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 → 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 website 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.

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

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

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. 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
- 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 → copy from real emails
  - URL → homograph attacks
  - SSL “lock” icon → 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
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

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