CSE467: Computer Security

20. Spoofing & Firewalls & IDS

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Department of Computer Science and Engineering

HW3 will be released today!

- Software Hacking Competition

HW3: Software Hacking Competition

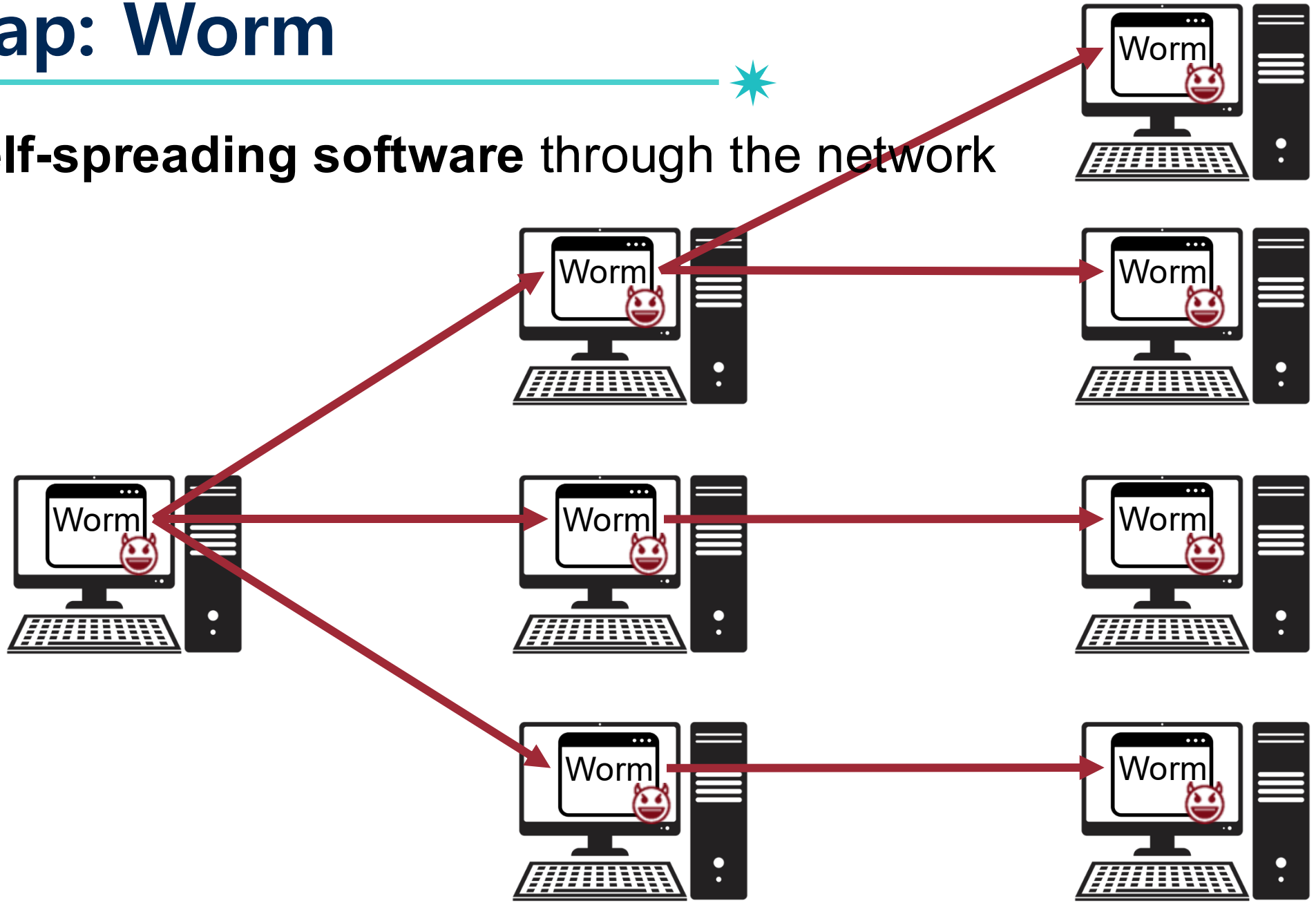
The student who is the quickest to complete all the problems will earn bonus points!

Recap: Computer Network

- A telecommunications network that allows **computers** to **exchange data**
- Networked computing devices pass data to each other along data connections

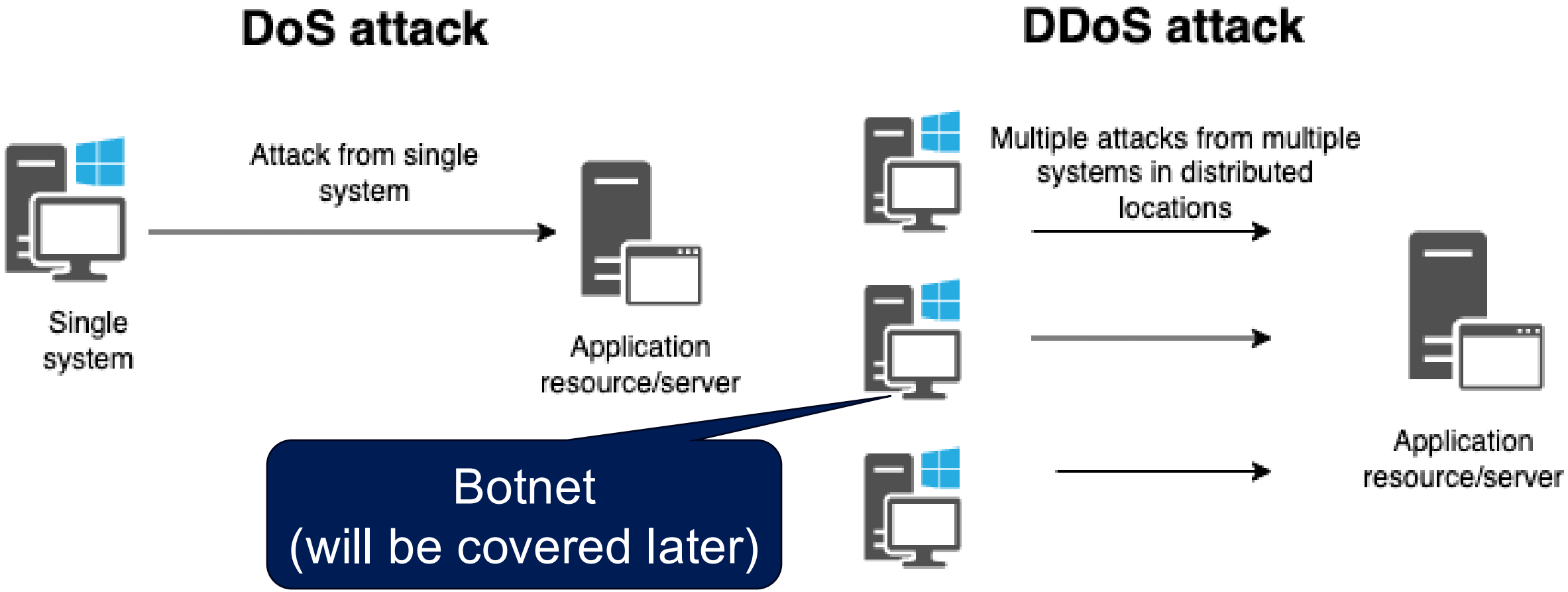
Recap: Worm

- A **self-spreading software** through the network



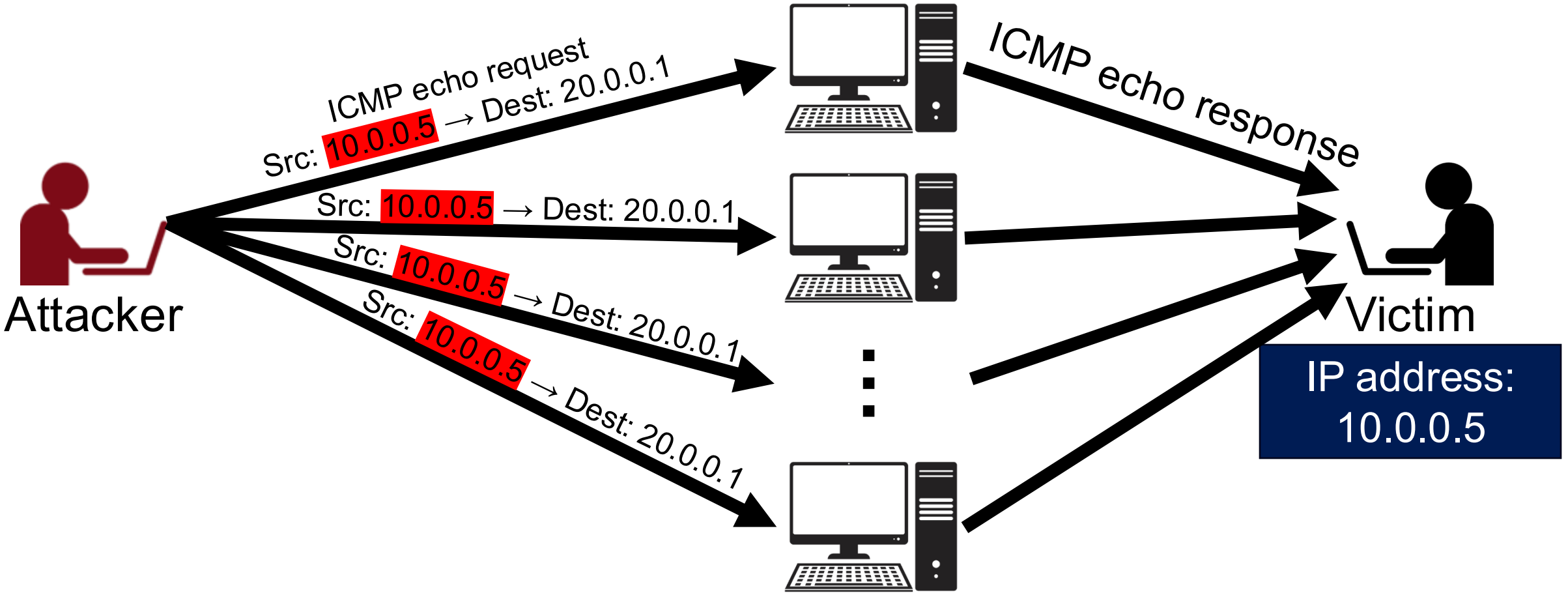
Recap: Distributed Denial-of-Service (DDoS)

- Employ **multiple (compromised) computers** to perform a coordinated and widely distributed DoS attack



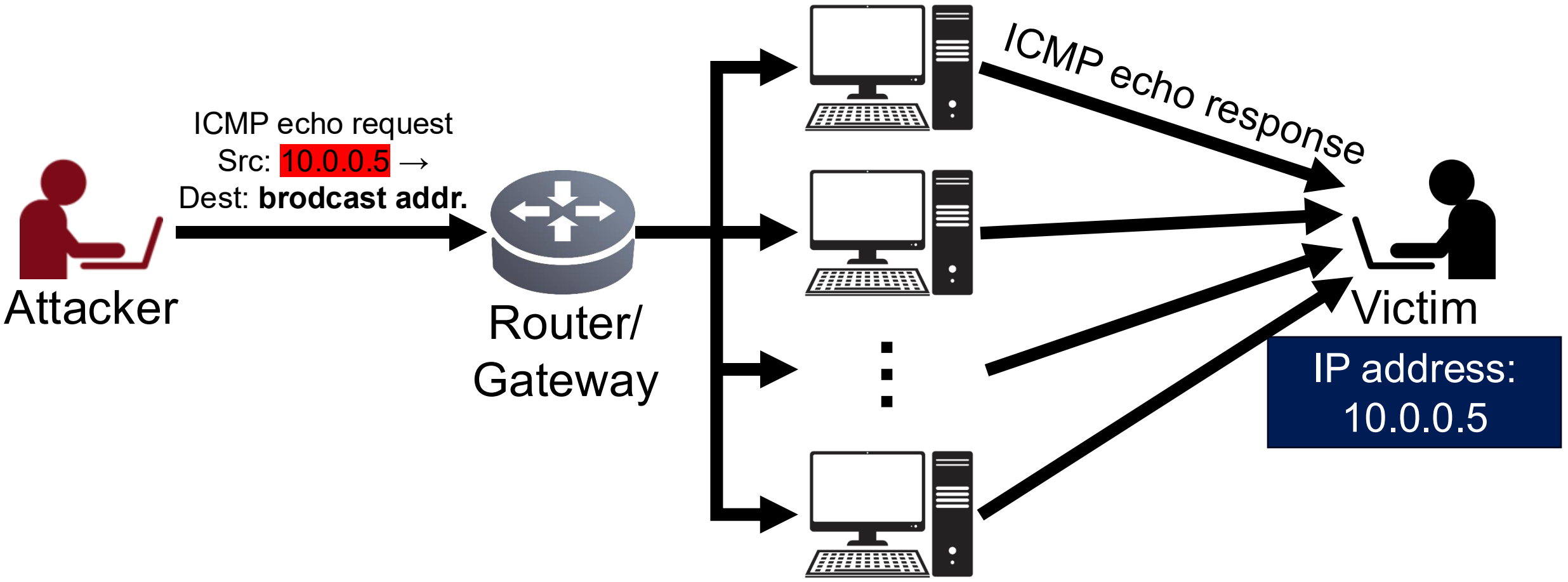
Recap: Ping Flood Attack

- The computing device is flooded with tons of Internet Control Message Protocol (ICMP) ping response



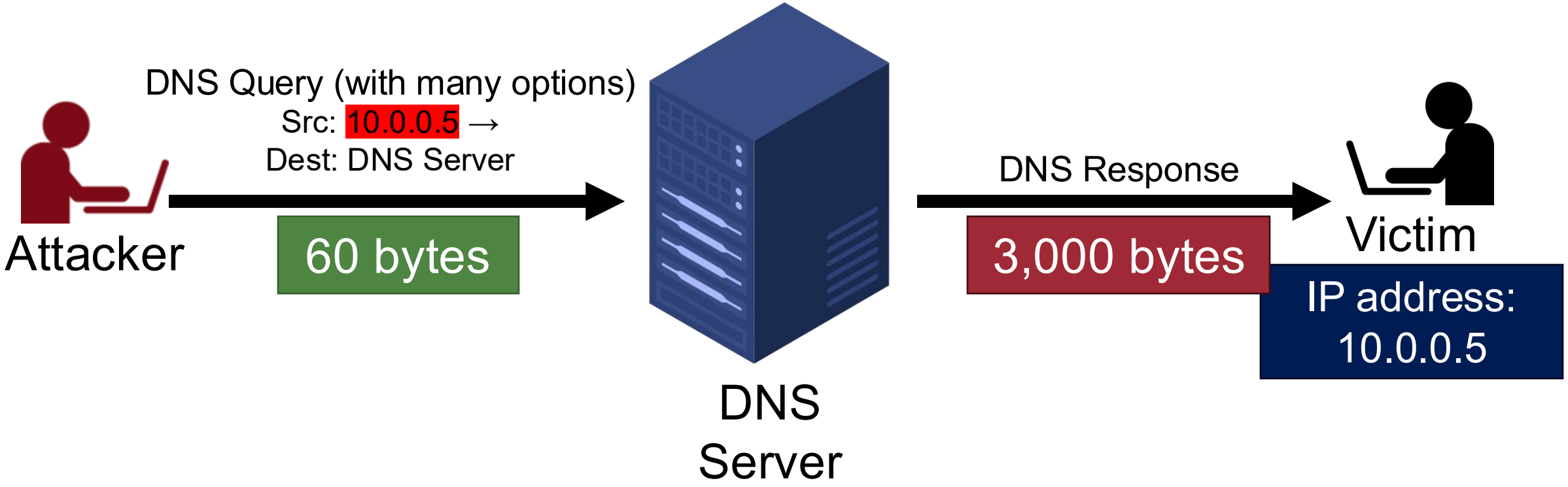
Recap: Smurf Attack

- Idea: sending ping request to **broadcast address**



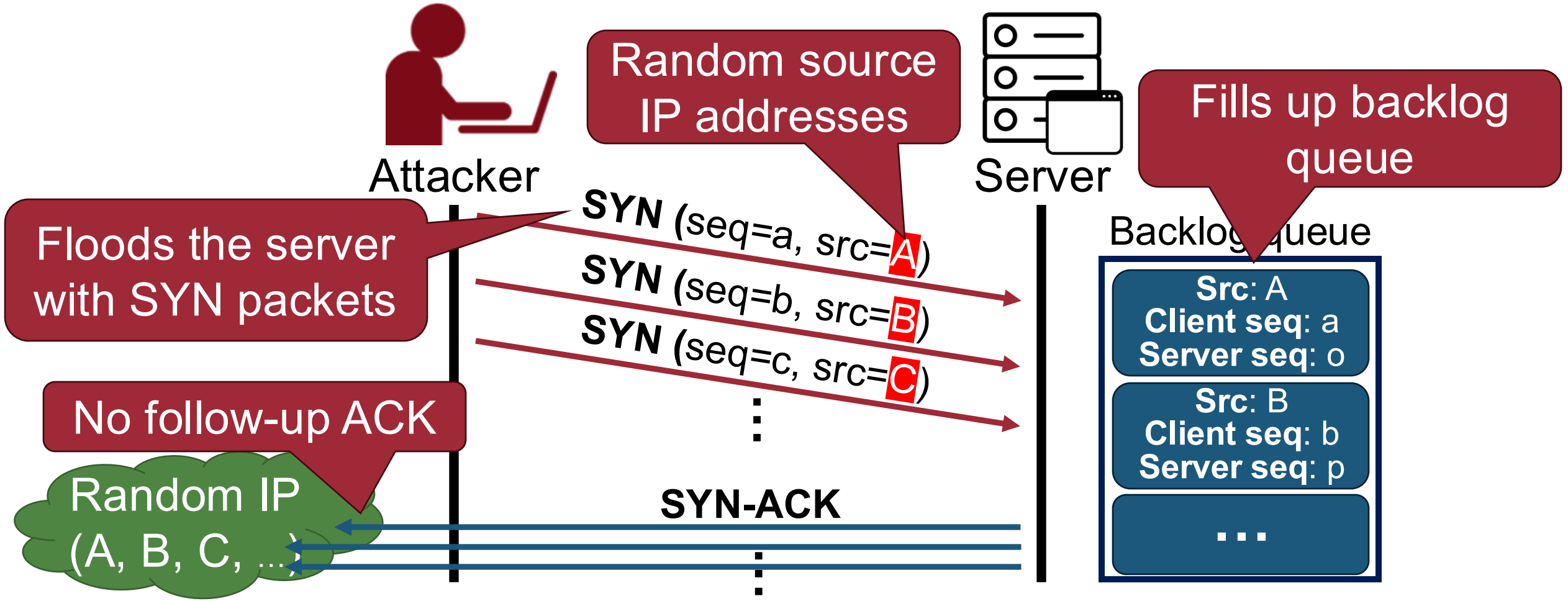
Recap: Amplification Attack

- Idea: controlling the **size of responses**, not the number of responses
- Example: DNS Amplification Attack



Recap: TCP SYN Flooding Attack

- Floods the server with SYN Packets



Recap: Mitigation

- Set the Queue Size for TCP Backlog

```
$ sysctl -w net.ipv4.tcp_max_syn_backlog=1024
```

✓ Limitation: Arms race! Attackers can easily win

- Set the Firewalls
  - E.g., Blocks if similar packets exceed 10 per second

```
$ iptables -A INPUT -p TCP --dport 80 --syn -m limit 10/second -j ACCEPT
$ iptables -A INPUT -p TCP --dport 80 --syn -j DROP
```

✓Limitation: Performance

- SYN Cookie

Recap: Command and Control (C&C) Server

- Essential for operation and support of botnet
- Two styles
  - Centralized
  - P2P

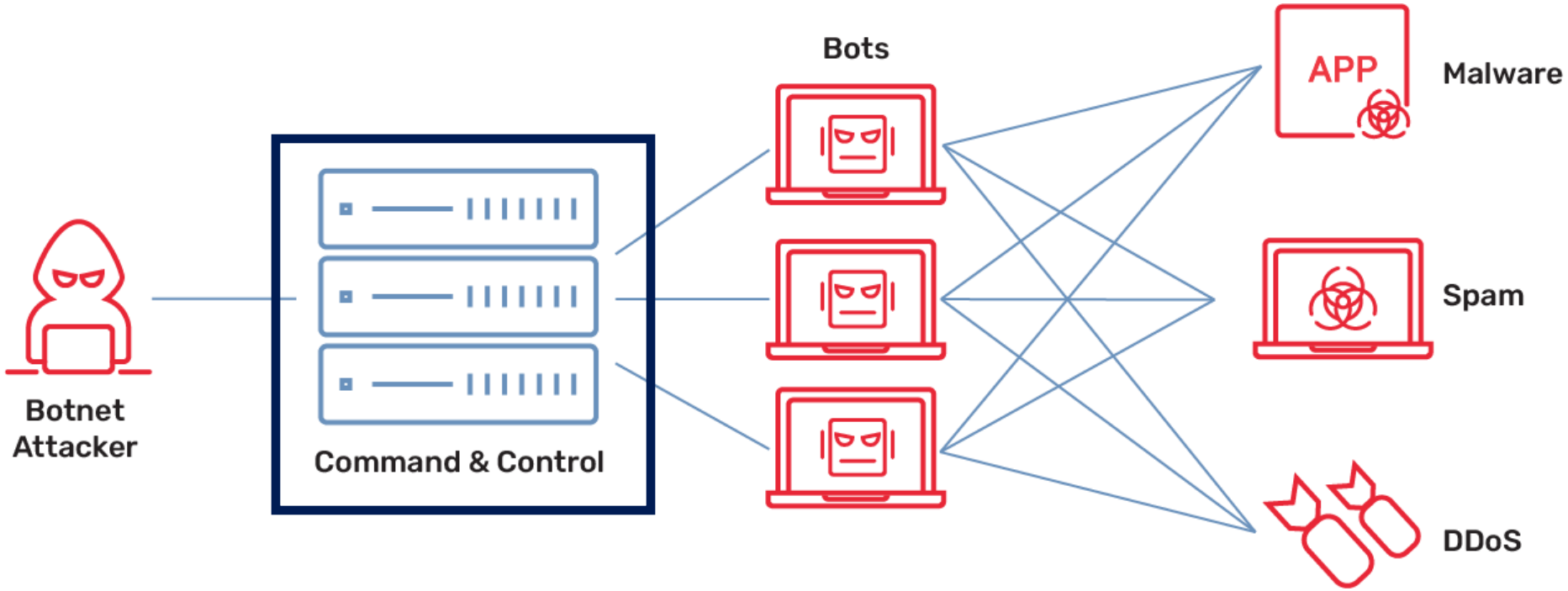


Image from https://www.a10networks.com/glossary/what-is-a-botnet-iot-botnet/

Spoofing 

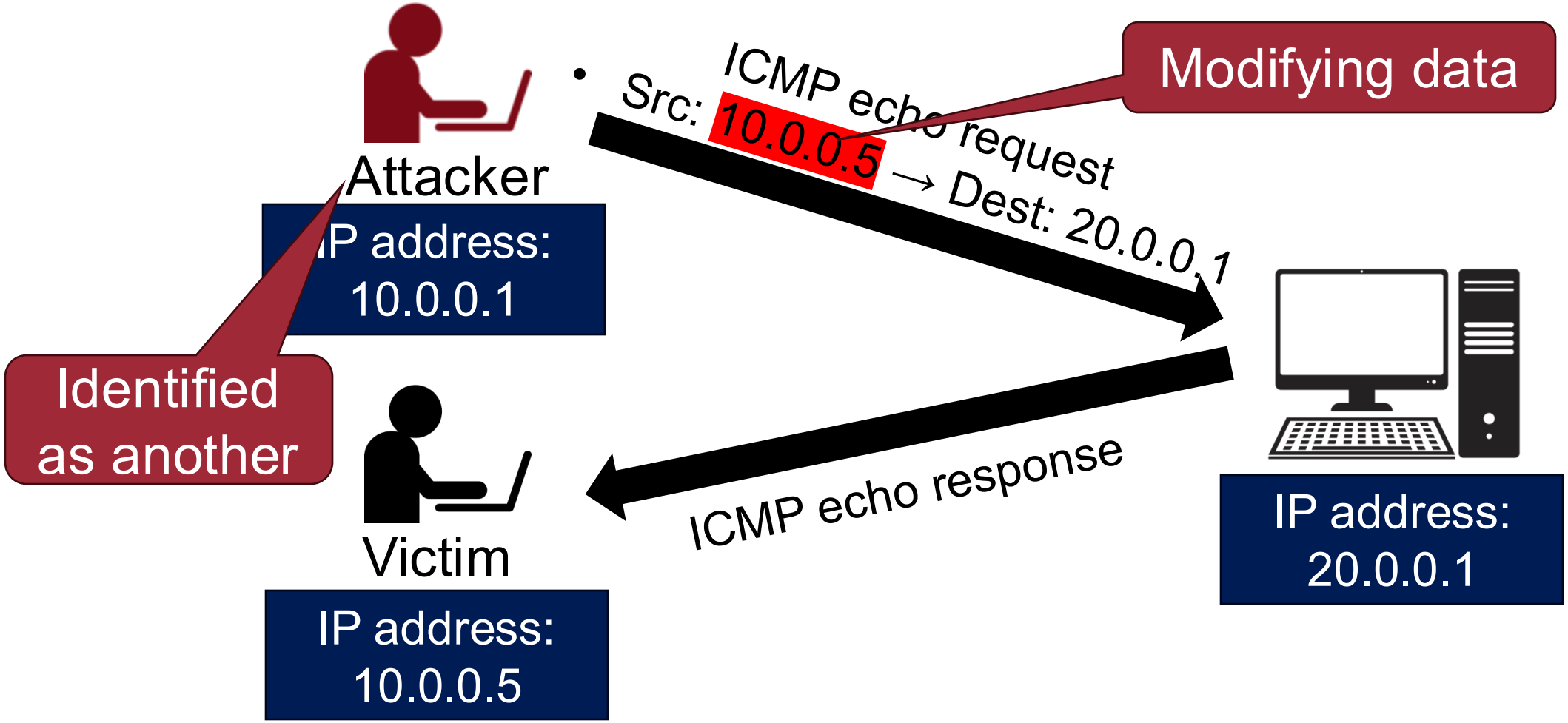
Spoofing

- A situation in which a person or program is successfully **identified as another** by **modifying data**

- IP spoofing
- ARP spoofing
- DNS spoofing

Recap: IP Spoofing

- A situation in which a person or program is successfully **identified as another** by **modifying data**



Recap: IP Spoofing Method

- How to
  - Network RAW socket programming
  - Nmap
    - My own IP address is 10.0.0.1
    - `$ nmap -e eth0 -S 10.0.0.5 20.0.0.1`
    - Use the network interface eth0 to send a spoofed packet (10.0.0.5) to 20.0.0.1
  - …

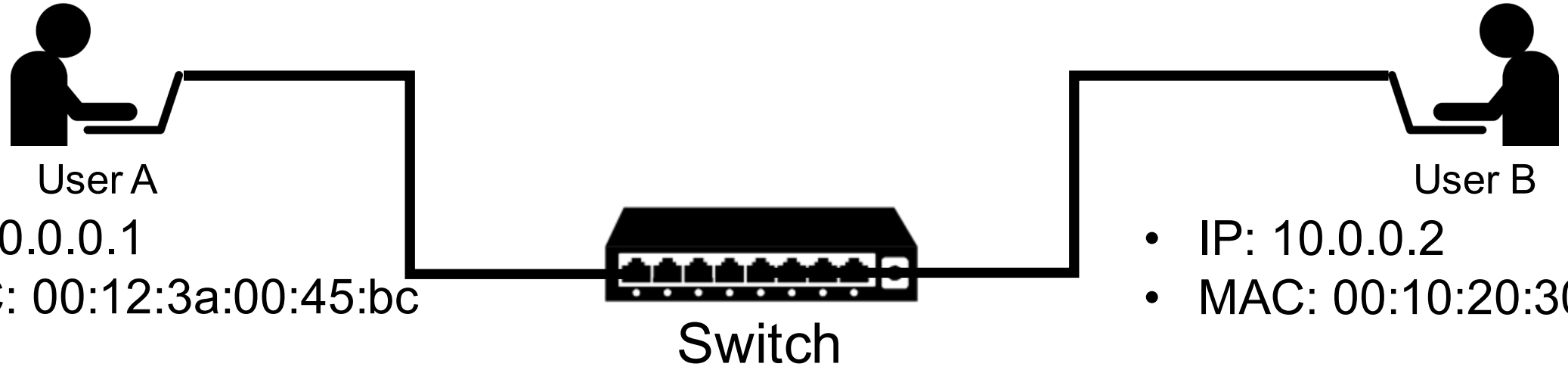
ARP Spoofing

- An attacker sends spoofed Address Resolution Protocol (ARP) response messages

- Also known as ARP cache poisoning attack

Address Resolution Protocol (ARP)

- A protocol that maps an *ever-changing* **IP address** to a *fixed* physical machine address (**MAC address**)

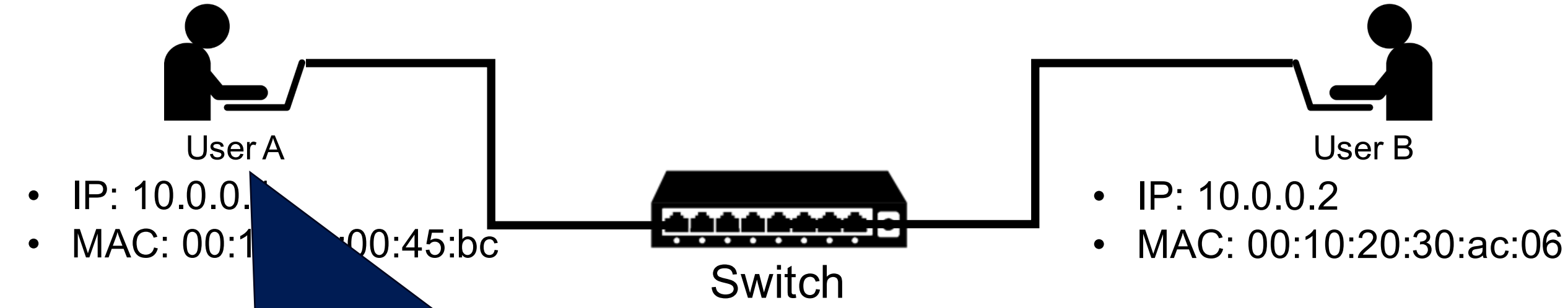


- IP: 10.0.0.1
- MAC: 00:12:3a:00:45:bc

- IP: 10.0.0.2
- MAC: 00:10:20:30:ac:06

Address Resolution Protocol (ARP)

- A protocol that maps an *ever-changing* **IP address** to a *fixed* physical machine address (**MAC address**)



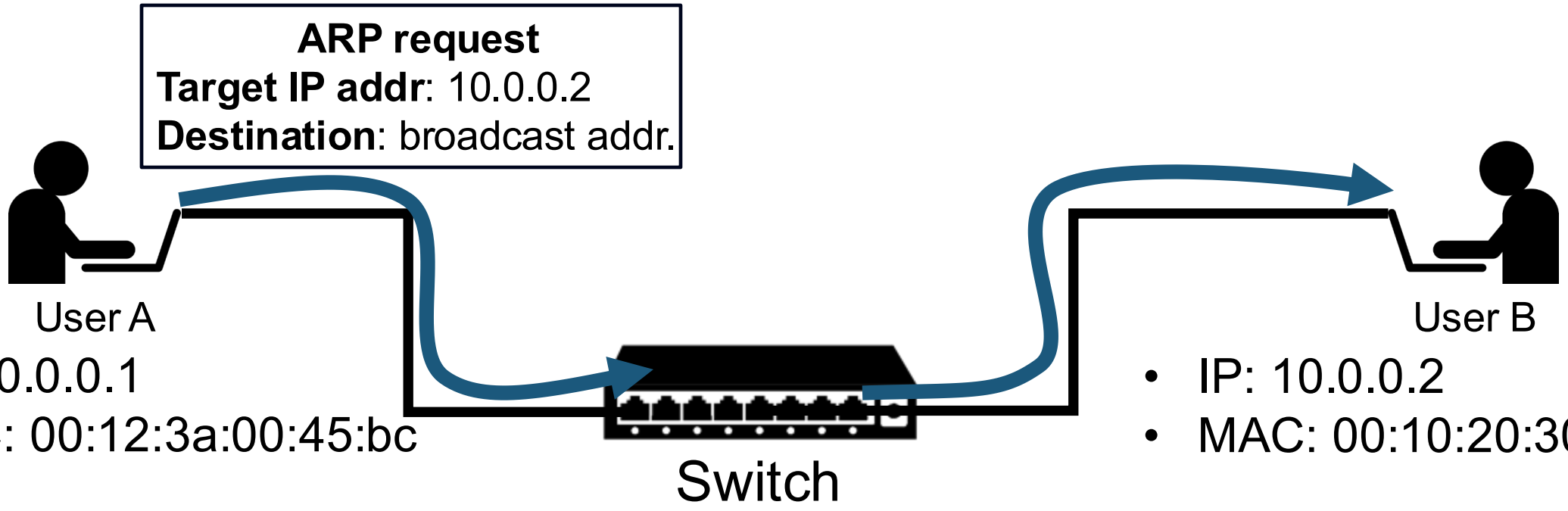
- IP: 10.0.0.1
- MAC: 00:1[illegible]:00:45:bc

- IP: 10.0.0.2
- MAC: 00:10:20:30:ac:06

To communicate with 10.0.0.2,
User A needs to know User B's MAC address
→ Use ARP protocol

Address Resolution Protocol (ARP)

What is the MAC address of 10.0.0.2?



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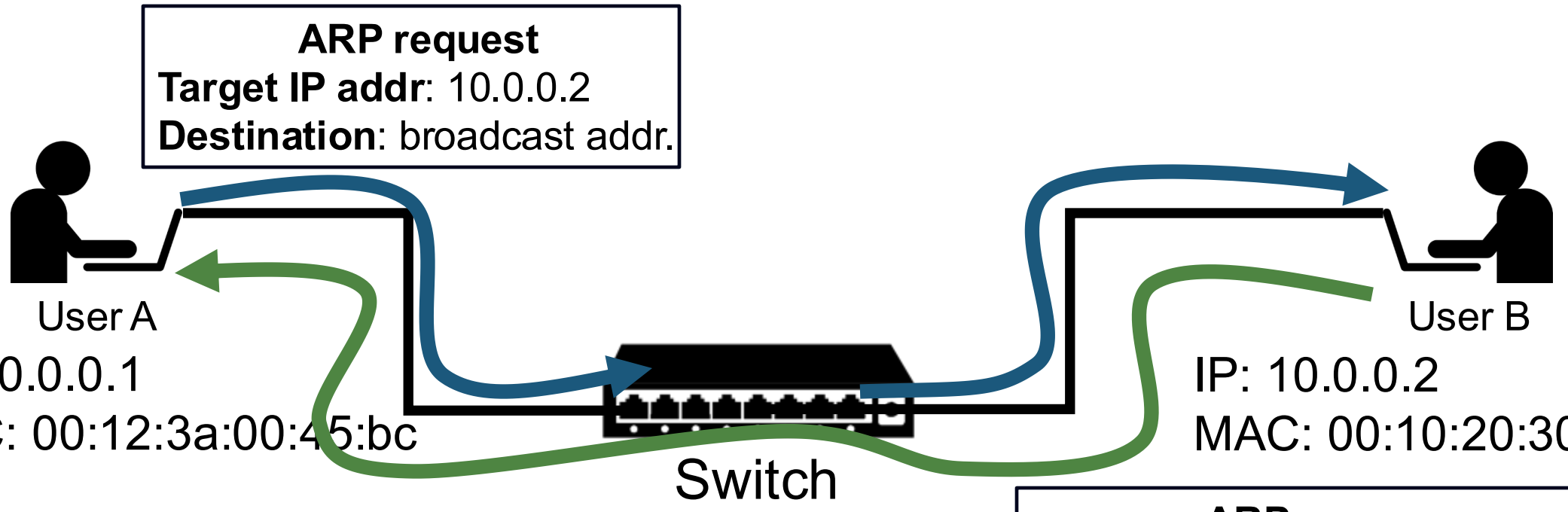


- IP: 10.0.0.1
- MAC: 00:12:3a:00:45:bc

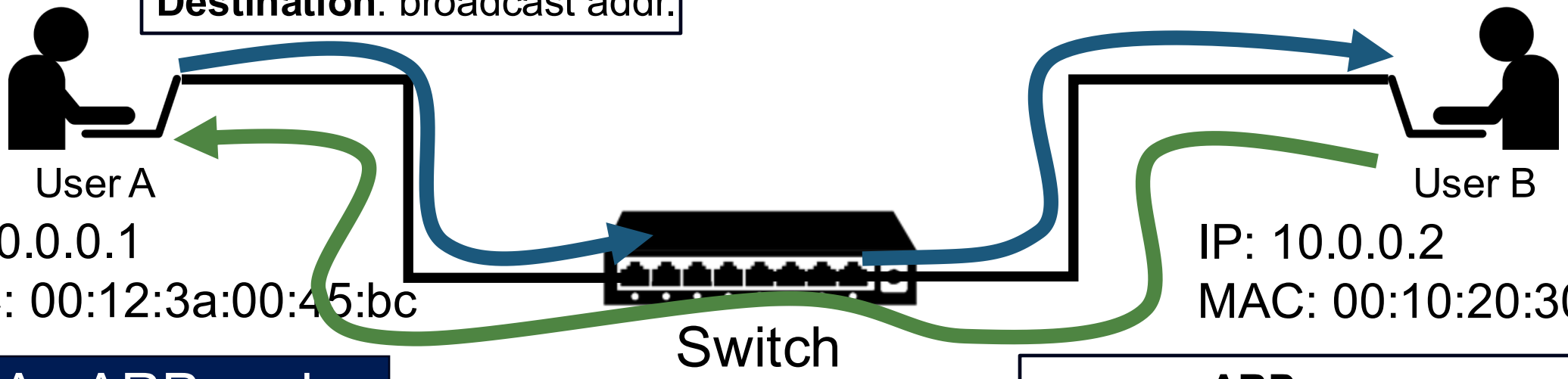
IP: 10.0.0.2
MAC: 00:10:20:30:ac:06

My MAC address is 00:10:20:30:ac:06

Address Resolution Protocol (ARP)

What is the MAC address of 10.0.0.2?

ARP request
Target IP addr: 10.0.0.2
Destination: broadcast addr.



- IP: 10.0.0.1
- MAC: 00:12:3a:00:45:bc

IP: 10.0.0.2
MAC: 00:10:20:30:ac:06

User A - ARP cache

IP Addr	Mac Addr
10.0.0.2	00:10:20:30:ac:06

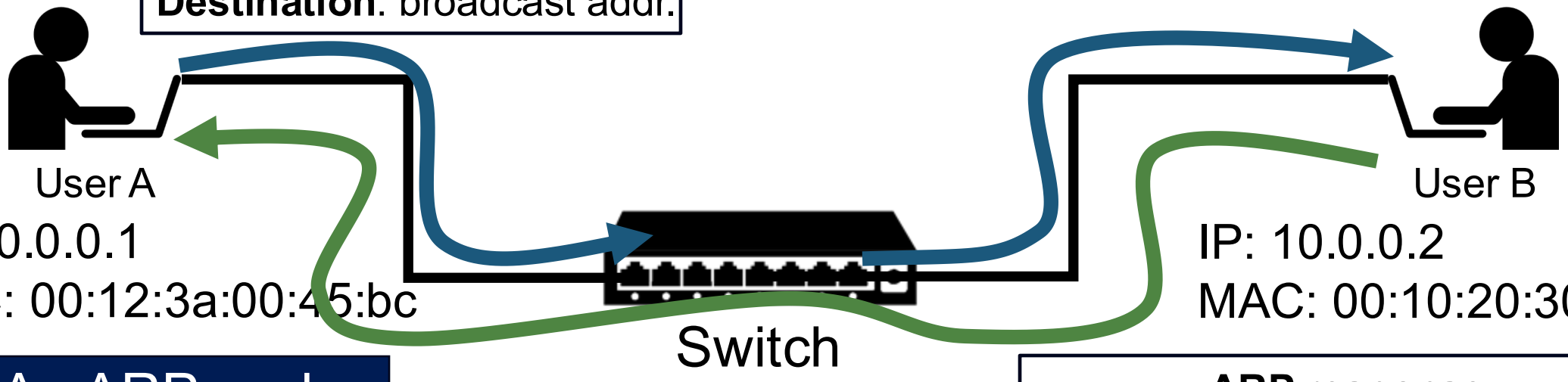
ARP response
My IP Addr: 10.0.0.2
My MAC addr: 00:10:20:30:ac:06
Destination: User A

My MAC address is 00:10:20:30:ac:06

Address Resolution Protocol (ARP)

What is the MAC address of 10.0.0.2?

ARP request
Target IP addr: 10.0.0.2
Destination: broadcast addr.



- IP: 10.0.0.1
- MAC: 00:12:3a:00:45:bc

IP: 10.0.0.2
MAC: 00:10:20:30:ac:06

User A - ARP cache

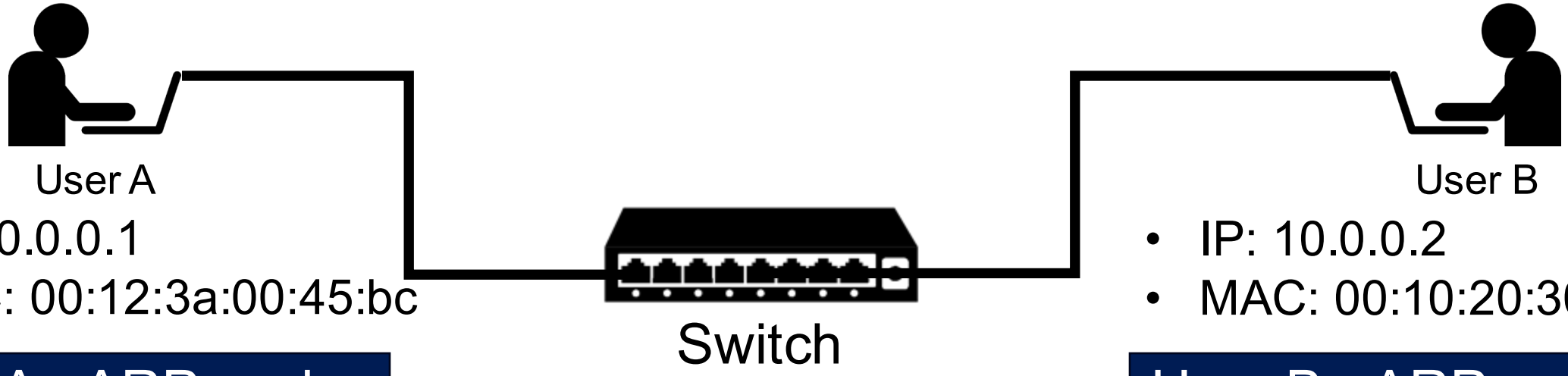
IP Addr	Mac Addr
10.0.0.2	00:10:20:30:ac:06

User A can get the IP-MAC addr. mapping info.

ARP response
: 10.0.0.2
dr: 00:10:20:30:ac:06
: User A

My MAC address is 00:10:20:30:ac:06

Address Resolution Protocol (ARP)



- IP: 10.0.0.1
- MAC: 00:12:3a:00:45:bc

- IP: 10.0.0.2
- MAC: 00:10:20:30:ac:06

User A - ARP cache

IP Addr	Mac Addr
10.0.0.2	00:10:20:30:ac:06

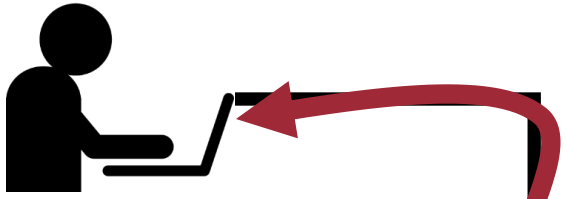
User B - ARP cache

IP Addr	Mac Addr
10.0.0.1	00:12:3a:00:45:bc

ARP Spoofing

ARP response
My IP Addr: 10.0.0.2
My MAC addr: 00:01:12:44:3a:6c
Destination: User A

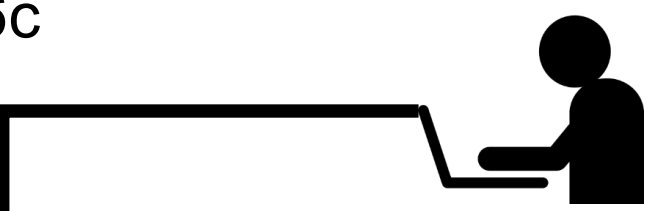
- IP: 10.0.0.3
- MAC: 00:01:12:44:3a:6c



User A

- IP: 10.0.0.1
- MAC: 00:12:3a:00:45:bc

Switch



User B

- IP: 10.0.0.2
- MAC: 00:10:20:30:ac:06

User A - ARP cache

IP Addr	Mac Addr
10.0.0.2	00:10:20:30:ac:06

User B - ARP cache

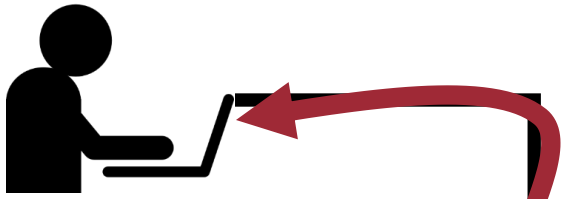
IP Addr	Mac Addr
10.0.0.1	00:12:3a:00:45:bc

ARP Spoofing

ARP response
My IP Addr: 10.0.0.2
My MAC addr: 00:01:12:44:3a:6c
Destination: User A

An attacker sends spoofed ARP messages

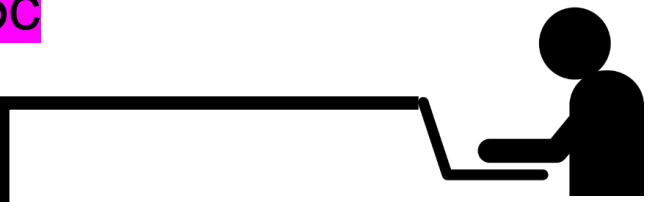
- IP: 10.0.0.3
- MAC: 00:01:12:44:3a:6c



User A

- IP: 10.0.0.1
- MAC: 00:12:3a:00:45:bc

Switch



User B

- IP: 10.0.0.2
- MAC: 00:10:20:30:ac:06

User A - ARP cache

IP Addr	Mac Addr
10.0.0.2	00:10:20:30:ac:06

User B - ARP cache

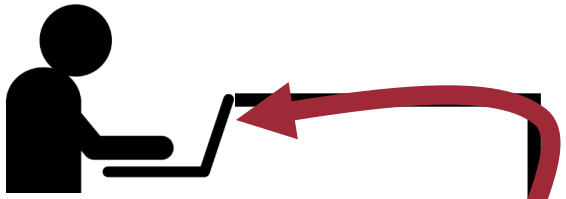
IP Addr	Mac Addr
10.0.0.1	00:12:3a:00:45:bc

ARP Spoofing

ARP response
My IP Addr: 10.0.0.2
My MAC addr: 00:01:12:44:3a:6c
Destination: User A

An attacker sends spoofed ARP messages

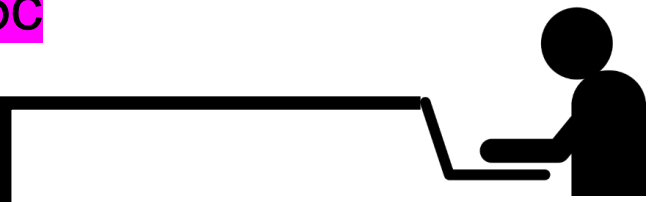
- IP: 10.0.0.3
- MAC: 00:01:12:44:3a:6c



User A

- IP: 10.0.0.1
- MAC: 00:12:3a:00:45:bc

Switch



User B

- IP: 10.0.0.2
- MAC: 00:10:20:30:ac:06

User A - ARP cache

IP Addr	Mac Addr
10.0.0.2	~~00:10:20:30:ac:06~~ 00:01:12:44:3a:6c

User B - ARP cache

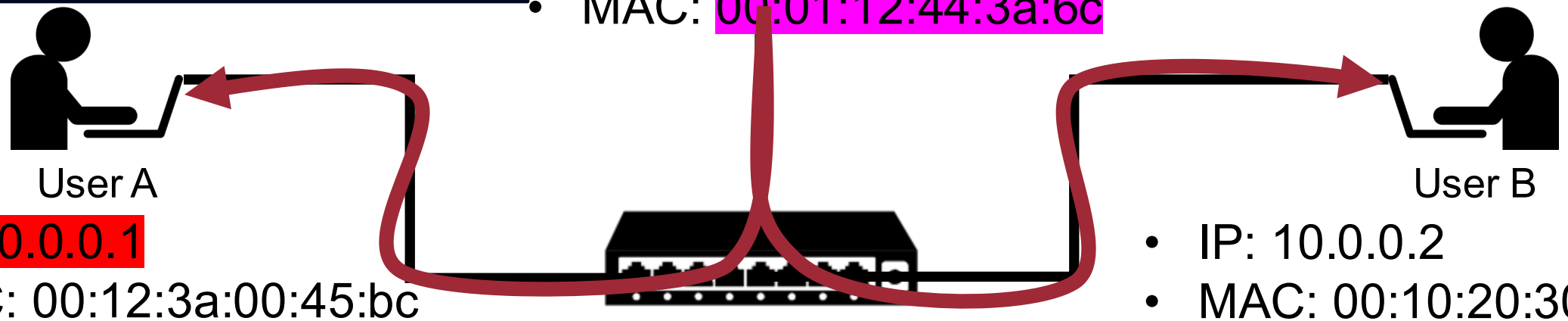
IP Addr	Mac Addr
10.0.0.1	00:12:3a:00:45:bc

ARP Spoofing

ARP response
My IP Addr: 10.0.0.2
My MAC addr: 00:01:12:44:3a:6c
Destination: User A

ARP response
My IP Addr: 10.0.0.1
My MAC addr: 00:01:12:44:3a:6c
Destination: User B

- IP: 10.0.0.3
- MAC: 00:01:12:44:3a:6c



User A

- IP: 10.0.0.1
- MAC: 00:12:3a:00:45:bc

Switch

User B

- IP: 10.0.0.2
- MAC: 00:10:20:30:ac:06

User A - ARP cache

IP Addr	Mac Addr
10.0.0.2	~~00:10:20:30:ac:06~~ 00:01:12:44:3a:6c

User B - ARP cache

IP Addr	Mac Addr
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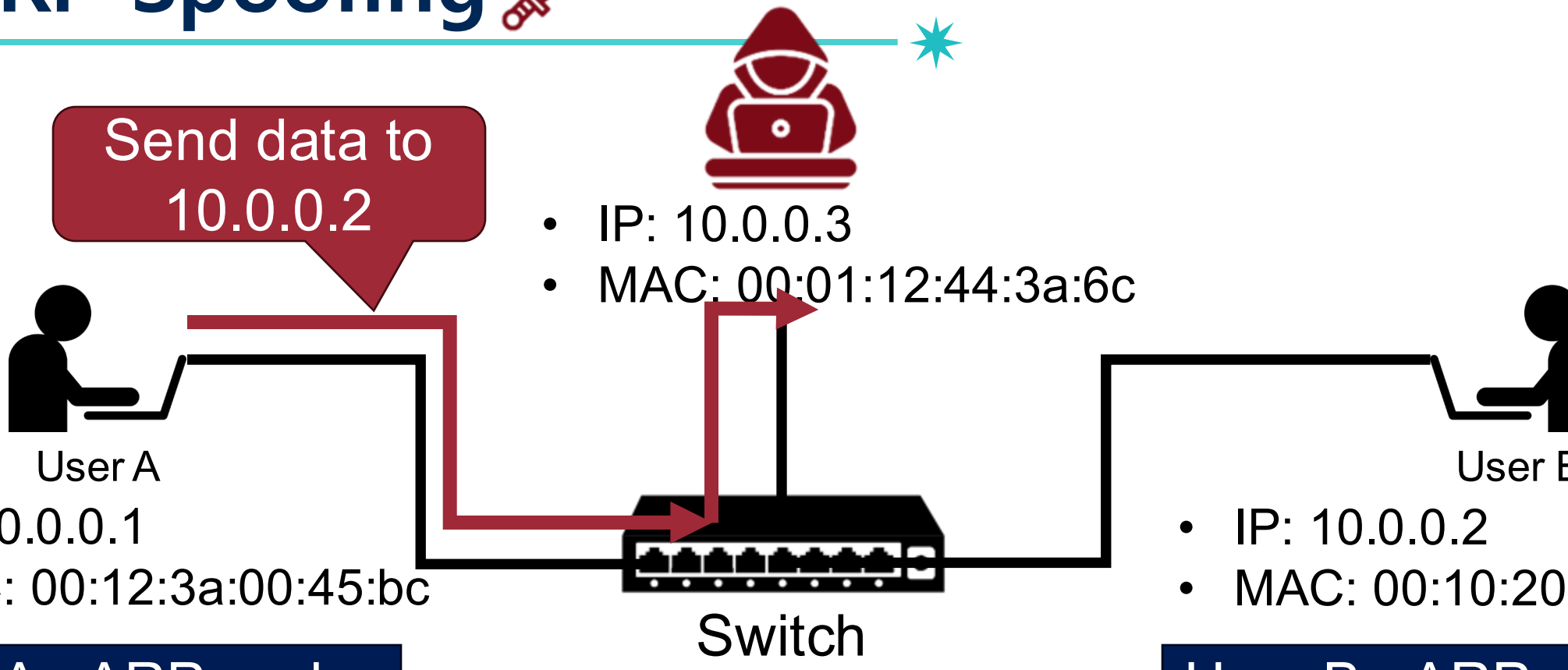
ARP Spoofing



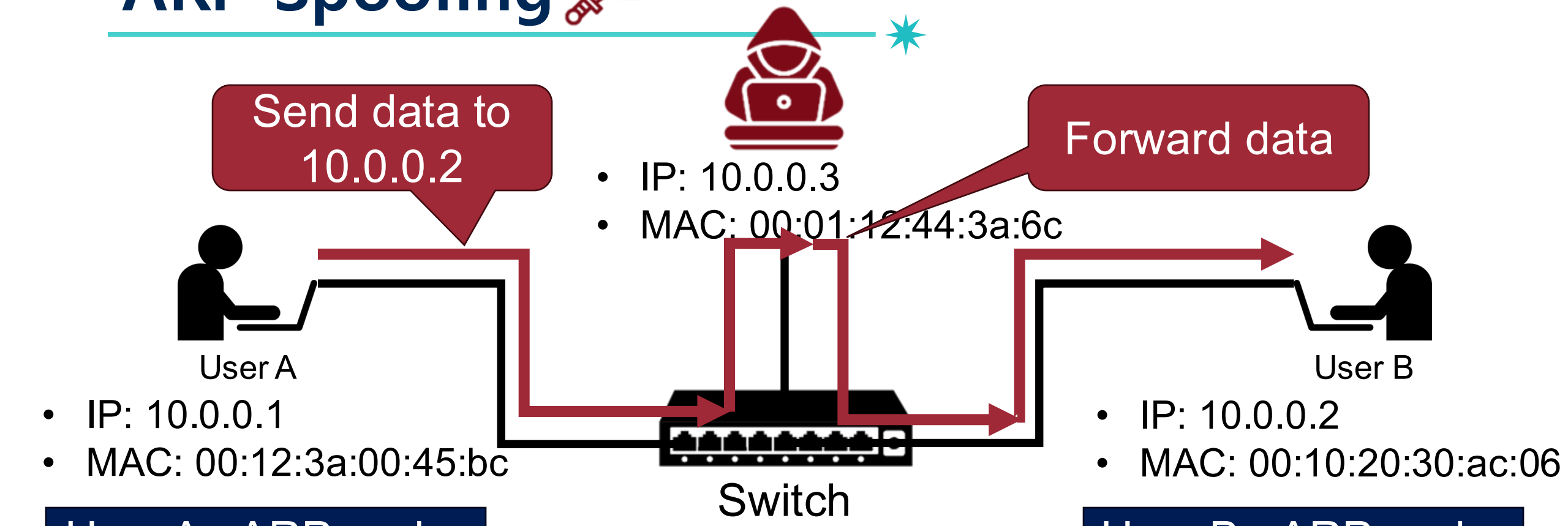
User A - ARP cache

IP Addr	Mac Addr
10.0.0.2	~~00:10:20:30:ac:06~~ 00:01:12:44:3a:6c

User B - ARP cache

IP Addr	Mac Addr
10.0.0.1	~~00:12:3a:00:45:bc~~ 00:01:12:44:3a:6c

ARP Spoofing



User A - ARP cache

IP Addr	Mac Addr
10.0.0.2	~~00:10:20:30:ac:06~~ 00:01:12:44:3a:6c

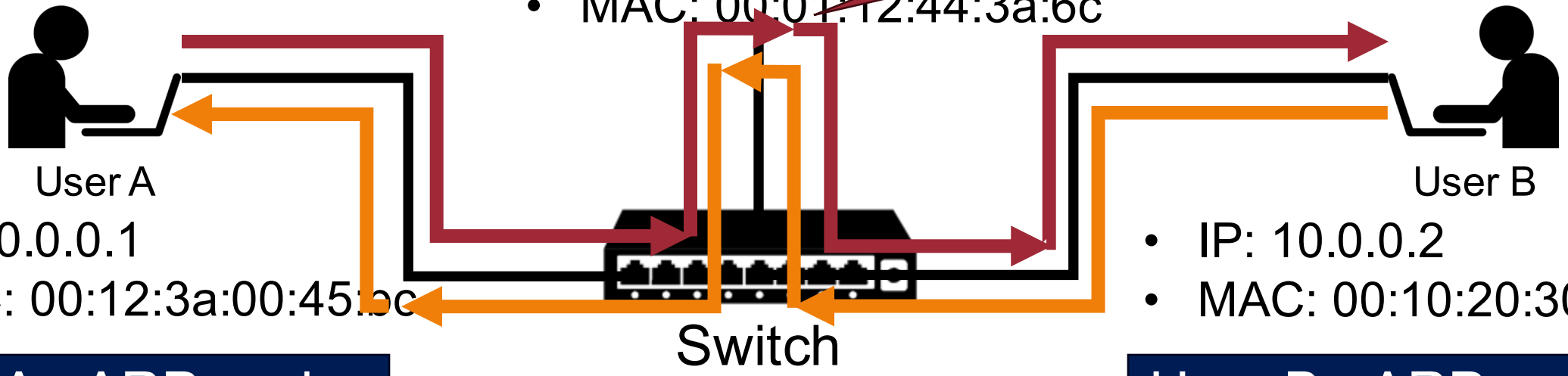
User B - ARP cache

IP Addr	Mac Addr
10.0.0.1	~~00:12:3a:00:45:bc~~ 00:01:12:44:3a:6c

ARP Spoofing

Man-in-the-Middle (MITM) attack

- IP: 10.0.0.3
- MAC: 00:01:12:44:3a:6c



User A

- IP: 10.0.0.1
- MAC: 00:12:3a:00:45:bc

Switch

User B

- IP: 10.0.0.2
- MAC: 00:10:20:30:ac:06

User A - ARP cache

IP Addr	Mac Addr
10.0.0.2	~~00:10:20:30:ac:06~~ 00:01:12:44:3a:6c

User B - ARP cache

IP Addr	Mac Addr
10.0.0.1	~~00:12:3a:00:45:bc~~ 00:01:12:44:3a:6c

ARP Spoofing – Use Case

Public WIFI is vulnerable to MITM attacks
(via ARP spoofing)

Home > 전체기사

카페서 와이파이 쓰다 스마트폰 가로채기 당한다?

입력 : 2015-10-29 11:30

모바일에서 공유기 통해 외부 접근시 공격자가 스마트폰 정보 가로채기 가능

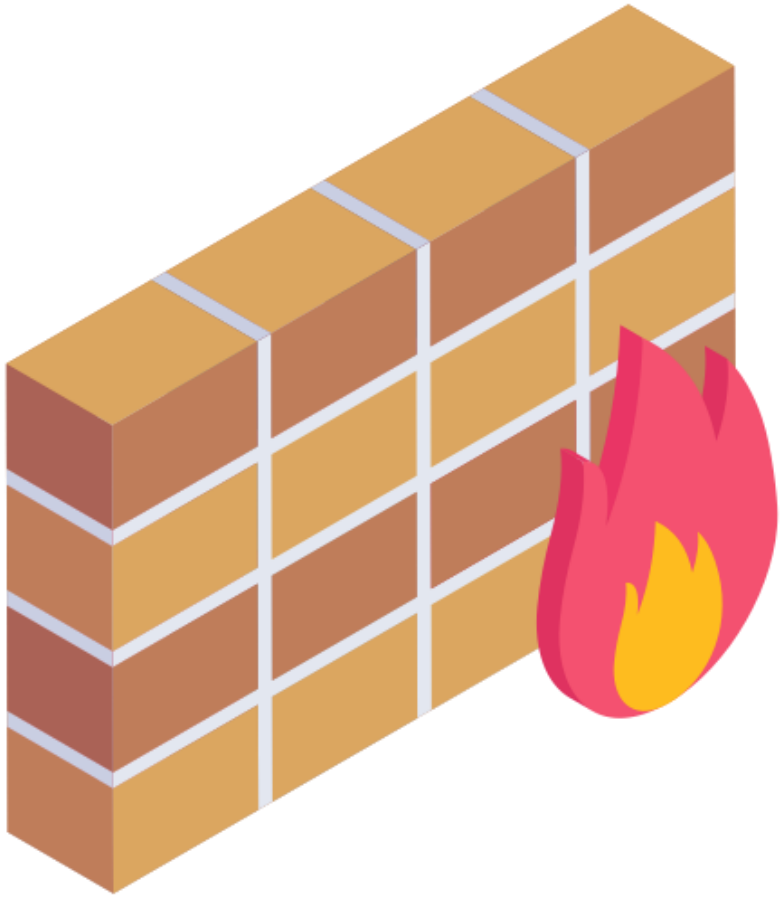
[보안뉴스 김경애] 올해 1분기 주요 보안 이슈로 떠오른 바 있는 공유기 보안 문제가 좀처럼 해결되지 않고 있다. 사람들이 이용하는 카페 등 공공장소에서 공유기를 통해 무료 와이파이를 이용할 경우 모바일을 이용해 정보를 가로챌 수 있는 ARP 스푸핑(Spoofing) 공격이 가능한 것으로 드러났기 때문이다. 이에 따라 공공장소나 카페에서 와이파이 접속시 이용자들의 주의가 요구된다.

Not recommended to use public WIFI!

How to Mitigate ARP Spoofing Attacks?

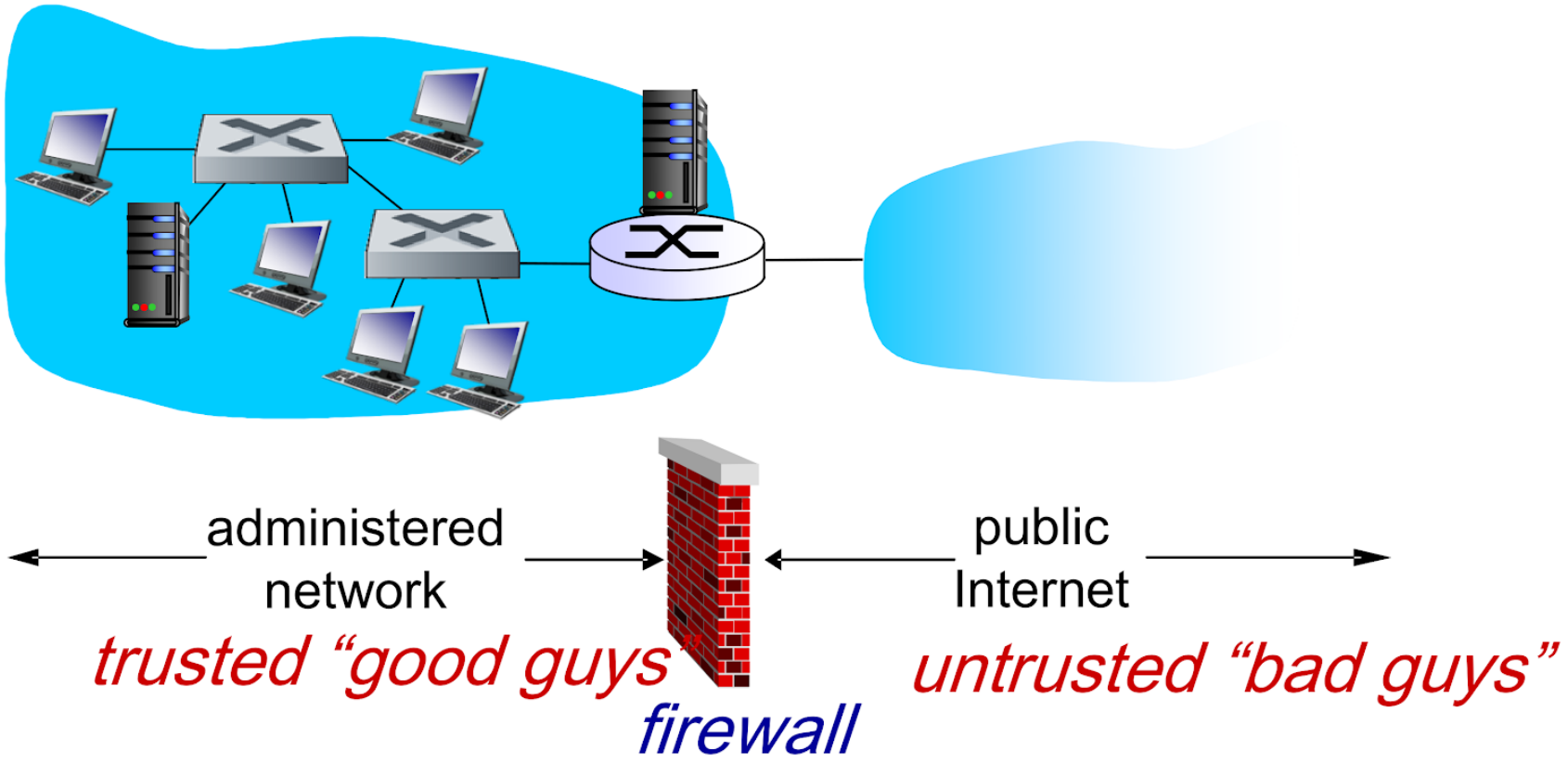
- Packet encryption
  - E.g., Visit websites via HTTPs protocol
- Static ARP caches
  - IP-MAC address mappings in the local ARP cache may be statically entered
- Packet filtering
  - Check if many ARP responses are sent without a request

Firewalls



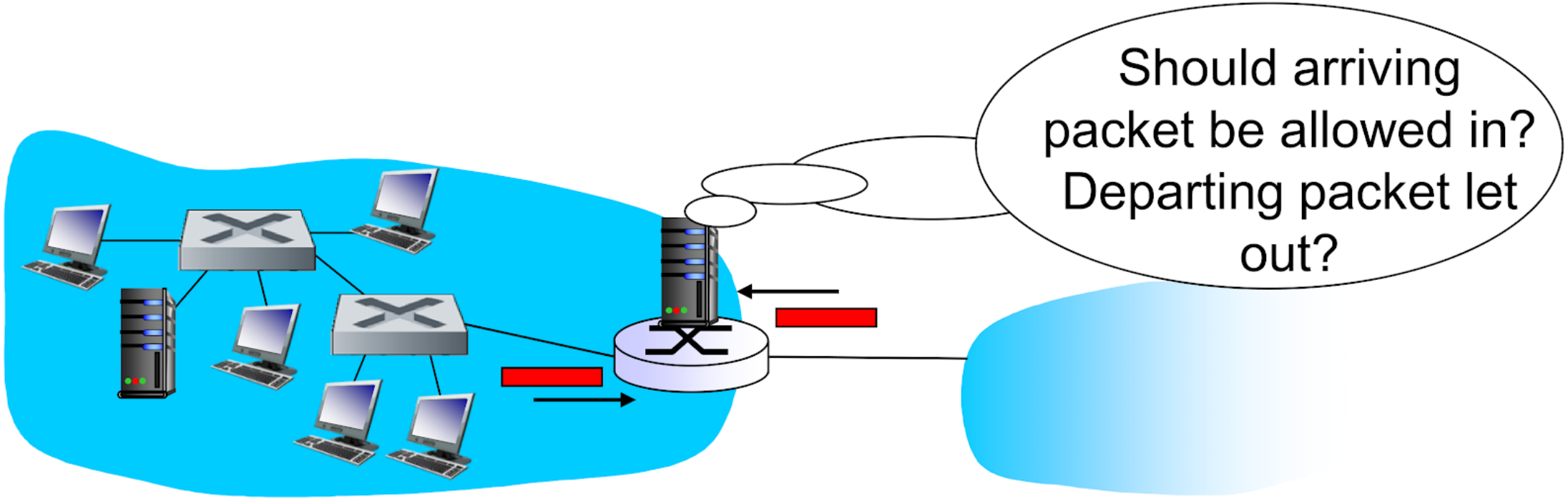
Firewalls

- Isolate organization's internal net from larger Internet, allowing some packets to pass, blocking others



Main Goals of Firewall

- Restrict incoming and outgoing traffic by IP address, ports, or users
  - Block invalid traffic and only authorized traffic is allowed



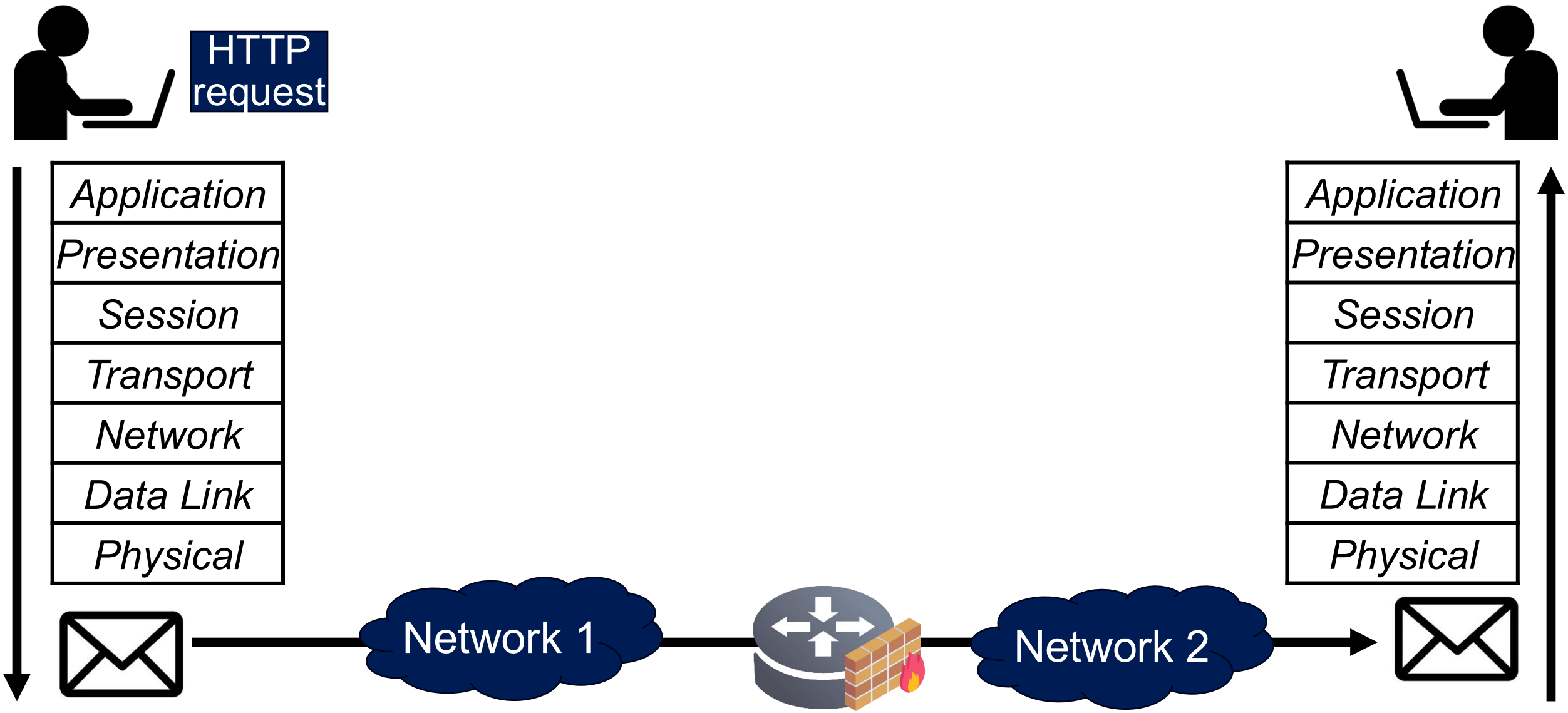
Types of Firewall

- Three types of firewalls:
  - Packet filters
  - Application gateways

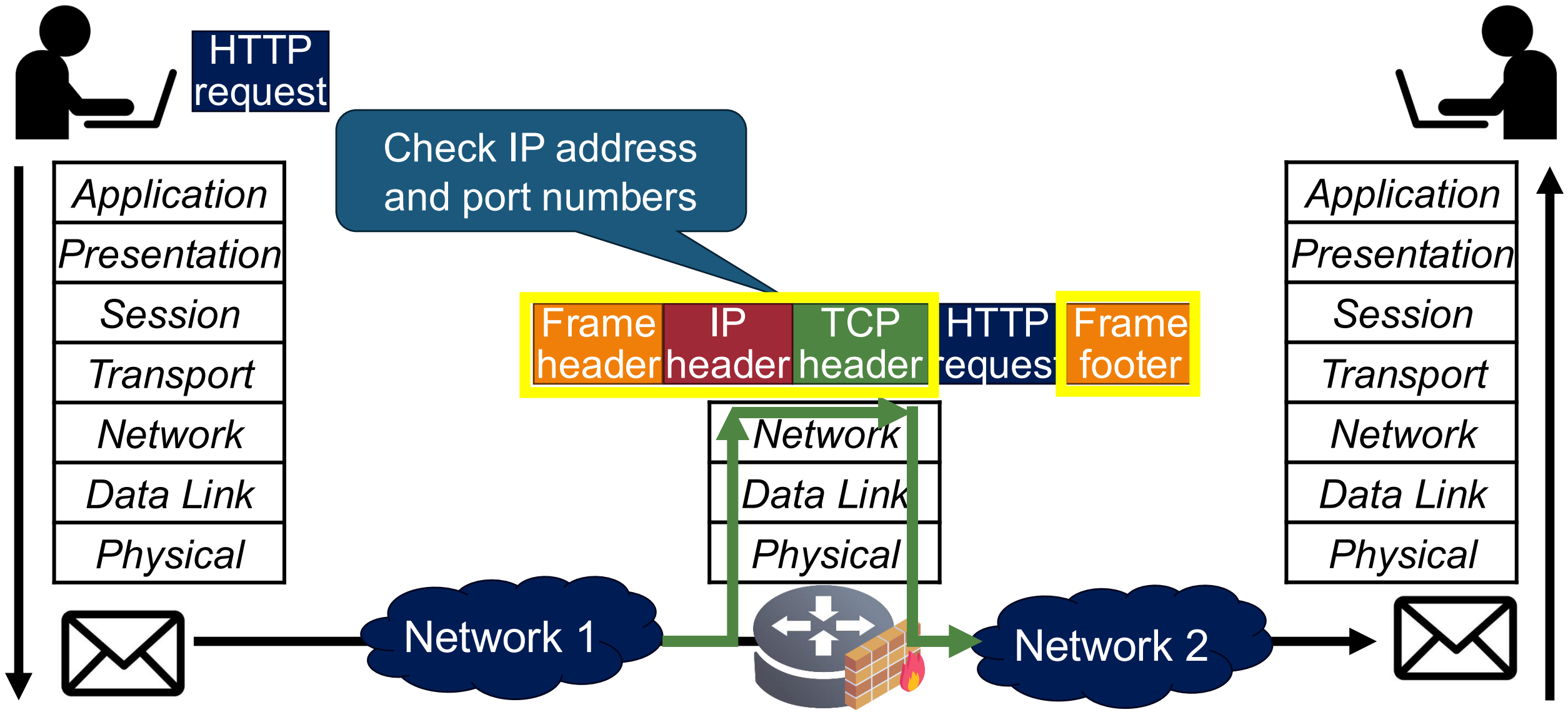
Packet Filters

- Internal network connected to Internet via router firewall
- Router filters packet-by-packet from the network layer, decision to forward/drop packet based on:
  - Source/destination IP address
  - Source/destination port numbers
  - ICMP message type
  - Protocol status (e.g., TCP SYN, TCP ACK, …)

Packet Filters via Router Firewall



Packet Filters via Router Firewall



Packet Filters – High-level Example

Policy	Firewall Setting
No incoming web access	Drop all incoming packets to any IP address, port 80
No incoming TCP connections, except those for institution's public web server only	Drop all incoming TCP SYN packets to any IP except 130.207.244.203, port 80
Prevent your network from being used for a ICMP flooding attack	Drop all ICMP packets going to a "broadcast" address

Packet Filters – Detailed Example

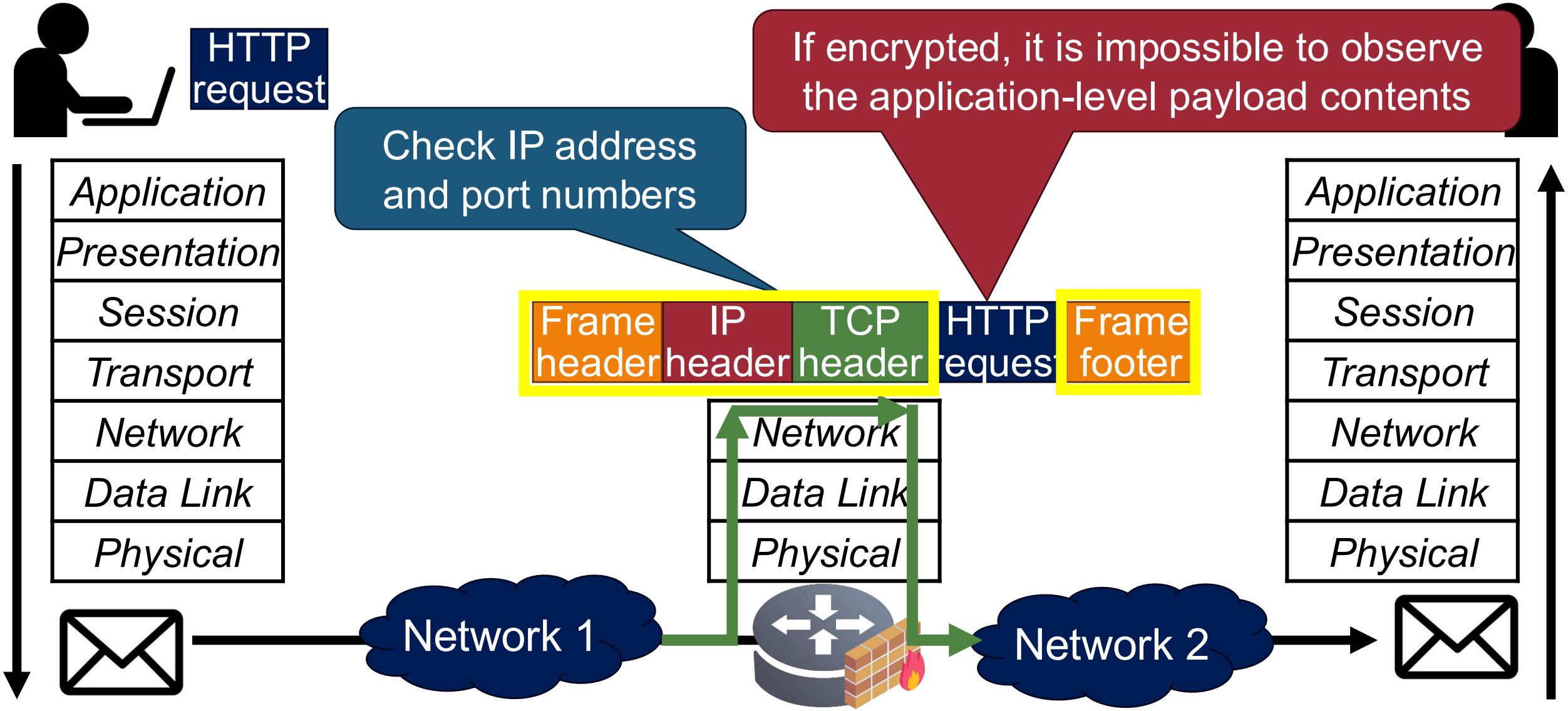
Action	Source Address	Dest. Address	Protocol	Source port	Dest port	Flag bit
Allow	222.22/16	Outside of 222.22/16	TCP	> 1023	80	any
Allow	Outside of 222.22/16	222.22/16	TCP	80	> 1023	ACK
Allow	222.22/16	Outside of 222.22/16	UDP	> 1023	53	---
Allow	Outside of 222.22/16	222.22/16	UDP	53	> 1023	---
Deny	all	all	all	all	all	all

Packet Filters – Pros and Cons

- Pros
  - Simple to implement
  - Low impact on network performance

- Cons
  - Malicious content in application data cannot be filtered out

Packer Filter: Limitation

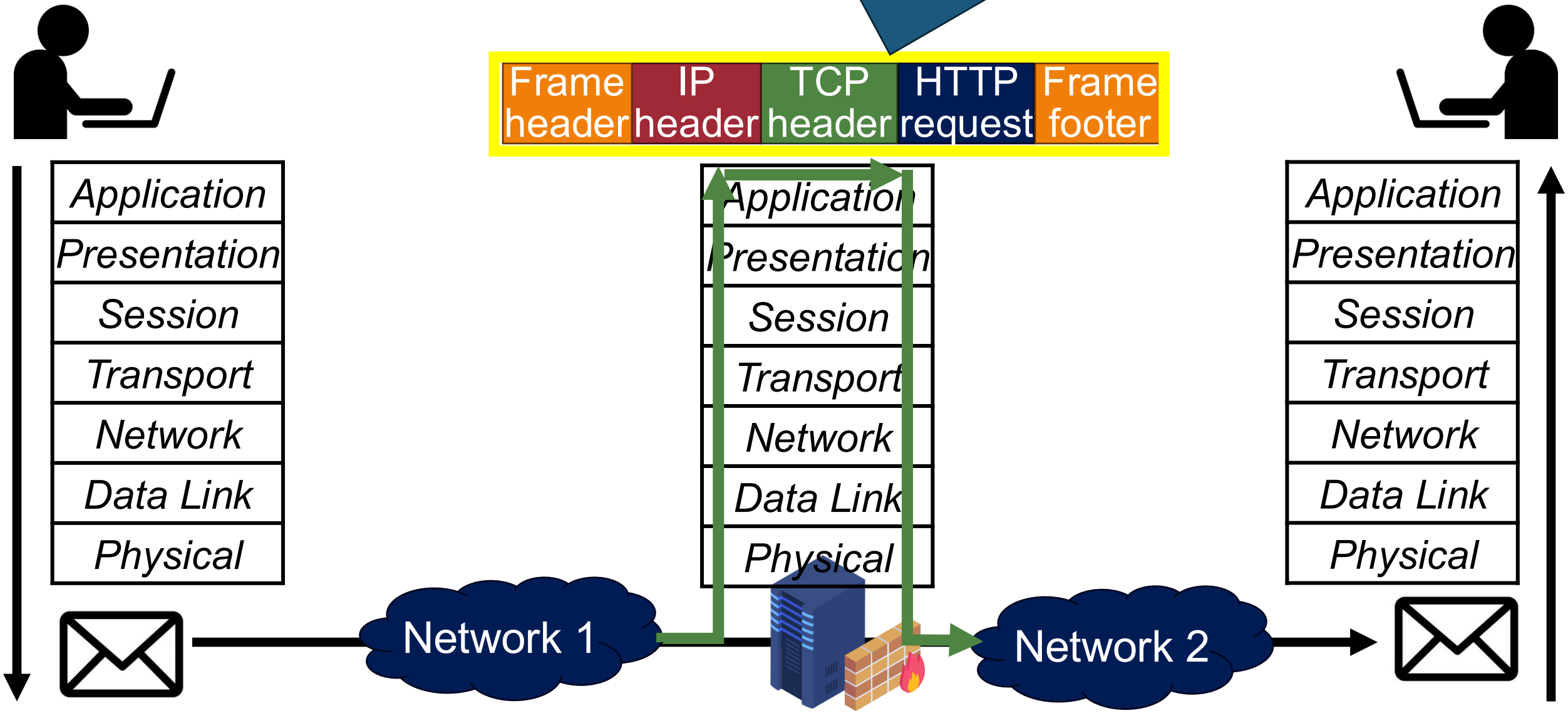


Application Gateways

- Filter packets on **application data** as well as on IP/TCP/UDP fields

Application Gateway

Filter packets on application data as well as on IP/TCP/UDP fields



Application Gateways – Pros and Cons

- Pros
  - Tend to be **more secure** than packet filters because they can examine every layer of the communication
- Cons
  - Complex to implement
  - High impact on network performance

Intrusion Detection System (IDS)

Intrusion Detection

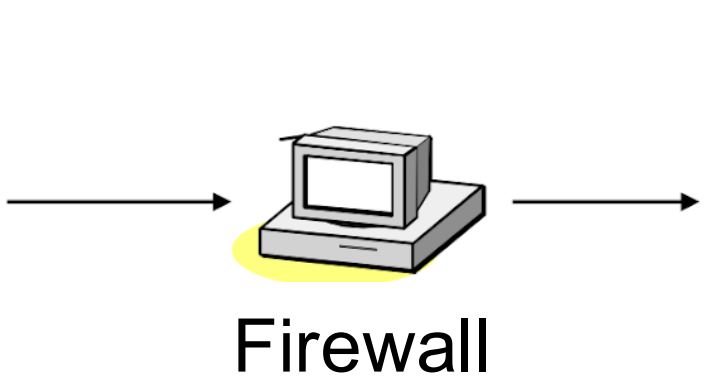
- Intrusion
  - A set of actions aimed to compromise the security goals

- Intrusion detection
  - The process of identifying and responding to intrusion activities

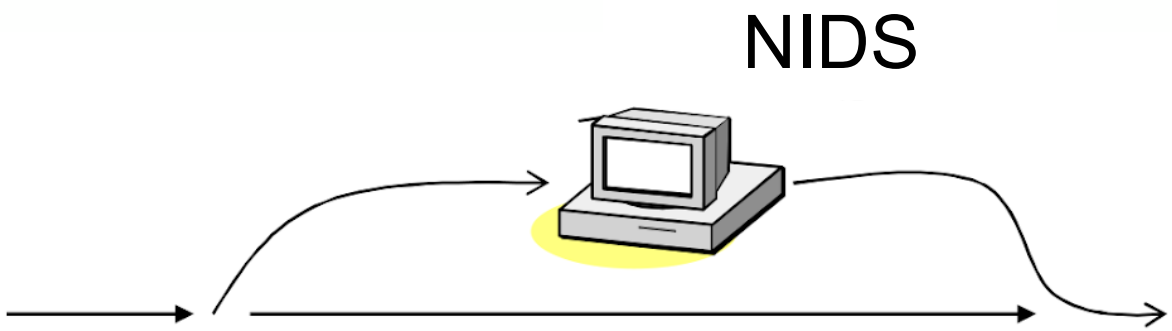
Firewall vs. IDS

- Firewall
  - Active filtering (prevent intrusion)
  - Location: Between networks (if an attack is from inside the network it doesn't signal)

- IDS
  - Passive monitoring (detect intrusion)
  - Location: Inside the network



Firewall



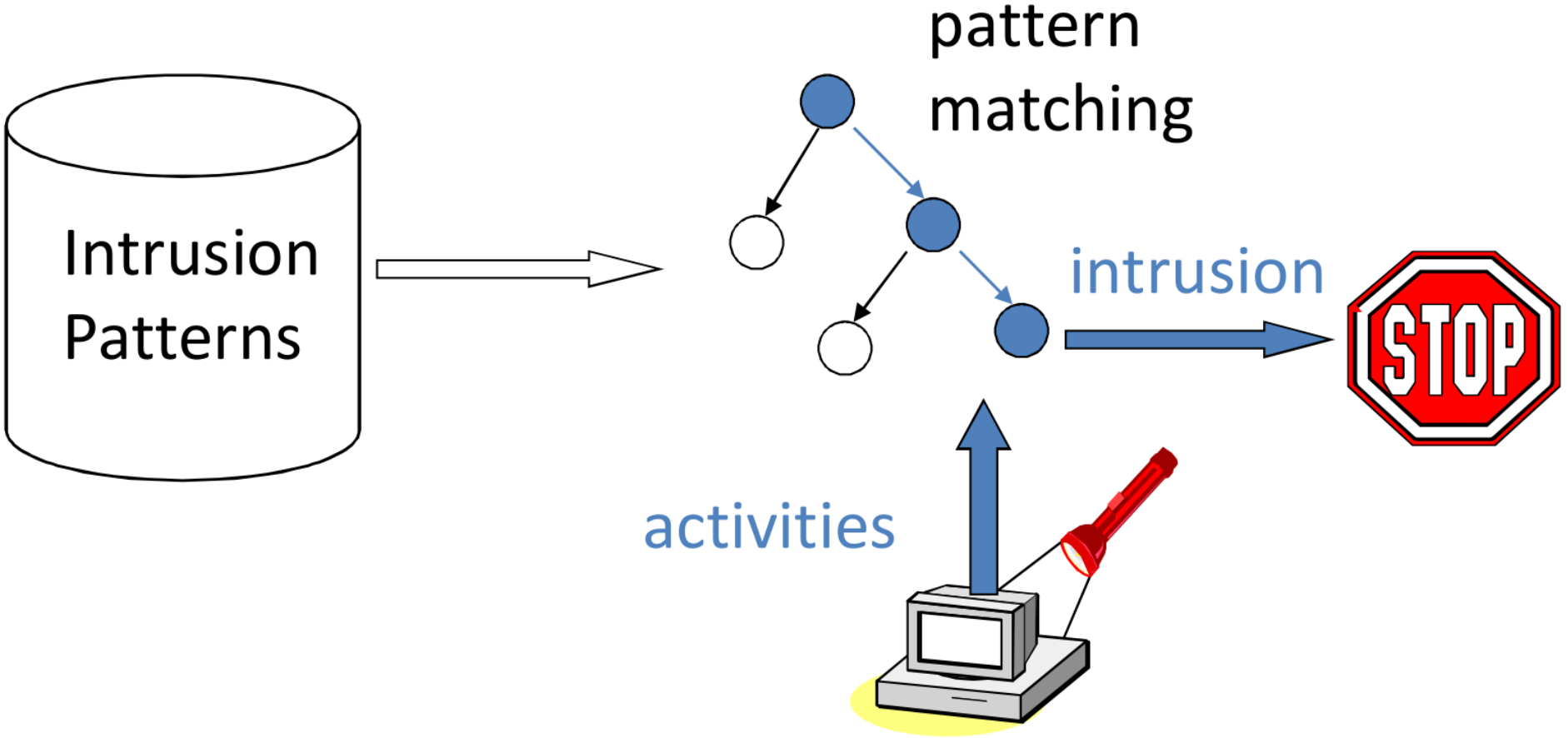
Detection Methods of IDS

1. Signature-based detection

2. Anomaly-based detection

IDS Type #1. Signature-based Detection

- Detects the attacks on the basis of the **specific patterns**
  - E.g., Snort, Bro



IDS Type #1. Signature-based Detection

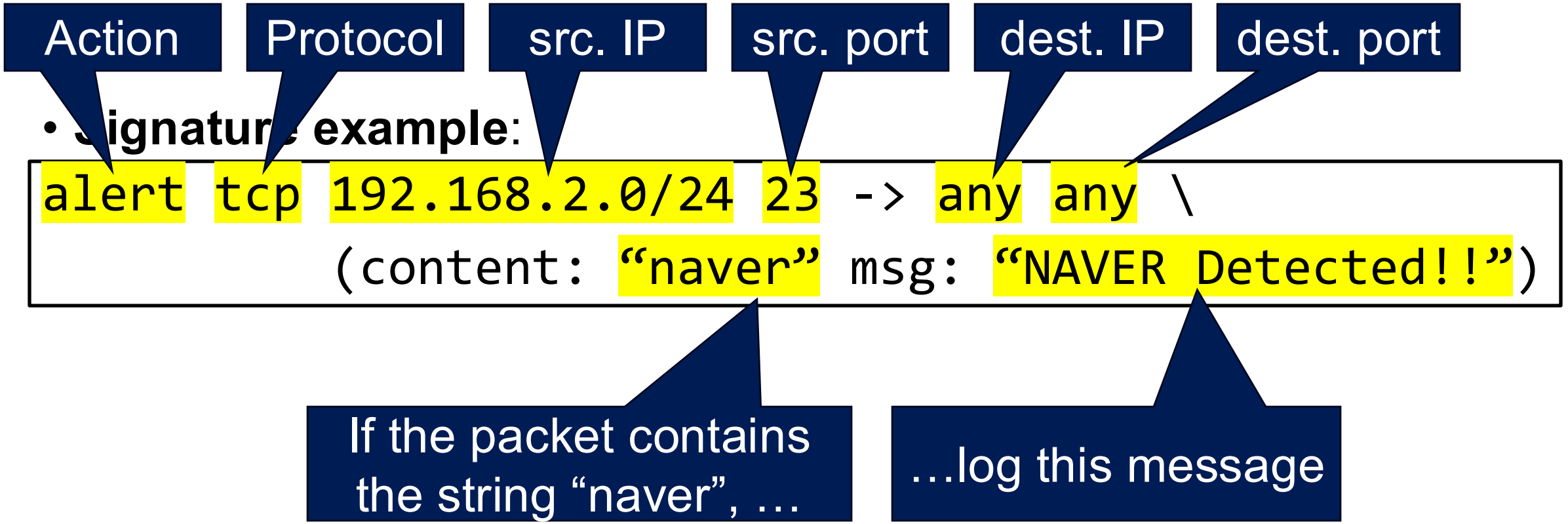
Alternative?

Example: Snort

- **Signature example**:

```
alert tcp 192.168.2.0/24 23 -> any any \
          (content: “naver” msg: “NAVER Detected!!”)
```

Example: Snort

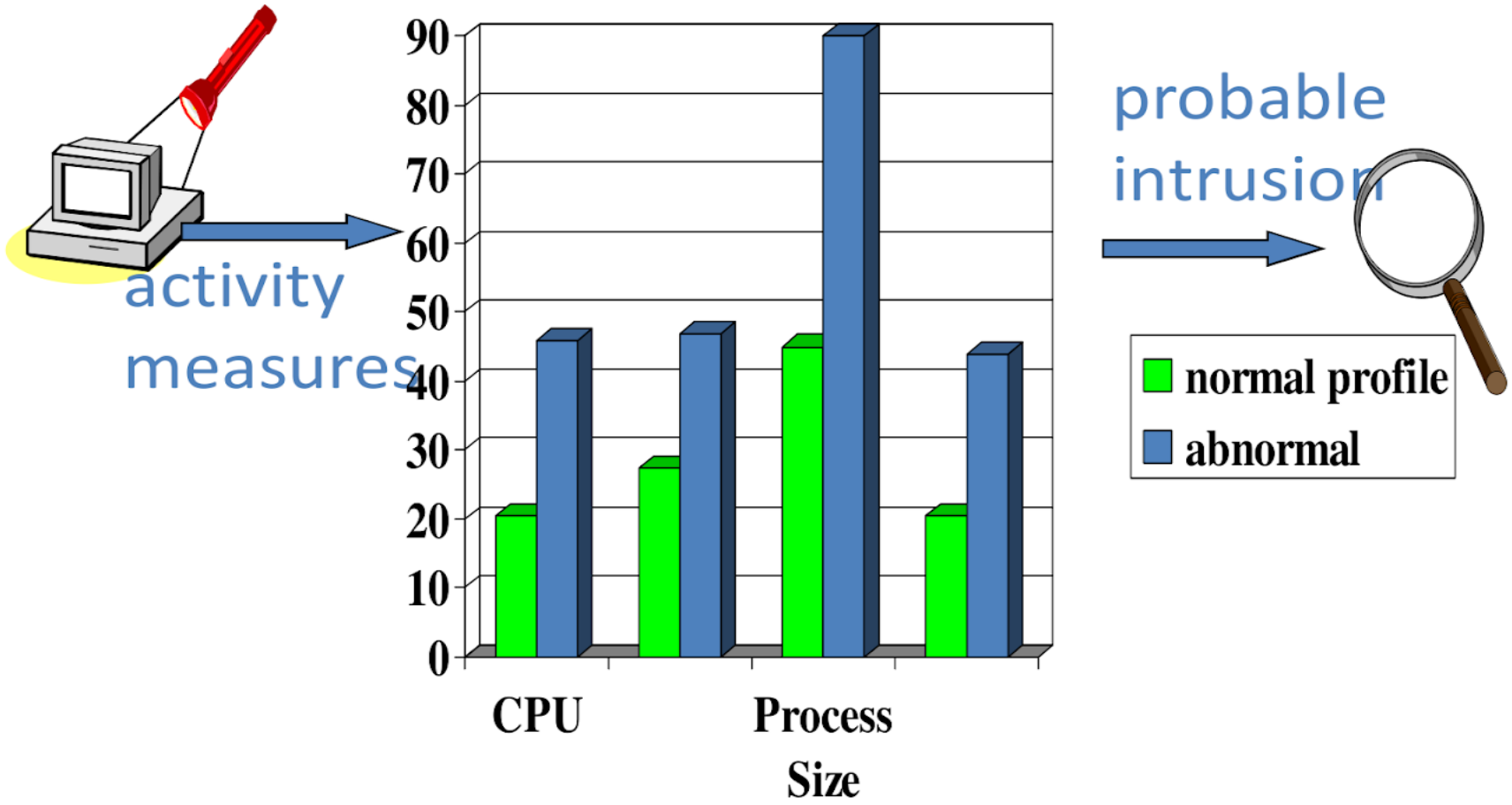


IDS Type #1. Signature-based Detection

- Detects the attacks on the basis of the **specific patterns**
- Limitation: difficult to detect new malware attacks as their pattern is not known

IDS Type #2. Anomaly-based Detection

- Detects the attacks on the basis of the statistical models or machine learning models

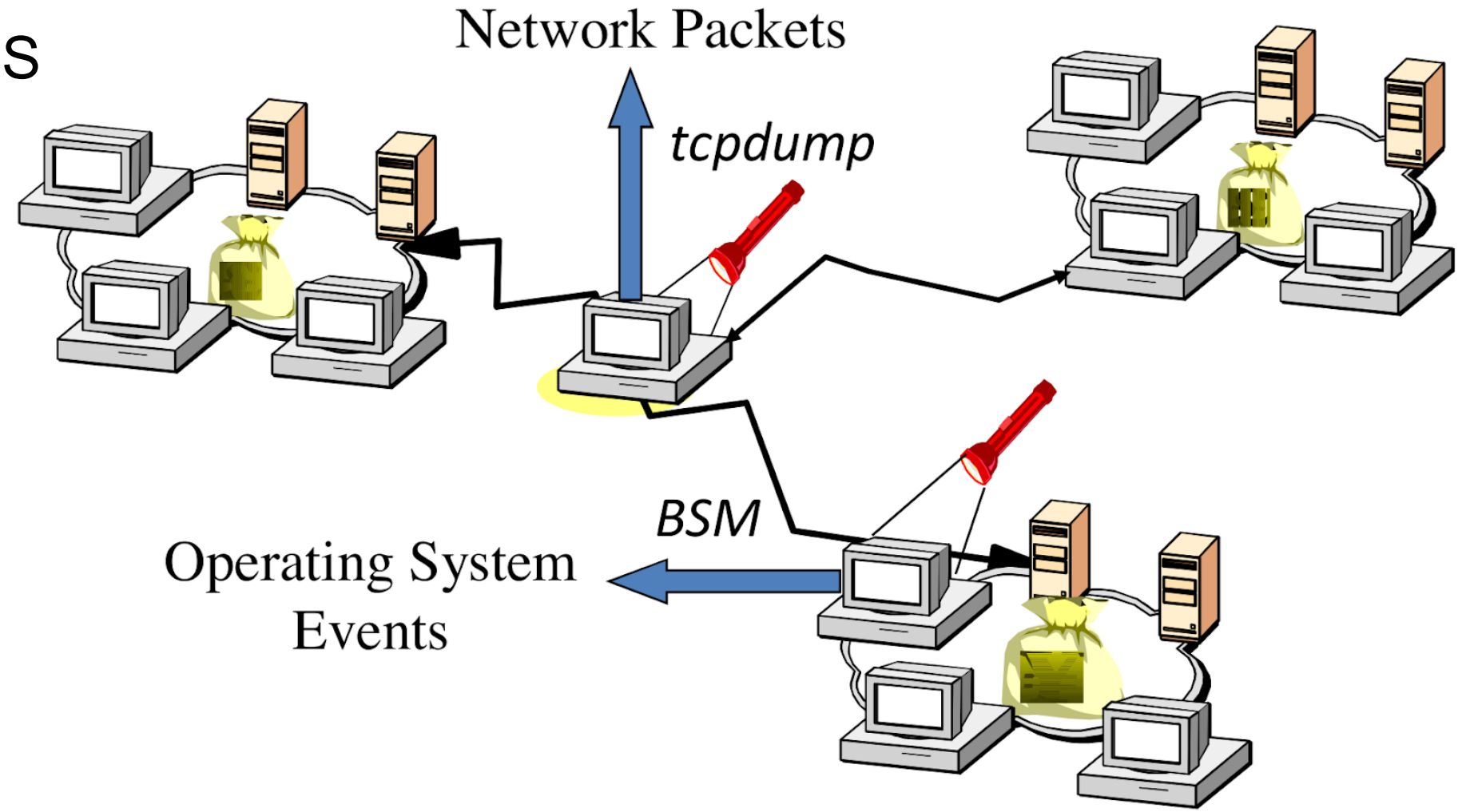


IDS Type #2. Anomaly-based Detection

- Detects the attacks on the basis of the statistical models or machine learning models
- Limitation: relatively high false positive rate – anomalies can just be new normal activities

Deployment of IDS

1. Host IDS
2. Network IDS



HIDS (Host IDS)

- Using **OS auditing mechanisms**
  - e.g., BSM on Solaris: logs all direct or indirect events generated by a user
  - `strace` for system calls made by a program
- Monitoring user activities
  - e.g., Analyze shell commands
- Monitoring executions of system programs
  - e.g., Analyze abnormal system calls

Limitations:

- Occupies a certain portion of host resources
- An IDS must be installed and operated on every individual host

NIDS (Network IDS)

- Deploying sensors at strategic locations
  - e.g., Packet sniffing via `tcpdump` at routers
- Inspecting **network traffic**
  - Watch for violations of protocols and unusual connection patterns
- Monitoring user activities
  - Look into the data portions of the packets for malicious command sequences

Limitations:

- Easily defeated by encryption

Summary

- Worm: first network attack
- Denial of Service (DoS)
  - Distributed DoS (DDoS)
  - Ping Flood Attack
  - Amplification Attack
  - SYN Flooding Attack
- ARP Spoofing Attack
- Defense: Firewalls, IDS, IPS

Question?