CIS 551 / TCOM 401

Computer and Network Security

Spring 2009

Lecture 21

Announcements

- Plan for Today:
  - Human Authentication
  - Anonymity

- Project 4 is due 28 April 2009 at 11:59 pm
  - Available on the web

- Final exam has been scheduled:
  Friday, May 8, 2009
  9:00am – 11:00am, Moore 216

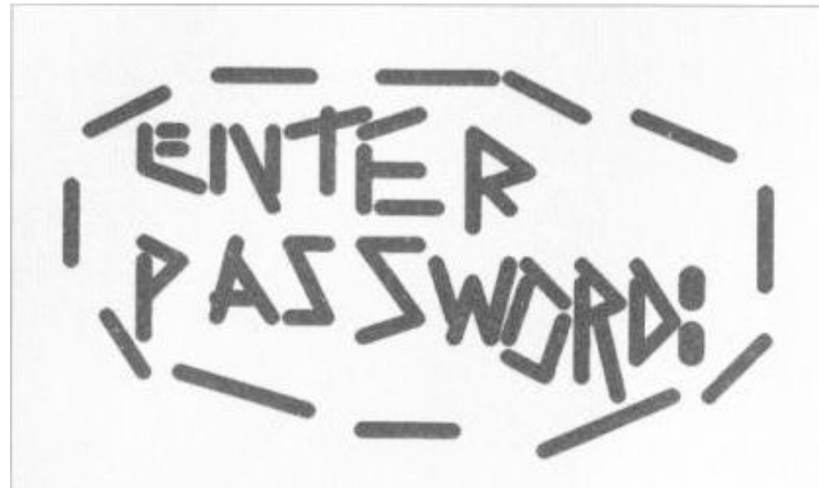
Identifying a particular human

- Human Authentication is based on one or more of the following:
- Something you know
  - password
- Something you have
  - driver's license, Penn Card
- Something inherent about you
  - Biometrics, location

Passwords

- Shared code/phrase
- Client sends to authenticate

- Simple, right?
- How do you…
  - Establish them to begin with?
  - Stop them from leaking?
  - Stop them from being guessed?



SOURCE: NASA

Prime Mover Problem

- Out of band
  - Physical mail
  - Email
  - Attached to the box
- Piggybacking
  - Swipe Penn Card to make PennKey
  - But where does the chain stop?
    - Penn Card -> drivers license -> birth certificate

Leaks & Challenges

- Social engineering
- Managing large numbers of passwords:
  - Writing the password down on paper
  - Storing it in an electronic "safe"
  - Using a web browsers 'remember this password' feature
- Legal and responsibility
  - Shared password == shared liability

Guessing

- The "no such user" mistake
  - Gives an attacker information about usernames
- The "here's who we are" mistake
  - Gives an attacker information about who might have an account
- Common words, phrases for passwords
- Null passwords, "password", username, backwards, etc.
- Dictionary attacks

- How bad is it?

1979 Survey of 3,289 Passwords

- With no constraints on choice of password, Morris and Thompson got the following results:
  - 15 were a single ASCII letter.
  - 72 were strings of two ASCII letters.
  - 464 were strings of three ASCII letters.
  - 47 were strings of four alphanumerics.
  - 706 were five letters, all upper-case or all lower-case.
  - 605 were six letters, all lower case.

1990s Surveys of 15K Passwords

- Klein (1990) and Spafford (1992)
  - 2.7% guessed in 15 minutes
  - 21% in a week
  - Sounds ok? Not if the passwords last 30 days
- Tricks
  - Letter substitutions, words backwards, common names, patterns, etc.
  - Anything you can think of off the top of your head, a hacker can think of too
- Lazy users!
  - Weakest link is always the way of the attack

More Recent Password Surveys

- 2009:
  - ~33% of users have one password for all web sites
  - ~48% of users have multiple passwords
  - ~19% of users have unique password for each site

- 2005 survey by RSA Inc:
  - ~28% IT employees must remember > 13 passwords
  - ~30% IT employees have 6 – 12 passwords

- 2003: Users will give away their password for a cheap gift.

Heuristics for Guessing Attacks

- The dictionary with the words spelled backwards
- A list of first names (best obtained from some mailing list). Last names, street names, and city names also work well.
- The above with initial upper-case letters.
- All valid license plate numbers in your state. (About 5 hours work in 1979 for New Jersey.)
- Room numbers, social security numbers, telephone numbers, and the like.
- Sports teams, etc.

What makes a good password?

- Password Length
  - 64 bits of randomness is hard to crack
  - 64 bits is roughly 20 “common” ASCII characters
  - But… People can’t remember random strings
  - Longer not necessarily better: people write the passwords down
- Pass phrases
  - English Text has roughly 1.3 random bits/char.
  - Thus about 50 letters of English text
  - Hard to type without making mistakes!
- In practice
  - Non-dictionary, mixed case, mixed alphanumeric
  - Not too short (or too long) 8 - 12 characters
  - Tools that check password strength
    - http://www.microsoft.com/protect/yourself/password/checker.mspx
    - http://www.fastcrack.com/pwcheck.html

Hacks on plaintext password file

- Is the password file readable by the OS?
  - Then if I break the OS
- Can privileged users see the file?
  - … and make copies
- Is the file backed up somewhere
  - … insecure?
- Is the file/password in plaintext somewhere in memory?
  - Core dump
- Fool the user
  - A program that masquerades as the authentication program

Counter-hacks

- Control-Alt-Del for logging in
  - Establishes a "trusted path" in hardware
  - Prevents trojan horses from intercepting passwords
- Slow down / restrict number of tries
  - Make guessing take too long
  - e.g. 3 tries and you're blocked for 30 seconds
- Encrypt the password file
  - “Salt" - to prevent duplicates
  - Use one way hashes or encryptions on the passwords

Add Salt

- "Salt" the passwords by adding random bits.
  - Decreases the likelihood that two identical passwords will appear as identical entries in the password file.
- 12 bit salt results in 4,096 versions of each password.
- Unix: /etc/passwd entry:

user_id	$salt_u$	$Hash(salt_u + passwd_u)$	…

- Modern implementations use so-called *shadow* password files /etc/shadow that aren't world readable.

One Time Passwords

- Shared lists.
- Sequentially updated.
- One-time password sequences based on a one-way (hash) function.

- "Dongles"
  - Small devices that generate a sequence of random numbers from a secret seed.
  - Synchronized with the remote location when the dongle is assigned to a user
  - Often requires a pin or other password for local authentication
  - Can be stolen or lost!

Hash-based 1-time Passwords

- Alice identifies herself to verifier Bart using a well-known one-way hash function H.

- One-time setup.
  - Alice chooses a secret w.
  - Fixes a constant t for the number of times the authentication can be done.
  - Alice securely transfers $H^t(w)$ to Bart

$$\underbrace{H(H(H\ldots(H(w))}_{t \text{ times}}\ldots))$$

Hash-based 1-time Passwords

- Protocol actions. For session i, claimant A does the following to identify itself:
  - A computes w' = $H^{(t-i)}(w)$ and transmits the value to B.
  - B checks that i is the correct session (i.e. that the previous session was i-1) and checks to see if H(v) = w' where v was the last value provided by A (as part of session i-1).
  - B saves w' and i for use in the next session.

- It's hard to compute x from H(x).
  - Even though attacker gets to see $H^{(t-i)}(x)$, they can't guess then next message $H^{(t-(i+1))}(x)$.

One-time passwords: i^{th} authentication

Alice

$\{A, i, H^{(t-i)}(w)\}$ →

Bart

W
H(-)

$H^{(t-i+1)}(w)$,
H(-)

- Alice does the following to identify herself:
  - A computes w' = $H^{(t-i)}(w)$ and transmits the value to B.
  - B checks that i is the correct session (i.e.. that the previous session was i-1) and checks to see if H(w') = v where v was the last value provided by A (as part of session i-1).
  - B saves w' and i for use in the next session.

S/Key Passwords

- Hash-based one-time authentication used in practice
  - RFC 1760 / 2289
- Internally, S/Key uses 64 bit numbers
- For human use, each 64 bit number is mapped to 6 short words:
  - Example: "ROY HURT SKI FAIL GRIM KNEE"
- Should be used in conjunction with other encryption to prevent man-in-the-middle attacks

Biometrics

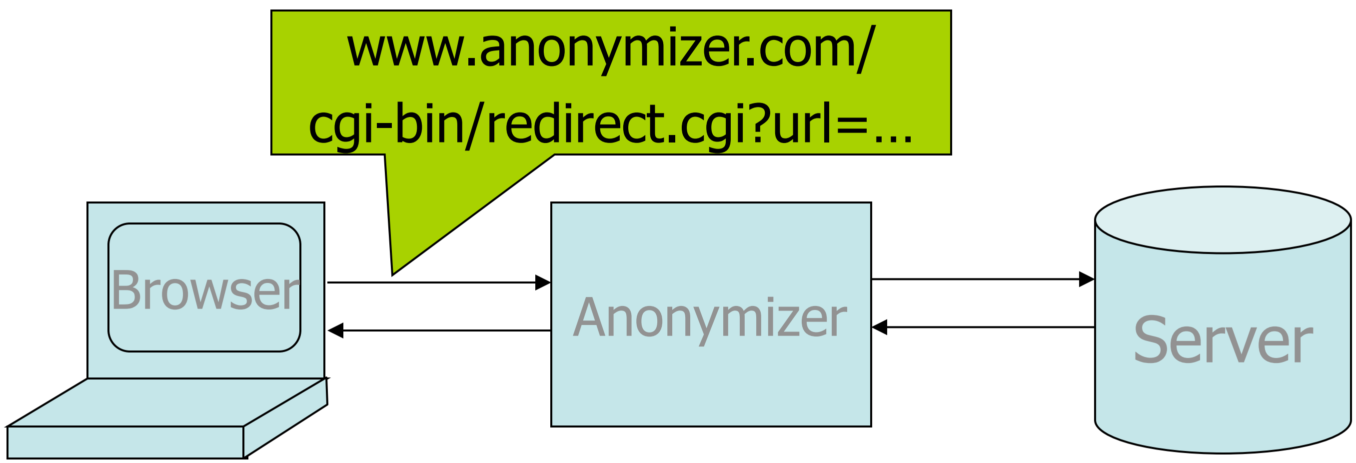
- Fingerprints:
  - Scanner gets geometry of identifiable features on the fingerprint
  - Used in laptops, some high-end PDAs
  - Requires clean hands
- Face recognition:
  - Identifies features like distance between eyes, nose width, etc. to generate a set of numbers
  - Can work even from a distance via a camera
- Retinal image:
  - Pattern of blood vessels at the back of the eye
  - Scanning takes ~15 seconds of looking into the scanner
  - Used in military and government installations
- Iris scan, voice analysis, signature, hand print

Anonymity?

- Sender anonymity:
  - The identity of the sender is hidden, while the receiver (and message) might not be
- Receiver anonymity:
  - The identity of the receiver is hidden (message and sender might not be)
- Unlinkability of sender and receiver:
  - Although the sender and receiver can be identified as participating in communication, they cannot be identified as communicating *with each other*.

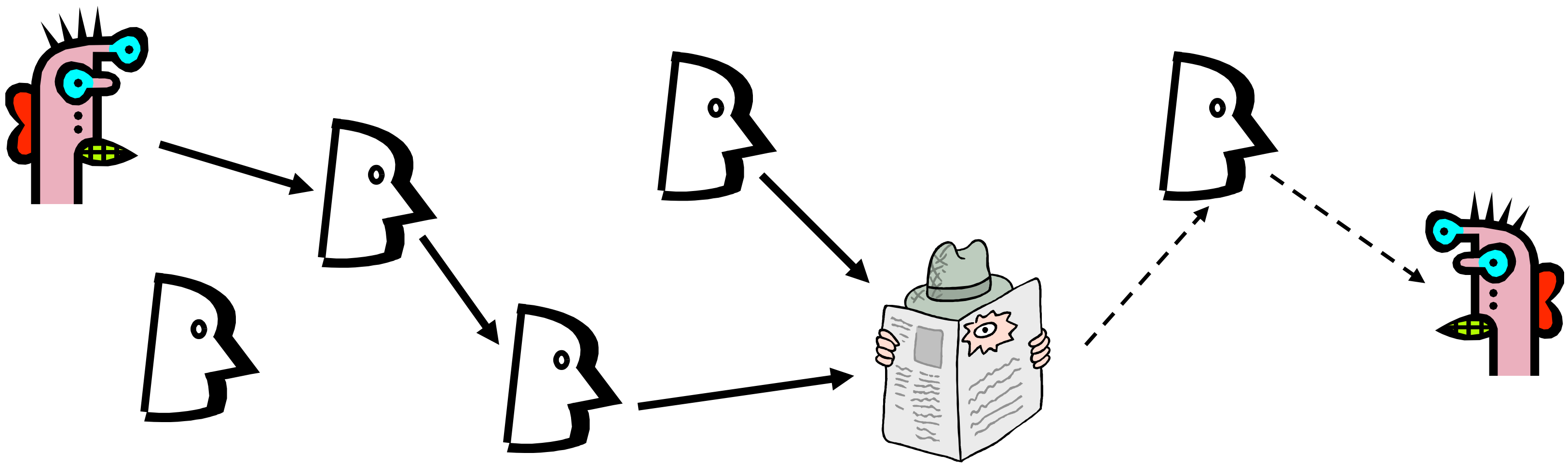
Browsing Anonymizers

- Anonymizer.com
- Web Anonymizer hides your IP address



- What does anonymizer.com know about you?

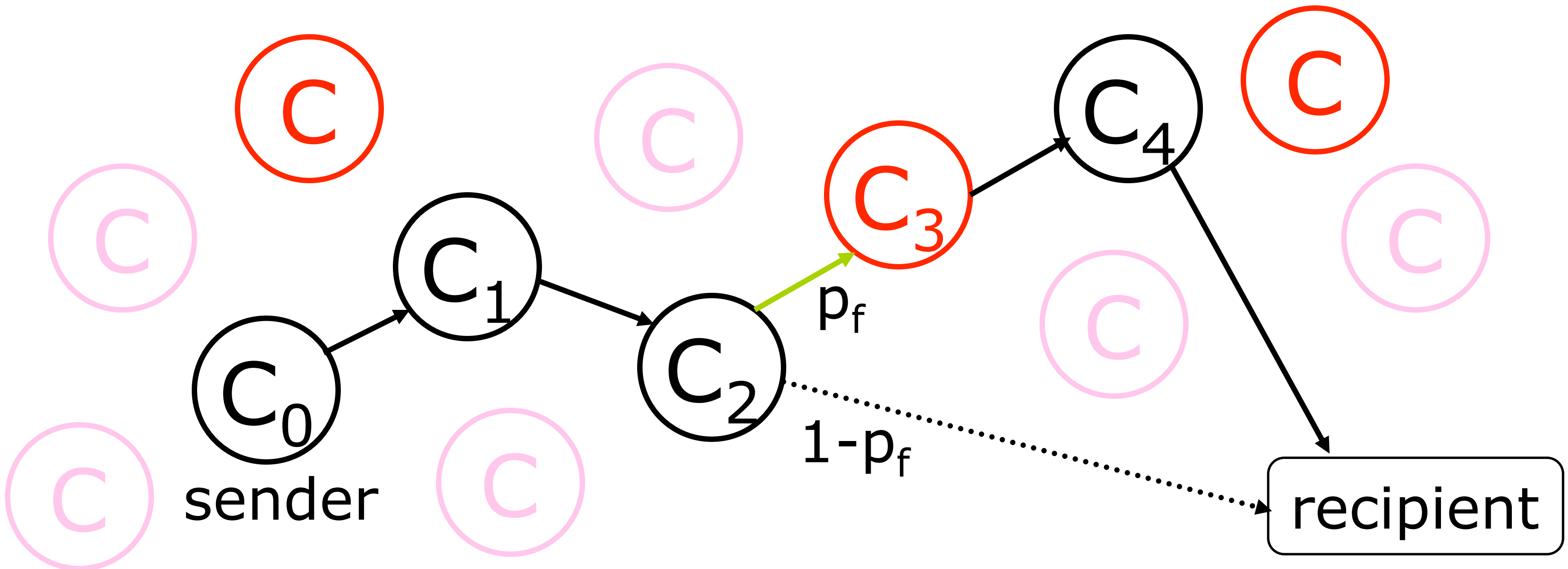
Related approach to anonymity



- Hide source of messages by routing them randomly
- Routers don't know for sure if the apparent source of the message is the actual sender or simply another router
  - Only secure against local attackers!
- Existing systems: Freenet, Crowds, etc.

Crowds

http://avirubin.com/crowds.pdf [Reiter,Rubin '98]



- Sender randomly chooses a path through the crowd
- Some routers are honest, some corrupt
- After receiving a message, honest router flips a coin
  - With probability P_f routes to the next member on the path
  - With probability $1- P_f$ sends directly to the recipient

What Does Anonymity Mean?

- Degree of anonymity:
  - Ranges from absolute privacy to provably exposed
- Beyond suspicion
  - The observed source of the message is no more likely to be the actual sender than anybody else
- Probable innocence
  - Probability <50% that the observed source of the message is the actual sender

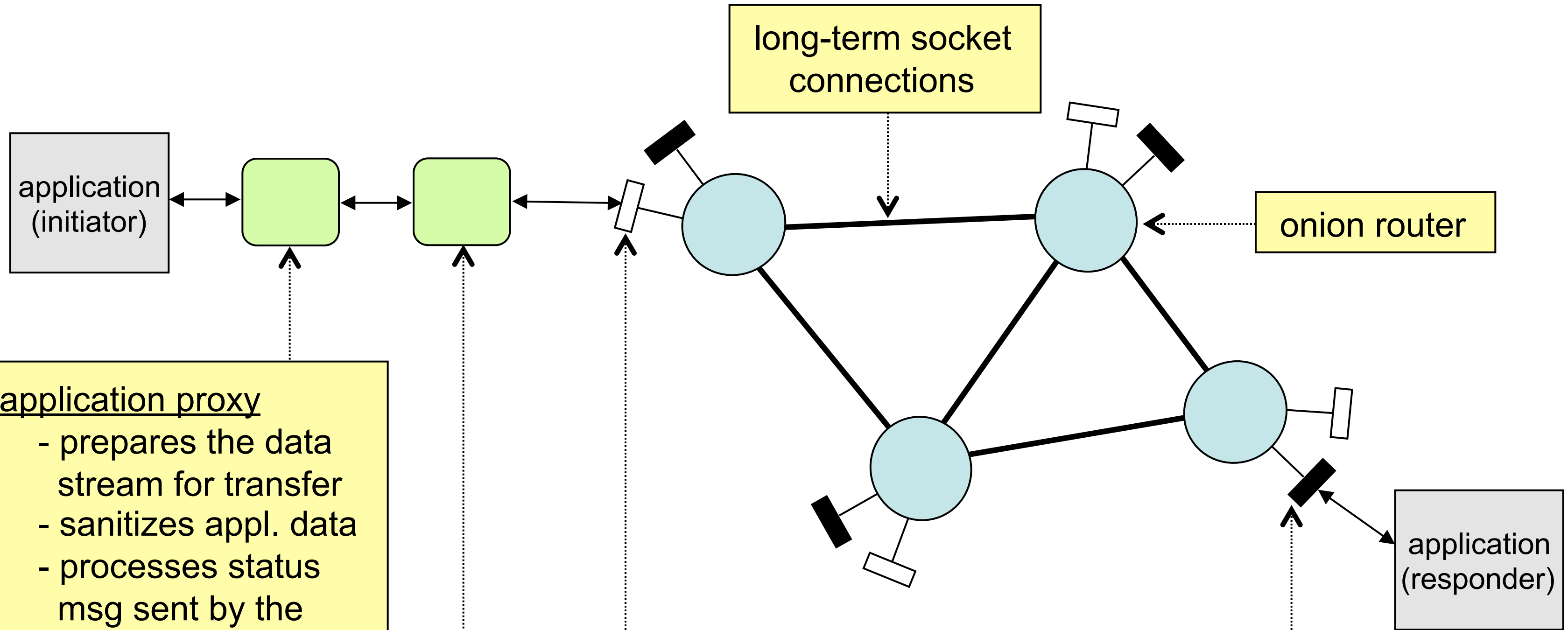
Guaranteed by Crowds if there are sufficiently few corrupt routers

- Possible innocence
  - Non-trivial probability that the observed source of the message is not the actual sender

A real-time MIX network – Onion routing

- general purpose infrastructure for anonymous communications over a public network (e.g., Internet)
- supports several types of applications (HTTP, FTP, SMTP, rlogin, telnet, …) through the use of application specific proxies
- operates over a (logical) network of onion routers
  - onion routers are real-time Chaum MIXes (messages are passed on nearly in real-time → this may limit mixing and weaken the protection!)
  - onion routers are under the control of different administrative domains → makes collusion less probable
- anonymous connections through onion routers are built dynamically to carry application data
- distributed, fault tolerant, and secure

Overview of OR architecture



<u>application proxy</u>
- prepares the data stream for transfer
- sanitizes appl. data
- processes status msg sent by the exit funnel

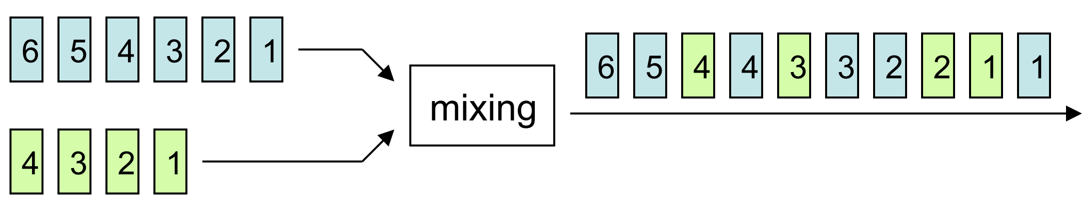
<u>onion proxy</u>
- opens the anonymous connection via the OR network
- encrypts/decrypts data

<u>entry funnel</u>
- multiplexes connections from onion proxies

<u>exit funnel</u>
- demultiplexes connections from the OR network
- opens connection to responder application and reports a one byte status msg back to the application proxy

OR network setup and operation

- long-term socket connections between "neighboring" onion routers are established → links
- neighbors on a link setup two DES keys using the Station-to-Station protocol (one key in each direction)
- several anonymous connections are multiplexed on a link
  - connections are identified by a connection ID (ACI)
  - an ACI is unique on a link, but not globally
- every message is fragmented into fixed size *cells* (48 bytes)
- cells are encrypted with DES in OFB mode (null IV)
  - optimization: if the payload of a cell is already encrypted (e.g., it carries (part of) an onion) then only the cell header is encrypted
- cells of different connections are mixed, but order of cells of each connection is preserved



Anonymous connection setup

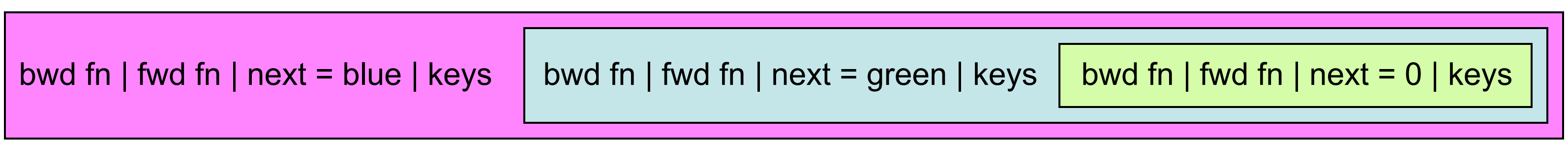
- the application is configured to connect to the application proxy instead of the real destination
- upon a new request, the application proxy
  - decides whether to accept the request
  - opens a socket connection to the onion proxy
  - passes a *standard structure* to the onion proxy
  - standard structure contains
    - application type (e.g., HTTP, FTP, SMTP, …)
    - retry count (number of times the exit funnel should retry connecting to the destination)
    - format of address that follows (e.g., NULL terminated ASCII string)
    - address of the destination (IP address and port number)
  - waits response from the exit funnel before sending application data

Anonymous connection setup (2)

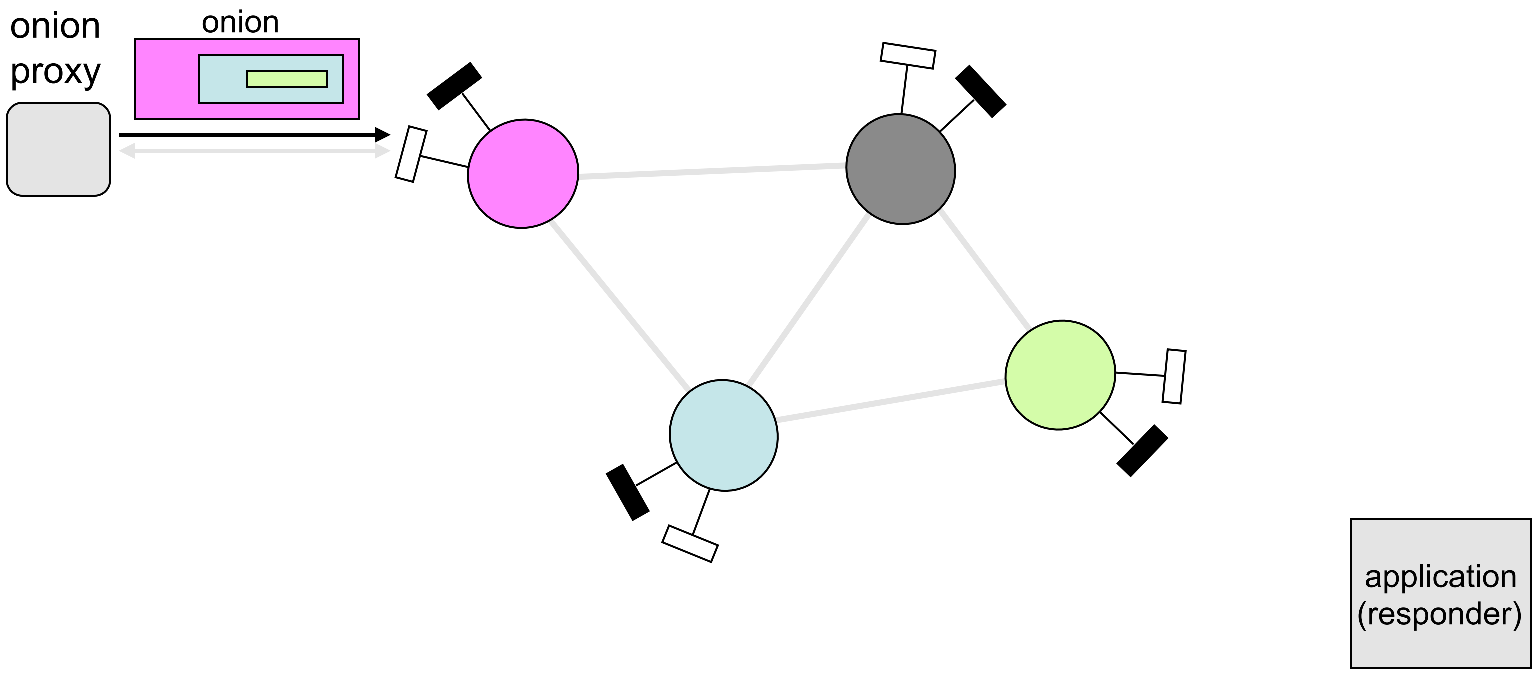
- upon reception of the standard structure, the onion proxy
  - decides whether to accept the request
  - establishes an anonymous connection through some randomly selected onion routers by constructing and passing along an *onion*
  - sends the standard structure to the exit funnel of the connection
  - after that, it relays data back and forth between the application proxy and the connection
- upon reception of the standard structure, the exit funnel
  - tries to open a socket connection to the destination
  - it sends back a one byte status message to the application proxy through the anonymous connection (in backward direction)
  - if the connection to the destination cannot be opened, then the anonymous connection is closed
  - otherwise, the application proxy starts sending application data through the onion proxy, entry funnel, anonymous connection, and exit funnel to the destination

Onions

- an onion is a multi-layered data structure
- it encapsulates the route of the anonymous connection within the OR network
- each layer contains
  - backward crypto function (DES-OFB, RC4)
  - forward crypto function (DES-OFB, RC4)
  - IP address and port number of the next onion router
  - expiration time
  - key seed material
    - used to generate the keys for the backward and forward crypto functions
- each layer is encrypted with the public key of the onion router for which data in that layer is intended



Anonymous connection setup



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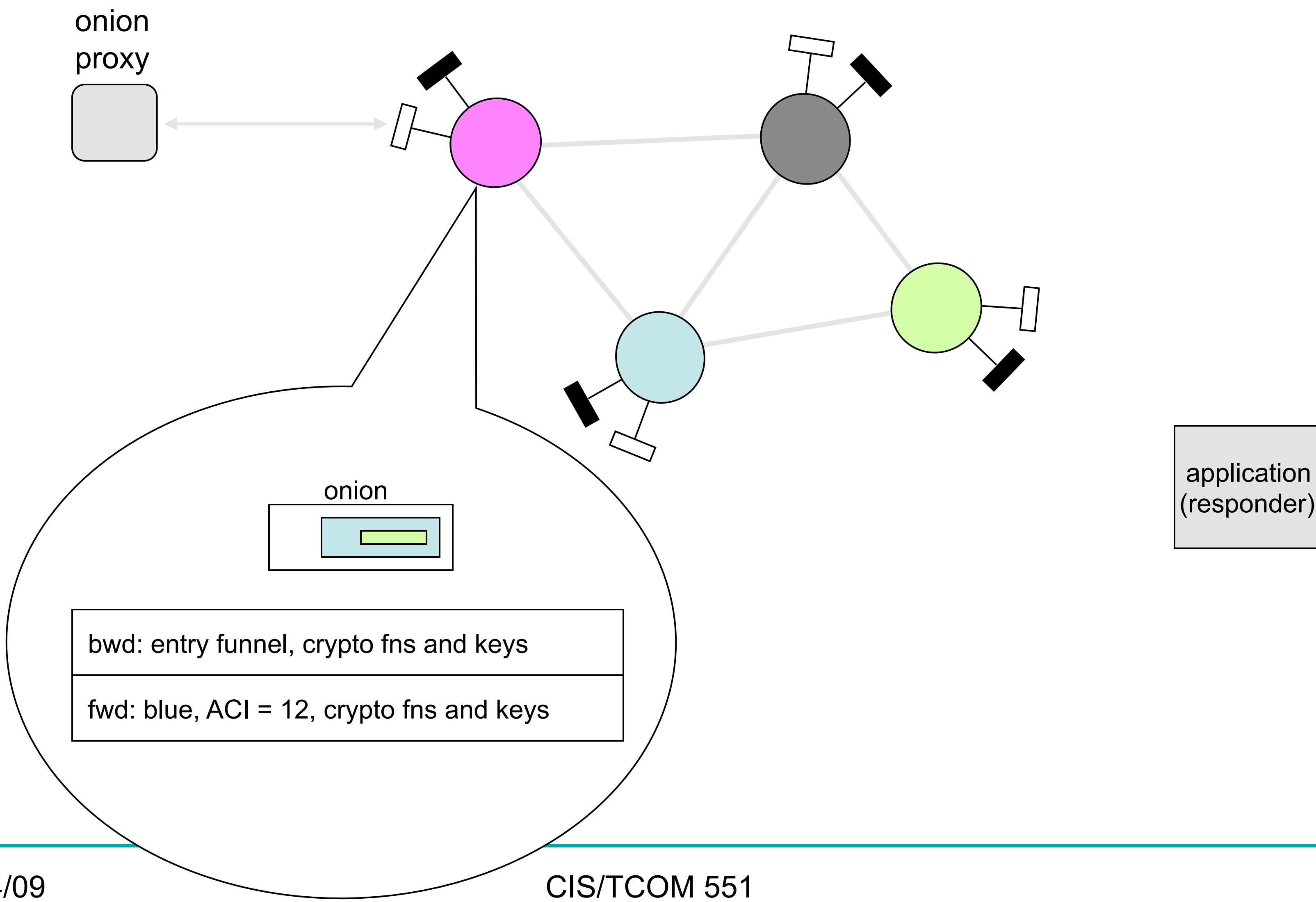

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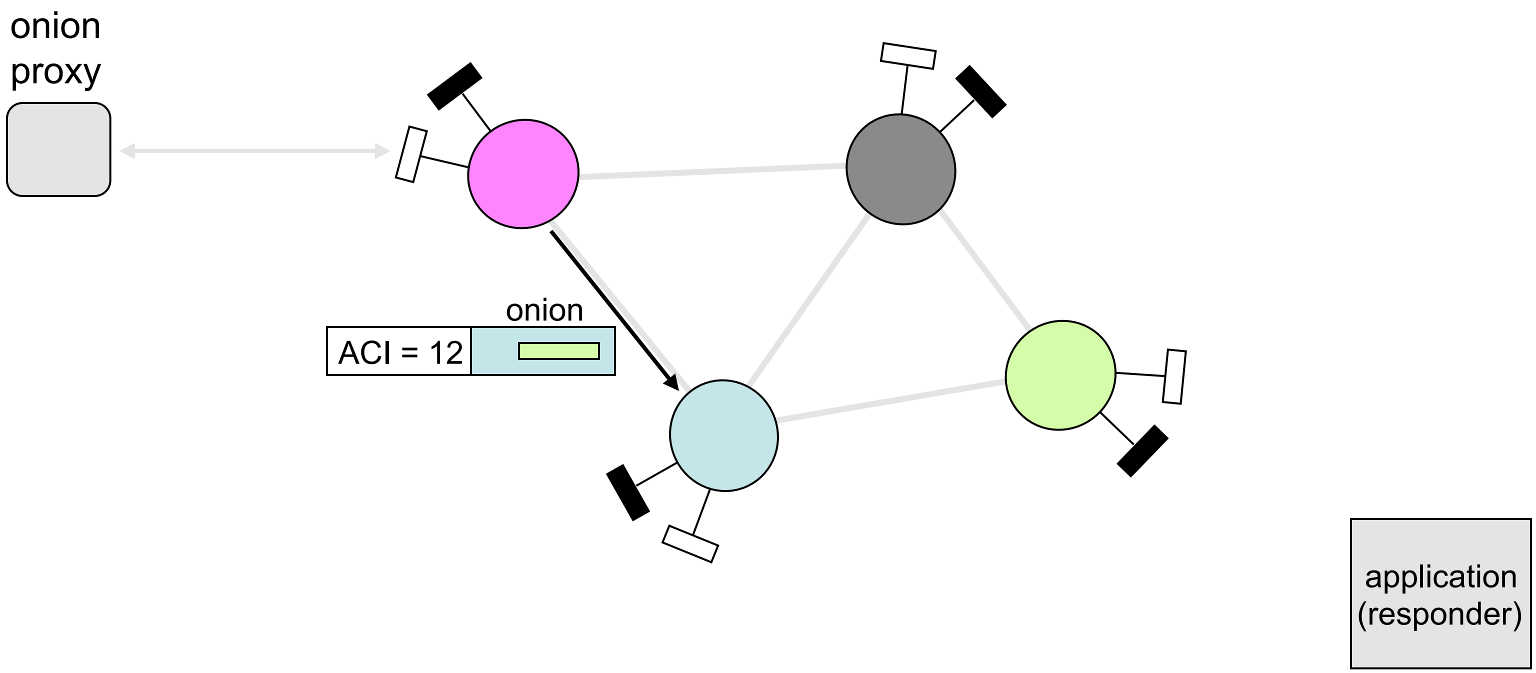

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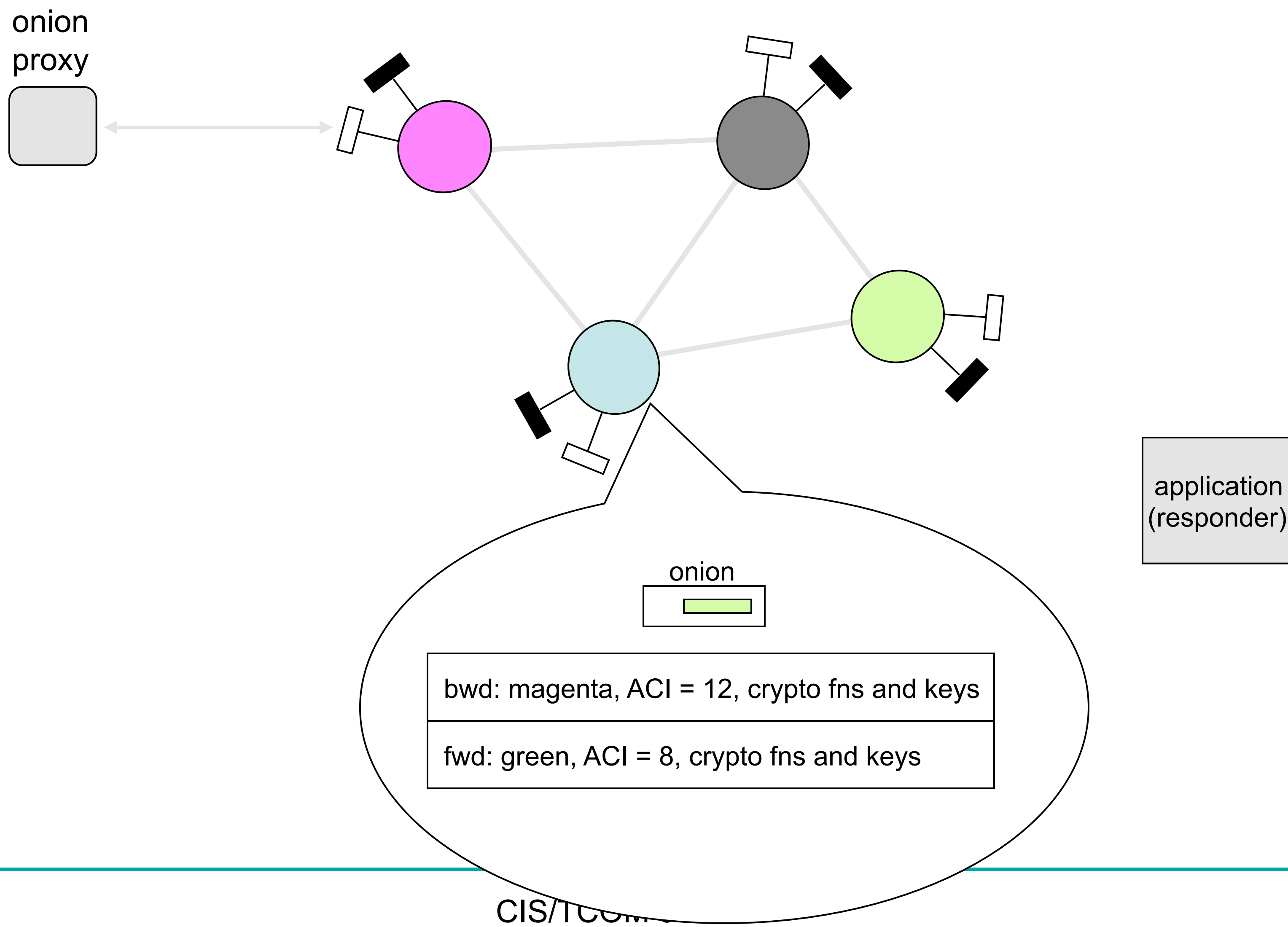

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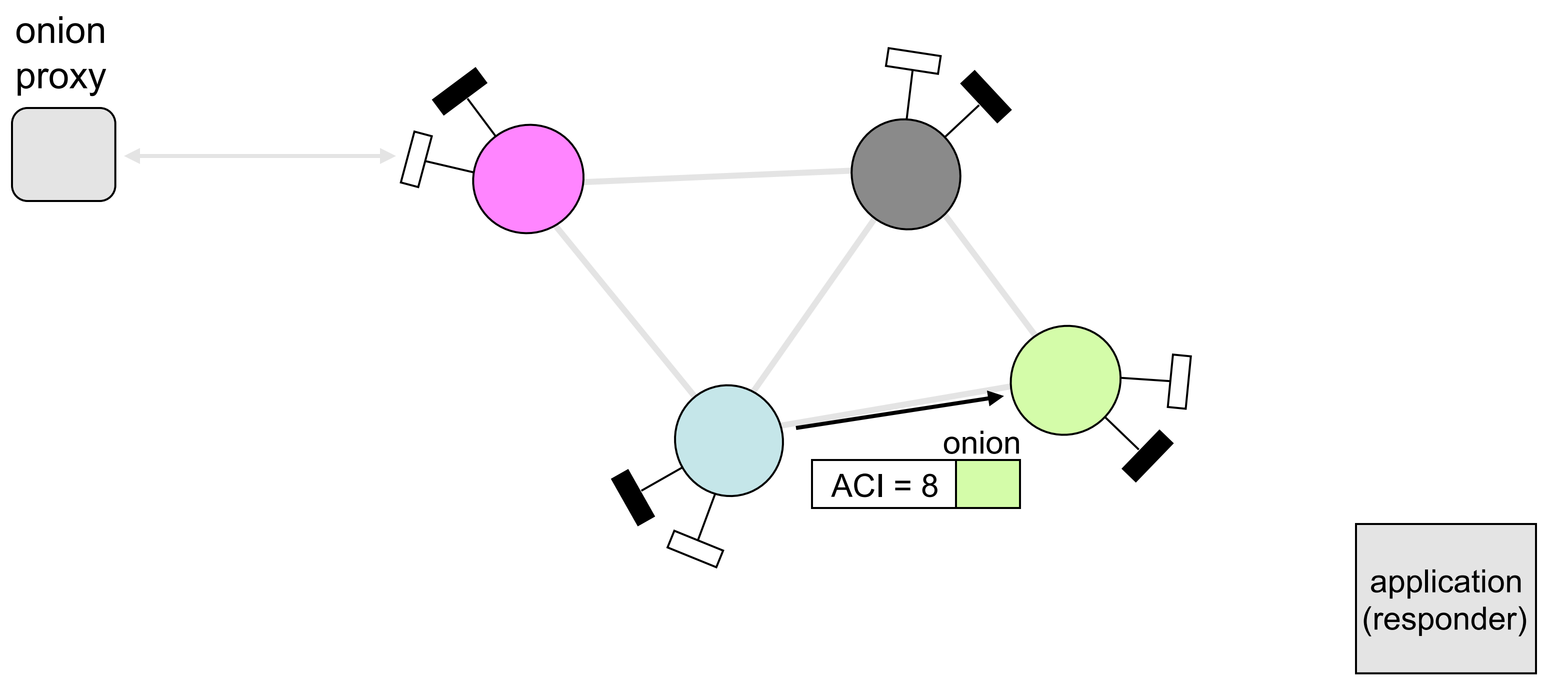

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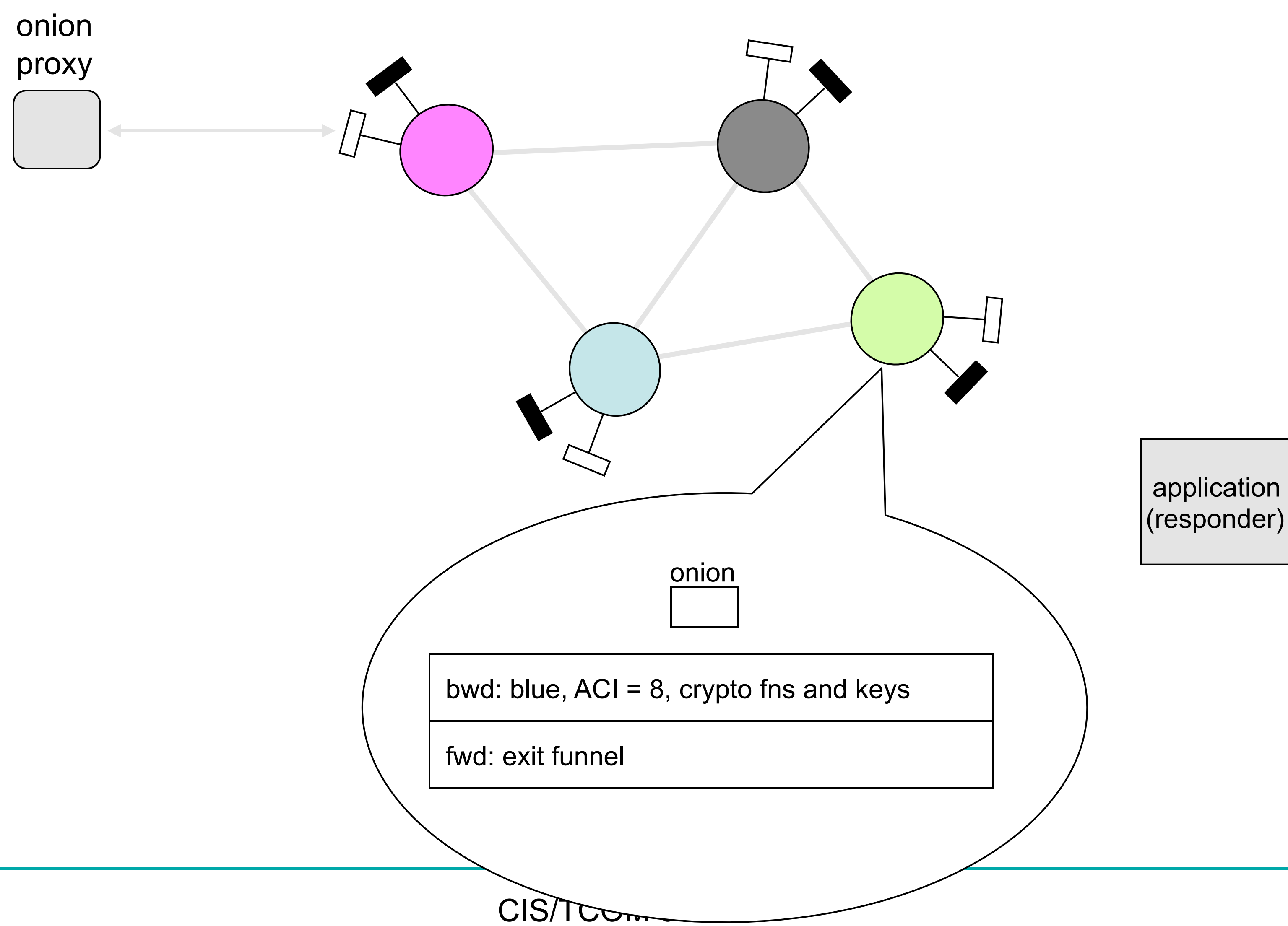

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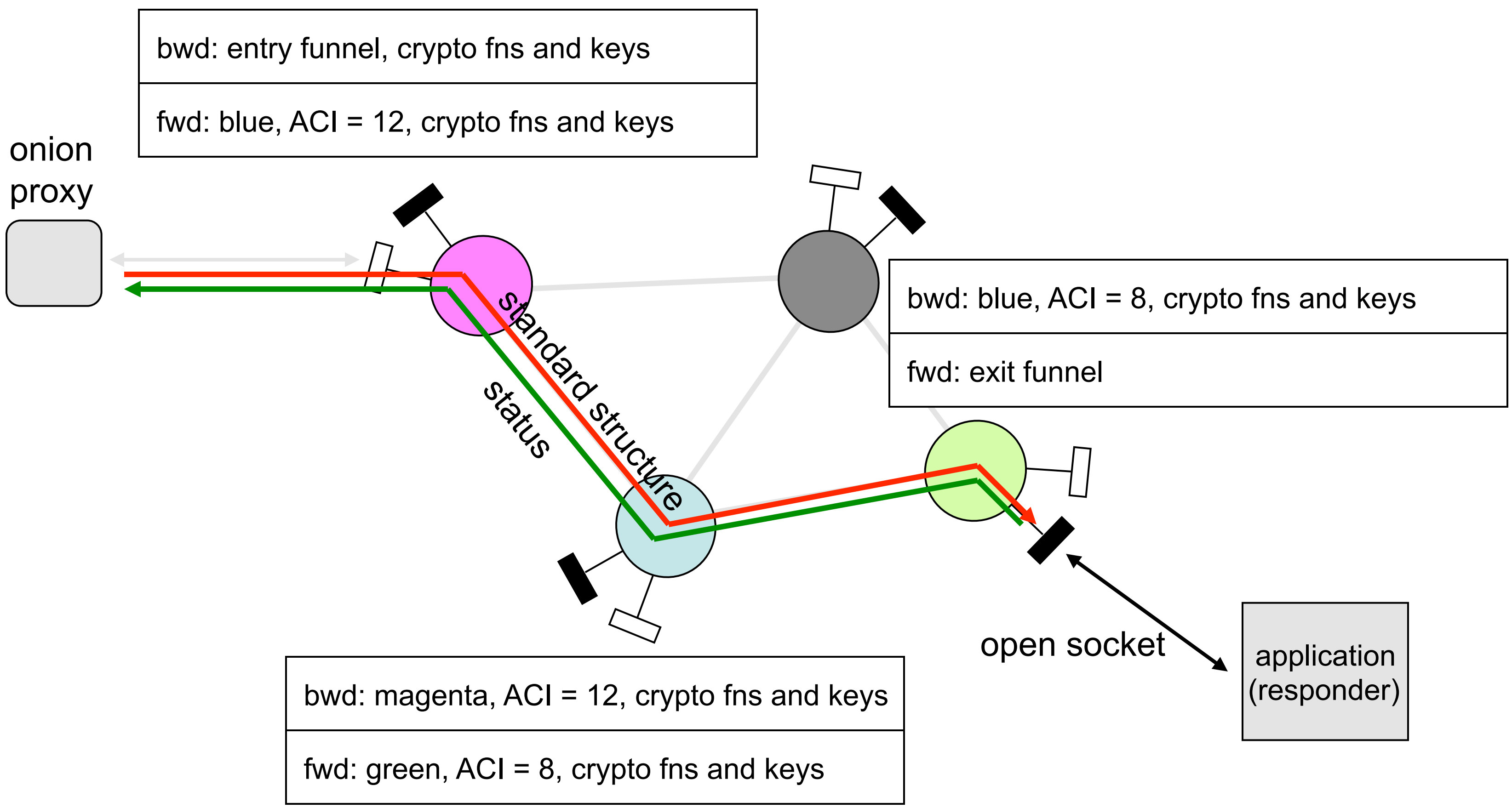

Data movement

- forward direction
  - the onion proxy adds all layers of encryption as defined by the anonymous connection
  - each onion router on the route removes one layer of encryption
  - responder application receives plaintext data
- backward direction
  - the responder application sends plaintext data to the last onion router of the connection (due to sender anonymity it doesn’t even know who is the real initiator application)
  - each onion router adds one layer of encryption
  - the onion proxy removes all layers of encryption