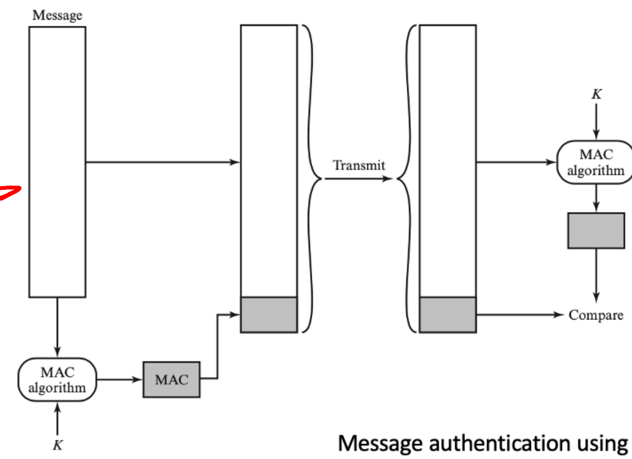
Message Authentication

Message authentication

- message authentication is concerned with:
  - 1. & protecting the integrity of a message
  - 2- & validating identity of originator
  - 3. non-repudiation of origin (dispute resolution)
- then three alternative functions used:
  - ✓ message encryption – symmetric
  - message authentication code (MAC)
  - digital signature



Message authentication using MAC

Message encryption

- Symmetric message encryption by itself also provides a measure of authentication
- if symmetric encryption is used then:
  - receiver knows sender must have created it
  - since only sender and receiver know key used
  - know content cannot be altered

Yes

the sender encrypted msg.
& use the same key
only belongs to the sender

group key

Homework 1 questions

- Symmetric Block Cypher provides authentication and confidentiality
  - Ans: True

Message encryption

Symetric — confidential / authentication

- if public-key encryption is used:
  - encryption provides no confidence of sender
  - since anyone potentially knows public-key
  - so, need to recognize corrupted messages
  - however, if private key
    - sender **signs** message using their private-key
    - then encrypts with recipients' public key
    - have both secrecy and authentication
  - but at cost of two public-key uses on message

Asymetric → authentication

only one pair private key

signed

private-key

PK

Two pairs keys

Reasons to avoid encryption authentication

- Encryption software is quite slow
- Encryption hardware costs are nonnegligible
- Encryption hardware is optimized toward large data sizes
- An encryption algorithm may be protected by a patent

RC4

① MAC (Hash function)

② Digital Signature

Hash Function

Hash functions

- Hash function: h = H(M)
  - M can be of any size
  - h is always of fixed size
  - Typically, h << size(M)

→ input message

$M >> h$

h → small bandwidth.

↘ compression

H( )

↓

compression

lossy compression

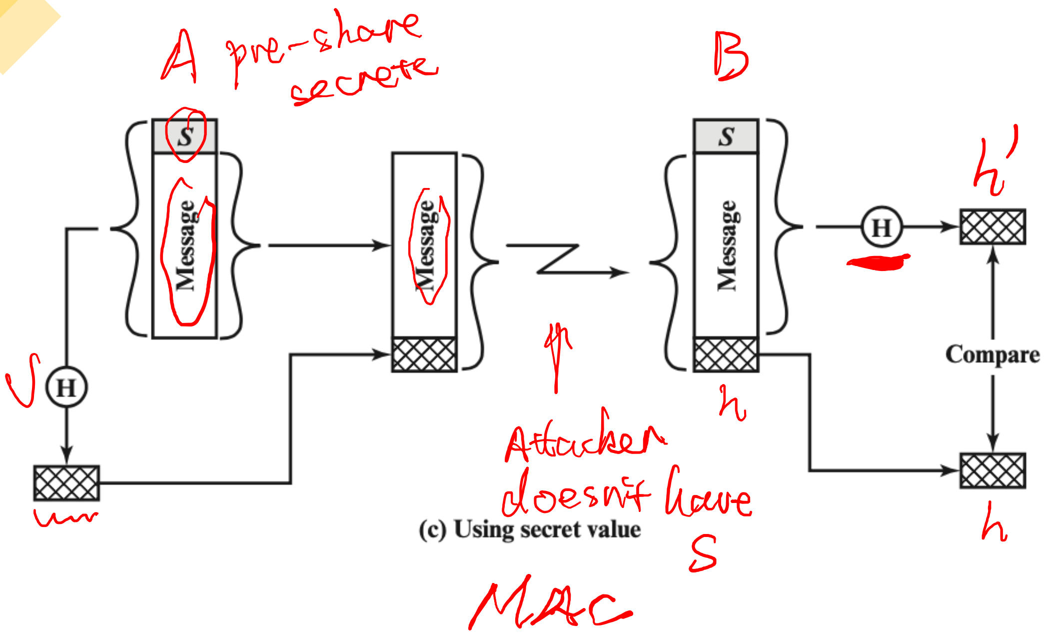
no loss compression

collision

LLM,

Loss → hallucination

One use case - using hash function



(c) Using secret value

- Initialization: A and B share a common secret, S_{AB}
- Message, M
- A calculates $MD_M = H(S_{AB} \mid\mid M)$
- B recalculates MD'_M, and check
- $MD'_M = MD_M$

Requirements for secure hash functions

- 1. can be applied to any sized message M
- 2. produces fixed-length output h

definition

- 3. is easy to compute $h=H(M)$ for any message M → fast to compute
- 4. given h is infeasible to find x s.t. $H(x)=h$
  - one-way property or preimage resistance

$x \xrightarrow{\text{easy, fast}} H(x)$

one-way

$H^{-1}(x)$

attacker

- 5. given x is infeasible to find x' s.t. $H(x')=H(x)$
  - weak collision resistance or second pre-image resistant
- 6. infeasible to find any pair of x, x' s.t. $H(x')=H(x)$
  - strong collision resistance

Hash Function: Collision Resistance

- **Collision**: Two different inputs with the same output
  - $x \neq x'$ and $H(x) = H(x')$ 5 & 6 $M >> n$ fast.
  - Can we design a hash function with no collisions?
    - No, because there are more inputs than outputs (pigeonhole principle)
  - However, we want to make finding collisions *infeasible* for an attacker
- **Collision resistance**: It is infeasible to (i.e. no polynomial time attacker can) find any pair of inputs $x' \neq x$ such that $H(x) = H(x')$

no possibility for no collision
$\Downarrow$
Attacker $x' \Rightarrow H(x') = H(x)$,
H^{-1}

Secure hash function

- A hash function that satisfies the first five properties is referred to as a weak hash function
- **Security:** random/unpredictability, no predictable patterns for how changing the input affects the output
  - Changing 1 bit in the input causes the output to be completely different
  - Also called "random oracle" assumption

avoid

$x \rightarrow H(x)$

0 1 0 1 $\rightarrow H(x)$

$x' \rightarrow H(x')$

randomize the output $H(x)$

uniform entropy

guess ← smart way

$H(x_1')$

$H(x_2')$

$H(x_3')$

use observing statistics of $H(x')$

security
(1) output uniform
(2) One-way
(3) reduce collision

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- A message digest
  - a cryptographic hash function containing a string of digits created by a one-way hashing formula
  - provides data integrity
- Examples: SHA-1 (Secure Hash Algorithm 1), SHA-2, SHA-3, MD5

Hash Function: Examples

- MD5
  - Output: 128 bits
  - Security: Completely broken
- SHA-1
  - Output: 160 bits
  - Security: Completely broken in 2017
  - Was known to be weak before 2017, but still used sometimes

time

- SHA-2
  - Output: 256, 384, or 512 bits (sometimes labeled SHA-256, SHA-384, SHA-512)
  - Not currently broken, but some variants are vulnerable to a length extension attack
  - Current standard
- SHA-3 (Keccak)
  - Output: 256, 384, or 512 bits
  - Current standard (not meant to replace SHA-2, just a different construction)

Length Extension Attacks

- **Length extension attack**: Given $H(x)$ and the length of x, but not x, an attacker can create $H(x \mid\mid m)$ for any m of the attacker's choosing
  - Length extension attack - Wikipedia
- SHA-256 (256-bit version of SHA-2) is vulnerable
- SHA-3 is not vulnerable