CSci 5271
Introduction to Computer Security
Tor and usability combined lecture

Stephen McCamant
University of Minnesota, Computer Science & Engineering

Outline

Tor: an overlay network

- Tor (originally from "the onion router")
  - `https://www.torproject.org/`
- An anonymous network built on top of the non-anonymous Internet
- Designed to support a wide variety of anonymity use cases

Low-latency TCP applications

- Tor works by proxying TCP streams
  - (And DNS lookups)
- Focuses on achieving interactive latency
  - WWW, but potentially also chat, SSH, etc.
  - Anonymity tradeoffs compared to remailers

Tor Onion routing

- Stream from sender to D forwarded via A, B, and C
  - One Tor circuit made of four TCP hops
- Encrypt packets (512-byte "cells") as $\mathrm{E}_{\mathrm{A}}(\mathrm{B}, \mathrm{E}_{\mathrm{B}}(\mathrm{C}, \mathrm{E}_{\mathrm{C}}(\mathrm{D}, \mathrm{P})))$
- TLS-like hybrid encryption with "telescoping" path setup

Client perspective

- Install Tor client running in background
- Configure browser to use Tor as proxy
  - Or complete Tor+Proxy+Browser bundle
- Browse web as normal, but a lot slower
  - Also, sometimes `google.com` is in Swedish

Entry/guard relays

- "Entry node": first relay on path
- Entry knows the client's identity, so particularly sensitive
  - Many attacks possible if one adversary controls entry and exit
- Choose a small random set of "guards" as only entries to use
  - Rotate slowly or if necessary
- For repeat users, better than random each time

Exit relays

- Forwards traffic to/from non-Tor destination
- Focal point for anti-abuse policies
  - E.g., no exits will forward for port 25 (email sending)
- Can see plaintext traffic, so danger of sniffing, MITM, etc.

Centralized directory

- How to find relays in the first place?
- Straightforward current approach: central directory servers
- Relay information includes bandwidth, exit polices, public keys, etc.
- Replicated, but potential bottleneck for scalability and blocking

Outline

Tor basics

Tor experiences and challenges

Usability and security

Usable security example areas

Anonymity loves company

- Diverse user pool needed for anonymity to be meaningful
  - Hypothetical Department of Defense Anonymity Network
- Tor aims to be helpful to a broad range of (sympathetic sounding) potential users

Who (arguably) needs Tor?

- Consumers concerned about web tracking
- Businesses doing research on the competition
- Citizens of countries with Internet censorship
- Reporters protecting their sources
- Law enforcement investigating targets

Tor and the US government

- Onion routing research started with the US Navy
- Academic research still supported by NSF
- Anti-censorship work supported by the State Department
  - Same branch as Voice of America
- But also targeted by the NSA
  - Per Snowden, so far only limited success

Volunteer relays

- Tor relays are run basically by volunteers
  - Most are idealistic
  - A few have been less-ethical researchers, or GCHQ
- Never enough, or enough bandwidth
- P2P-style mandatory participation?
  - Unworkable/undesirable
- Various other kinds of incentives explored

Performance

- Increased latency from long paths
- Bandwidth limited by relays
- Recently 1-2 sec for 50KB, 3-7 sec for 1MB
- Historically worse for many periods
  - Flooding (guessed botnet) fall 2013

Anti-censorship

- As a web proxy, Tor is useful for getting around blocking
- Unless Tor itself is blocked, as it often is
- *Bridges* are special less-public entry points
- Also, protocol obfuscation arms race (uneven)

Hidden services

- Tor can be used by servers as well as clients
- Identified by cryptographic key, use special rendezvous protocol
- Servers often present easier attack surface

Undesirable users

- P2P filesharing
  - Discouraged by Tor developers, to little effect
- Terrorists
  - At least the NSA thinks so
- Illicit e-commerce
  - "Silk Road" and its successors

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 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

Traffic confirmation attacks

- If the same entity controls both guard and exit on a circuit, many attacks can link the two connections
  - "Traffic confirmation attack"
  - Can't directly compare payload data, since it is encrypted
- Standard approach: insert and observe delays
- Protocol bug until recently: covert channel in hidden service lookup

Hidden service traffic conf.

- Bug allowed signal to guard when user looked up a hidden service
  - Non-statistical traffic confirmation
- For 5 months in 2014, 115 guard nodes (about 6%) participated in this attack
  - Apparently researchers at CMU's SEI/CERT
- Beyond "research," they also gave/sold info. to the FBI
  - Apparently used in Silk Road 2.0 prosecution, etc.

Outline

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 basics

Tor experiences and challenges

Usability and security

Usable security example areas

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

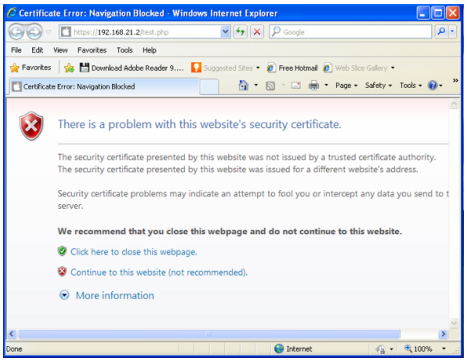
Phishing defenses

- 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

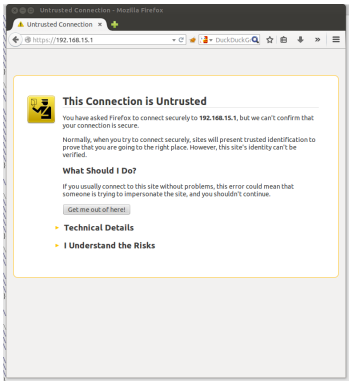
Older SSL warning



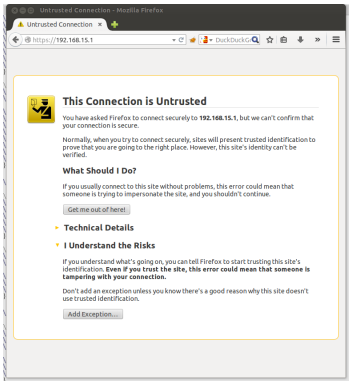
SSL warnings: effectiveness

- 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

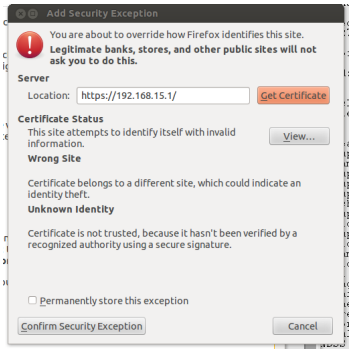
Modern Firefox warning



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

Trusted UI for privileged actions

- Trusted UI works better when asking permission (e.g., Oakland'12)
- Say, "take picture" button in phone app
  - Requested by app
  - Drawn and interpreted by OS
  - OS well positioned to be sure click is real
- Little value to attacker in drawing fake button