

CSci 5271
Introduction to Computer Security
Day 23: Anonymizing the network

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Outline

Anonymous communications techniques

Announcements intermission

Tor basics

Tor experiences and challenges

Traffic analysis

- What can you learn from encrypted data? A lot
- Content size, timing
- Who's talking to who
 - countermeasure: anonymity

Nymity slider (Goldberg)

- Verinymity
 - Social security number
- Persistent pseudonymity
 - Pen name ("George Eliot"), "moot"
- Linkable anonymity
 - Frequent-shopper card
- Unlinkable anonymity
 - (Idealized) cash payments

Nymity ratchet?

- It's easy to add names on top of an anonymous protocol
- The opposite direction is harder
- But, we're stuck with the Internet as is
- So, add anonymity to conceal underlying identities

Steganography

- One approach: hide real content within bland-looking cover traffic
- Classic: hide data in least-significant bits of images
- Easy to fool casual inspection, hard if adversary knows the scheme

Dining cryptographers



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Dining cryptographers

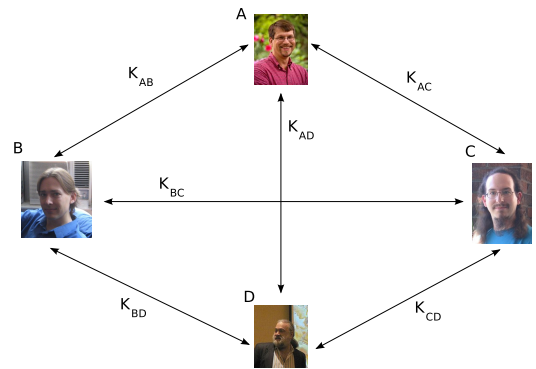


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Dining cryptographers

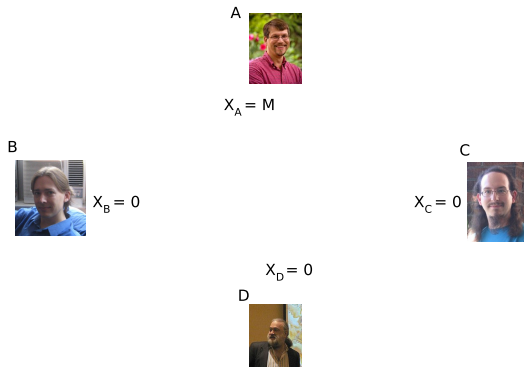


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Dining cryptographers

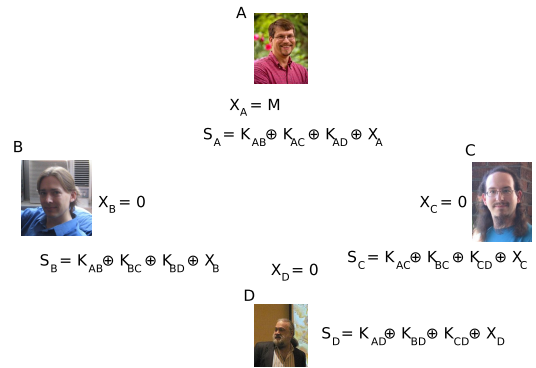


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Dining cryptographers

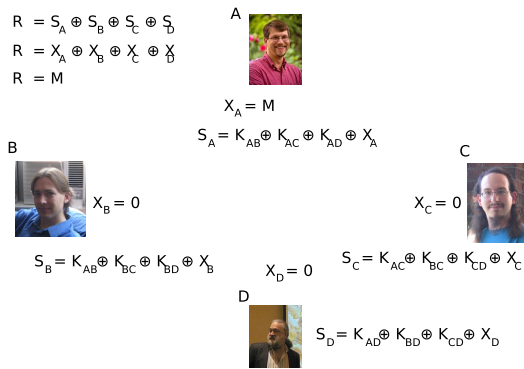


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DC-net challenges

- Quadratic key setups and message exchanges per round
- Scheduling who talks when
- One traitor can anonymously sabotage
- Improvements subject of ongoing research

Mixing/shuffling

- Computer analogue of shaking a ballot box, etc.
- Reorder encrypted messages by a random permutation
- Building block in larger protocols
- Distributed and verifiable variants possible as well

Anonymous remailers

- Anonymizing intermediaries for email
 - First cuts had single points of failure
- Mix and forward messages after receiving a sufficiently-large batch
- Chain together mixes with multiple layers of encryption
- Fancy systems didn't get critical mass of users

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Upcoming events

- Progress meetings starting next week
 - Please send list of available times by tonight
- Exercise set 4 next Tuesday

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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 $E_A(B, E_B(C, E_C(D, P)))$
- 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 policies, public keys, etc.
- Replicated, but potential bottleneck for scalability and blocking

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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
- Currently 1-2 sec for 50KB, 5-10 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 (currently behind)

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 last year: 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.

Next time

- How usability affects security