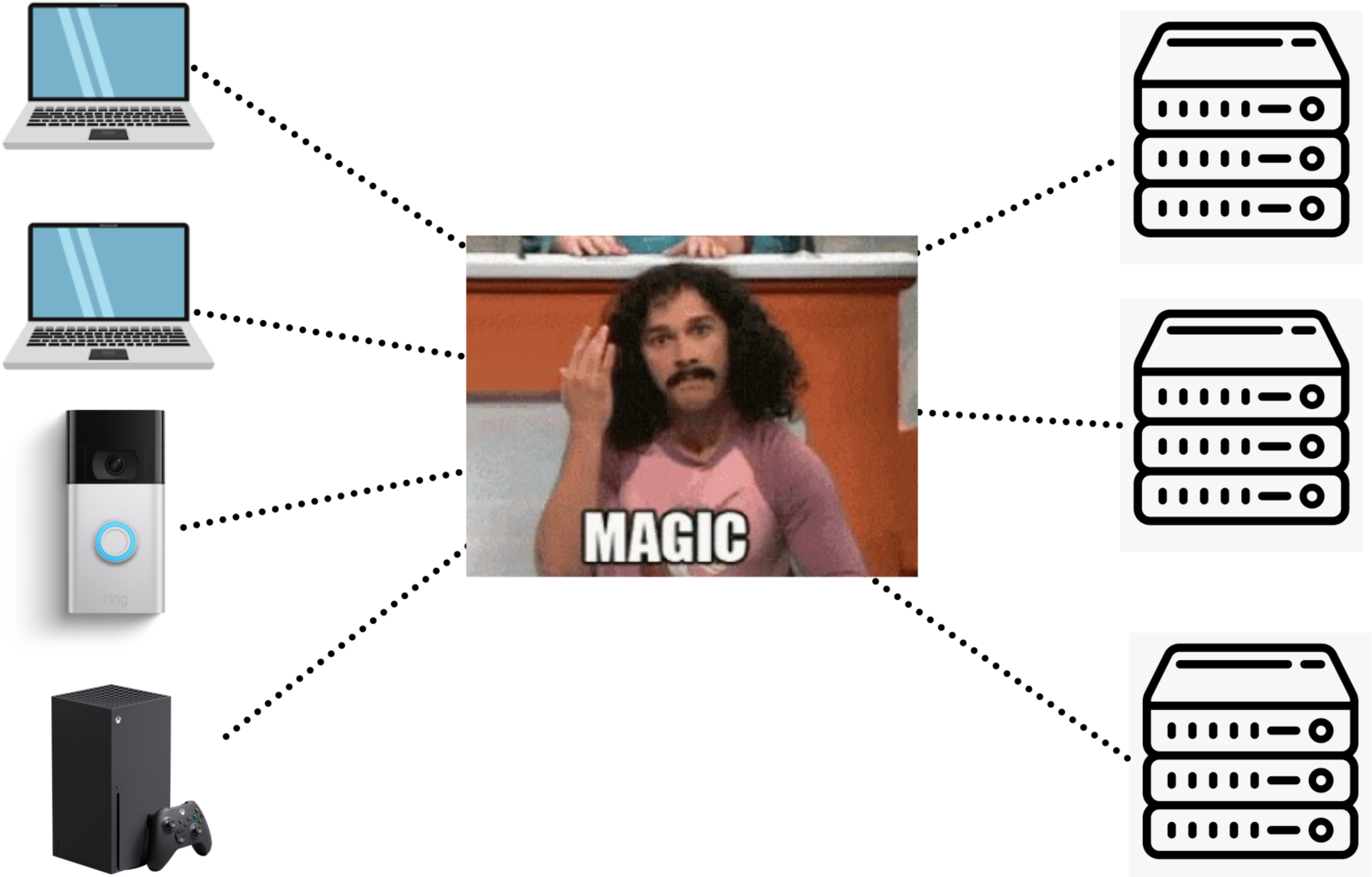
AI for Security (AI4Sec)

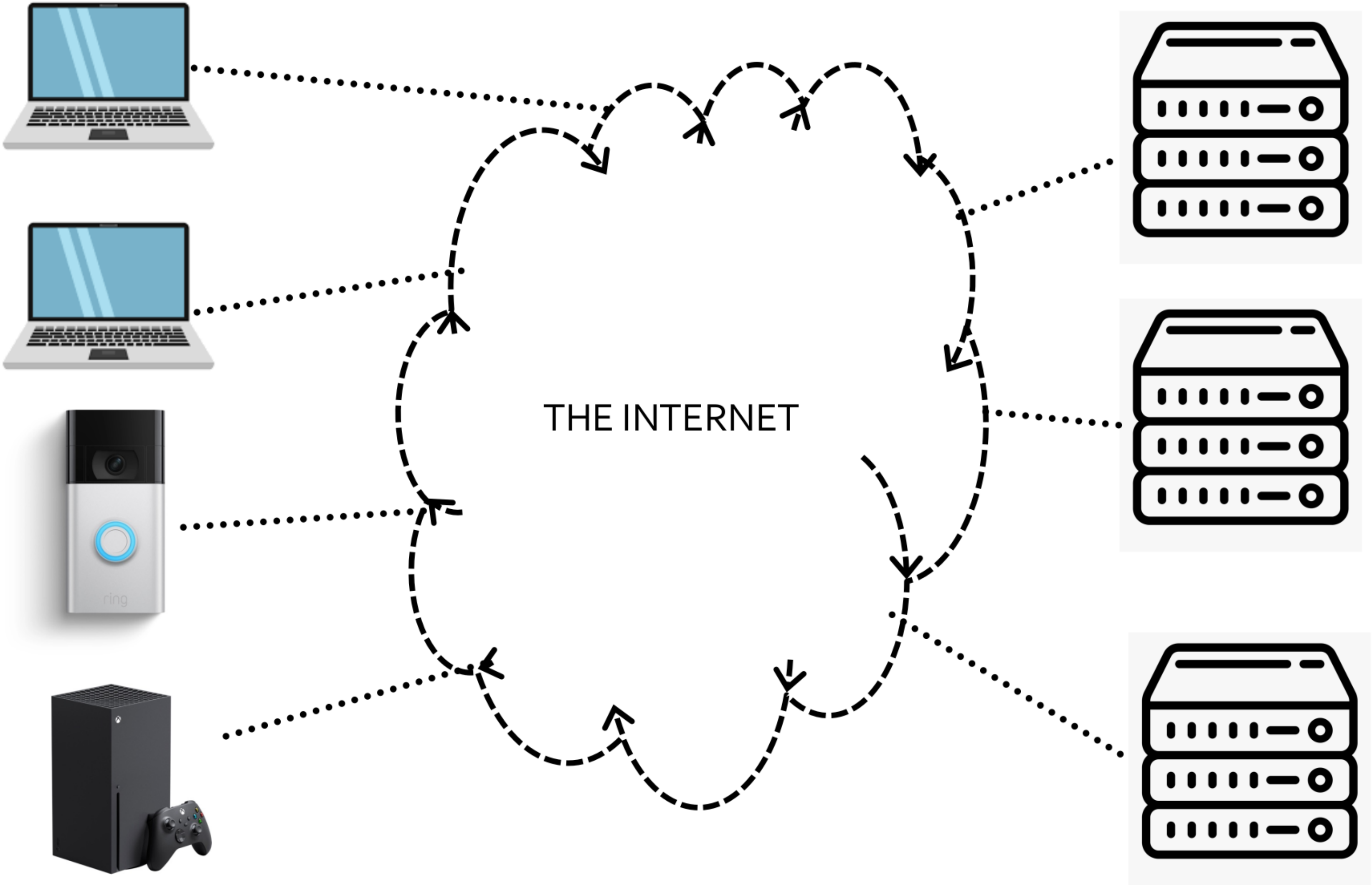
Network Security Overview

COMP-5870/6870

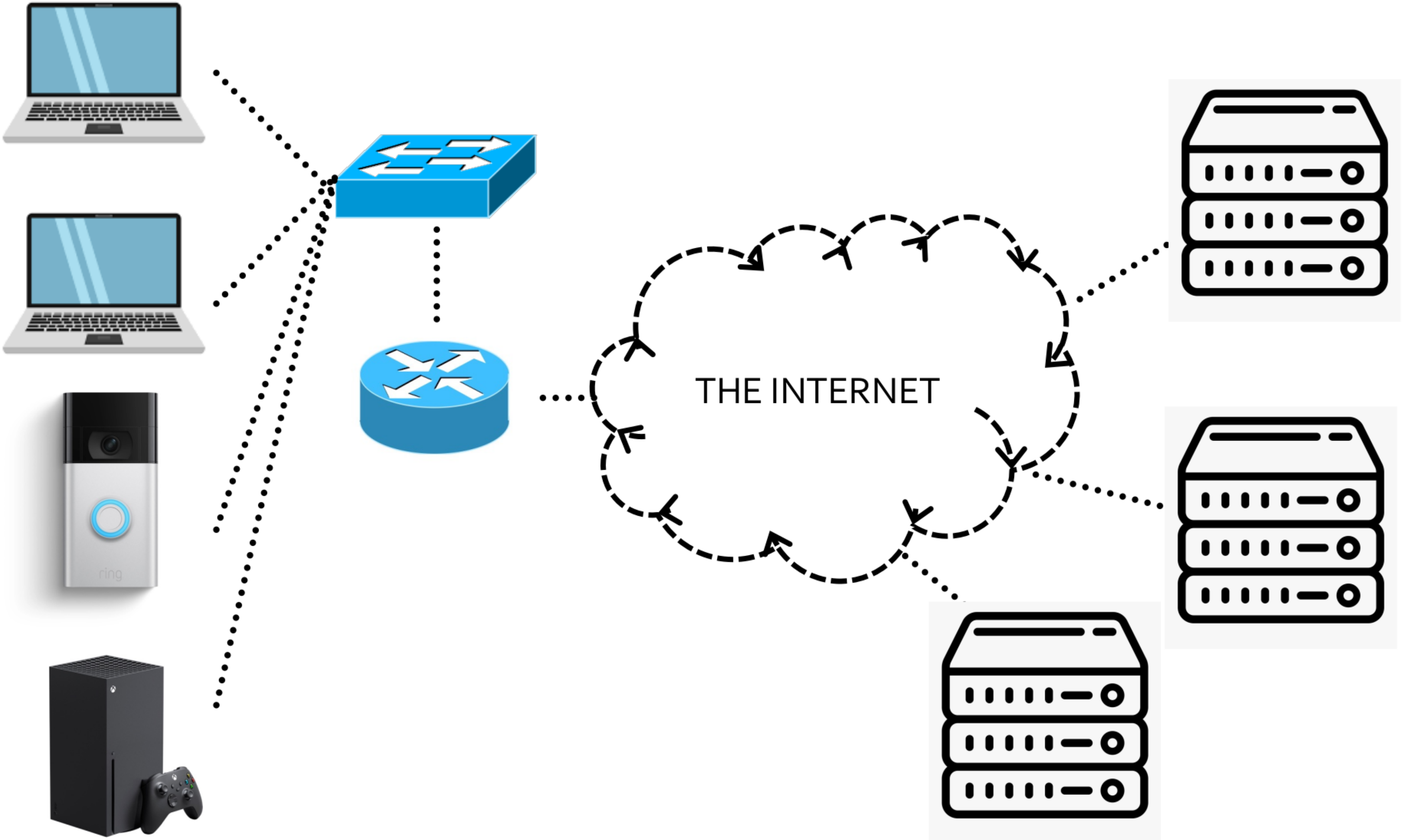
ring

ring


MAGIC
ring

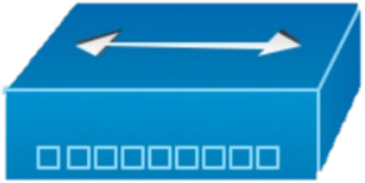

THE INTERNET

Home Network



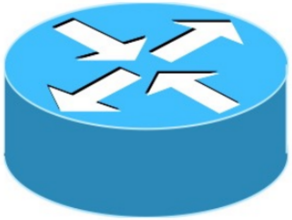
Network Devices

- **Hubs** are L1 devices
  - Packet comes in, packets go-out

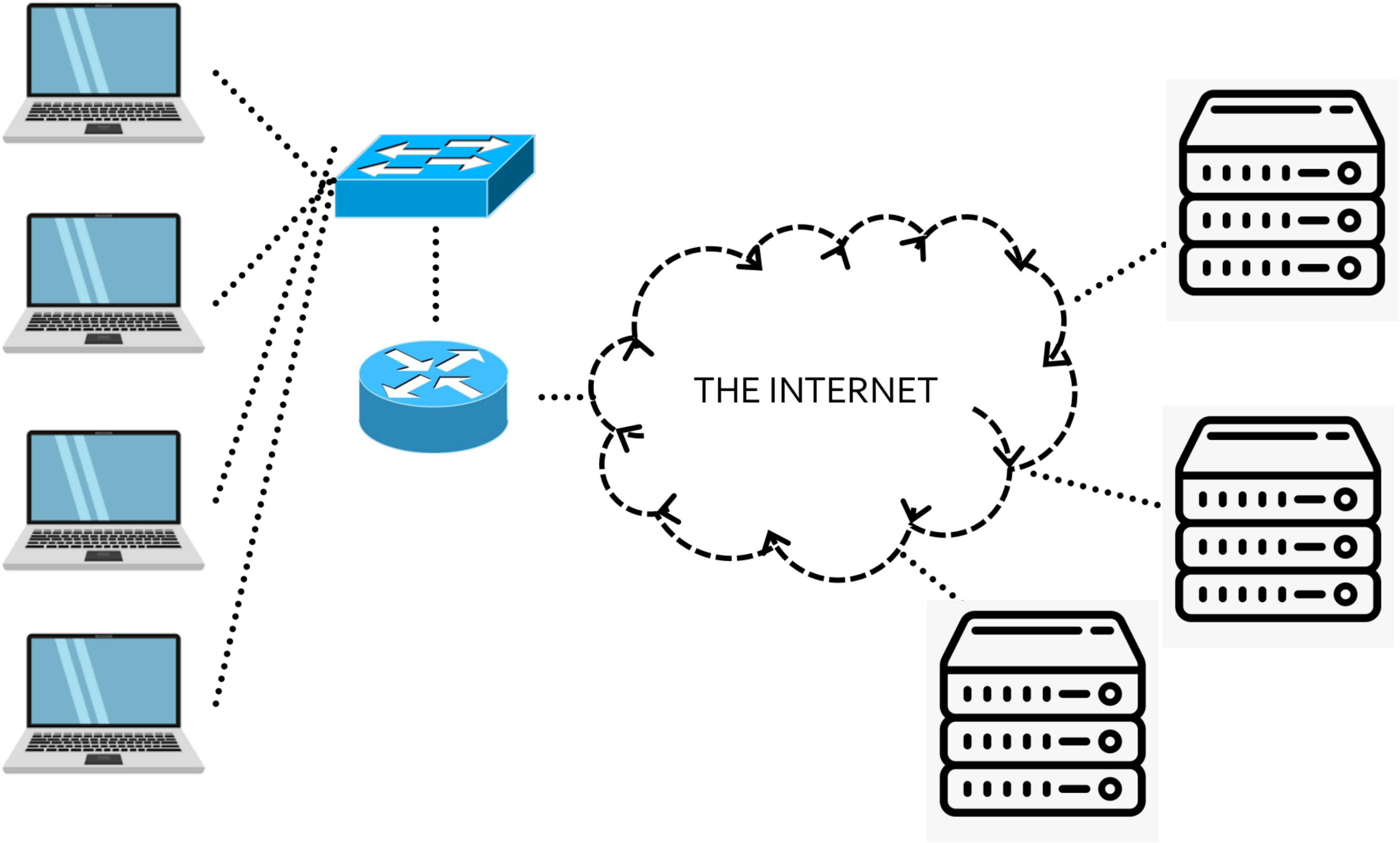


- **Switches** are L2 devices
  - Dispatch packets via MAC address
  - “L3 switches” are common but are not what we’re talking about

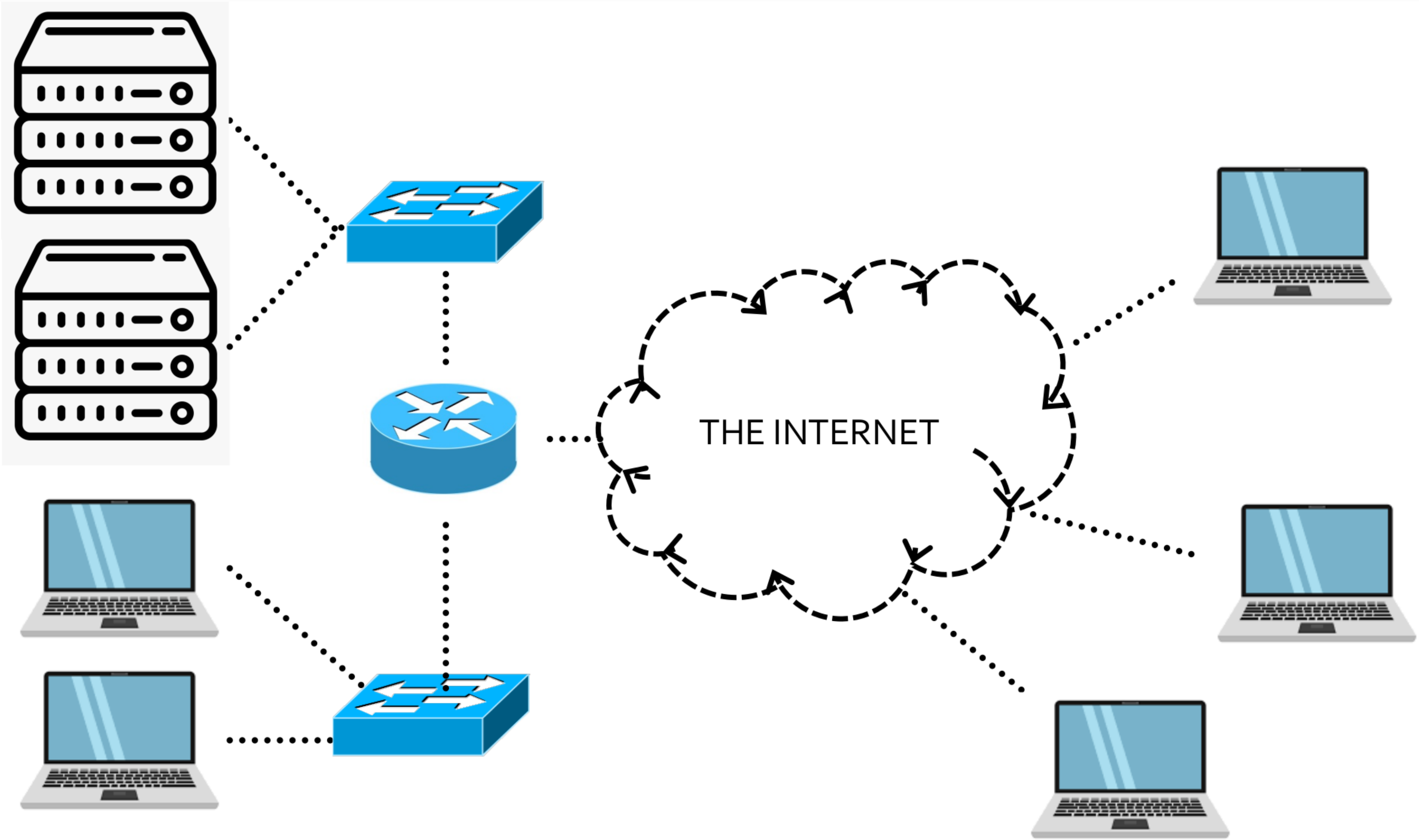
- **Routers** are L3 devices
  - Dispatch packets via IP address
  - Lots of things called “routers” aren’t actually **routers** (but some are)



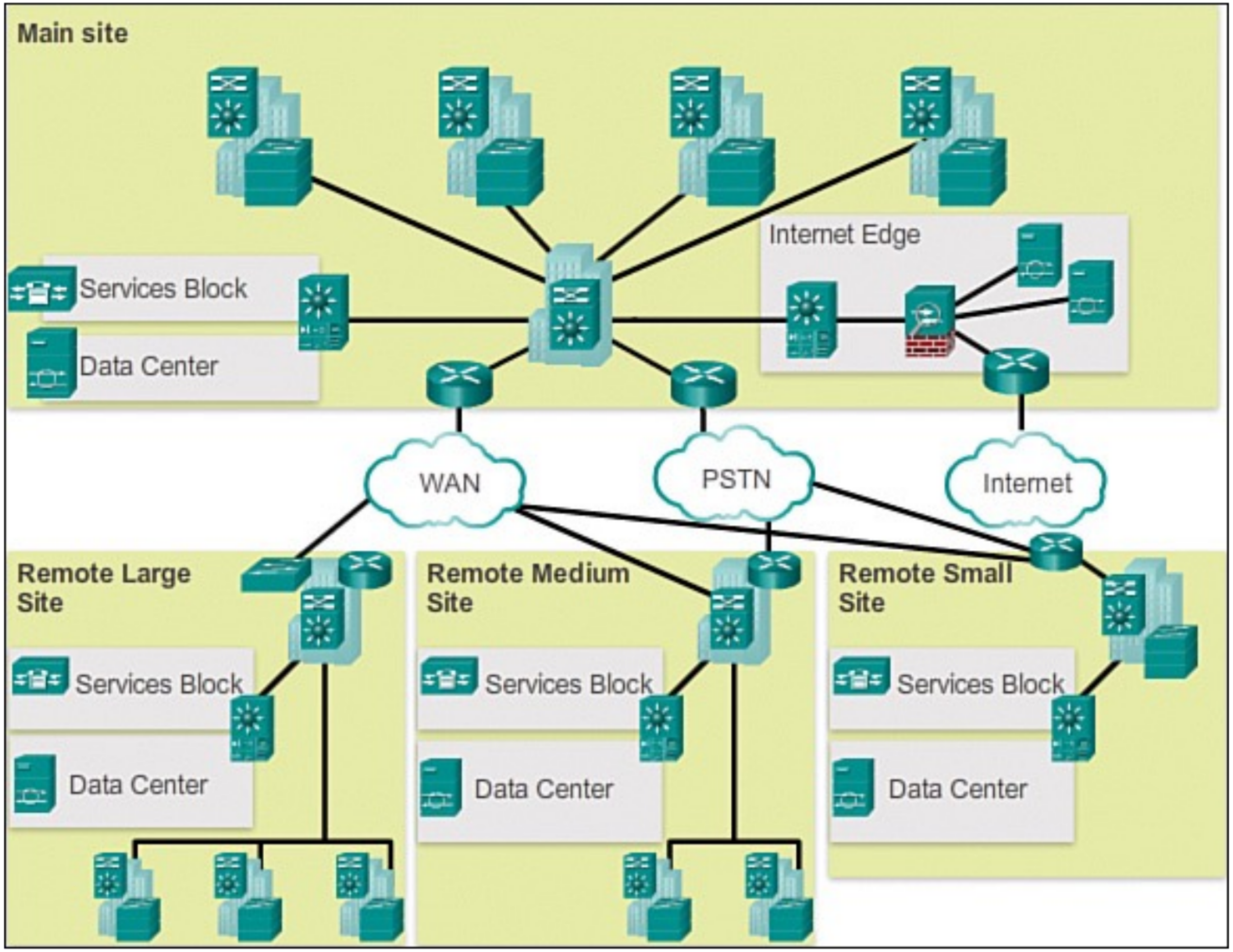
Home Network



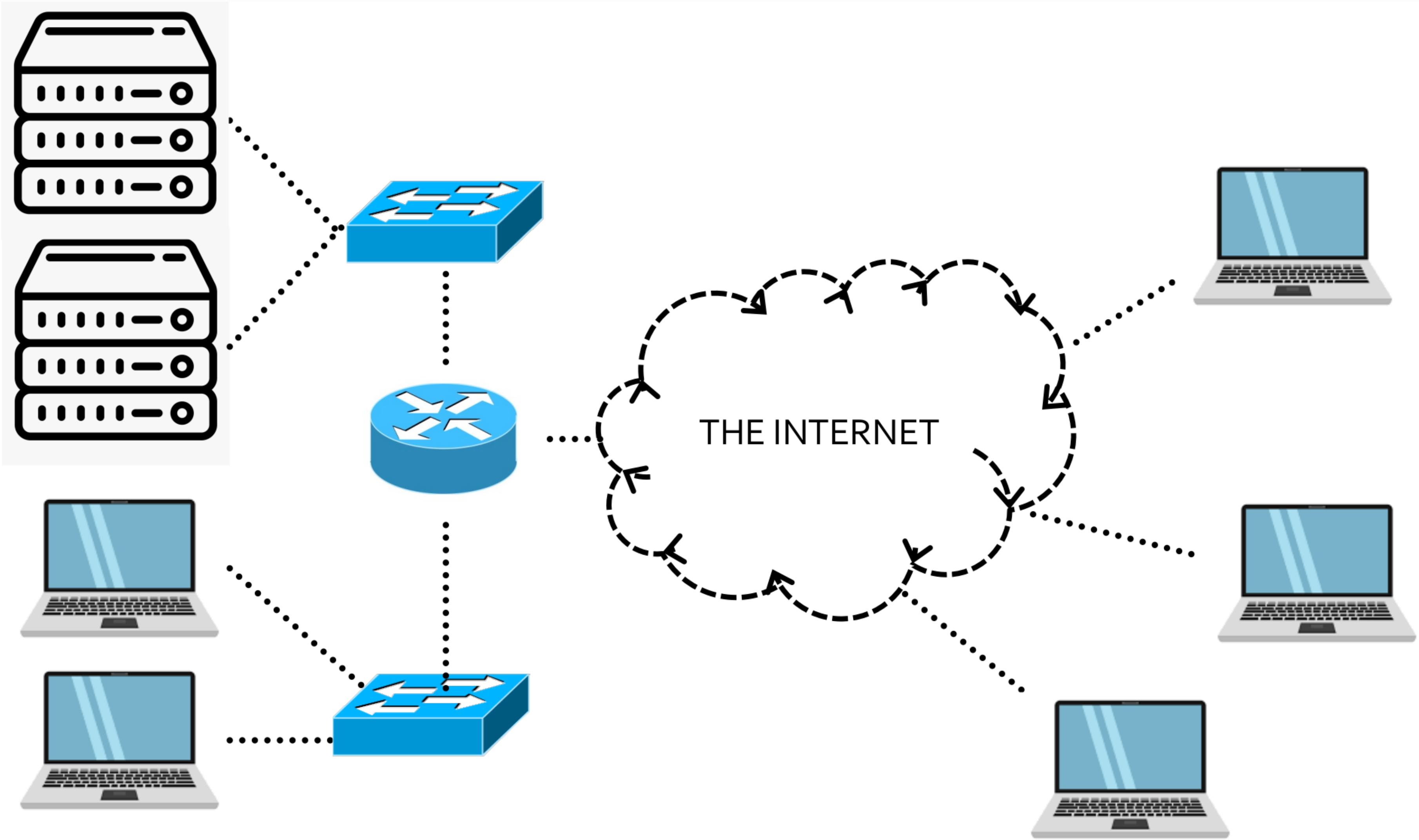
Simple Enterprise Network



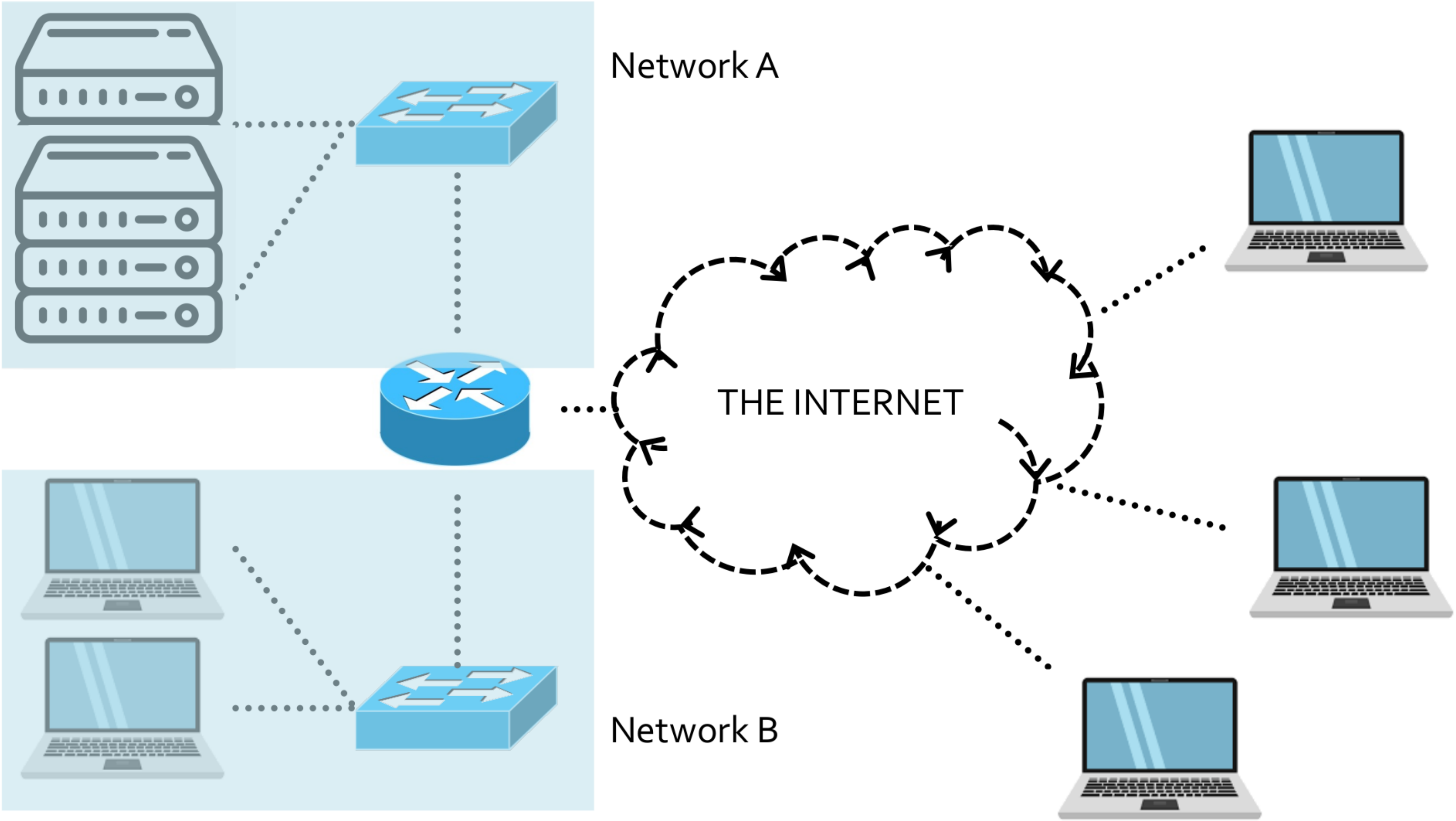
Enterprise Network

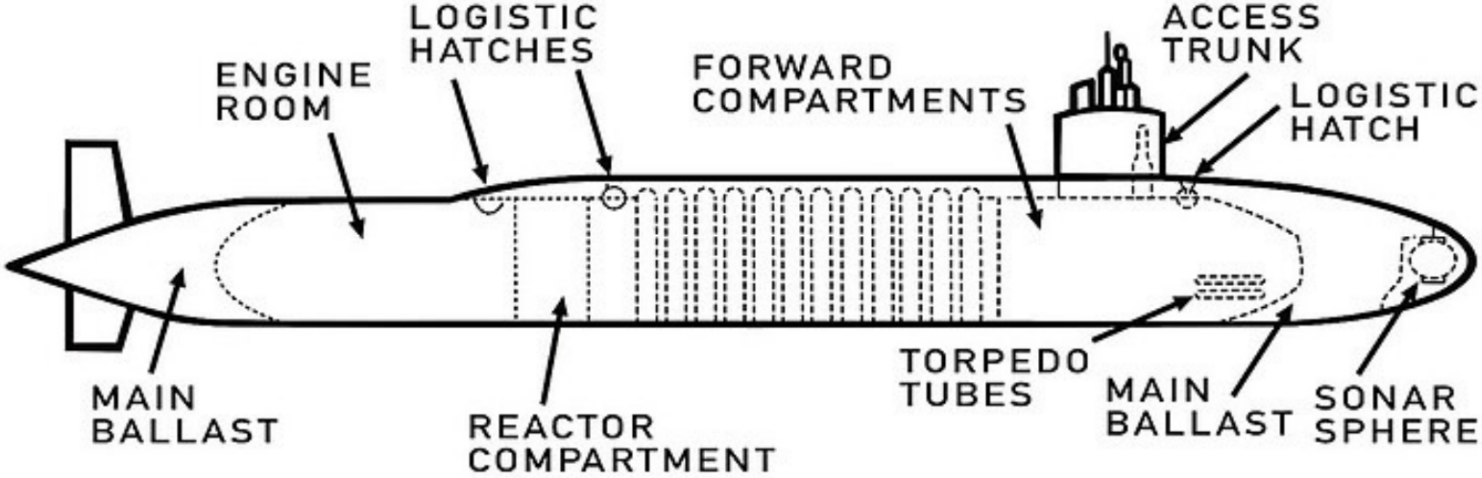


Simple Enterprise Network



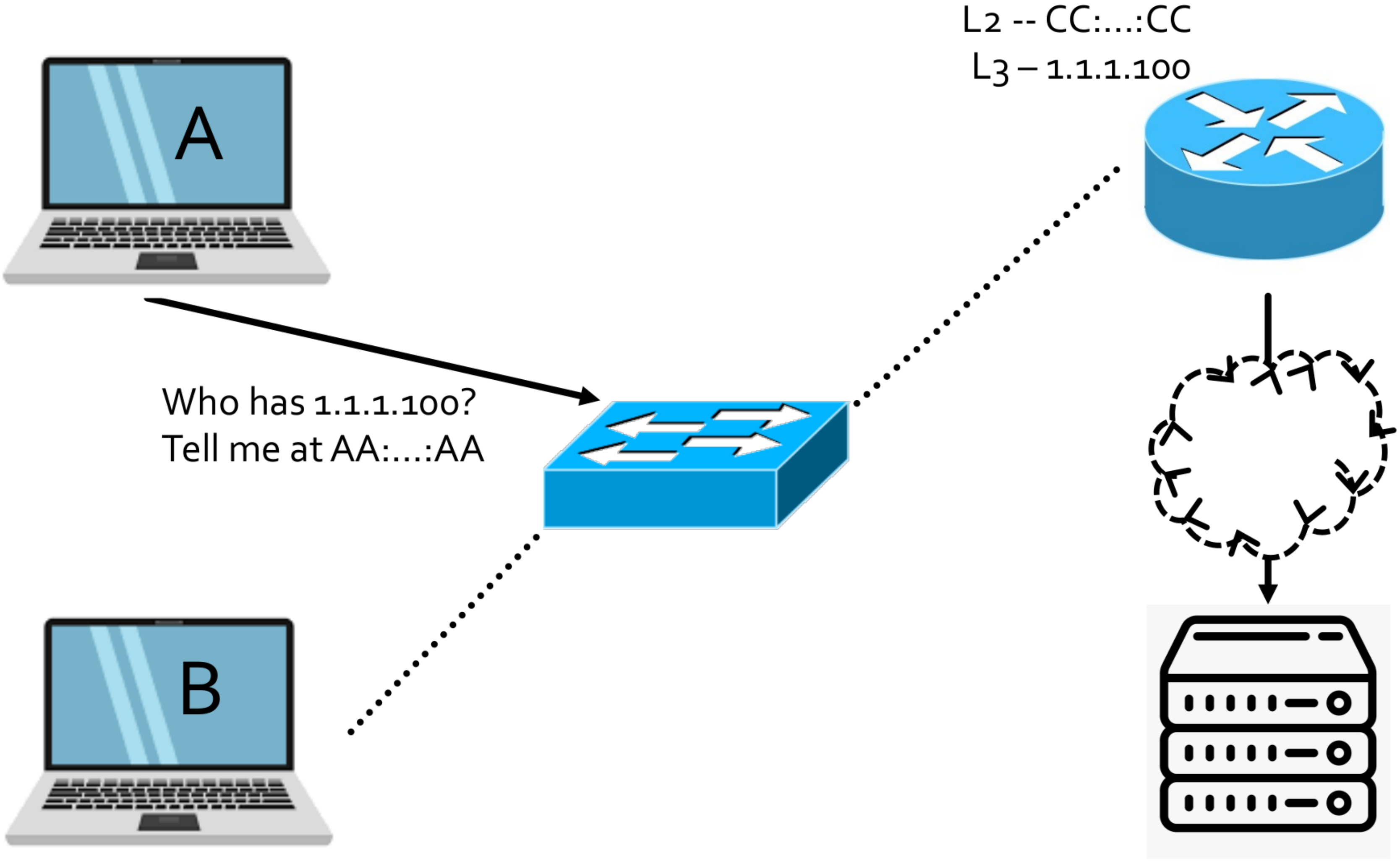
Network Segmentation



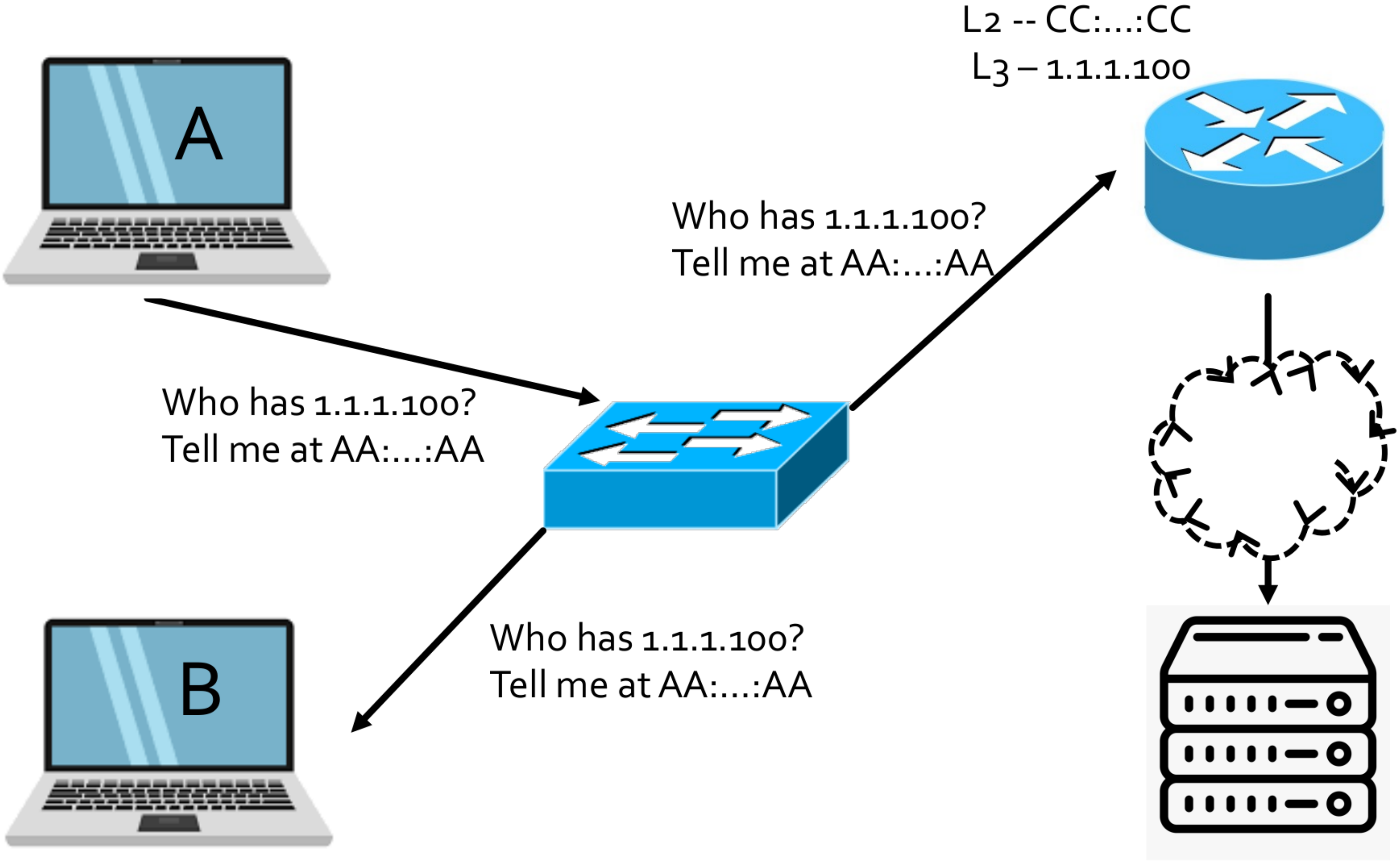


OHIO-CLASS SUBMARINE

Network Broadcasts (ARP)



Network Broadcasts (ARP)



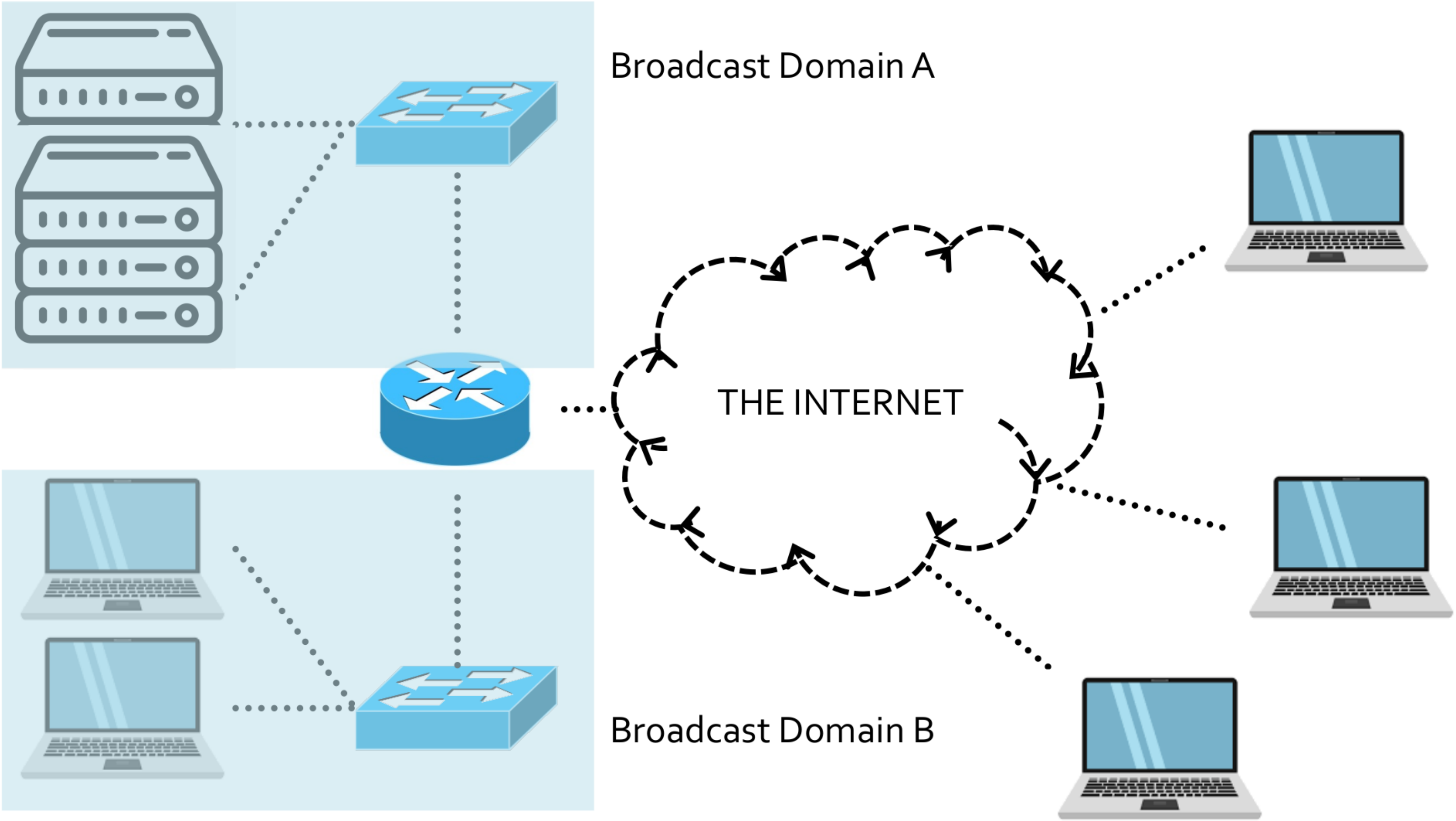
L2 -- CC:...:CC
L3 – 1.1.1.100

Who has 1.1.1.100?
Tell me at AA:...:AA

Who has 1.1.1.100?
Tell me at AA:...:AA

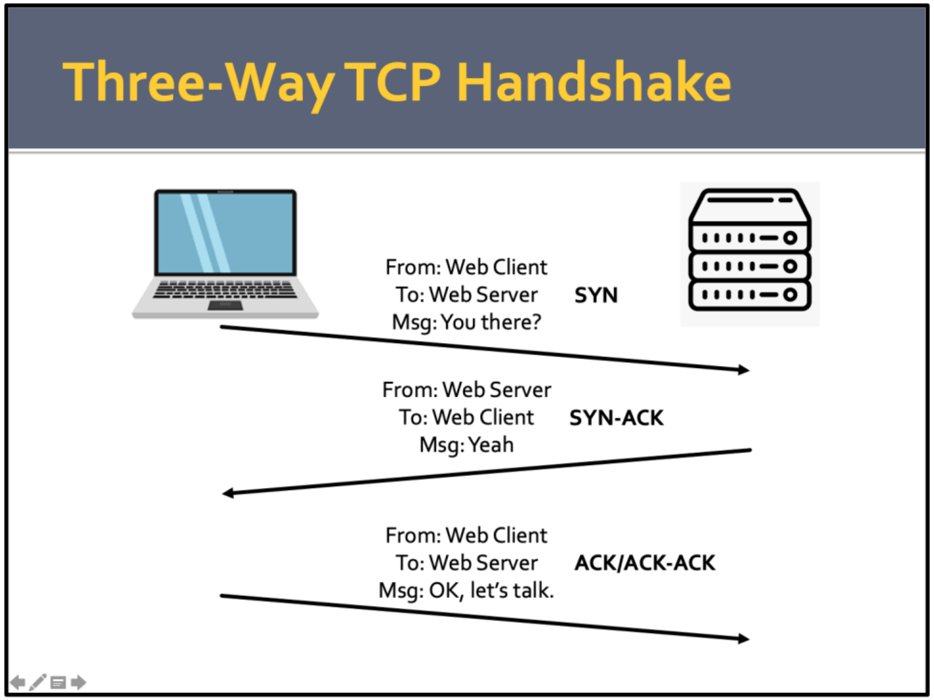
Who has 1.1.1.100?
Tell me at AA:...:AA

Broadcast Domains



Port Scanning

Port scanning is a reconnaissance technique that is used by attackers to gain information to aid them in their attacks.



Three-Way TCP Handshake

From: Web Client
To: Web Server
Msg: You there?

SYN

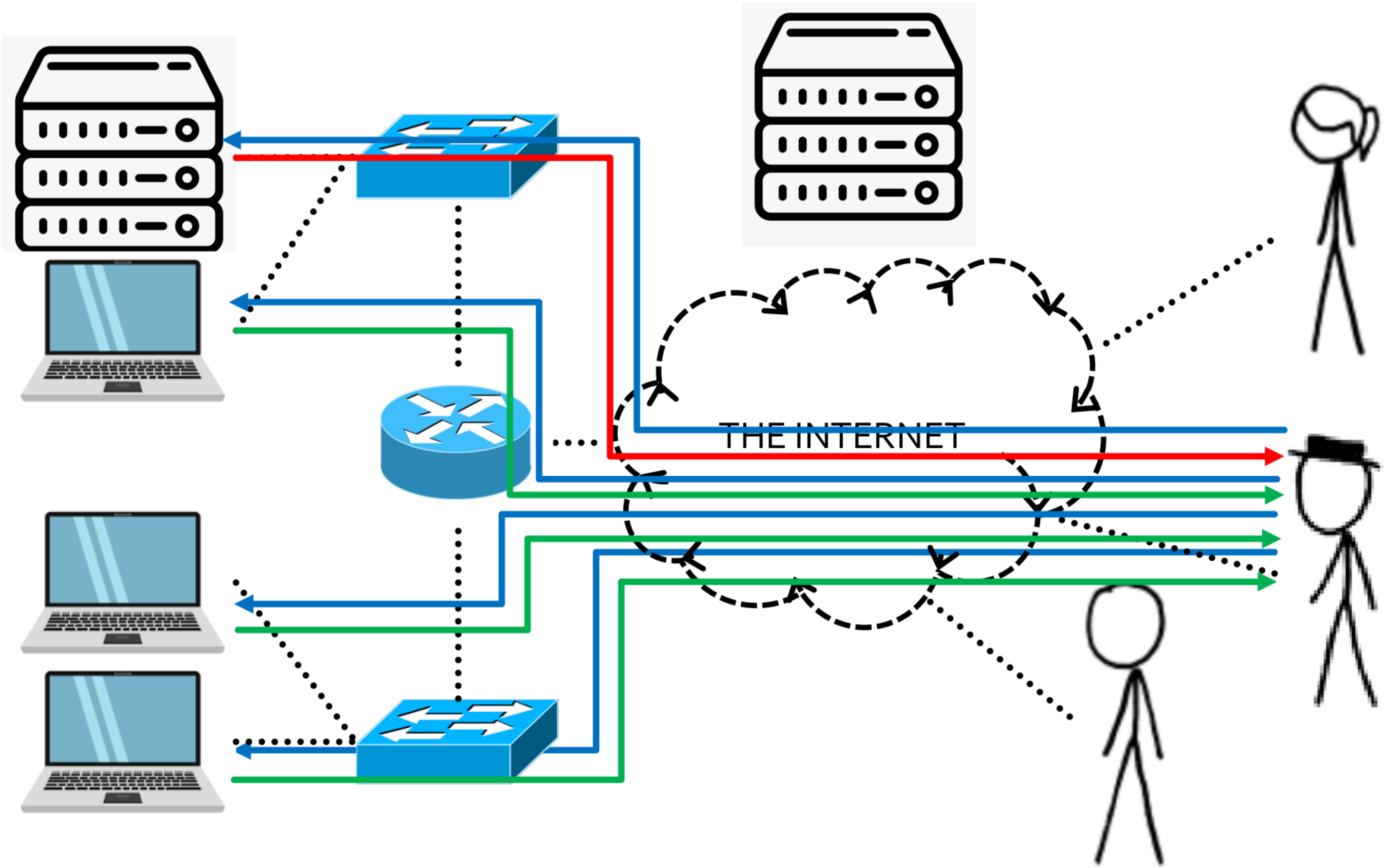
From: Web Server
To: Web Client
Msg: Yeah

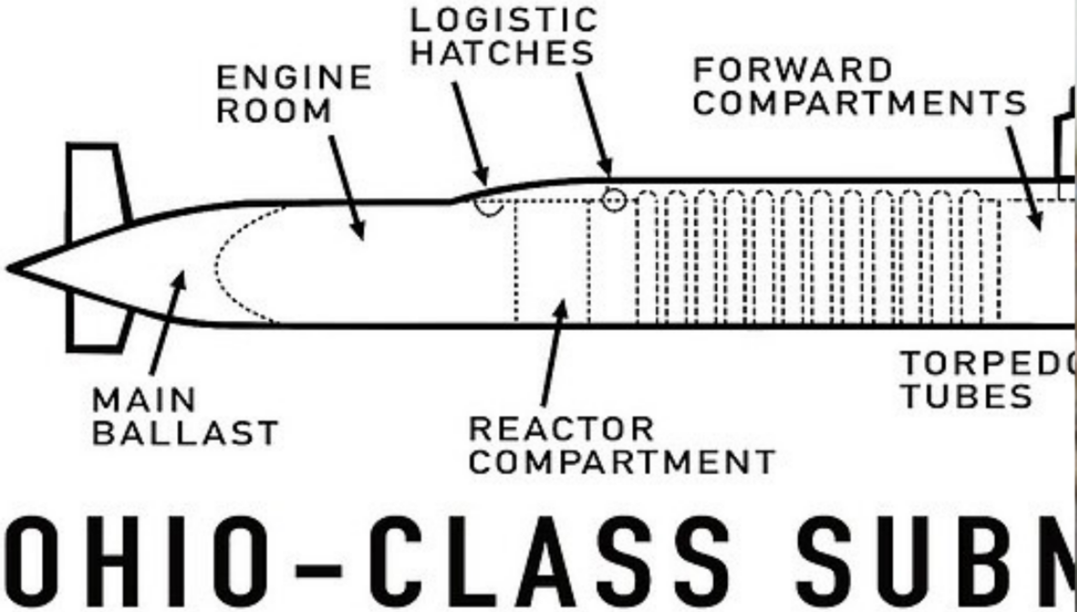
SYN-ACK

From: Web Client
To: Web Server
Msg: OK, let's talk.

ACK/ACK-ACK

Port Scanning




LOGISTIC HATCHES
ENGINE ROOM
FORWARD COMPARTMENTS
MAIN BALLAST
REACTOR COMPARTMENT
TORPEDO
TUBES
OHIO-CLASS SUBN

Firewalls

A **firewall** is a generic name for a network-level defense tactic that blindly applies a rule-based policy to network traffic.

Firewalls

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- Operate on L3 and L4 (IPs and TCP/UDP)

Canonical Protocols

Application Layer Protocol	Transport Layer Protocol	Port	Name
FTP	TCP	20	File Transfer Protocol – Data
FTP	TCP	21	FTP – Connection
Telnet	TCP	23	Telnet
SMTP	TCP	25	Simple Mail Transfer Protocol
DNS	TCP / UDP	53	Domain Name System – Zone Transfer / Lookups
DHCP	UDP	67 / 68	Dynamic Host Configuration Protocol – Server / Client
HTTP	TCP	80	Hypertext Transfer Protocol
POP3	TCP	110	Post Office Protocol
SNMP	UDP	161	Simple Network Management Protocol (v1,2)
RDP	TCP / UDP	3389	Remote Desktop Protocol

…and many, many more…

Firewalls

A **firewall** is a generic name for a network-level defense tactic that blindly applies a rule-based policy to network traffic.

- Operate on L3 and L4 (IPs and TCP/UDP)
- Logically, the rules are straight-forward
  - **DO** allow port 80 (HTTP)
  - **DON'T** allow port 22 (SSH)
  - **DON'T** allow port 21 (FTP) **UNLESS** comes from <*remote office IP*>

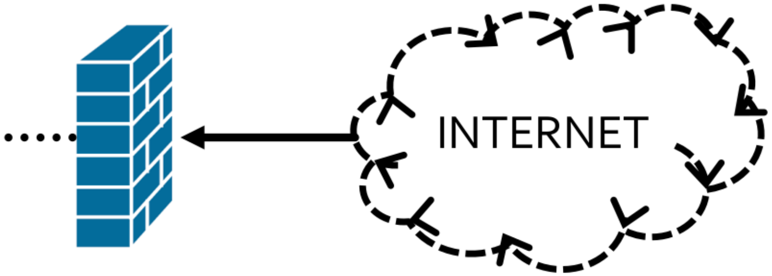
Firewall Implementations

- Blacklisting traffic
  - Match rule? **BLOCK**
- Whitelisting traffic
  - Match rule? **ALLOW**

There’s always a default action if doesn’t match a specific rule!

Firewall Example

1. **BLOCK** TCP/22
2. **BLOCK** UDP/3389
3. **ALLOW** 1.2.3.4/32
4. **BLOCK** TCP/443
5. **ALLOW** by default



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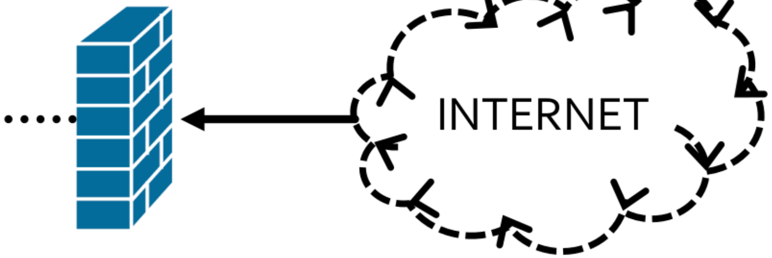
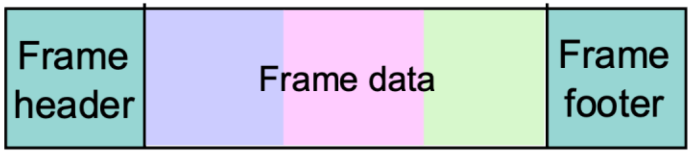



Frame header

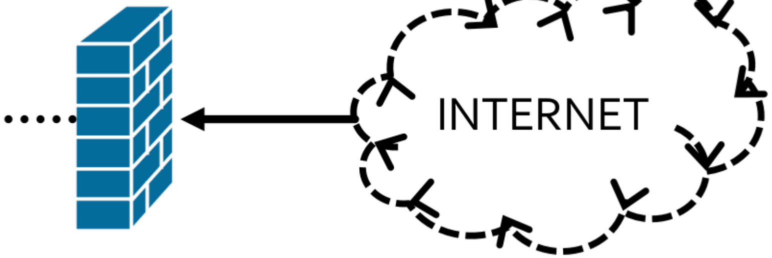
Frame data

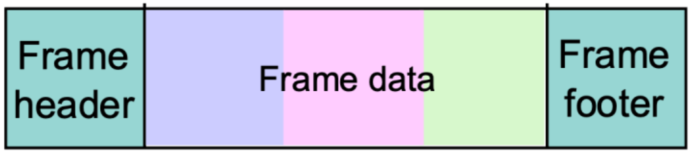
Frame footer

To: 99.99.99.99
TCP/22
XX:X...X:XX

Firewall Example

1. **BLOCK** TCP/22
2. **BLOCK** UDP/3389
3. **ALLOW** 1.2.3.4/32
4. **BLOCK** TCP/443
5. **ALLOW** by default





To: 1.42.13.37
UDP/53
XX:X…X:XX

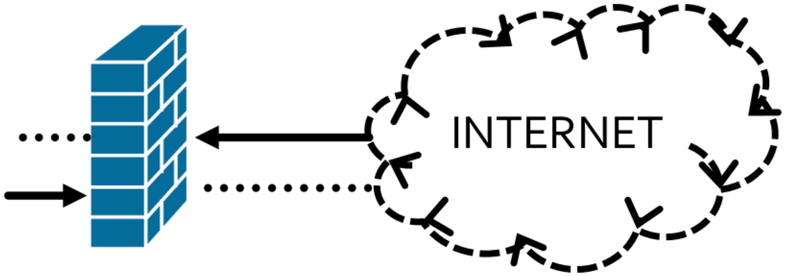
Firewall Implementations

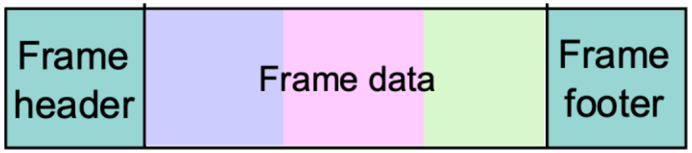
- Blacklisting traffic
  - Match rule? **BLOCK**
- Whitelisting traffic
  - Match rule? **ALLOW**
- Always have a “default rule”

FIREWALL RULES ARE DIRECTIONAL

Firewall Example

1. **BLOCK** inbound to:TCP/22
2. **BLOCK** inbound to:UDP/3389
3. **ALLOW** inbound to:1.2.3.4/32
4. **BLOCK** inbound to:TCP/443
5. **ALLOW** inbound by default
6. **ALLOW** outbound to:TCP/80
7. **ALLOW** outbound to:UDP/53
8. **BLOCK** outbound to:99.99.99.99/32
9. **ALLOW** outbound to:TCP/443
10. **ALLOW** outbound by default



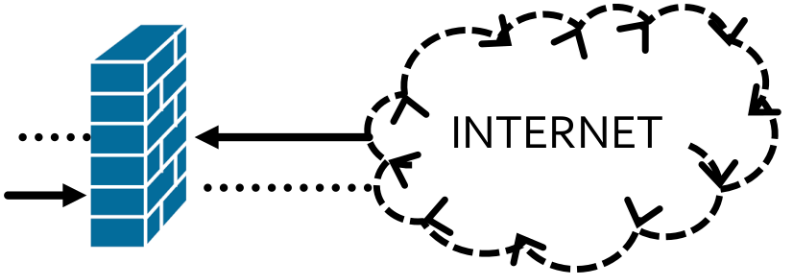


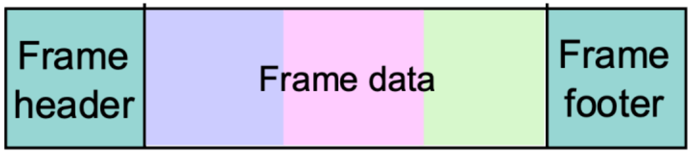
INBOUND

To: 1.2.3.4
TCP/443
XX:X...X:XX
From: 6.7.8.9
TCP/337
XX:X...X:XX

Firewall Example

1. **BLOCK** inbound to:TCP/22
2. **BLOCK** inbound to:UDP/3389
3. **ALLOW** inbound to:1.2.3.4/32
4. **BLOCK** inbound to:TCP/443
5. **ALLOW** inbound by default
6. **ALLOW** outbound to:TCP/80
7. **ALLOW** outbound to:UDP/53
8. **BLOCK** outbound to:99.99.99.99/32
9. **ALLOW** outbound to:TCP/443
10. **ALLOW** outbound by default



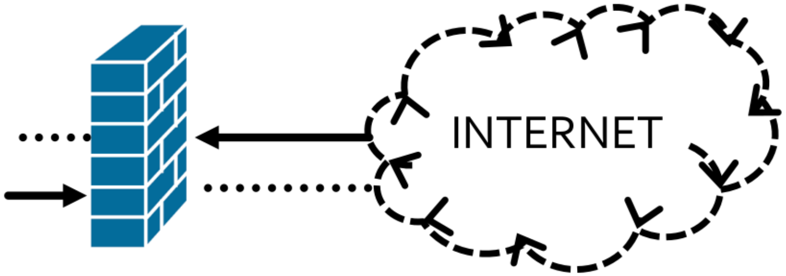


OUTBOUND

To: 1.2.3.4
TCP/443
XX:X…X:XX
From: 6.7.8.9
TCP/337
XX:X…X:XX

Semi-Realistic Firewall Rules

1. **ALLOW** outbound to:UDP/75
2. **BLOCK** inbound to:TCP/43
3. **ALLOW** inbound to:1.2.3.4/32
4. **BLOCK** inbound to:TCP/443
5. **ALLOW** outbound to:TCP/80
6. **BLOCK** outbound to:99.99.99.99/32
7. **ALLOW** outbound to:TCP/443
8. **BLOCK** inbound to:TCP/389
9. **BLOCK** inbound to:TCP/43
10. **ALLOW** outbound to:UDP/53
11. **BLOCK** outbound to:UDP/53
12. **ALLOW** outbound by default
13. **BLOCK** inbound to:TCP/243
14. **BLOCK** inbound to:TCP/443
15. **BLOCK** inbound to:TCP/694
16. **BLOCK** outbound to:UDP/1111
17. **BLOCK** outbound to:UDP/435
18. **BLOCK** outbound to:UDP/3943
19. **BLOCK** outbound to:UDP/954
20. **ALLOW** inbound by default



Realistic Firewall Rules

1. **ALLOW** outbound to:UDP/75
2. **BLOCK** inbound to:TCP/43
3. **ALLOW** inbound to:1.2.3.4/32
4. **BLOCK** inbound to:TCP/443
5. **ALLOW** outbound to:TCP/80
6. **BLOCK** outbound to:99.99.99.99/32
7. **ALLOW** outbound to:TCP/443
8. **BLOCK** inbound to:TCP/389
9. **BLOCK** inbound to:TCP/43
10. **ALLOW** outbound to:UDP/53
11. **BLOCK** outbound to:UDP/53
12. **ALLOW** outbound by default
13. **BLOCK** inbound to:TCP/243
14. **BLOCK** inbound to:TCP/443
15. **BLOCK** inbound to:TCP/694
16. **BLOCK** outbound to:UDP/1111
17. **BLOCK** outbound to:UDP/435
18. **BLOCK** outbound to:UDP/3943
19. **BLOCK** outbound to:UDP/954
20. **ALLOW** inbound by default
21. **ALLOW** outbound to:UDP/75
22. **BLOCK** inbound to:TCP/43
23. **ALLOW** inbound to:1.2.3.4/32
24. **BLOCK** inbound to:TCP/443
25. **ALLOW** outbound to:TCP/80
26. **BLOCK** outbound to:99.99.99.99/32
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38. **BLOCK** outbound to:UDP/3943
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60. **ALLOW** inbound by default

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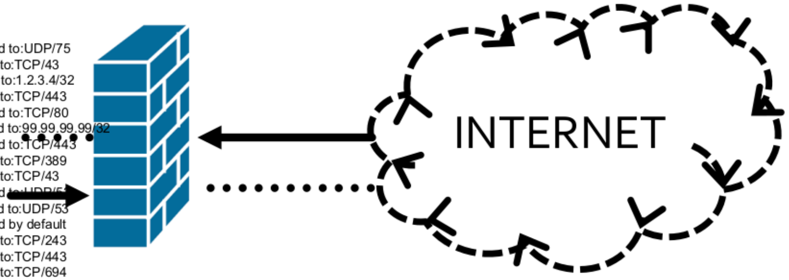
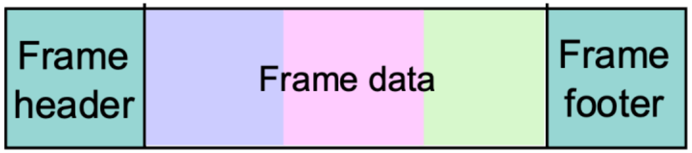


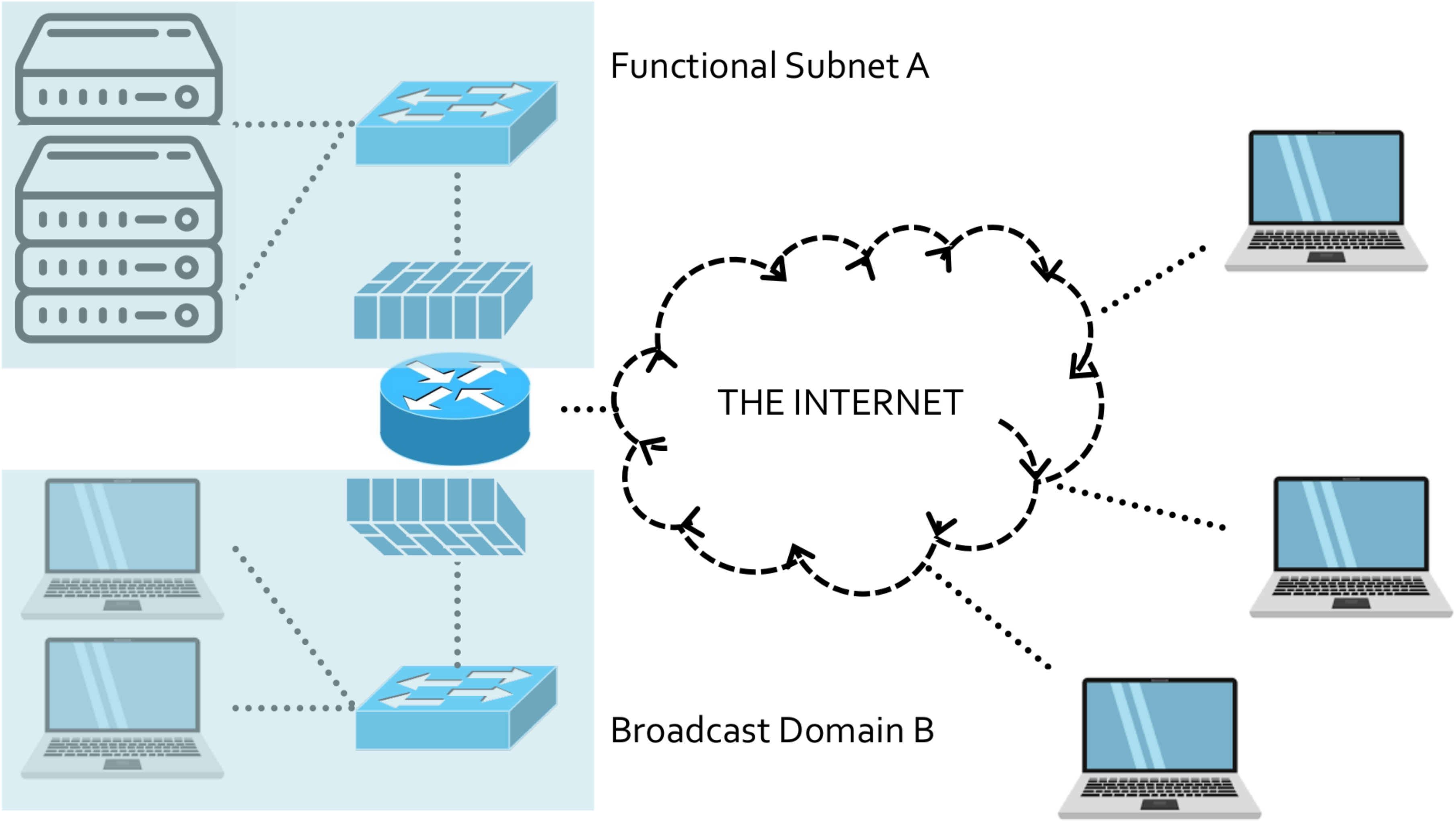


OUTBOUND

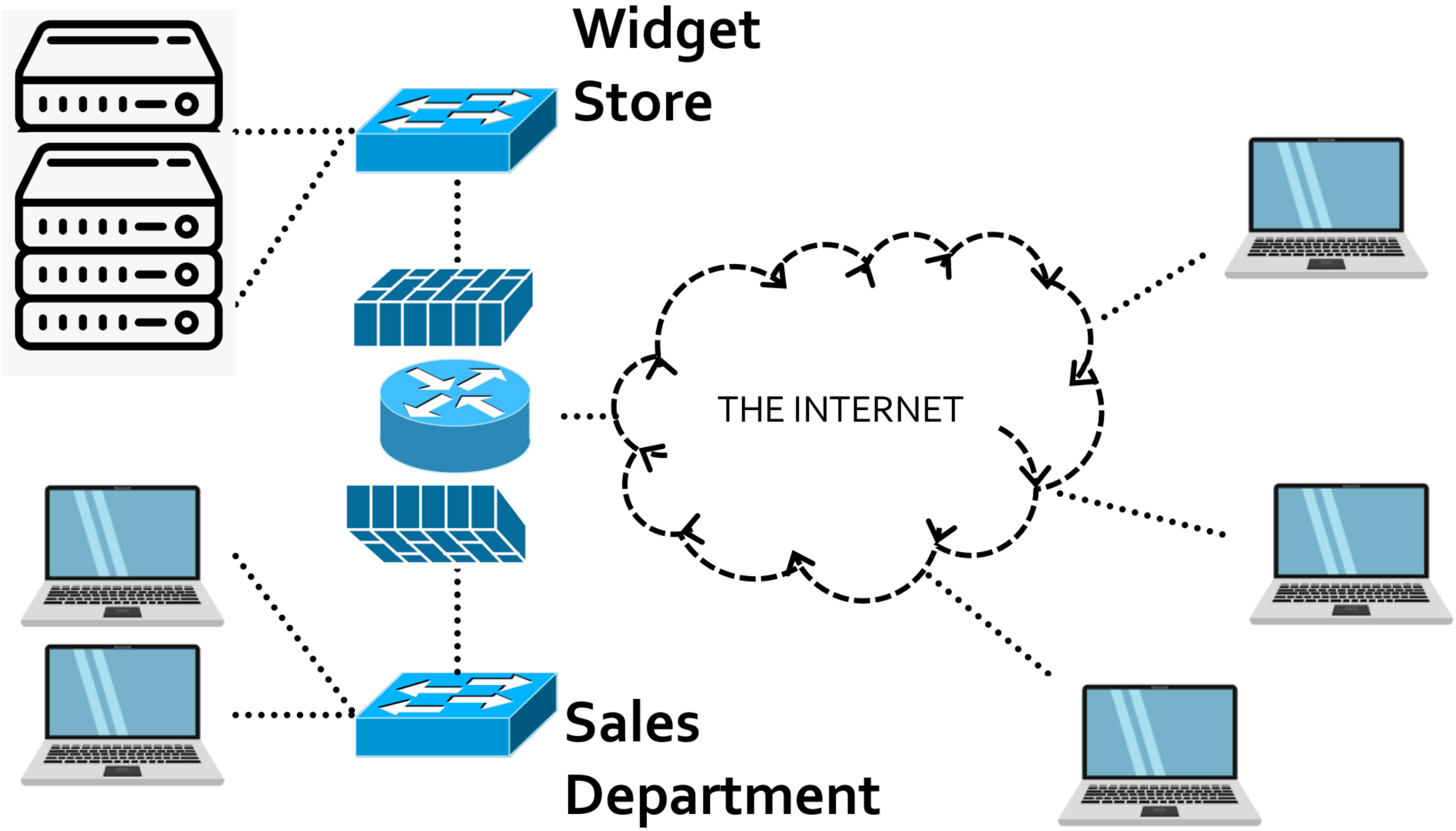
To: 3.43.43.53
TCP/133
XX:X…X:XX

From: 48.5.84.66
TCP/4935
XX:X…X:XX

Functional Subnetting



What might we setup?

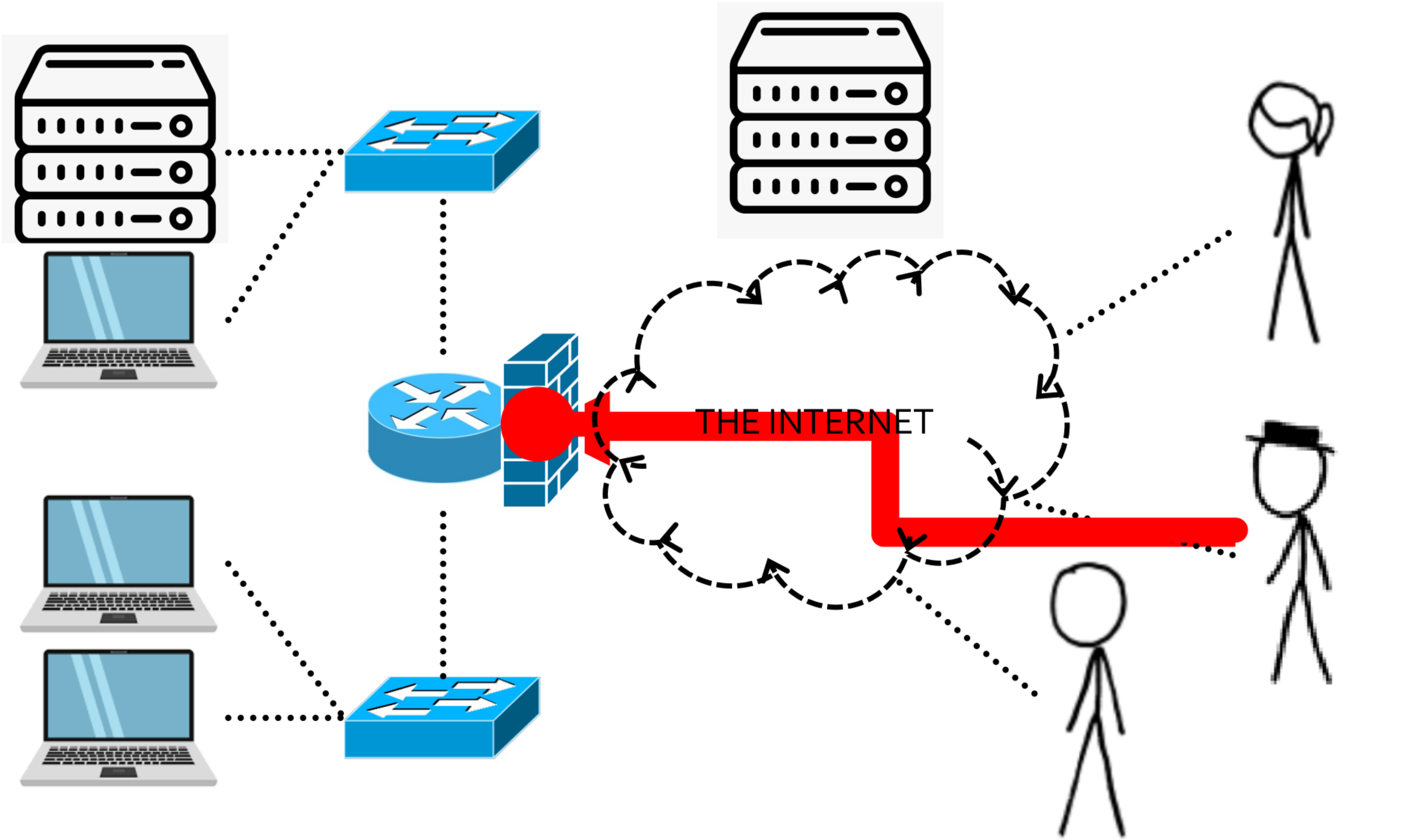


Denial of Service (DoS) Attacks

Denial of Service (DoS) is a type of attack which desires to prevent legitimate users from accessing a service.

- Come in many different varieties
- Usually based on an "asymmetric" tradeoff that favors the attacker
  - Attacker's cost is very small but defender's cost is very high

Naïve DoS



Intrusion Detection System (IDS)

An **Intrusion Detection System (IDS)** is a network monitoring component that is able to watch for signs of maliciousness.

- Capable of granular and complex rules
  - Beyond L3/L4 headers
  - “Deep Packet Inspection” (DPI)
- Capable of pattern/regex matching
- Capable of searching for multi-flow patterns

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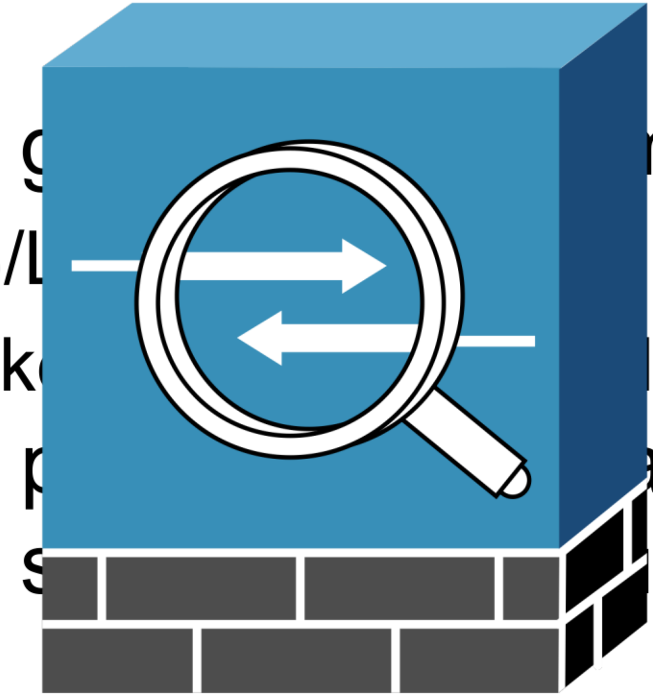

- Capable of g nplex rules
  - Beyond L3/L
  - "Deep Pack I)
- Capable of p atching
- Capable of s lti-flow patterns

ACCESS
OGISTIC
ATCH
SONAR
SPHERE
ENT
S SUBMARINE

FX

Intrusion Prevention System (IPS)

An **Intrusion Prevention System (IPS)** is a type of IDS which is able to actively block maliciousness when found.

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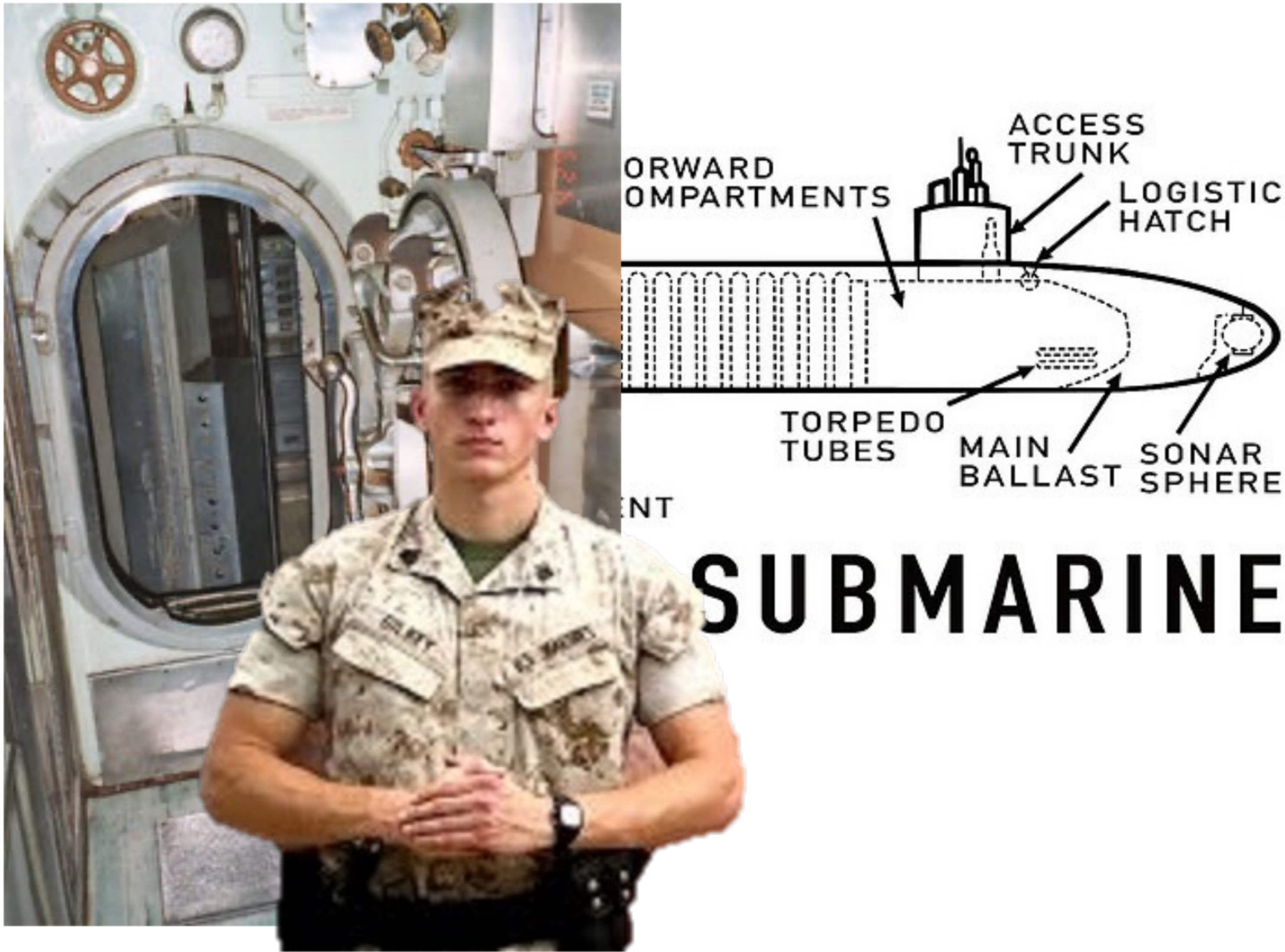
ACCESS TRUNK
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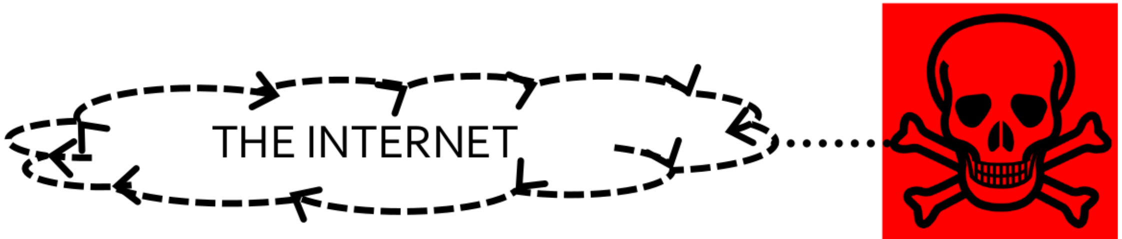
LOGISTIC HATCH
TORPEDO TUBES
MAIN BALLAST
SONAR SPHERE
NT
SUBMARINE



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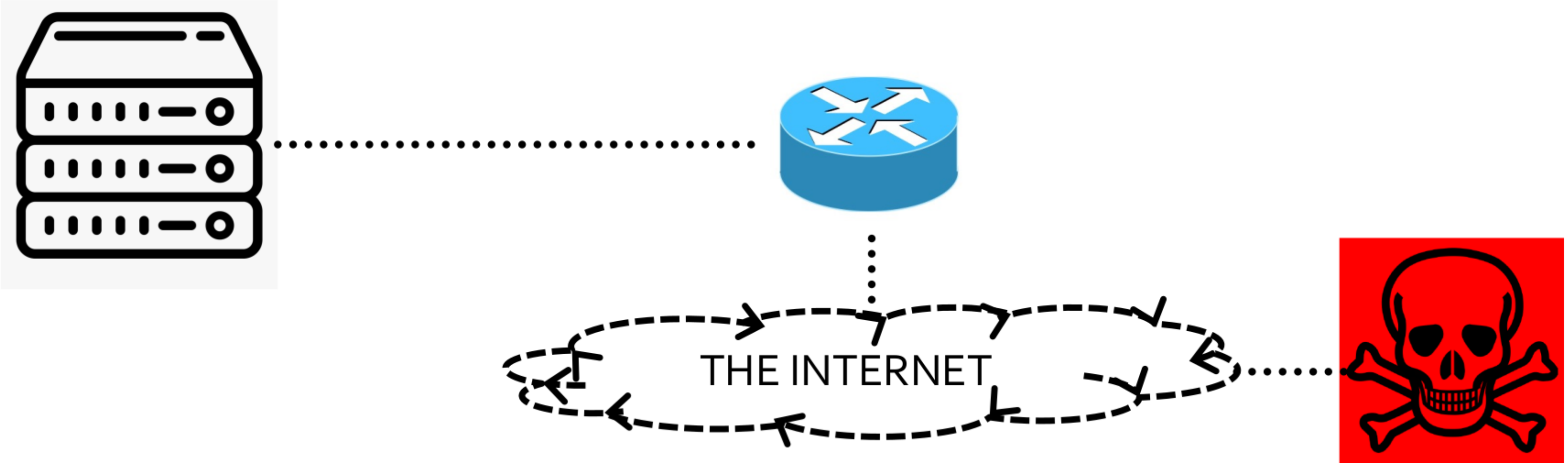
Network Enumeration (ext)



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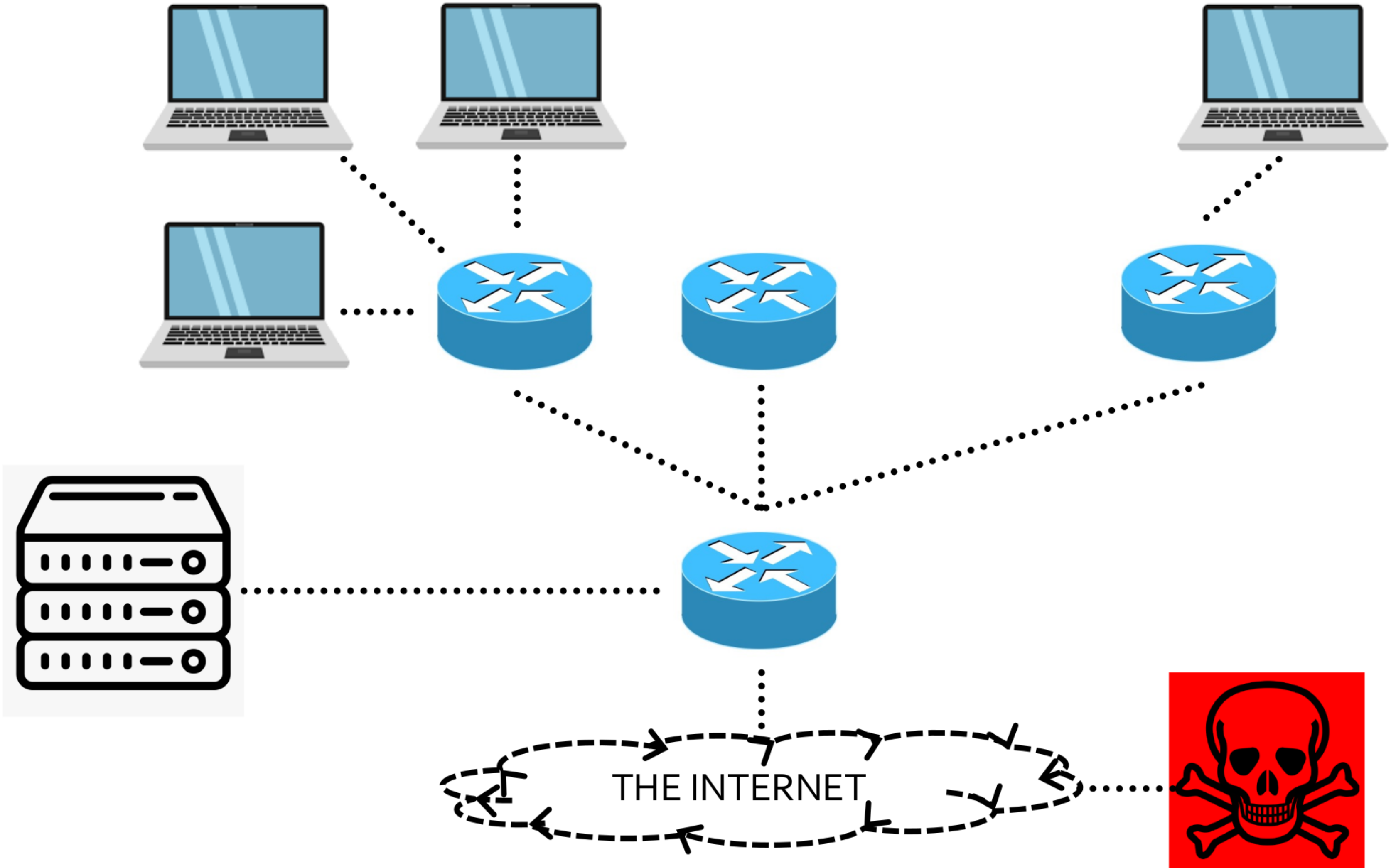

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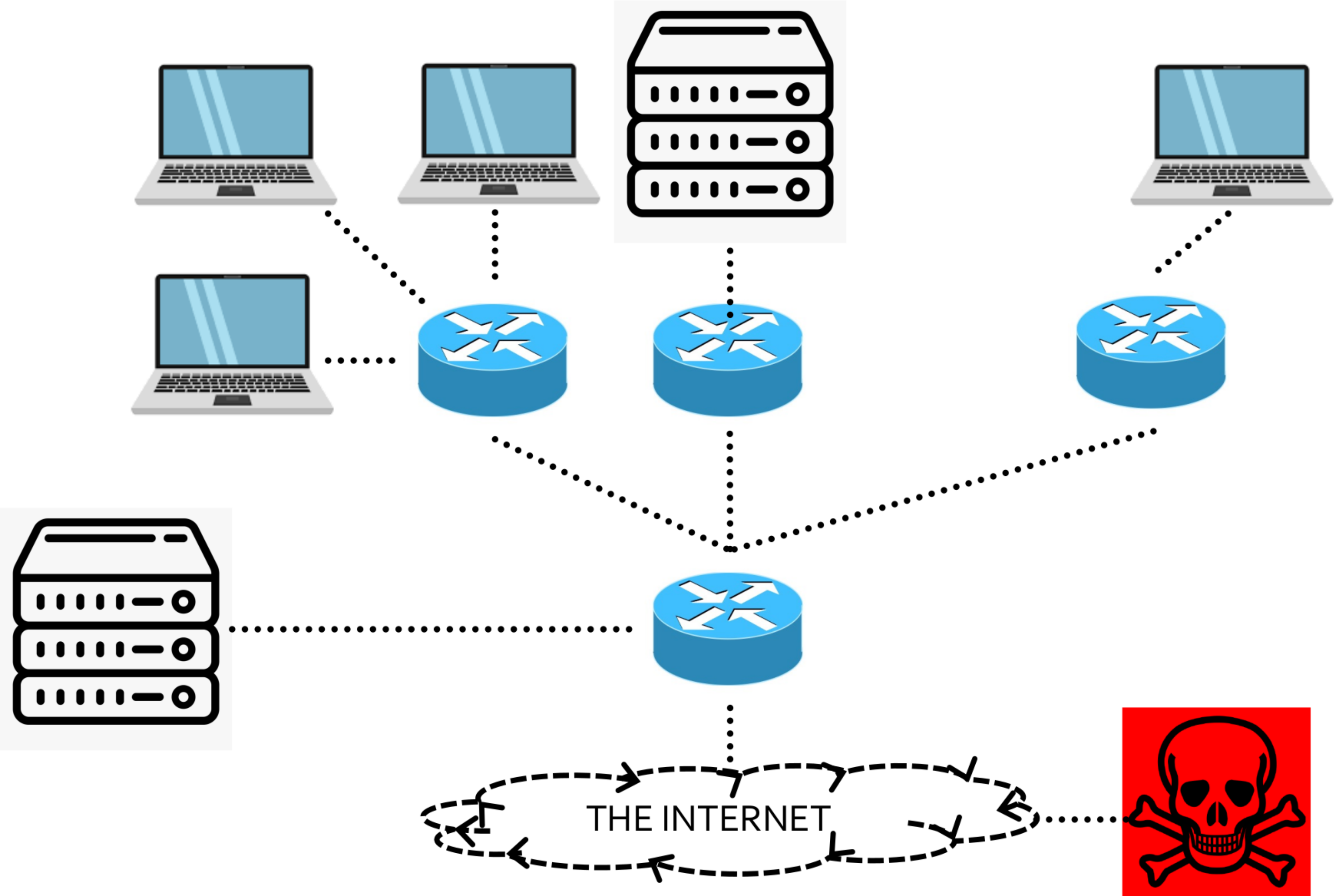

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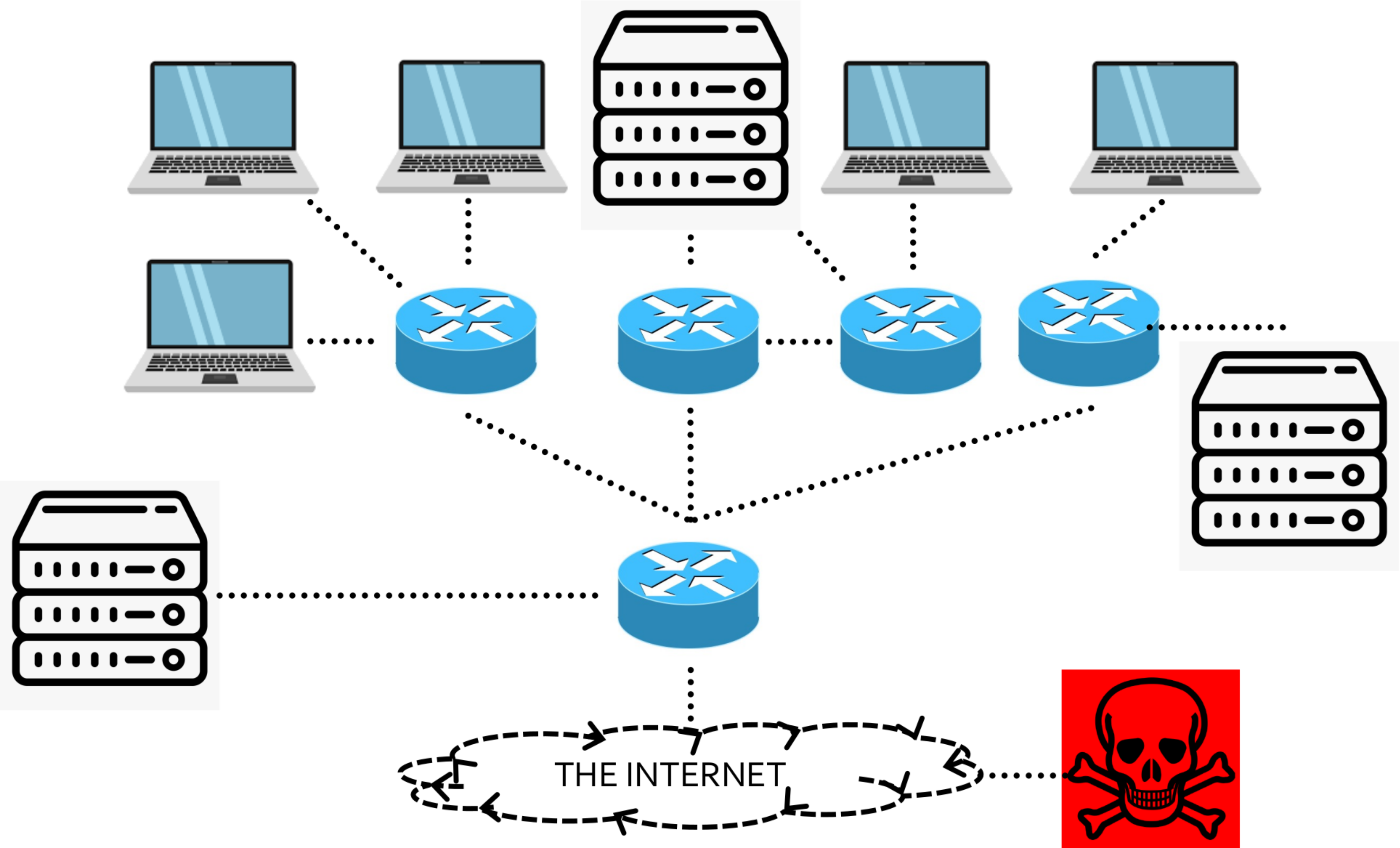
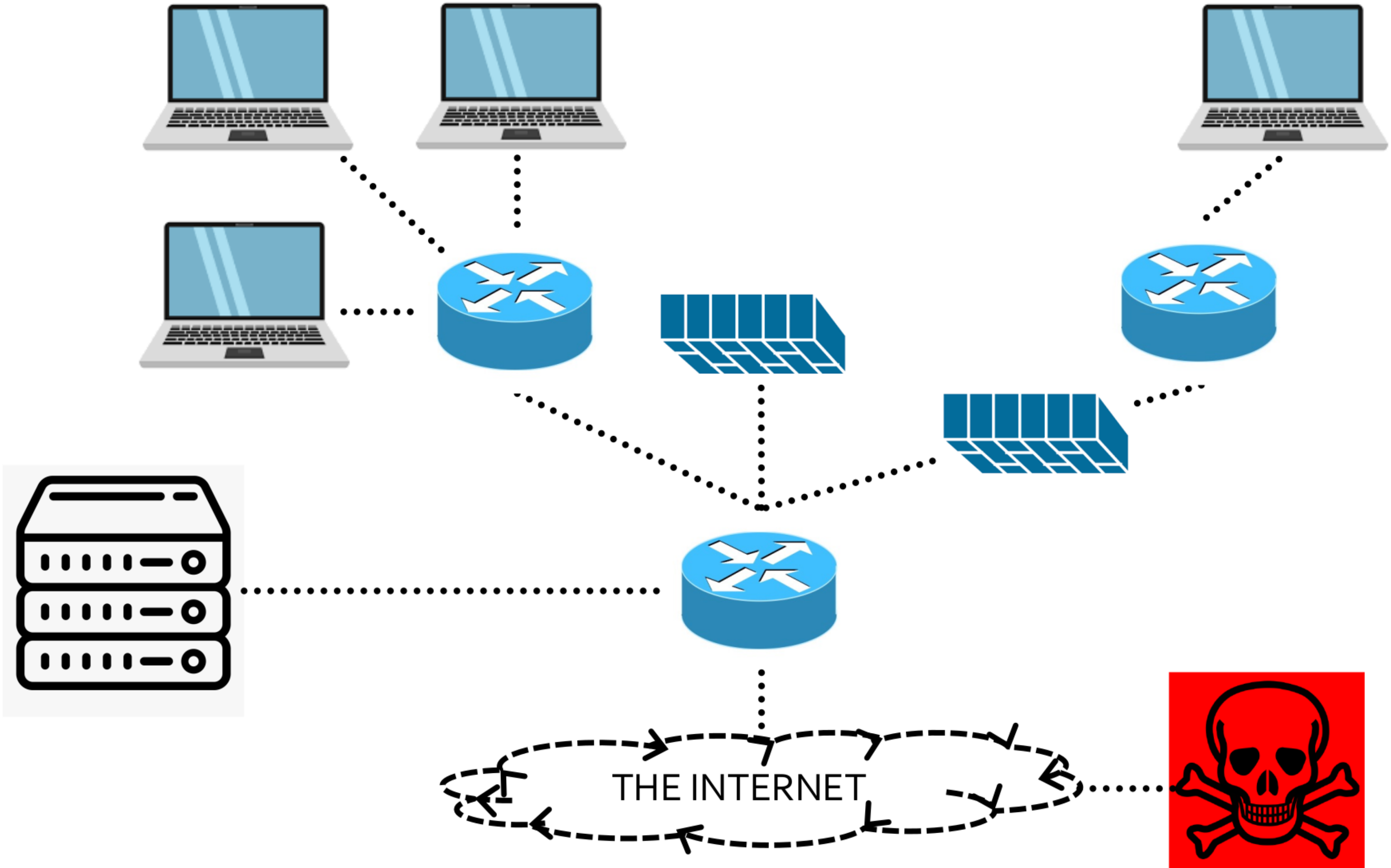


Firewall Defenses



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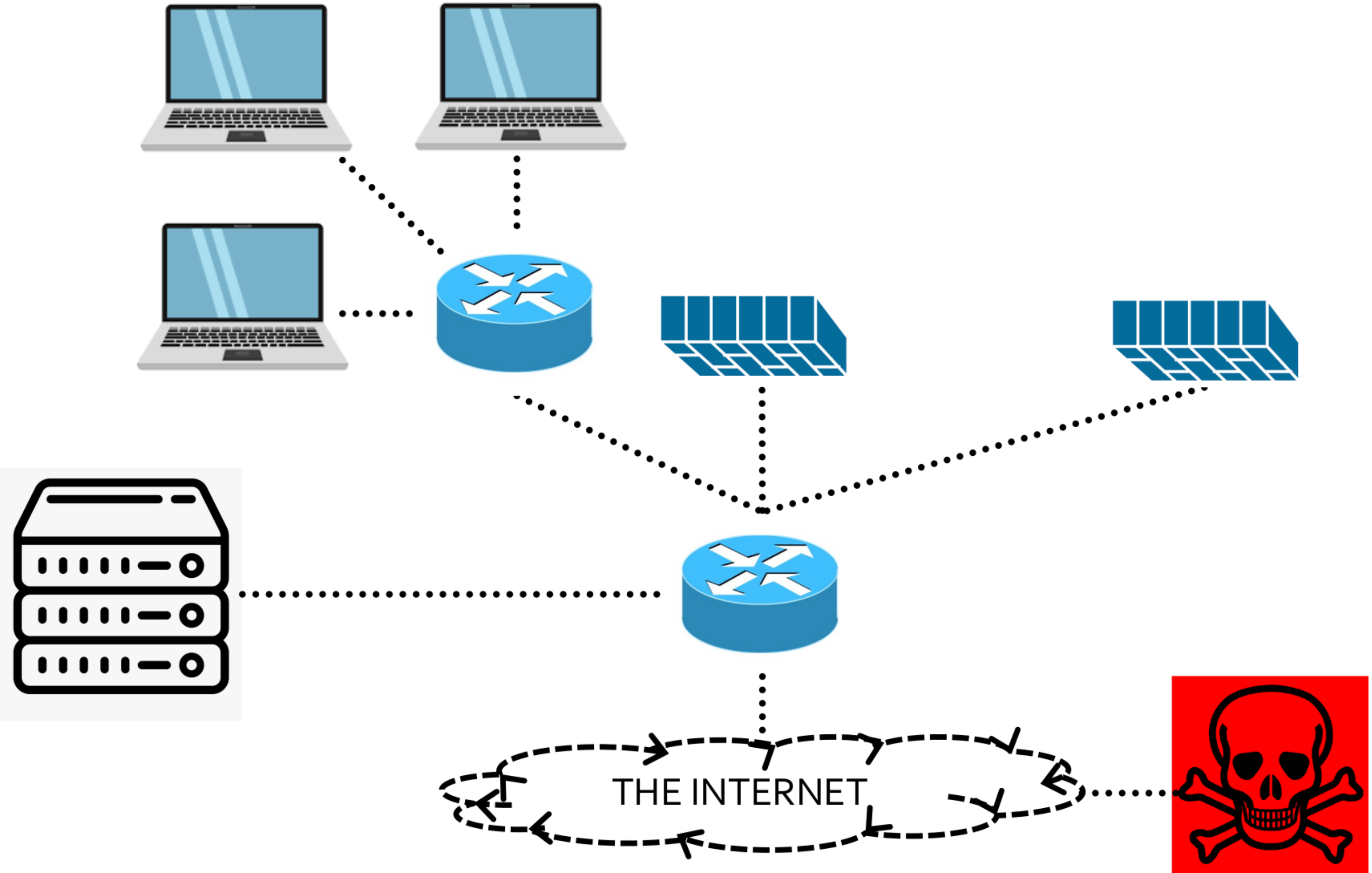

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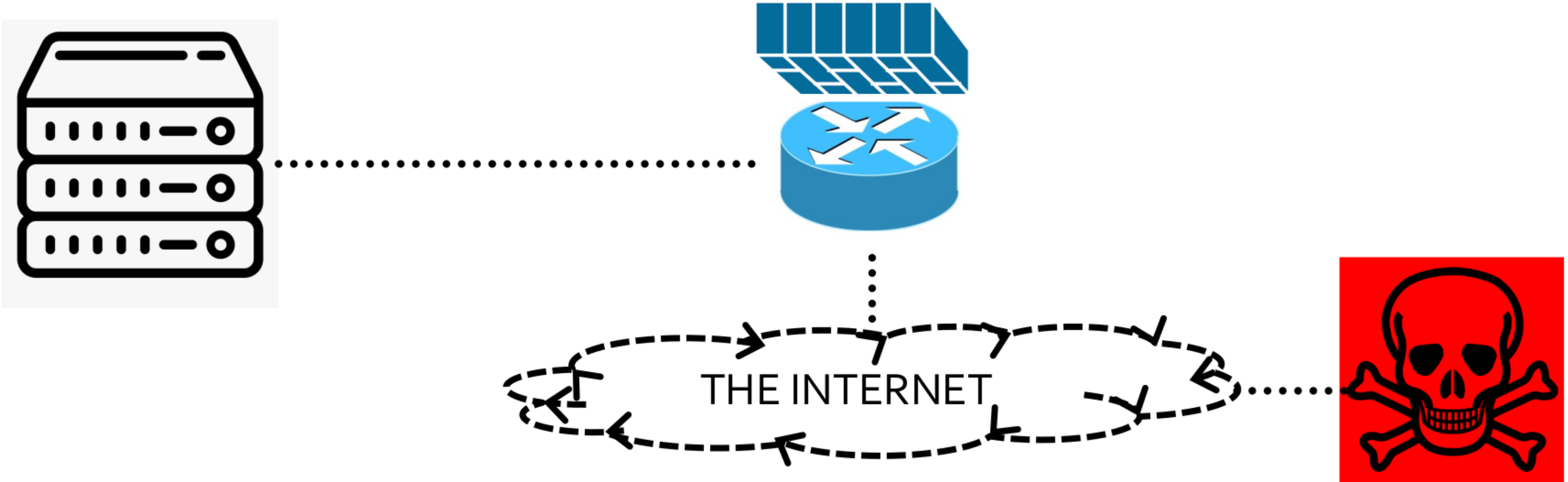
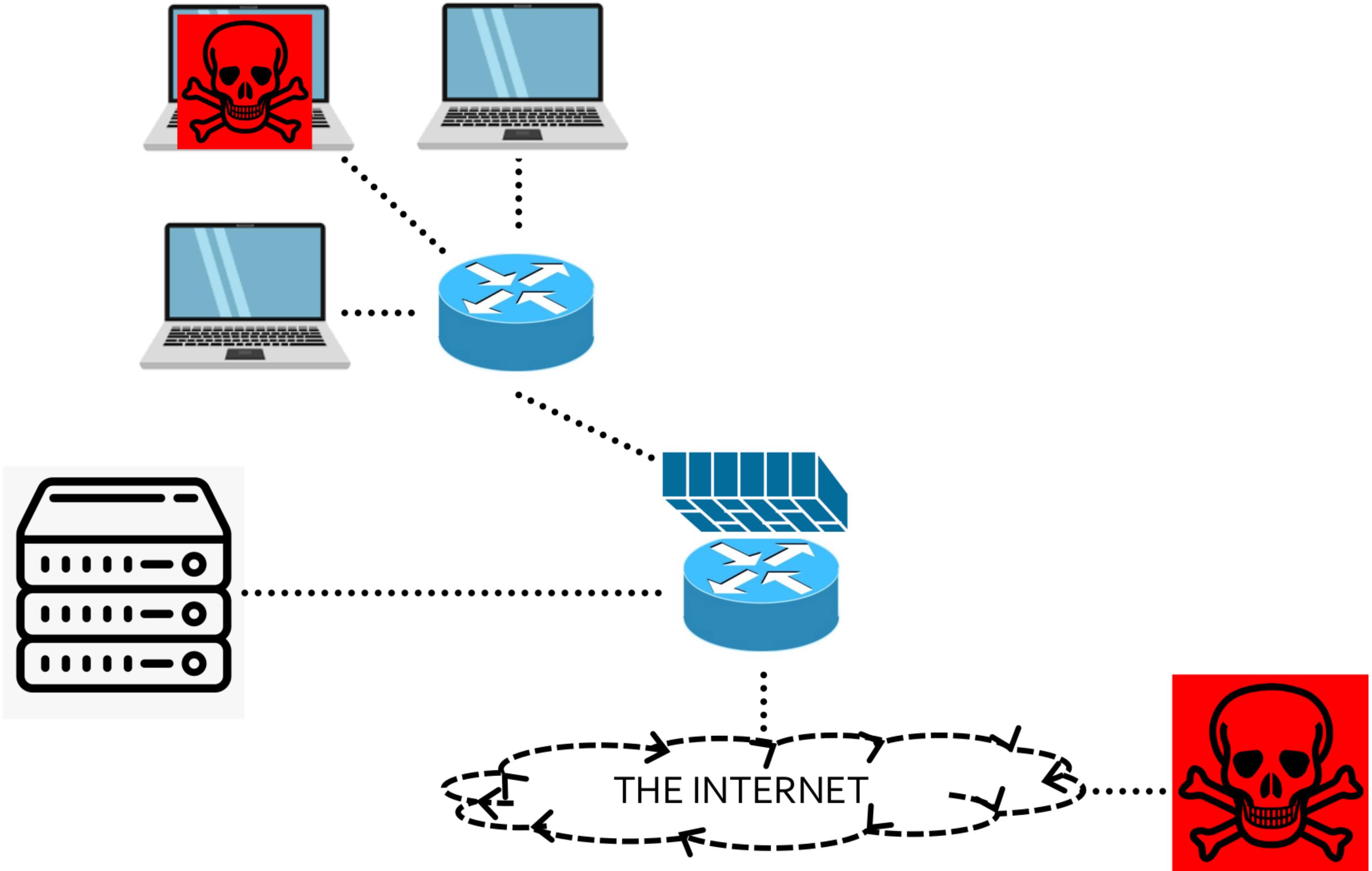


Network Enumeration (int)



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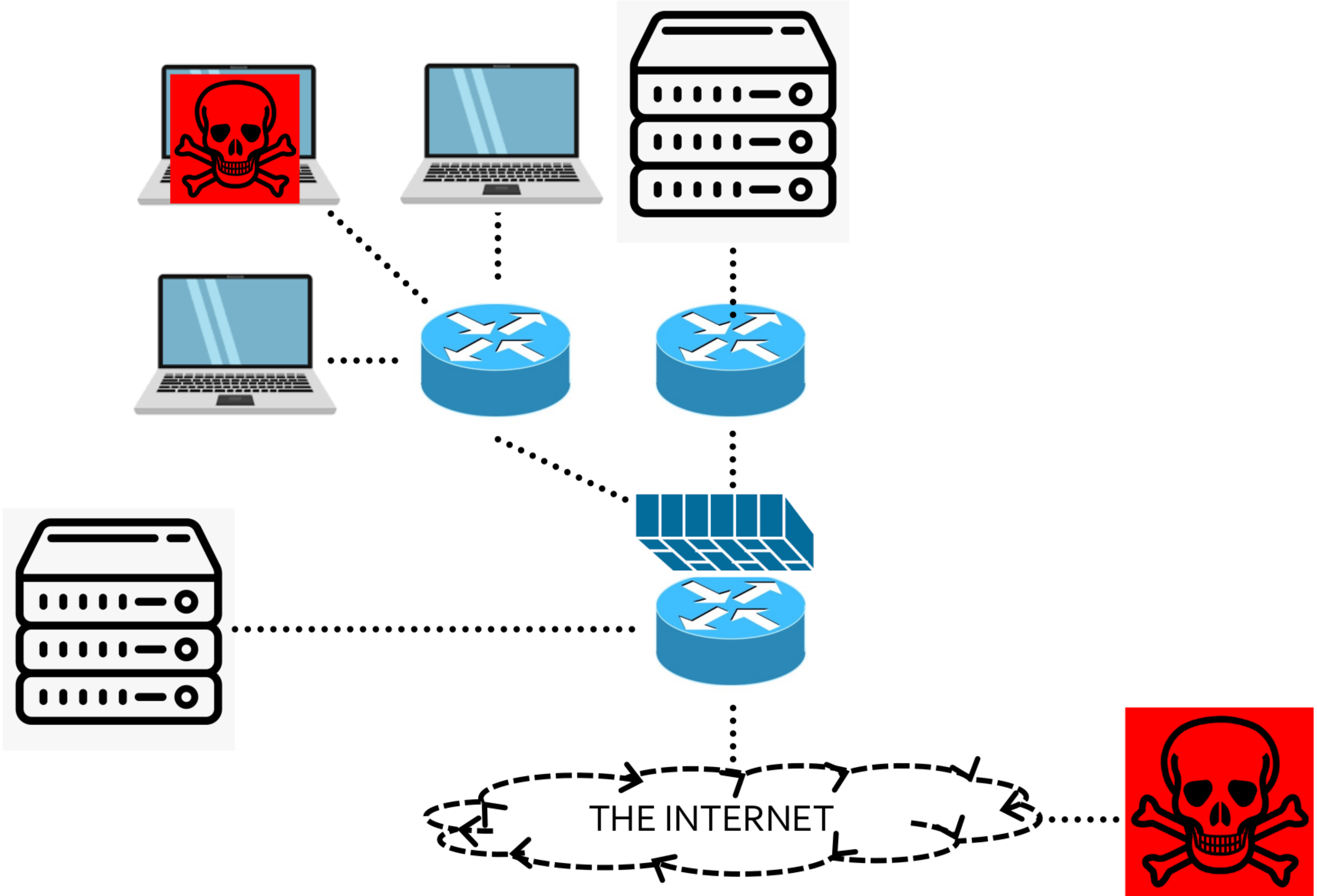

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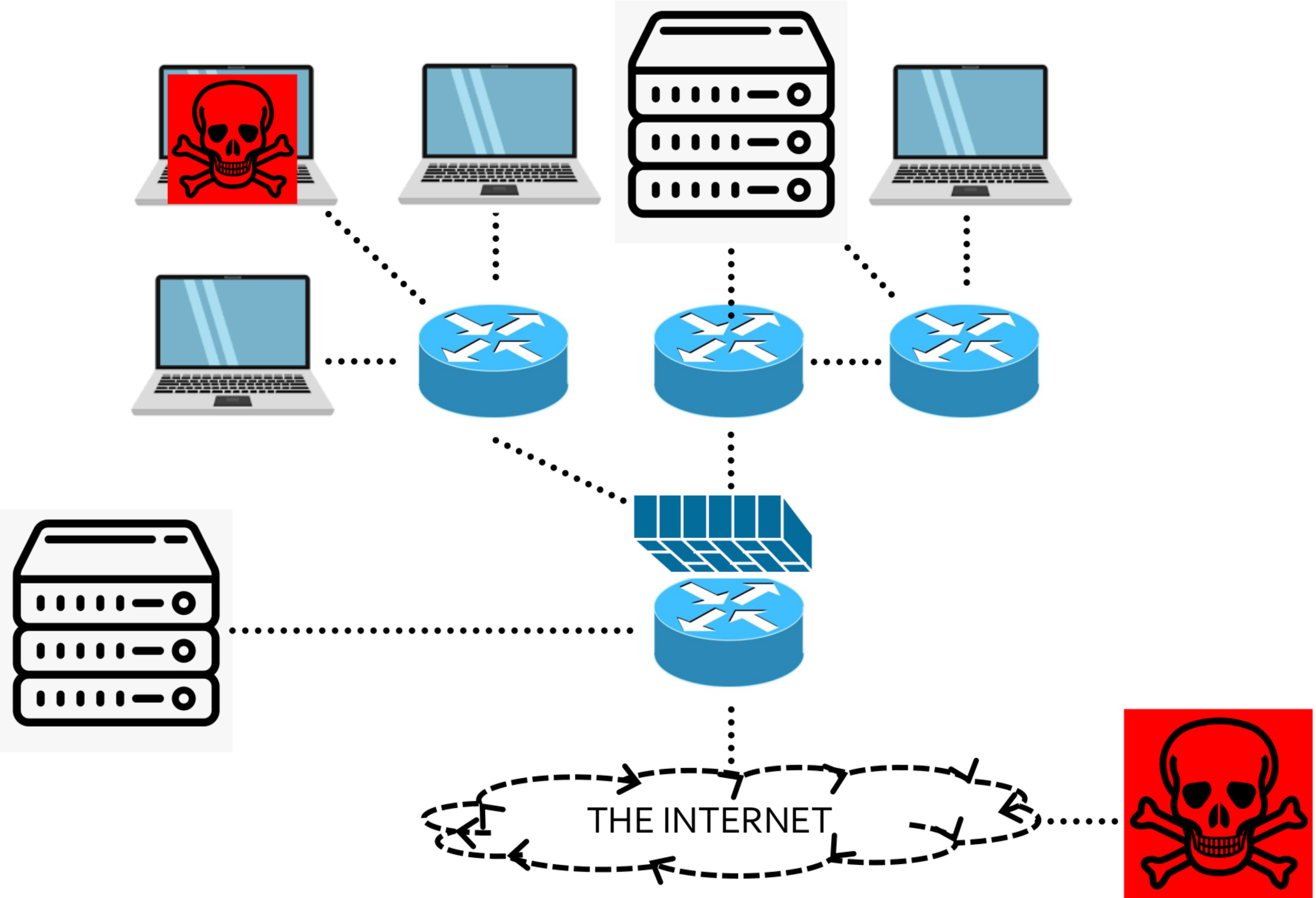

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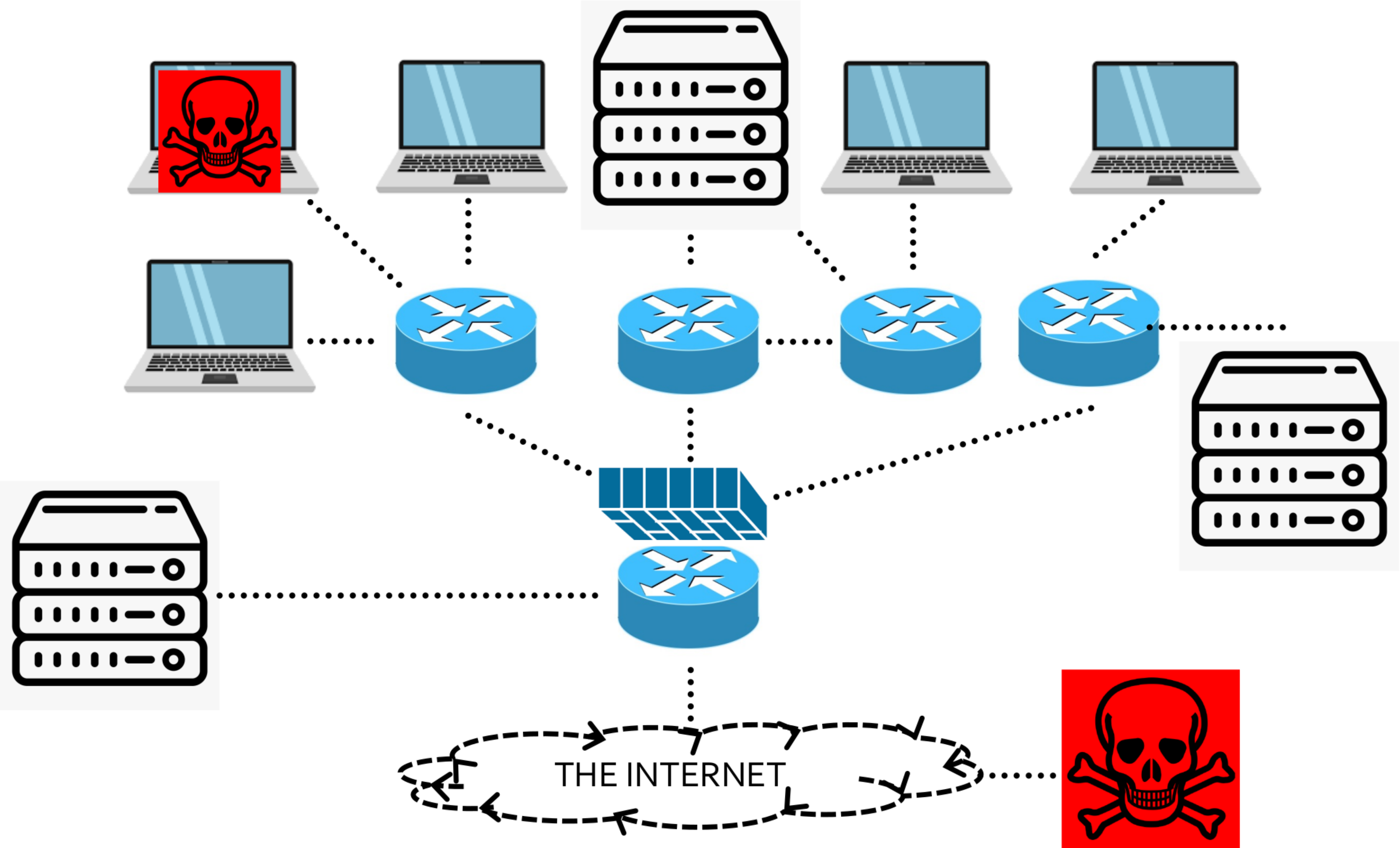
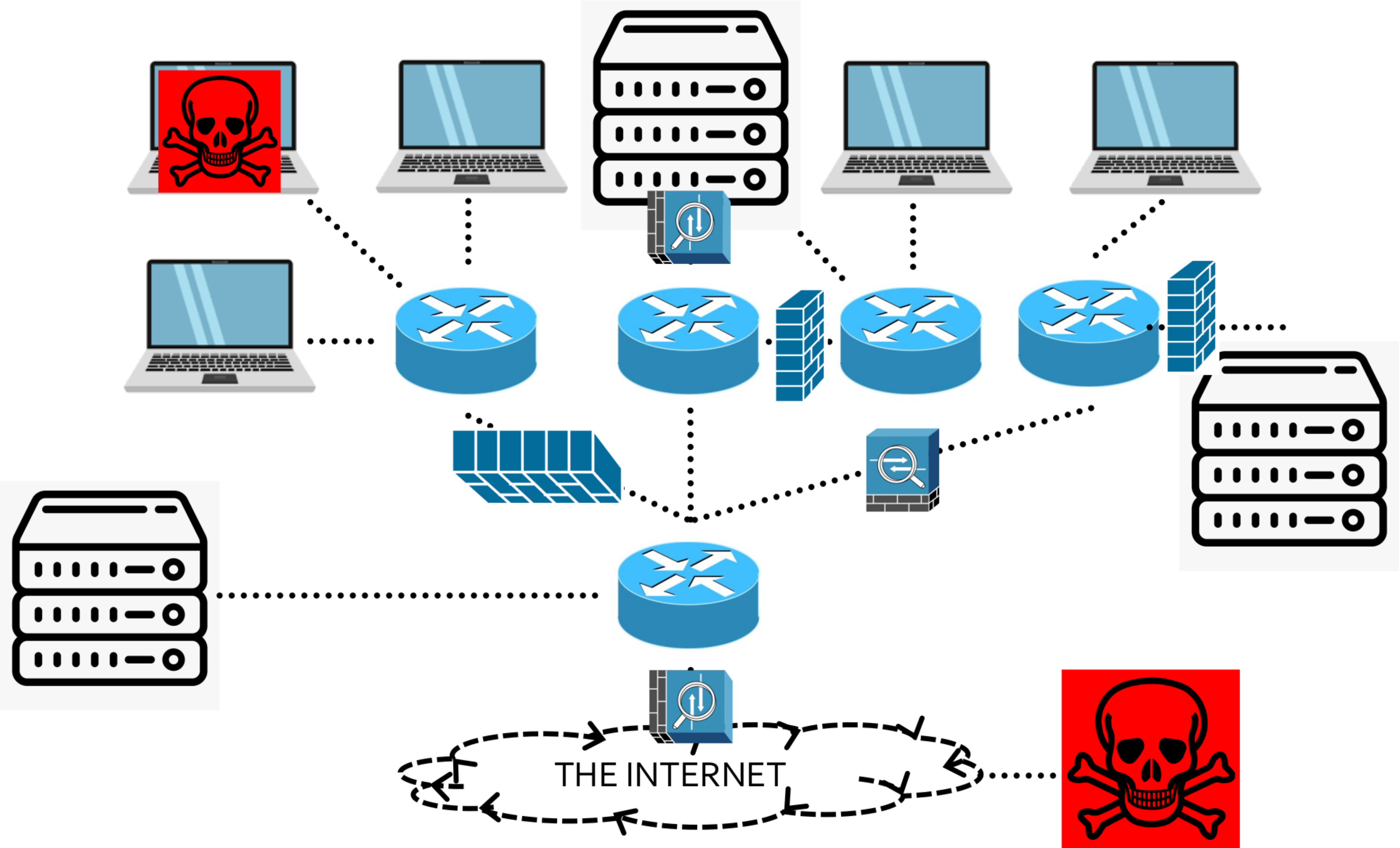


Network Traversal/ Lateral Movement



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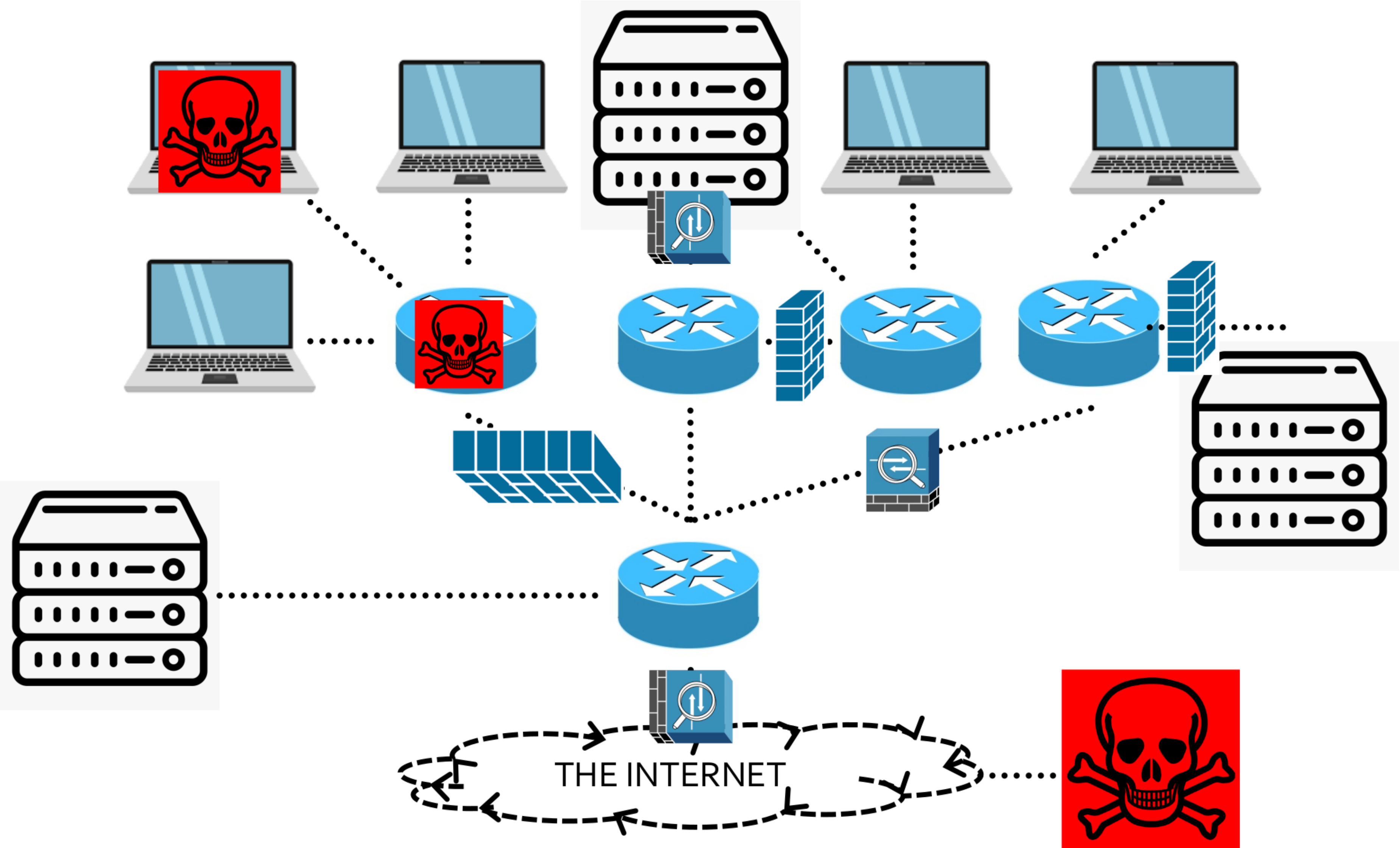

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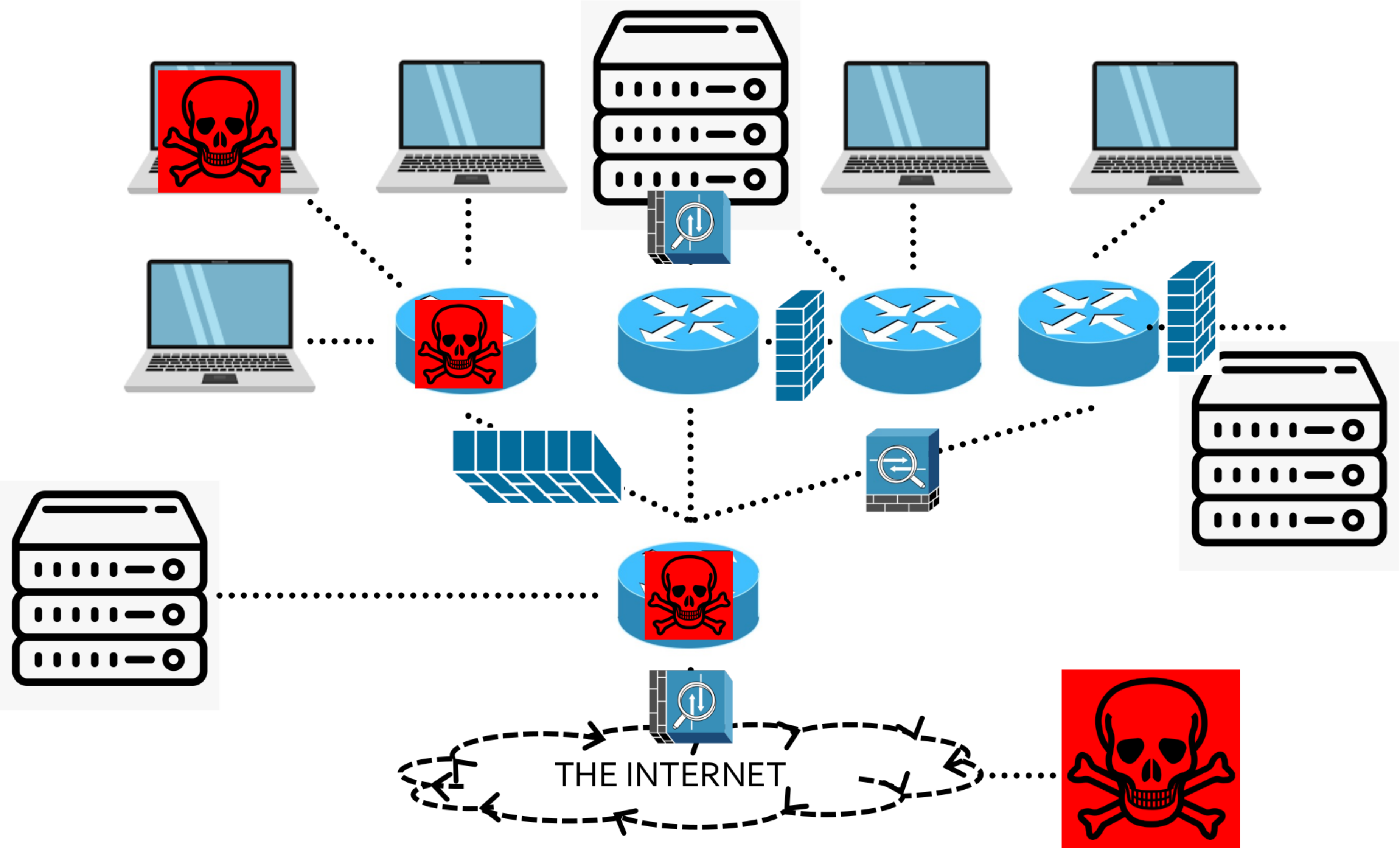

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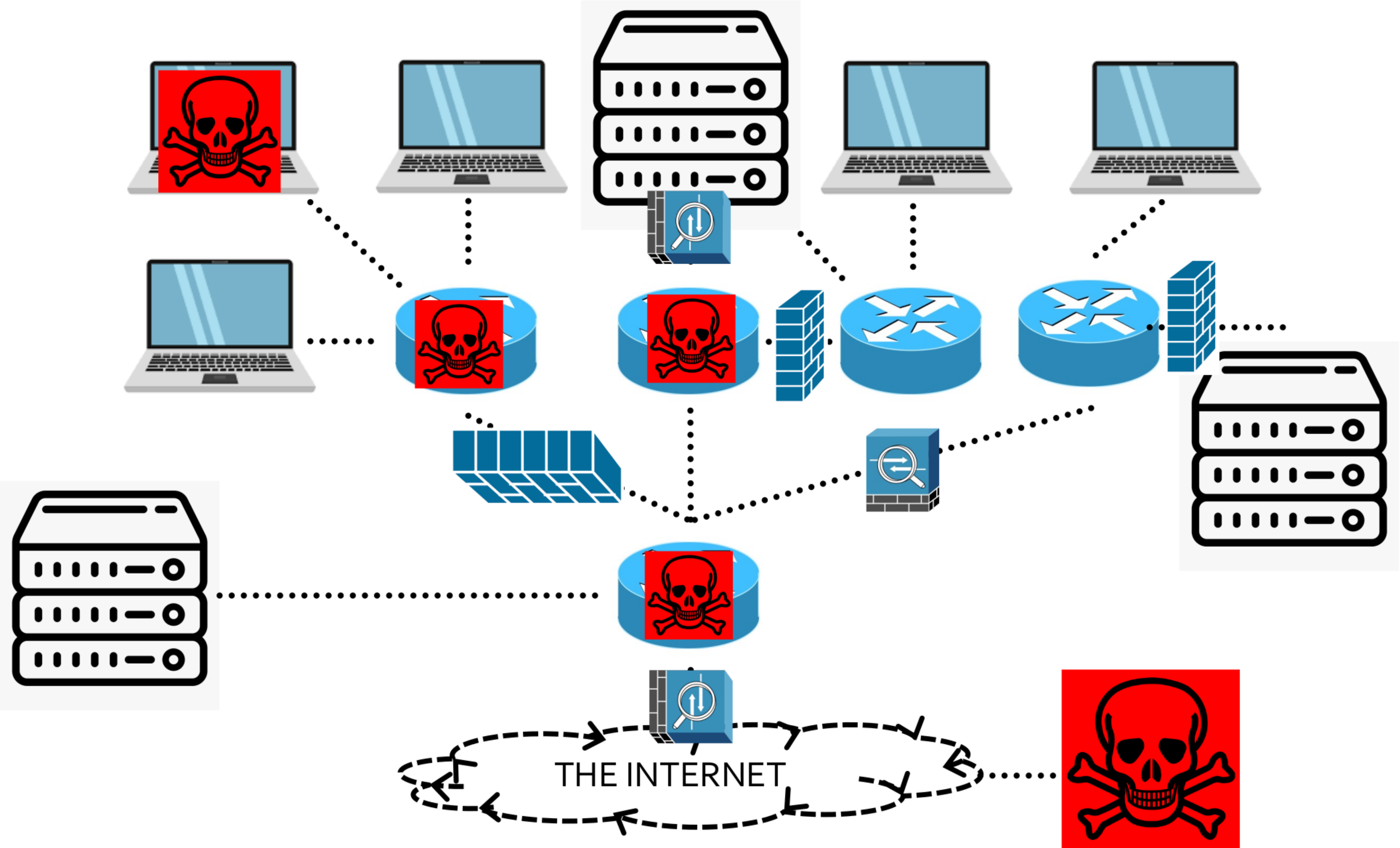

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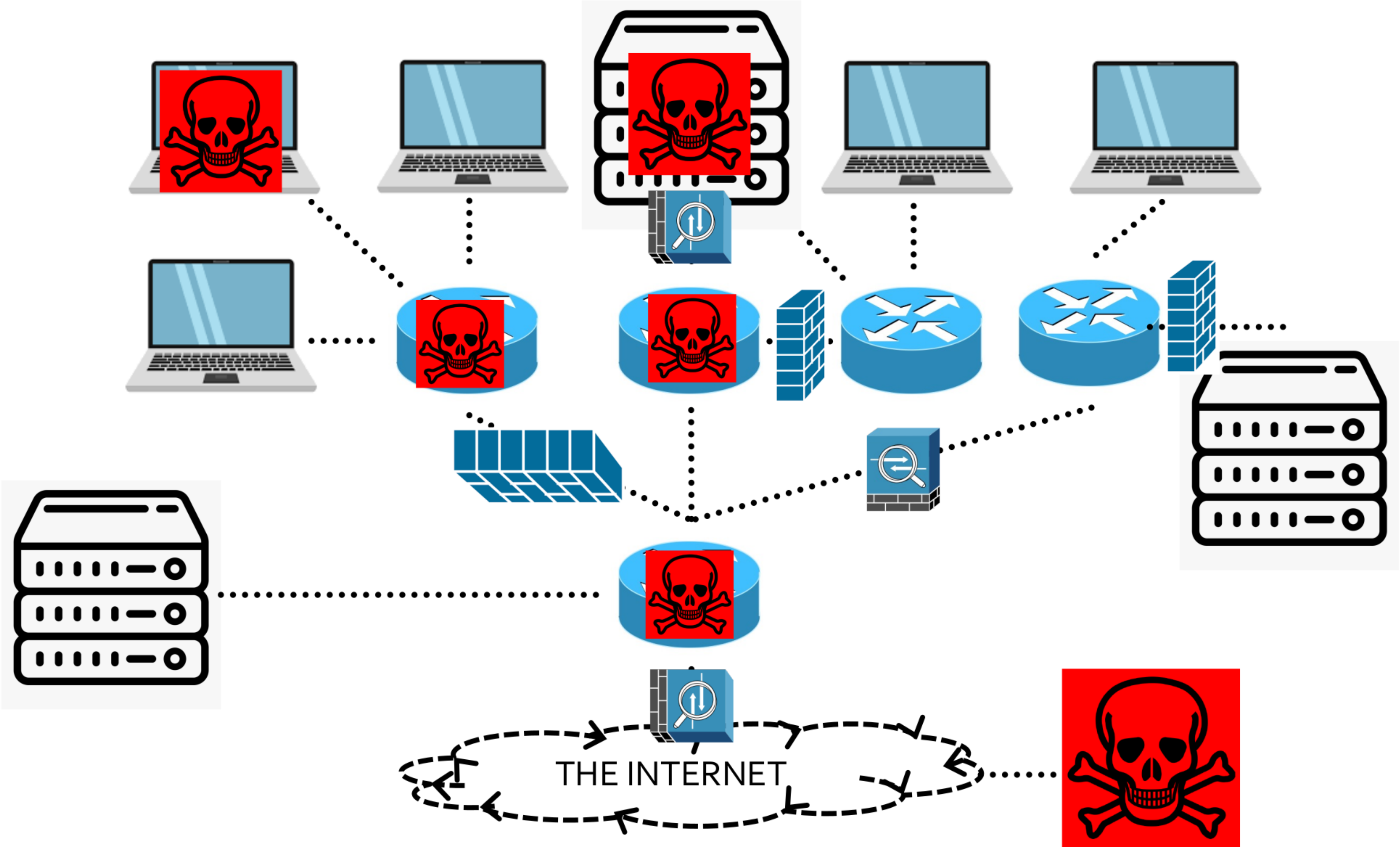
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