User attention is a resource

- Users have limited attention to devote to security
  - Exaggeration: treat as fixed
- If you waste attention on unimportant things, it won't be available when you need it
- Fable of the boy who cried wolf

Research: ecological validity

- User behavior with respect to security is hard to study
- Experimental settings are not like real situations
- Subjects often:
  - Have little really at stake
  - Expect experimenters will protect them
  - Do what seems socially acceptable
  - Do what they think the experimenters want

Research: deception and ethics

- Have to be very careful about ethics of experiments with human subjects
  - Enforced by institutional review systems
- When is it acceptable to deceive subjects?
  - Many security problems naturally include deception

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Tor technique question

Officially the name of the Tor network is not an acronym, but the "or" part of the name originated from this technique it uses:

A. $\boxed{\text{onion routing}}$
B. oatmeal reciprocity
C. one-time resilience
D. oilseed relaying
E. oblivious ratcheting

Because of last Wednesday's closure

- Bitcoin and electronic cash will not be part of this semester's course
- Still accepting late submissions of project progress reports
- Exercise set 5 release delayed, available now

Upcoming schedule

- Wed. 12/4: 4 project presentations
- Fri. 12/6: Exercise set 5 due (extended from Wed.)
- Mon. 12/9: 4 project presentations
- Wed. 12/11: 4 project presentations, course evaluations, final reports due
- Sat. 12/14: Final exam 10:30am

Project presentations

- Schedule on Canvas discussion board
- 15 minute slots, prepare 10 minute presentation
  - Extra time for audience Q&A, switching logistics
- Prefer to have just one person present
- Safest: your own laptop with HDMI port
  - This room also has VGA and USB-C, come early to test
  - My laptop or remote presentation possible with prior discussion

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Email encryption

- Technology became available with PGP in the early 90s
- Classic depressing study: "Why Johnny can't encrypt: a usability evaluation of PGP 5.0" (USENIX Security 1999)
- Still an open "challenge problem"
- Also some other non-UI difficulties: adoption, govt. policy

Phishing

- Attacker sends email appearing to come from an institution you trust
- Links to web site where you type your password, etc.
- *Spear phishing*: individually targeted, can be much more effective

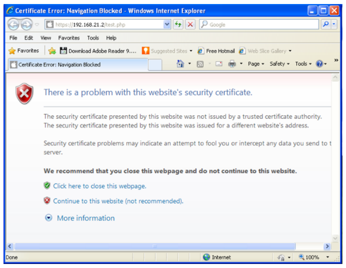
Phishing defenses

- Educate users to pay attention to X:
  - Spelling $\rightarrow$ copy from real emails
  - URL $\rightarrow$ homograph attacks
  - SSL "lock" icon $\rightarrow$ fake lock icon, or SSL-hosted attack
- Extended validation (green bar) certificates
- Phishing URL blacklists

SSL warnings: prevalence

- Browsers will warn on SSL certificate problems
- In the wild, most are false positives
  - `foo.com` vs. `www.foo.com`
  - Recently expired
  - Technical problems with validation
  - Self-signed certificates (HA2)
- Classic warning-fatigue danger

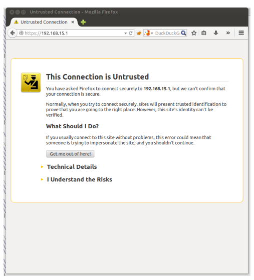
Older SSL warning



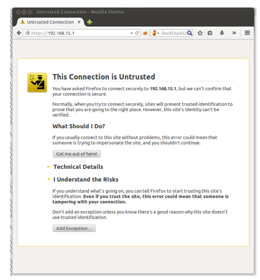
SSL warnings: effectiveness

- Early warnings fared very poorly in lab settings
- Recent browsers have a new generation of designs:
  - Harder to click through mindlessly
  - Persistent storage of exceptions
- Recent telemetry study: they work pretty well

Modern Firefox warning



Modern Firefox warning (2)



Modern Firefox warning (3)

Spam-advertised purchases

- "Replica" Rolex watches, herbal `V!@gr@`, etc.
- This business is clearly unscrupulous; if I pay, will I get anything at all?
- Empirical answer: yes, almost always
  - Not a scam, a black market
  - Importance of credit-card bank relationships

Advance fee fraud

- "Why do Nigerian Scammers say they are from Nigeria?" (Herley, WEIS 2012)
- Short answer: false positives
  - Sending spam is cheap
  - But, luring victims is expensive
  - Scammer wants to minimize victims who respond but ultimately don't pay

Trusted UI

- Tricky to ask users to make trust decisions based on UI appearance
  - Lock icon in browser, etc.
- Attacking code can draw lookalike indicators
  - Lock favicon
  - Picture-in-picture attack

Smartphone app permissions

- Smartphone OSes have more fine-grained per-application permissions
  - Access to GPS, microphone
  - Access to address book
  - Make calls
- Phone also has more tempting targets
- Users install more apps from small providers

Permissions manifest

- Android approach: present listed of requested permissions at install time
- Can be hard question to answer hypothetically
  - Users may have hard time understanding implications
- User choices seem to put low value on privacy

Time-of-use checks

- iOS approach: for narrower set of permissions, ask on each use
- Proper context makes decisions clearer
- But, have to avoid asking about common things
- iOS app store is also more closely curated

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Elections as a challenge problem

- Elections require a tricky balance of openness and secrecy
- Important to society as a whole
  - But not a big market
- Computer security experts react to proposals that seem insecure

History of US election mechanisms

- For first century or so, no secrecy
  - Secret ballot adopted in late 1800s
- Punch card ballots allowed machine counting
  - Common by 1960s, as with computers
  - Still common in 2000, decline thereafter
- How to add more technology and still have high security?

Election integrity

- Tabulation should reflect actual votes
  - No valid votes removed
  - No fake votes inserted
- Best: attacker can't change votes
- Easier: attacker can't change votes without getting caught

Secrecy, vote buying and coercion

- Alice's vote can't be matched with her name (unlinkable anonymity)
- Alice can't prove to Bob who she voted for (receipt-free)
- Best we can do to discourage:
  - Bob pays Alice $50 for voting for Charlie
  - Bob fires Alice if she doesn't vote for Charlie

Election verifiability

- We can check later that the votes were tabulated correctly
- Alice, that her vote was correctly cast
- Anyone, that the counting was accurate
- In paper systems, "manual recount" is a privileged operation

Politics and elections

- In a stable democracy, most candidates will be "pro-election"
- But, details differ based on political realities
- "Voting should be easy and convenient"
  - Especially for people likely to vote for me
- "No one should vote who isn't eligible"
  - Especially if they'd vote for my opponent

Errors and Florida

- Detectable mistakes:
  - Overvote: multiple votes in one race
  - Undervote: no vote in a race, also often intentional
- Undetectable mistakes: vote for wrong candidate
- 2000 presidential election in Florida illustrated all these, "wake-up call"

Precinct-count optical scan

- Good current paper system, used here in MN
- Voter fills in bubbles with pen
- Ballot scanned in voter's presence
  - Can reject on overvote
- Paper ballot retained for auditing

Vote by mail

- By mail universal in Oregon and Washington
  - Many other states have lenient absentee systems
  - Some people are legitimately absent
- Security perspective: makes buying/coercion easy
  - Doesn't appear to currently be a big problem

Vote by web?

- An obvious next step
- But, further multiplies the threats
- No widespread use in US yet
- Unusual adversarial test in D.C. thoroughly compromised by U. Michigan team

DRE (touchscreen) voting

- "Direct-recording electronic": basically just a computer that presents and counts votes
- In US, touchscreen is predominant interface
  - Cheaper machines may just have buttons
- Simple, but centralizes trust in the machine

Adding an audit trail

- VVPAT: voter-verified paper audit trail
- DRE machine prints a paper receipt that the voter looks at
- Goal is to get the independence and verifiability of a paper marking system

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Trusted client problem

- Everything the voter knows is mediated by the machine
  - (For Internet or DRE without VVPAT)
- Must trust machine to present and record accurately
- A lot can go wrong
  - Especially if the machine has a whole desktop OS inside
  - Or a bunch of poorly audited custom code

Should we use DRE at all?

- One answer: no, that's a bad design
- More pragmatic: maybe we can make this work
  - DREs have advantages in cost, disability access
  - If we implemented them well, they should be OK
  - Challenge: evaluating them in advance

US equipment market

- Voting machines are low volume, pretty expensive
- But jurisdictions are cost-conscious
- Makers are mostly small companies
  - One was temporarily owned by the larger Diebold
- Big market pressures: regulations, ease of administration

Security ecosystem

- Voting fraud appears to be very rare
  - Few elections worth stealing
  - Important ones are watched closely
  - Stiff penalties deter in-US attackers
- Downside: No feedback from real attacks
- Main mechanism is certification, with its limitations

Diebold case study

- Major manufacturer in early 2000s
  - During a post-2000 purchasing boom
  - Since sold and renamed
- Thoroughly targeted by independent researchers
  - Impolitic statement, blood in the water
- Later state-authorized audits found comprehensive problems
  - Your reading: from California

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End-to-end integrity and verification

- Tabulation cannot be 100% public
- But how can we still have confidence in it?
- Cryptography to the rescue, maybe
  - Techniques from privacy systems, others
  - Adoption requires to be very usable

Commitment to values

- Two phases: commit, later open
  - Similar to one use of envelopes
- Binding property: can only commit to a single value
- Hiding property: value not revealed until opened

Randomized auditing

- How can I prove what's in the envelope without opening it?
- n envelopes, you pick one and open the rest
  - Chance $1/n$ of successful cheating
- Better protection with repetition

Election mix-nets

- Independent election authorities similar to remailers
- Multi-encrypt ballot, each authority shuffles and decrypts
- Extra twist: prove no ballots added or removed, without revealing permutation
  - Instance of "zero-knowledge proof"
- Privacy preserved as long as at least one authority is honest

Pattern voting attack

- Widely applicable against techniques that reveal whole (anonymized) ballots
- Even a single race, if choices have enough entropy
  - 3-choice IRV with 35 candidates: 15 bits
- Buyer says: vote first for Bob, then 2nd and 3rd for Kenny and Xavier
  - Chosen so ballot is unique

Fun tricks with paper: visual crypto

- Want to avoid trusted client, but voters can't do computations by hand
- Analogues to crypto primitives using physical objects
- One-time pad using transparencies:

Scantegrity II

- Designed as end-to-end add-on to optical scan system
- Fun with paper 2: invisible ink
- Single trusted shuffle
  - Checked by random audits of commitments