

Introduction to Information Security

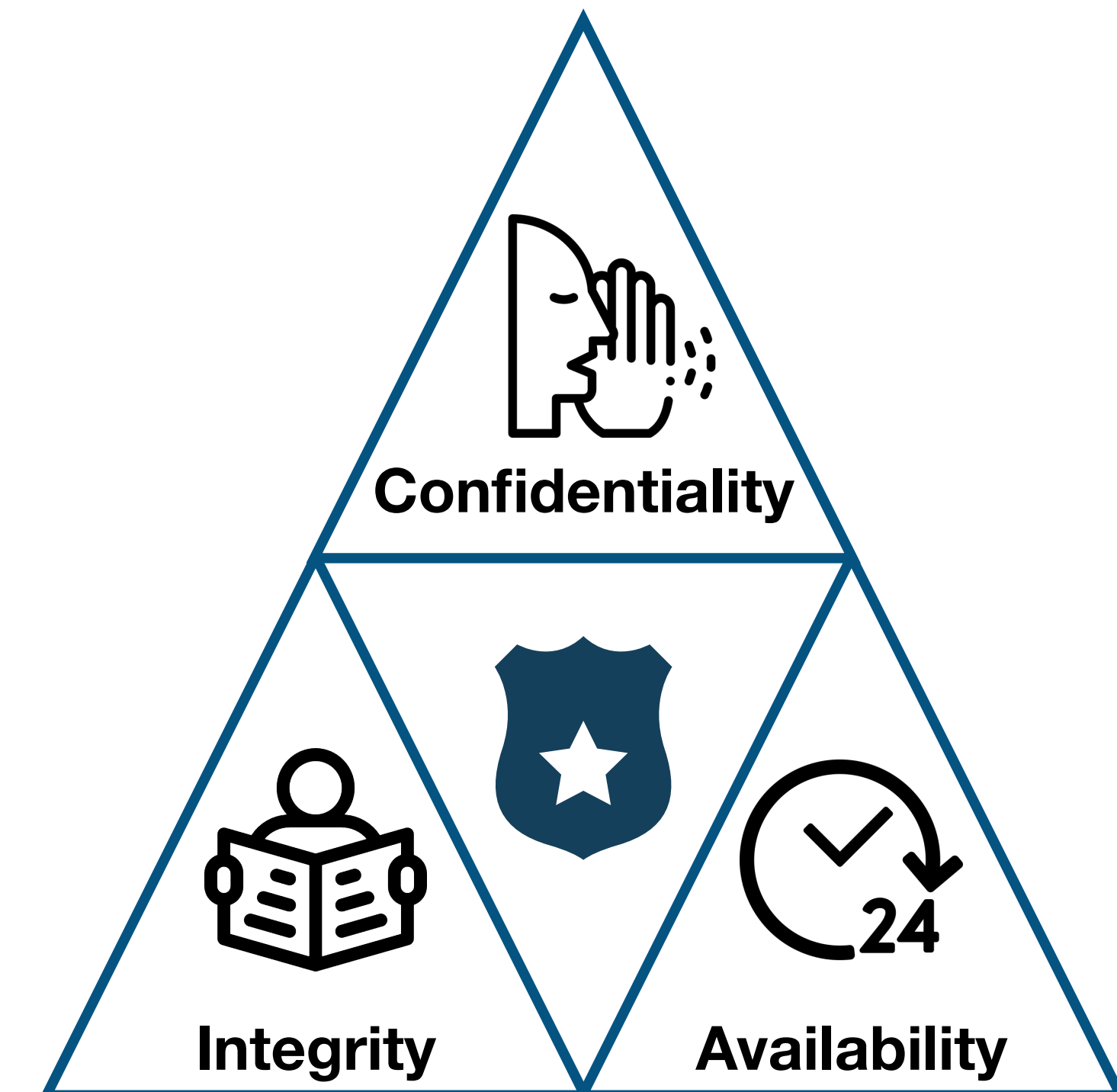
6. Availability

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Recall: The CIA Triad

- Three most important properties of computer security
- CIA: Confidentiality, Integrity, and Availability
- Example: a bank system
 - Confidentiality?
 - Integrity?
 - Availability?

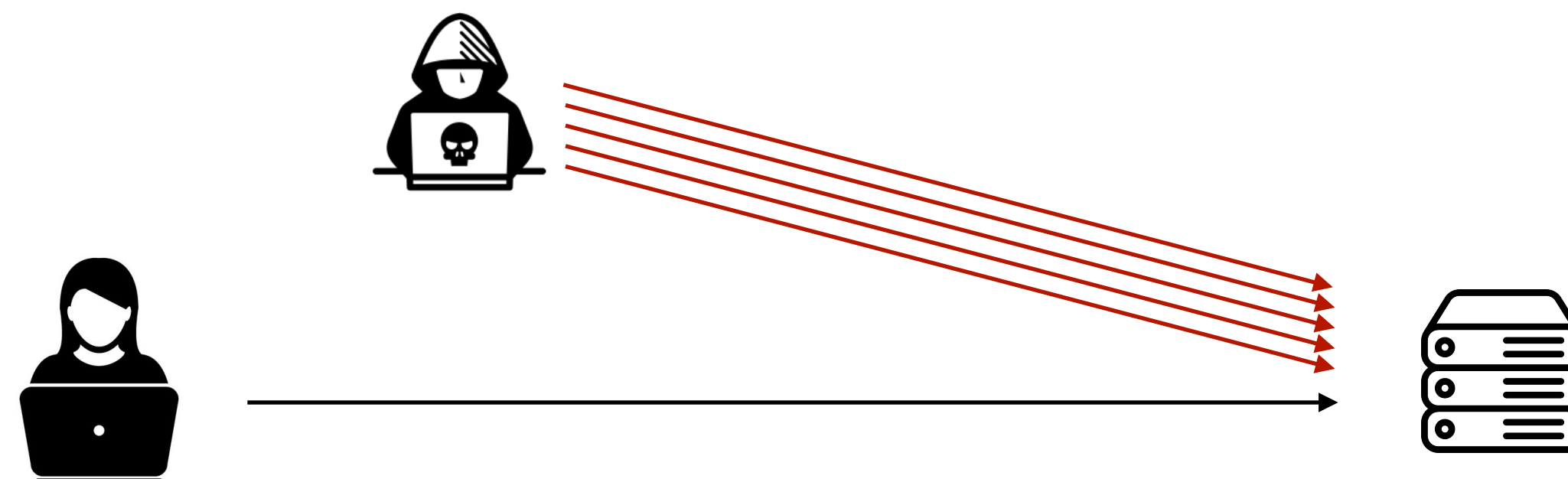


Denial-of-service (DoS) Attacks

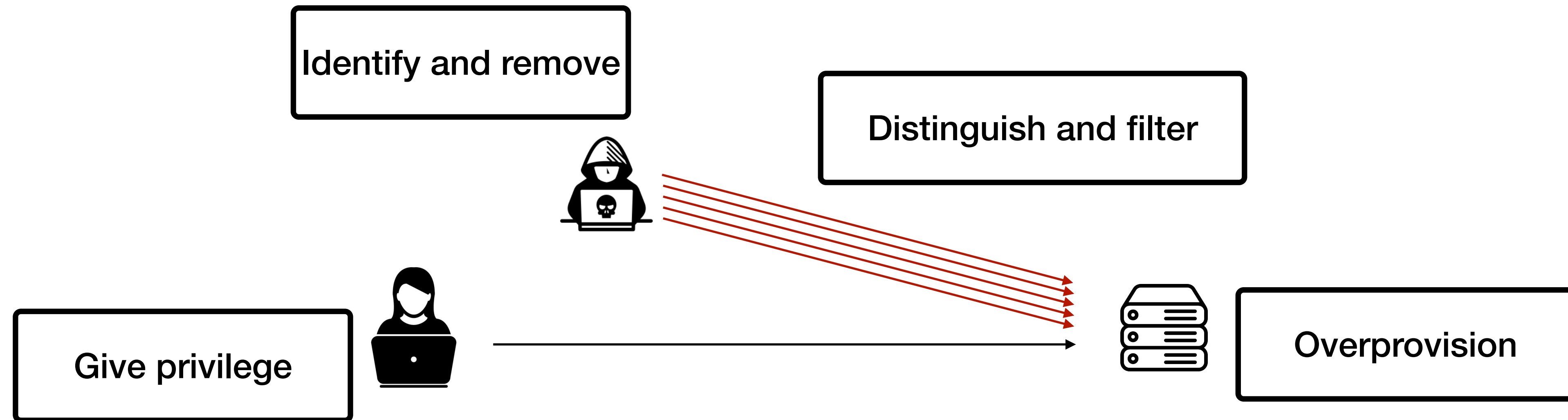
*“A group of **authorized users** of a specified service is said to **deny service to another group of authorized users** if the former group makes the **specified service unavailable** to the latter group for a period of time which exceeds the intended (and advertised) service maximum-waiting time”*

- V. Gligor, A Note on the Denial-of-Service Problem, IEEE Security & Privacy, 1983

- Not considered as a security problem until the late 80s
- Distributed denial-of-service (DDoS): DoS attacks by a large number of devices
- Solutions to DoS attacks in the Internet?



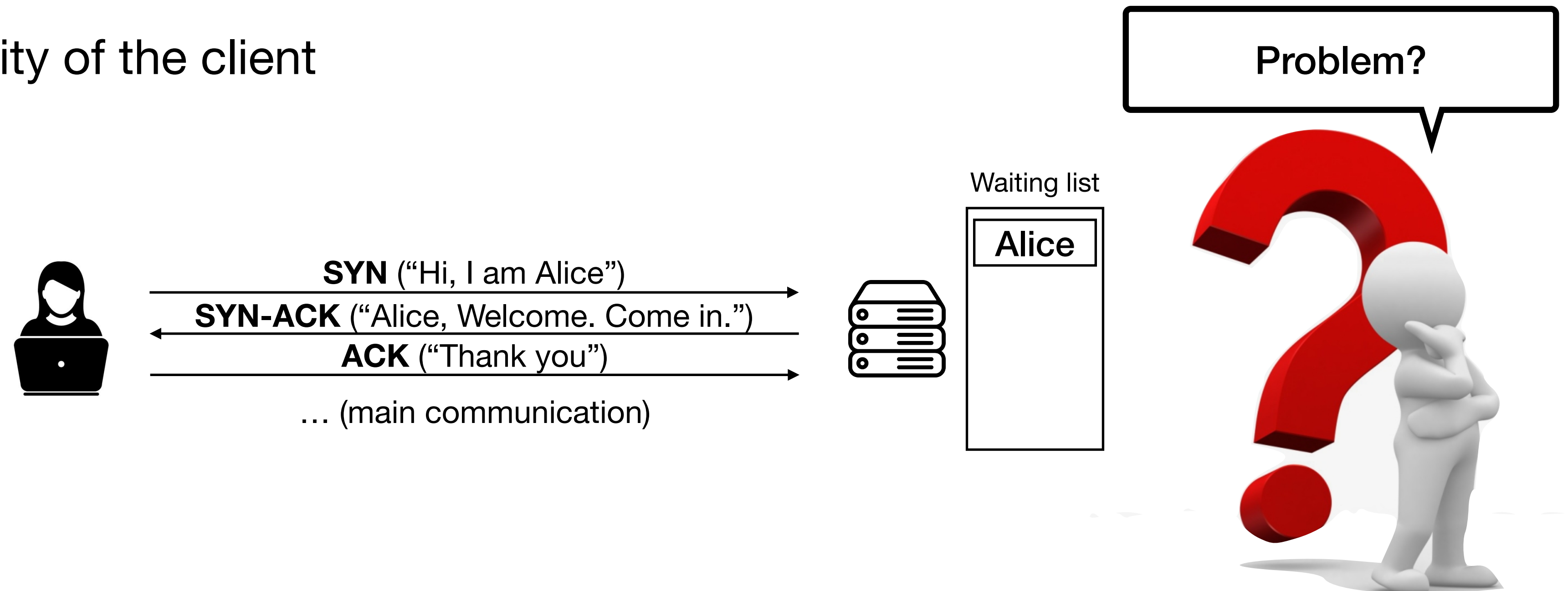
Solutions to DoS Attacks



- Unfortunately, there is no bulletproof scheme for availability!
 - Unlike other properties: encryption for confidentiality and MAC for integrity
- Theoretical solution: user agreement [Yu and Gligore 1988]
 - External constraints on service invocations that must be obeyed by all users
 - Hard to achieve in practice

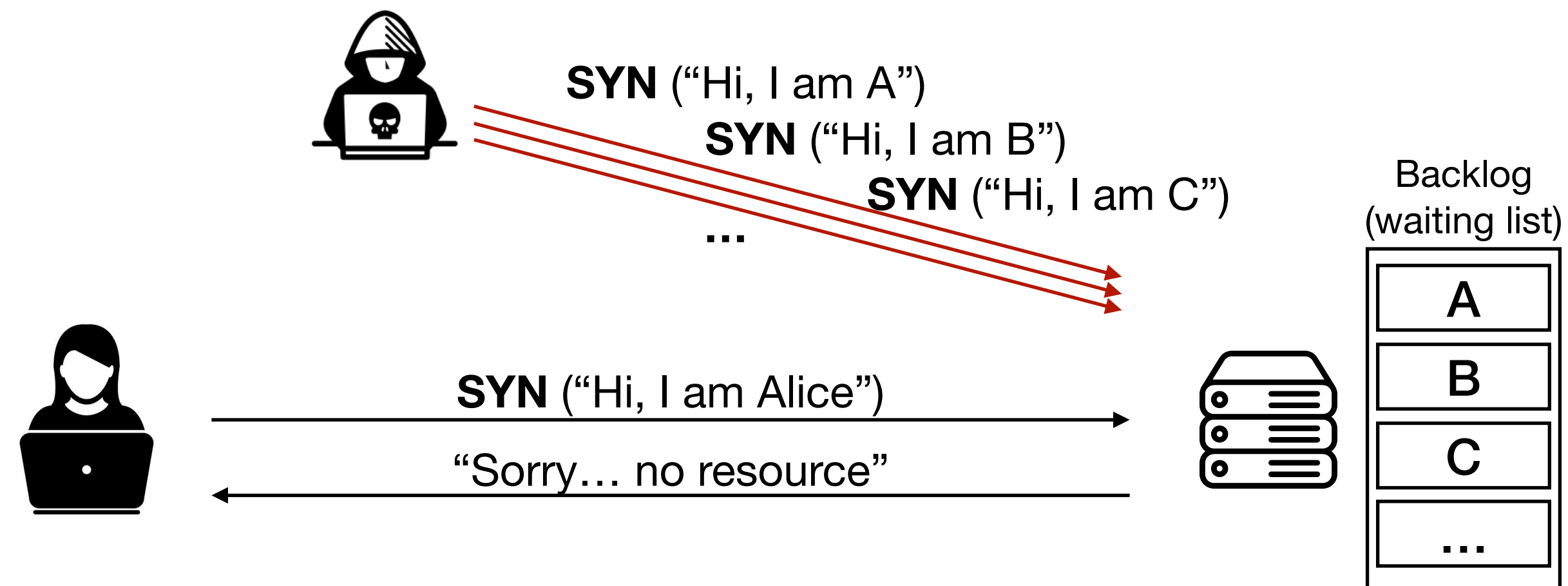
Example: SYN Flooding (1)

- Three-way handshake: establish a connection between the server and the client
 - Used in TCP/IP networks (e.g., the Internet)
- Servers store “half-open” connections while awaiting the third handshake message
 - To ensure the identity of the client



Example: SYN Flooding (2)

- Attacker floods the server with SYN packets but no follow-up ACK
- Server exhausts resources → DoS



Analysis

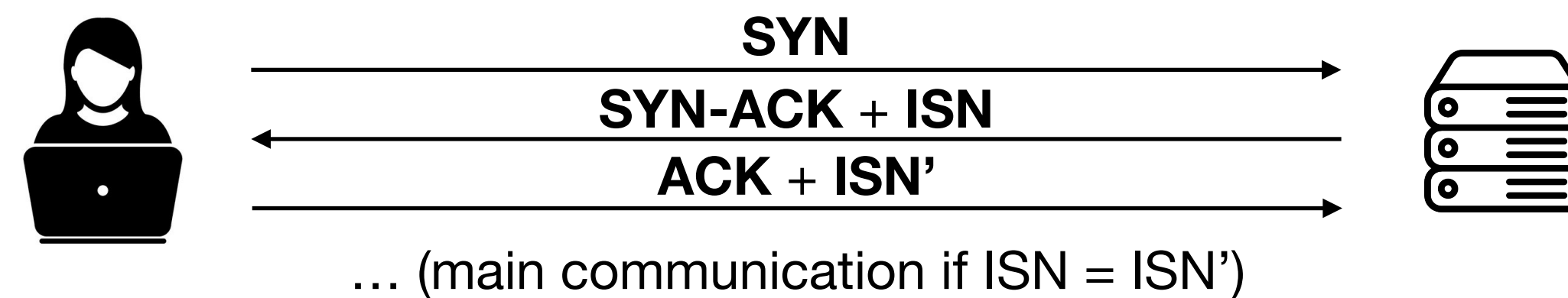
- Why does the server exhaust resources?
 - Need to store requests for 511 seconds
 - A finite-size queue for incomplete connections (usually 1024 entries)
- Why not store all requests (736 bytes/entry)?
 - Arms race! Attackers can easily win

How to make it secure?



SYN Cookie (1)

- Idea: DO NOT store! DO recompute!
- Server sends SYN-ACK with ISN (initial sequence number) based on the connection state
- Client sends ACK with the ISN
- Server verifies ISN and allocates the connection state if correct
- $ISN = H(S_{ip}, C_{ip}, S_{port}, C_{port})$



SYN Cookie (2)

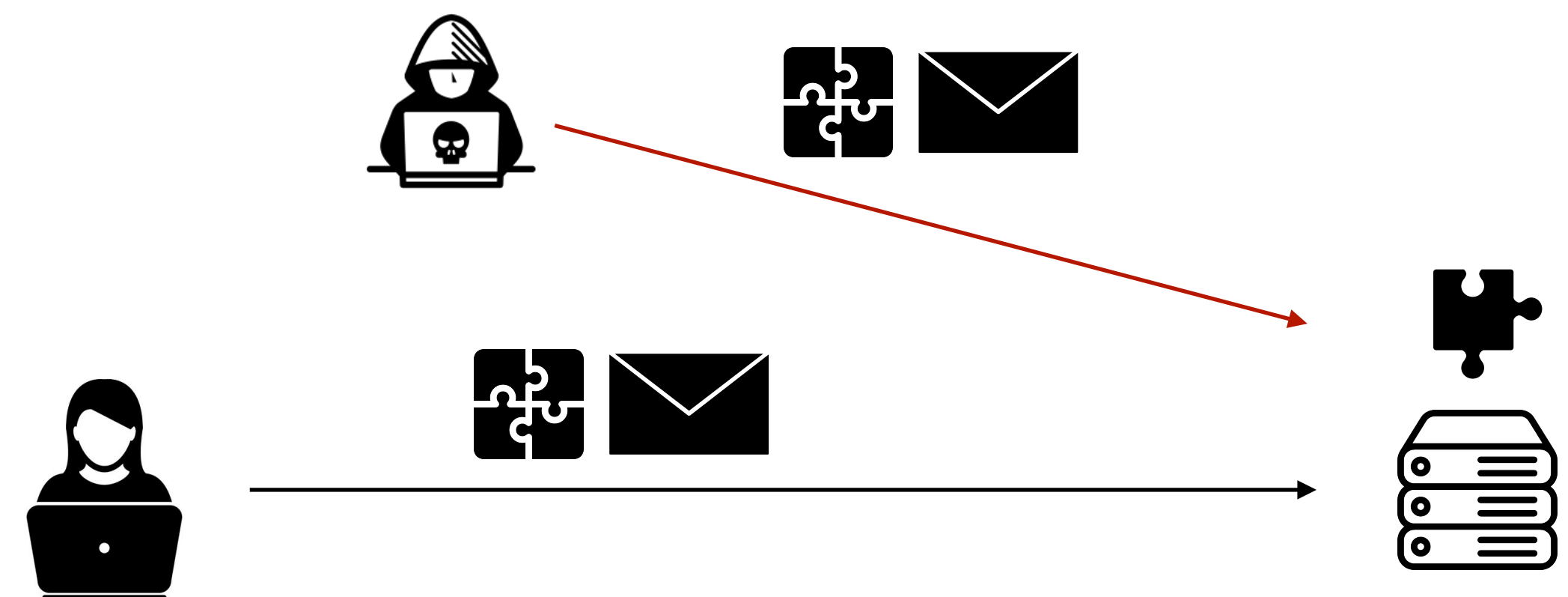
- What if attackers send massive valid ISNs?
 - $H(S_{ip}, C_{ip}, S_{port}, C_{port})$: public because H , S_{ip} , C_{ip} , S_{port} and C_{port} are all public
- Idea
 - $H(S_{ip}, C_{ip}, S_{port}, C_{port}, key)$ where key is a secret key of server

Two Types of DDos Attacks

- Application DDoS attacks
 - Server-side resource exhaustion
 - Example: SYN floods
 - Mitigation: making your server “stateless”
- Network (or volumetric) DDoS attacks
 - Overwhelm network capacity
 - Mitigation: puzzle-based defense

Puzzle-based DDoS Defense

- Idea: slow down attackers with puzzles
- Requirements
 - Making puzzle-solution pairs: easy
 - Sending puzzles to clients: easy
 - Solving puzzle: hard
 - Verifying solutions: easy



Example (1)

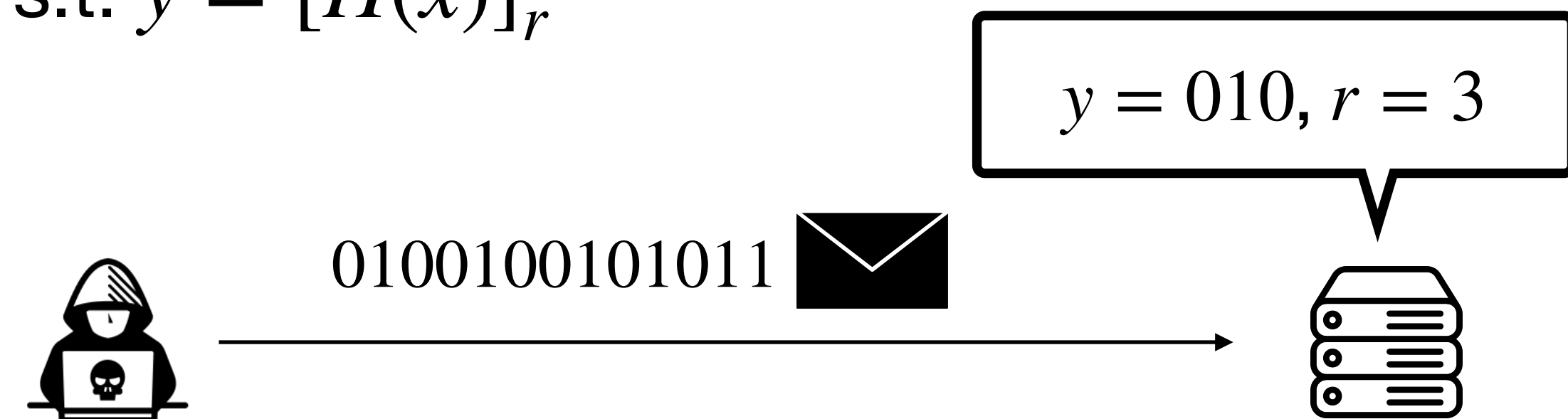
- Secure-hash-based proof of work: given y , find x s.t. $y = [H(x)]_r$

- $[A]_b$: b LSB bits of A

- Effort: $\sim 2^r$

- Issues

- Stateful operation: server has to remember all previous puzzles (족보)
- Rainbow table: precomputation



Example (2)

- Idea:
 - Generate puzzles with a secret key k
 - Verify puzzle solutions without keeping any state (stateless)
- Server sends $T = \text{Mac}_k(C_{ip}, C_{port})$ and r
- Client searches for x s.t. $[H(x || T)]_r = [T]_r$
 - $\sim 2^r$ operations of H

Summary

- Denial-of-service: a common attack on the availability of systems
- No bulletproof scheme
- Example: SYN flooding
- Lesson: stateless system design
- Defense: puzzle-based defense