# public key distribution

## certificates, passwords

slides
**bit.ly/cs161-disc**

feedback
**bit.ly/extended-feedback**

# hack of the day

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- [Trusted Platform Module 2.0, billions of PCs/IoT]
    - “crypto-processor” to store hardware-secured cryptographic functions
    - out of bounds read/write vulnerabilities are “the result of a lack of necessary length checks, resulting in buffer overflows that could pave the way for local information disclosure or escalation of privileges.”

# general questions, concerns, etc.

PRNGs → rollback resistance

↳ if internal state compromised, can't get past states / outputs

↓

IND-CPA

↳ CBC

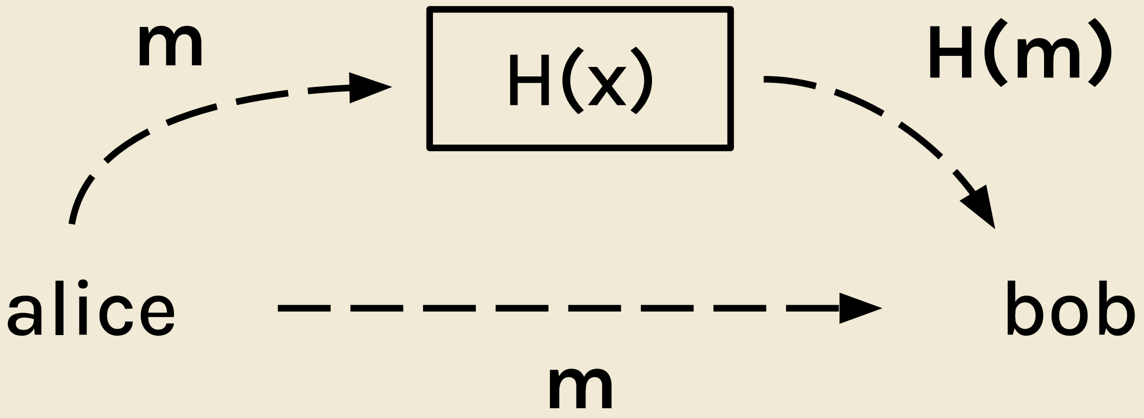
↳ CTR

IVs / nonce

# reminder: cryptography

- why?
  - secure communication
- goals:
  - confidentiality: adversary cannot <u>read</u> messages
  - integrity: adversary cannot <u>change</u> messages
  - authenticity: message is from the claimed author

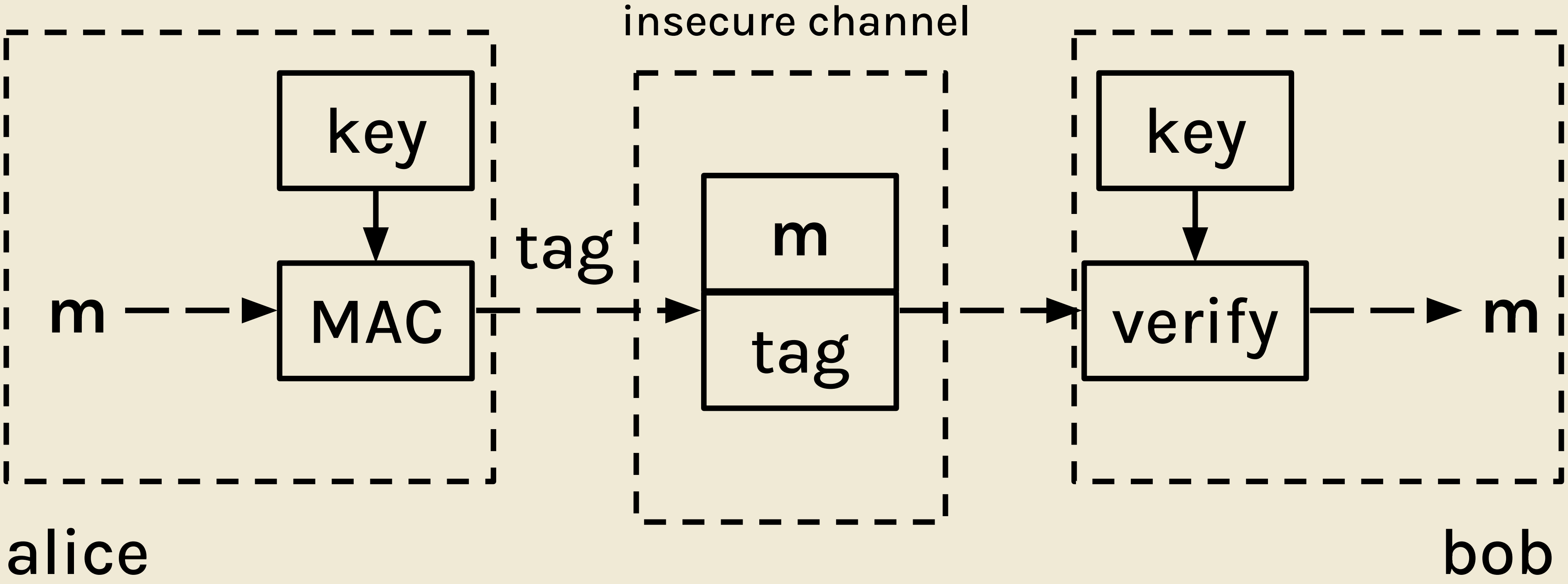
# recap: hashes and integrity




if the message is tampered with (and H(m) isn't), Bob can compute H(m) himself and make sure it matches the sent hash

# recap: message authentication codes

m: message



# recap: authenticated encryption (AE)

- MAC-then-encrypt: $\mathrm{Enc}(K1, M \,||\, \mathrm{MAC}(K2, M))$
- encrypt-then-MAC: $\mathrm{MAC}(K2, \mathrm{Enc}(K1, M))$
- which is better?
  - both are technically IND-CPA and EU-CPA
  - but MAC-then-encrypt requires decryption before tag verification
  - **always use encrypt-then-MAC**
    - more robust to mistakes

# diffie-hellman key exchange (lecture)

Public: $g, p$

Alice

Eve

Bob

Secret key

Public key

| Alice | Eve | Bob |
|---|---|---|
| Generate $a$ | | Generate $b$ |
| Calculate $g^a$ mod $p$ | $g^a$    $g^b$ | Calculate $g^b$ mod $p$ |
| Receive $g^b$ mod $p$ | | Receive $g^a$ mod $p$ |
| Calculate $(g^b)^a$ mod $p$ | | Calculate $(g^a)^b$ mod $p$ |
| $a, g^a, g^b \Rightarrow g^{ab}$ | $g^a, g^b \not\Rightarrow g^{ab}$ | $b, g^a, g^b \Rightarrow g^{ab}$ |

**Shared symmetric key is $g^{ab}$**

# RECAP
# public key crypto

# el gamal

- diffie-hellman, but with simultaneous encrypt
- Bob: private key $b$ and public key $B = g^b \bmod p$
- Alice: random $r$ and computes $R = g^r \bmod p$
- Alice sends $C_1 = R$, $C_2 = M \times B^r \bmod p$
- Bob: $C_2 \times C_1^{-b} = M \times B^r \times R^{-b} = M \times g^{br} \times g^{-br} = M \bmod p$

# RSA - encrypt

message: $\boxed{M}$ $\rightarrow$ encrypted message: $\boxed{C = M^e \mod N}$ $\rightarrow$ $\boxed{C}$ $\rightarrow$ decrypted message: $\boxed{\begin{aligned} M &= C^d \mod N \\ &= M^{ed} \mod N \end{aligned}}$

**Alice**

has access to Bob's
public keys N, e

**Bob**

has private key d,
public keys N, e

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    - no! what if mallory gives alice her public key instead of bob’s?

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- **trust anchor:** a root of trust—implicit trust

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- used by SSH

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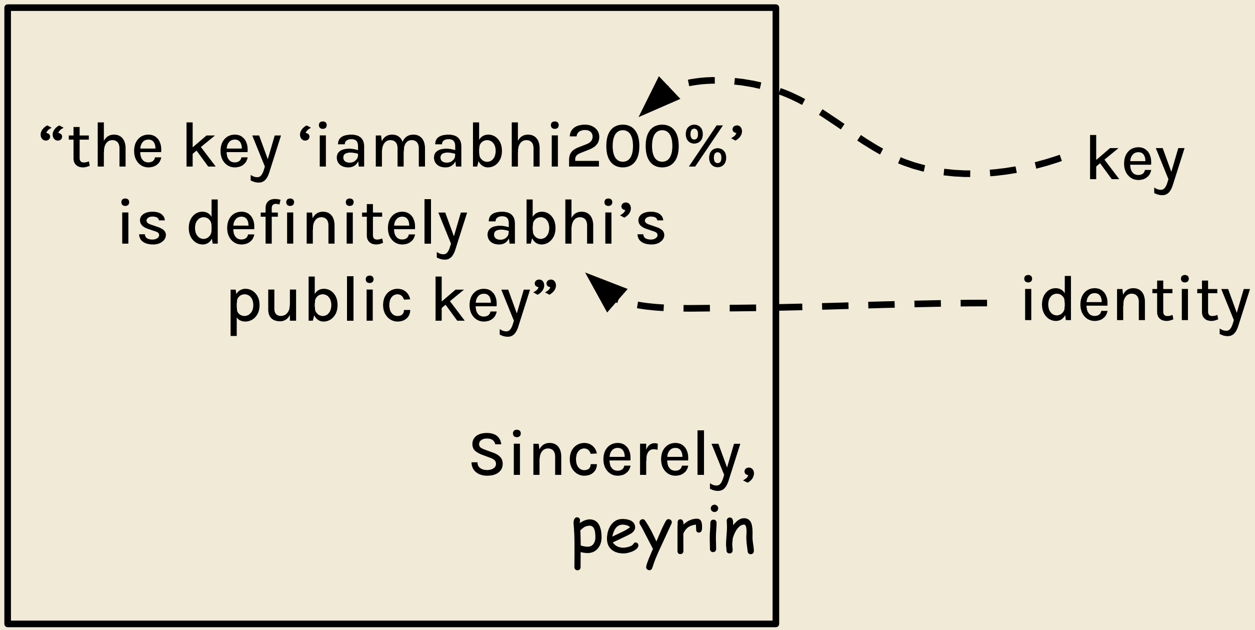

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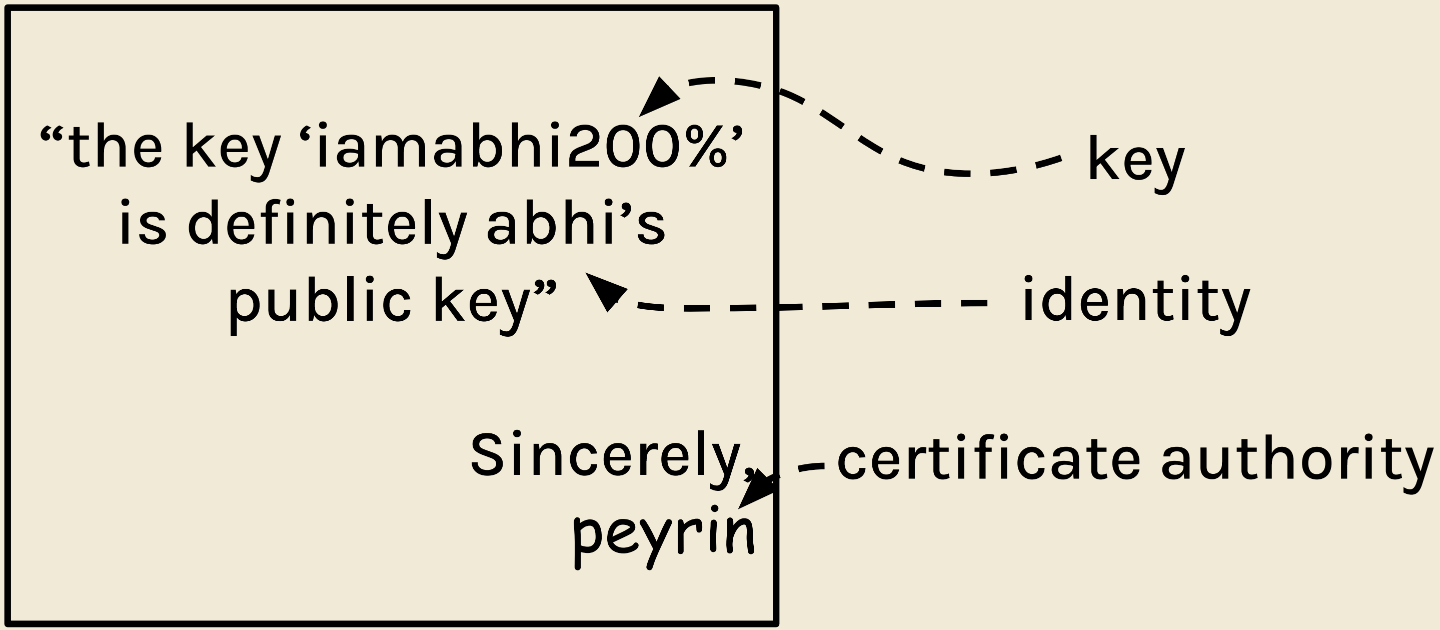

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- if we trust EvanBot and he sends $\{\text{“Bob’s public key is } PK_B\text{”}\}_{SK_E^{-1}}$, we trust this certificate

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    - the TD won't sign keys unless the owner is verified

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    - scalability: one directory for whole world
    - single point of failure: if directory is compromised, can't trust anyone

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  - hierarchical trust: a root CA signs other CAs, and they can certificates as well

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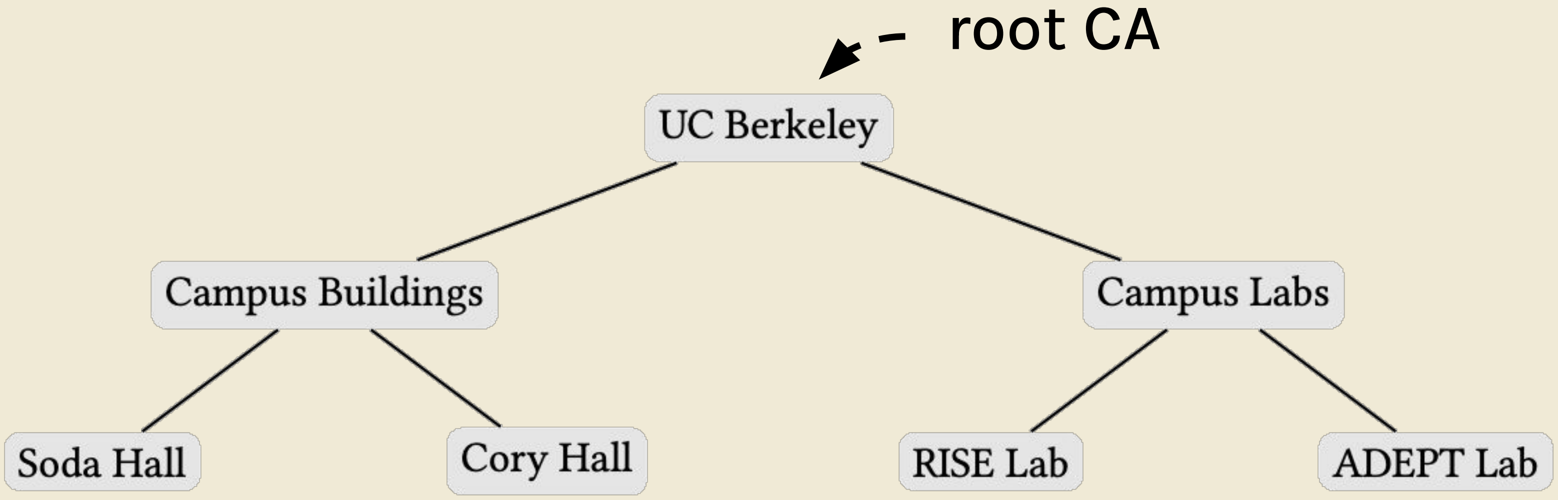

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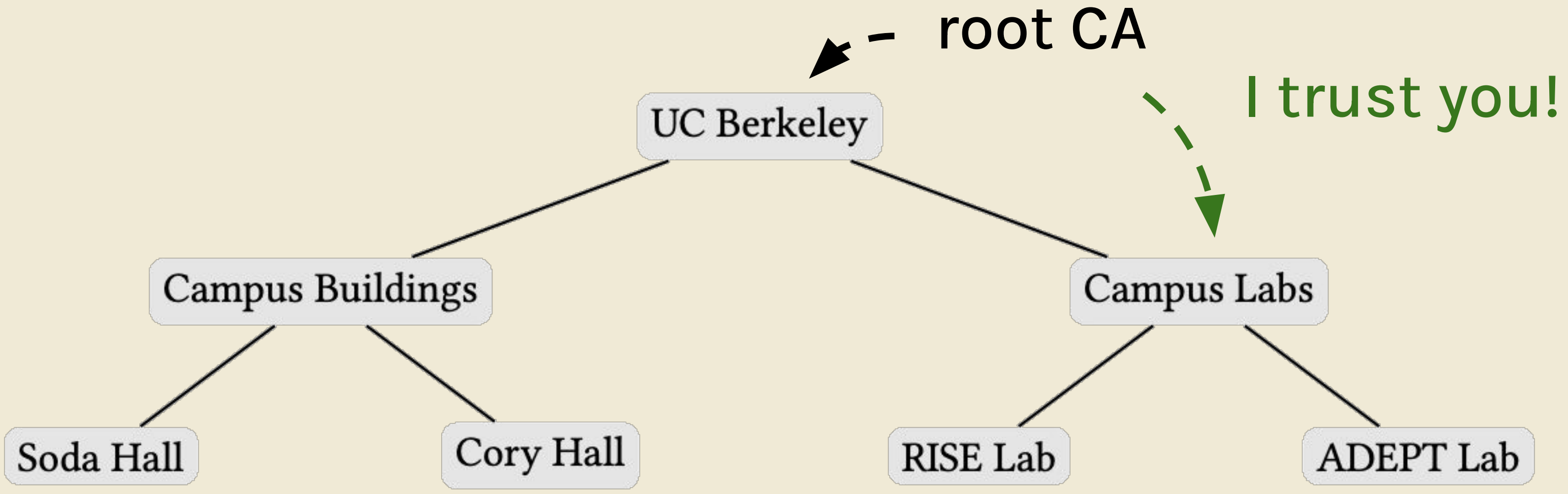

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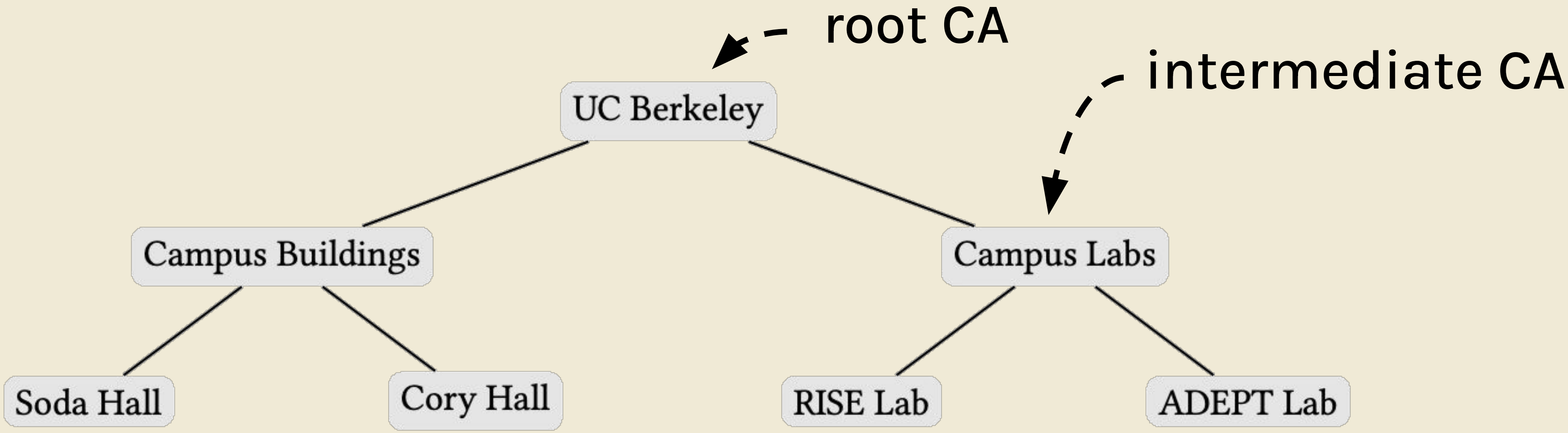

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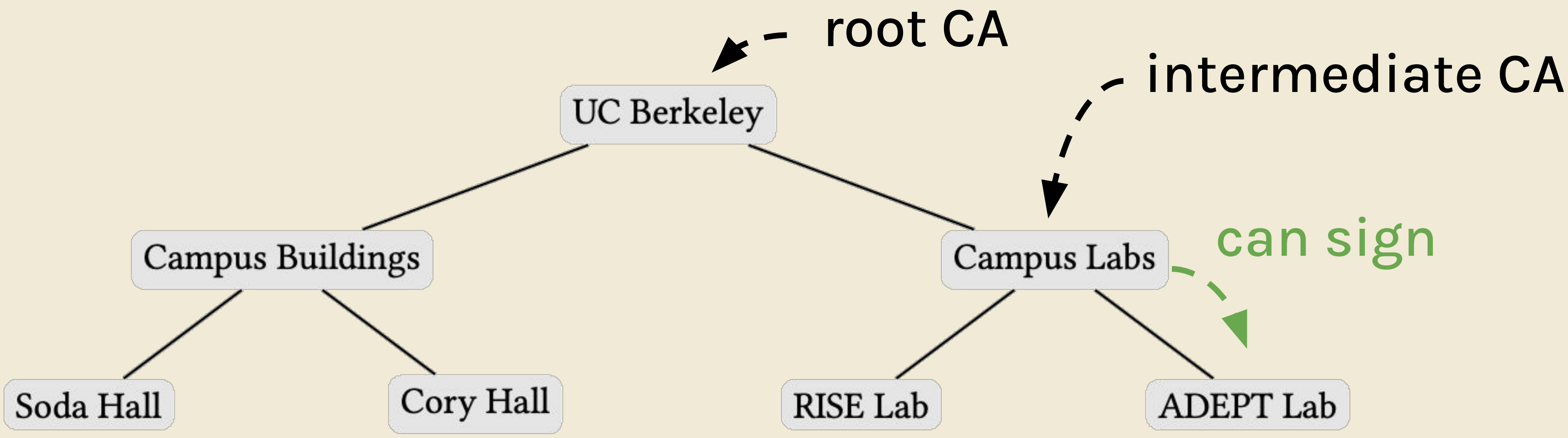

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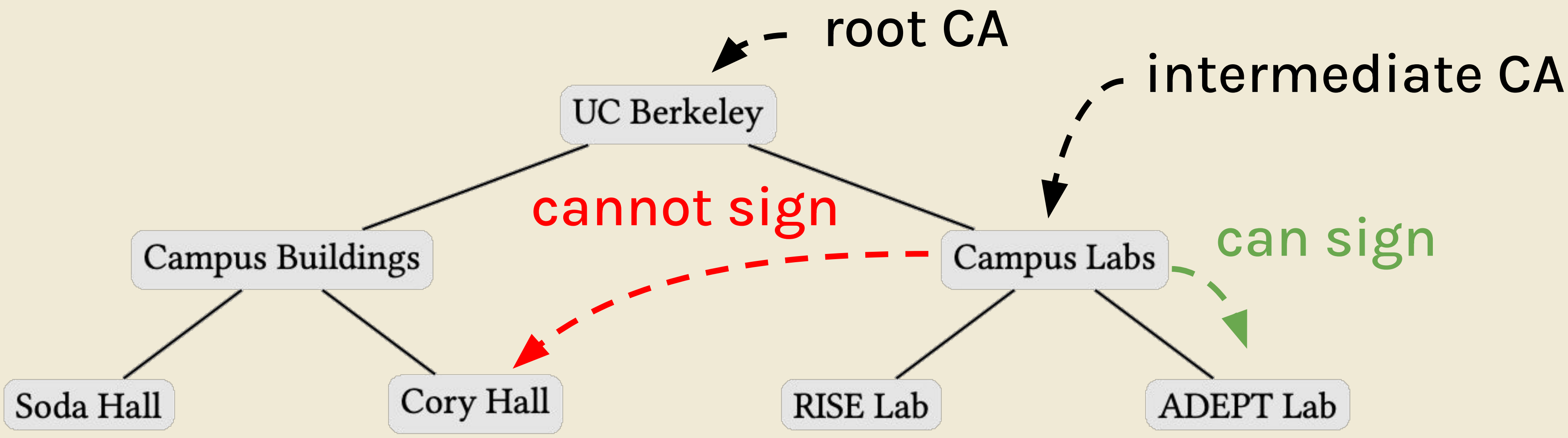

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# hashing—a review

- H(M): M is an arbitrary length message
  - output: <u>fixed length</u> n-bit hash
  - $\{0, 1\}^* \rightarrow \{0, 1\}^n$
- “look” random
- fast
- **one-way:** hard to find x given a y such that H(x) = y
- **collision-resistant:** hard to find x ≠ x’ s.t. H(x) = H(x’)

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- problem: brute-forcing passwords

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- rainbow tables: an algorithm to make brute-forcing easier

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only guessing 1 or 0 for 10 bits, 2 options
for each of 10 bits, $2 * 2 * 2 .... * 2 = 2^{10}$
guesses and then hashing each guess

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H(password123 7$cafxY$

@

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  - users can’t tell the difference between 0.001 and 0.1 second hashes, attackers computing thousands of hashes can

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  - defense: salted passwords, slow hashes, strong passwords

# worksheet

(on 161 website)

feedback

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