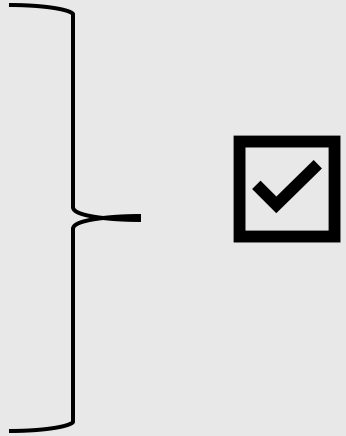
COMP435: *SECURITY CONCEPTS!*

Lecture 17: Intro to Network Security

tinyurl.com/comp435-fa25

Course Outline: ~6 Units

- Introduction to Security Concepts + Principles
- Cryptography
- Systems/OS Security
- Software Security
- Network Security
- Web Security
- *Bonus* Misc Unit at the End ☺



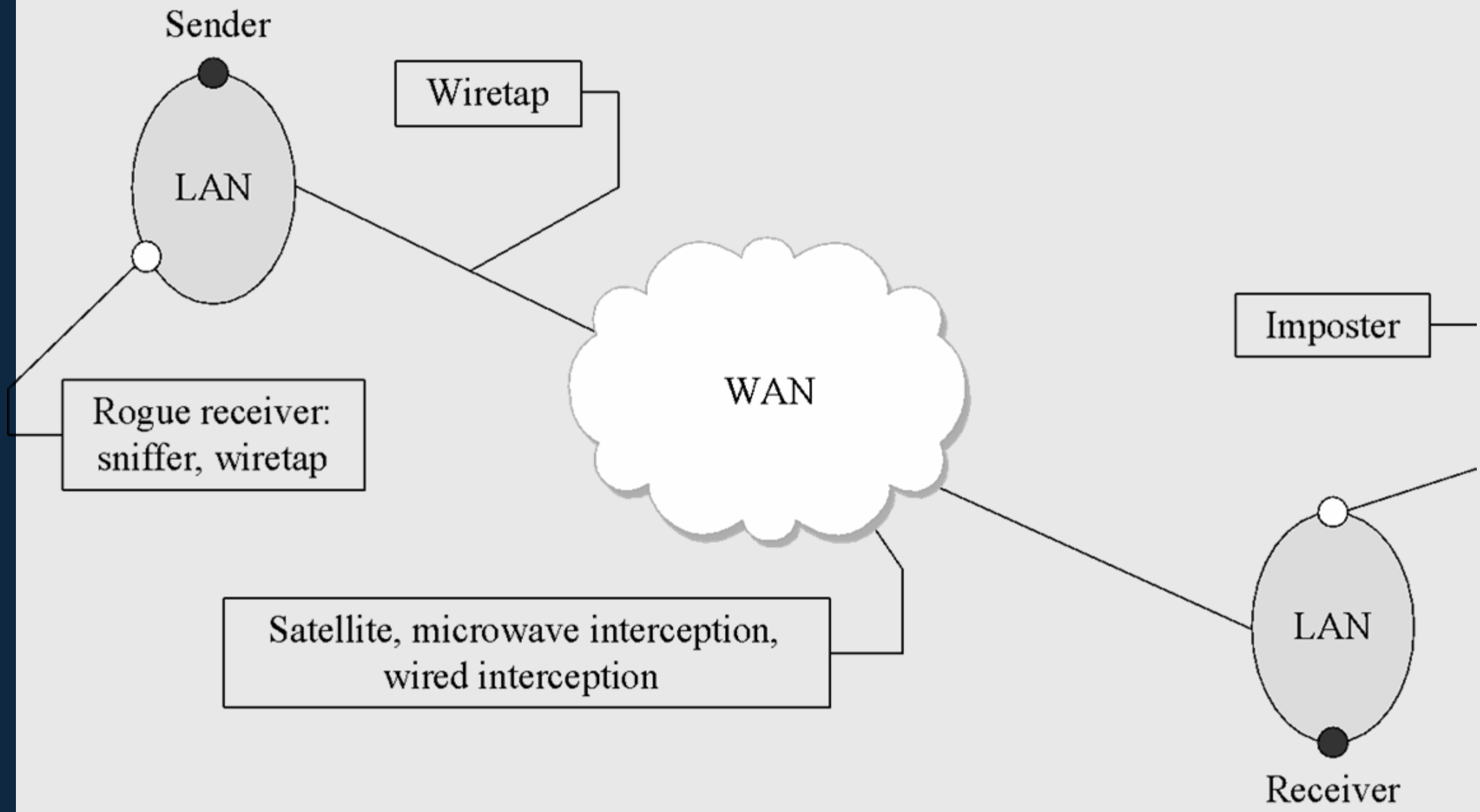
Quiz Topics & Logistics Updates

- Access Control Mechanisms
  - *Discretionary Access Control & Access Control Matrices*
  - *Bell LaPudula Model & Biba Integrity Model*
- Software Vulnerabilities – Should be familiar with the ones we studied in class and in the lab(s). How to identify the presence of a bug and potentially fix it if given a code listing.
  - *Heartbleed*
  - *Buffer overflow/overrun*
  - *Integer overflow/overrun*
  - *Confused deputy*
- New lab & WA out now!

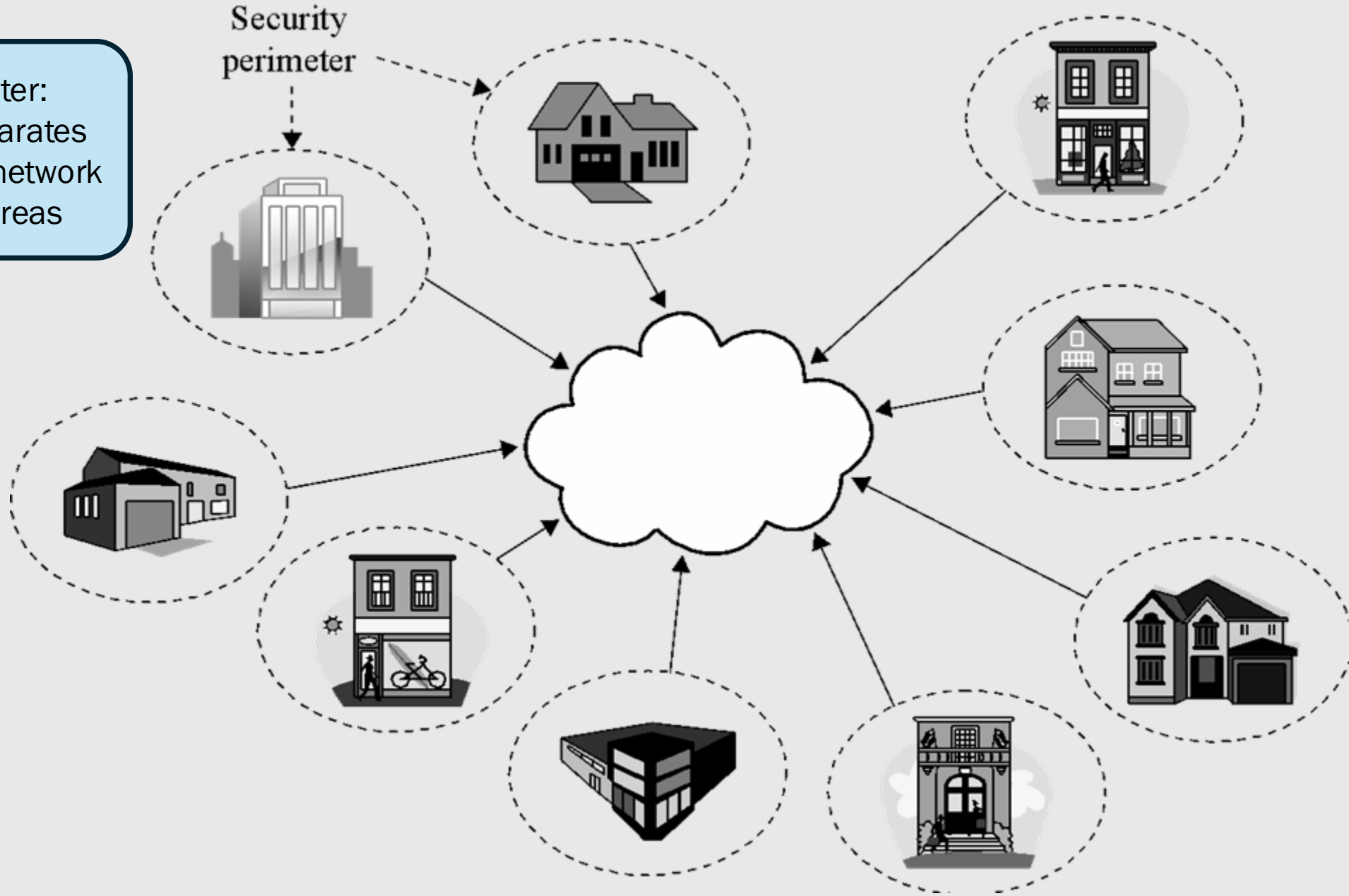
NETWORK SECURITY CONCEPTS

Challenges

- Anonymity
- Many points of attack
- Sharing
- Complexity
- Unknown perimeter
- Unknown path



Security perimeter: boundary that separates trusted part of the network from untrusted areas



Medium	Strengths	Weaknesses
Wire	• Cheap • Ubiquitous	• Signal emanation • Physical wiretapping
Optical Fiber	• No emanation • No wiretapping	• Weak at connection points
Microwave	• Strong signal	• Interception possible • Line of sight needed • Needs repeaters
Wireless	• Ubiquitous	• Interception possible • Short range
Satellite	• Strong signal	• Delay (long distance) • Interception possible

Threats

- Interception
- Modification
- Fabrication
- Interruption

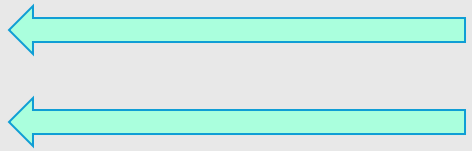
Threats

- Interception
- Modification
- Fabrication
- Interruption

confidentiality

Threats

- Interception
- Modification
- Fabrication
- Interruption



integrity

Threats

- Interception
- Modification
- Fabrication
- Interruption

availability

DOLEV-YAO MODEL

Dolev-Yao Model

- IEEE Transactions on Information Theory, 1983
- Active attacker
  - *Is a legitimate user of the network*
  - *Can obtain any message on the network*
  - *Can be a receiver to any user*

Dolev-Yao Model

- IEEE Transactions on Information Theory, 1983
- Active attacker
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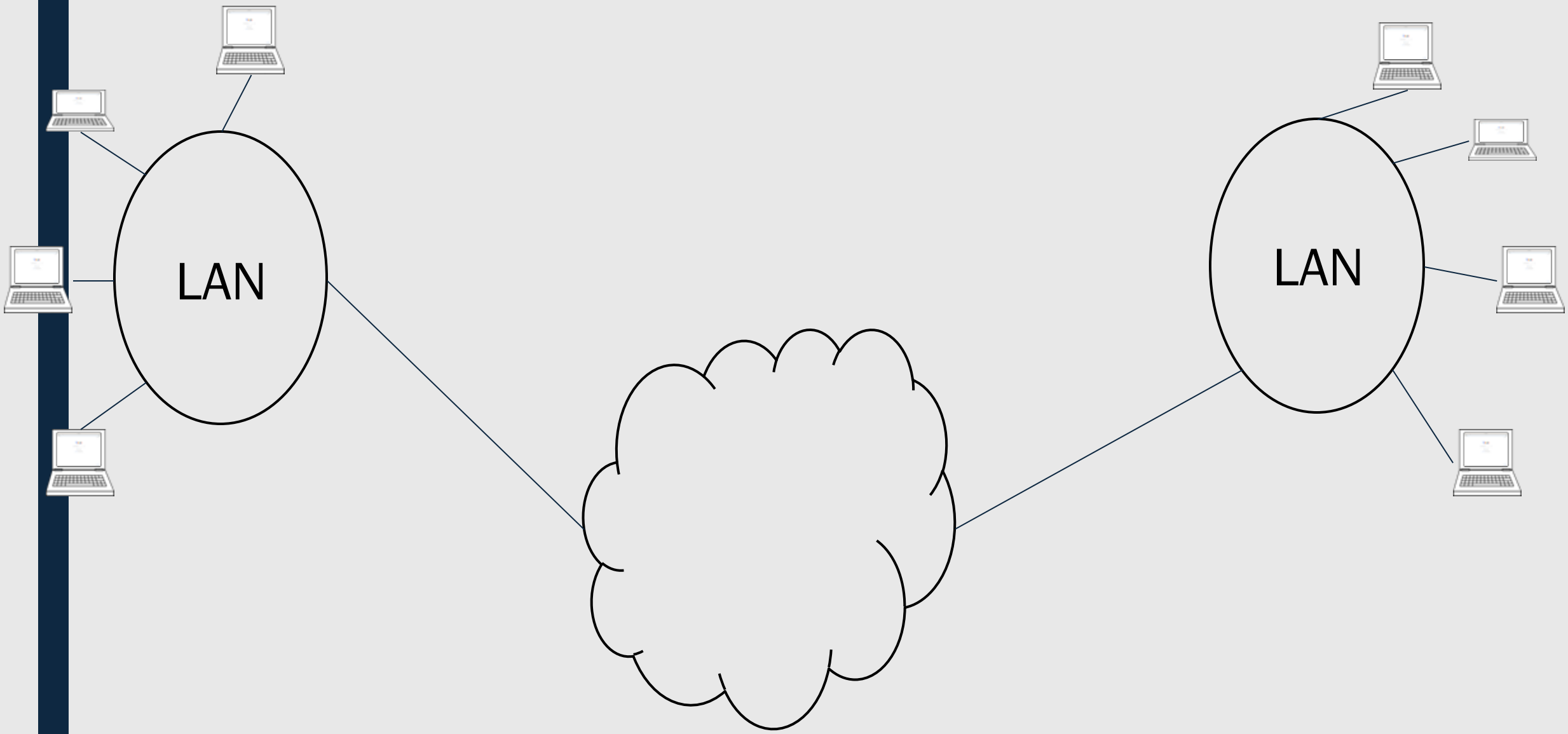
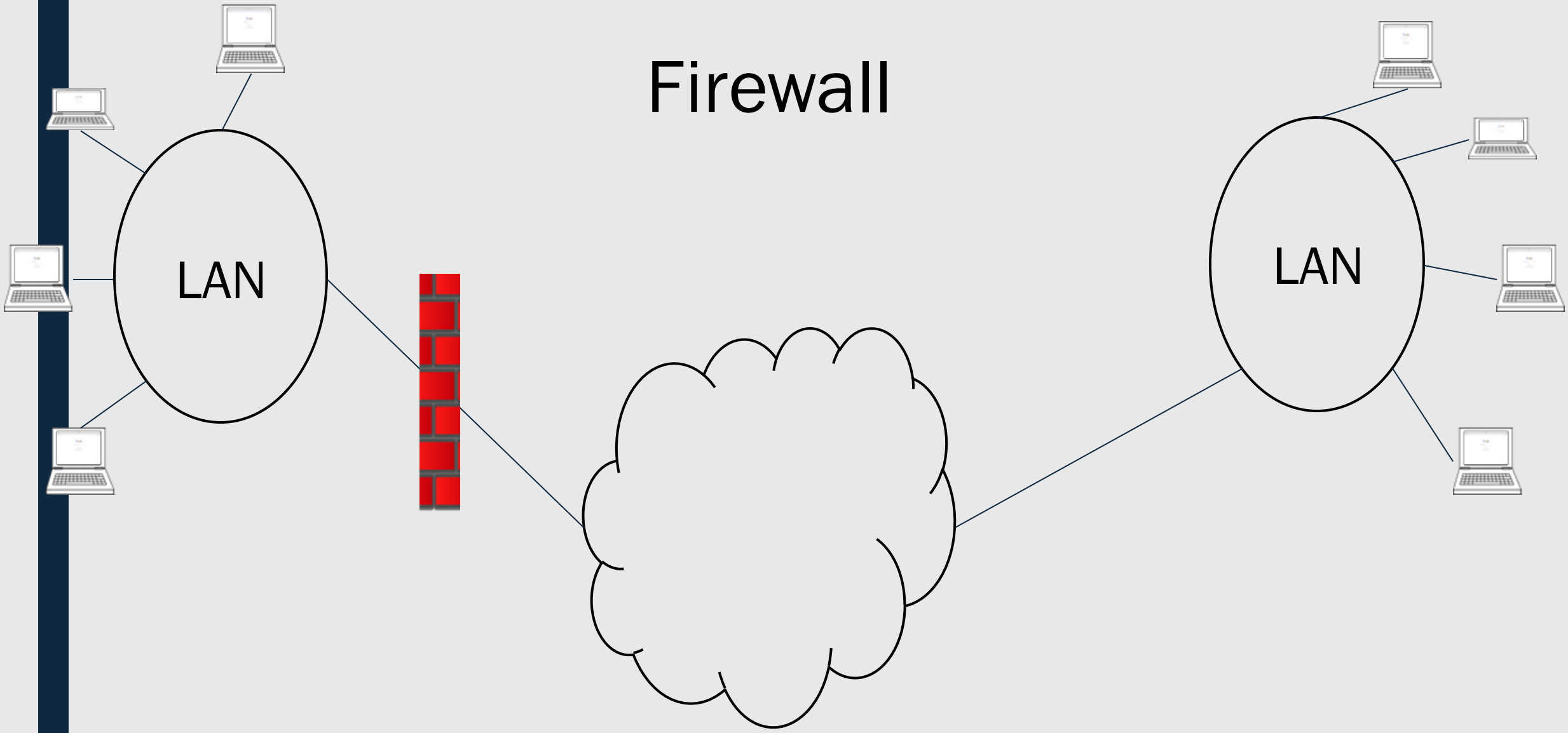
  - *Can obtain any message on the network*
  - *Can be a receiver to any user*

The attacker carries the message

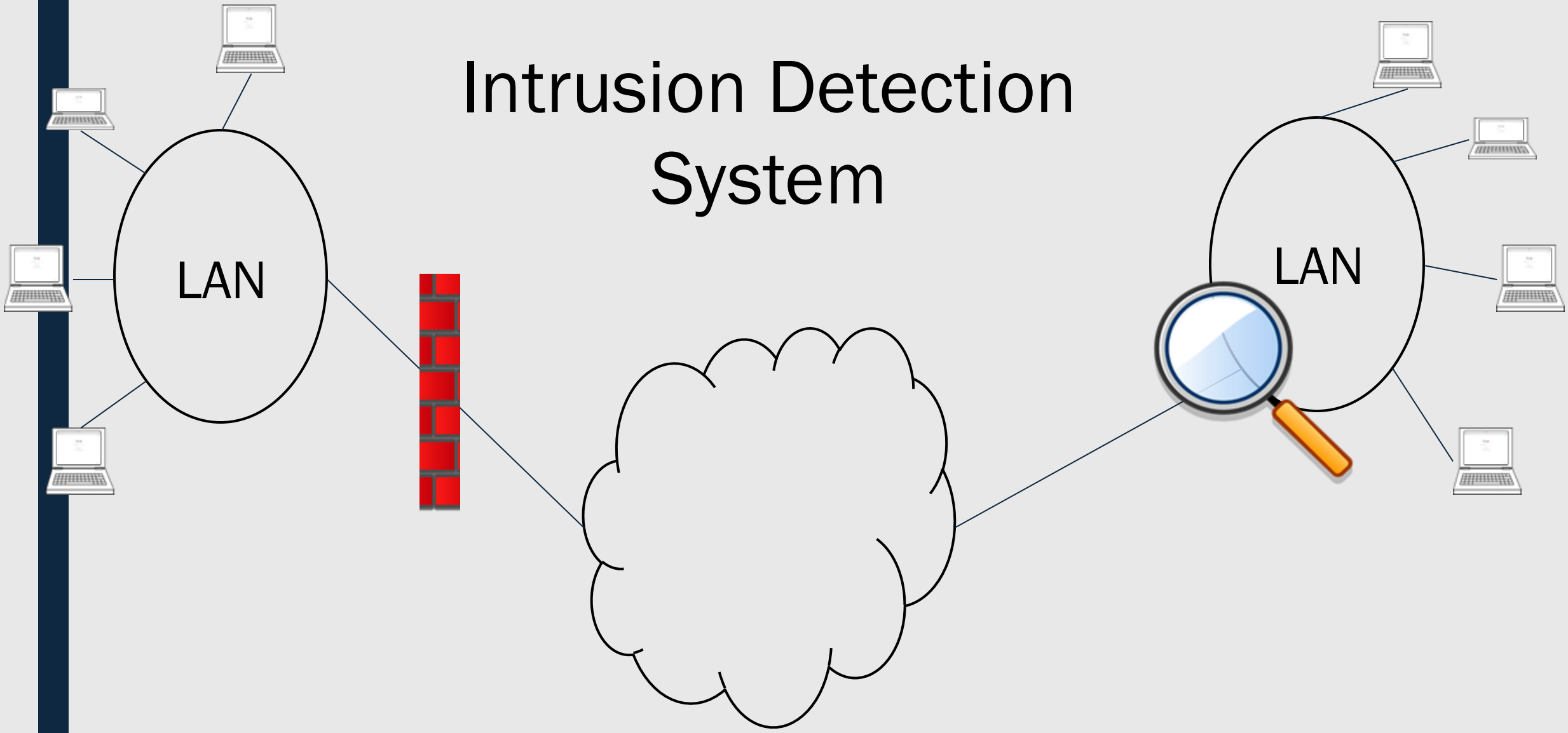
DEFENSE STRATEGIES


LAN
LAN

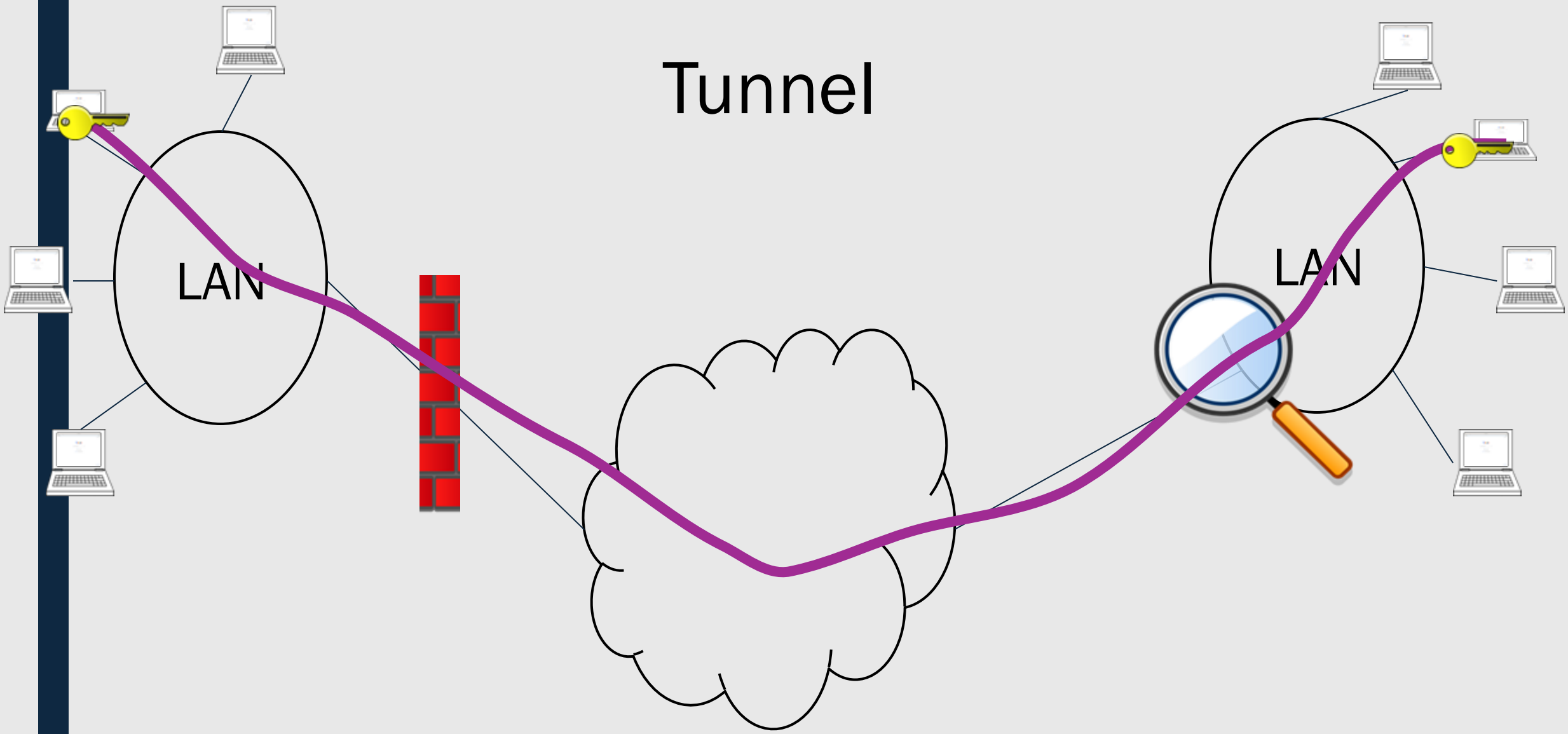
Firewall



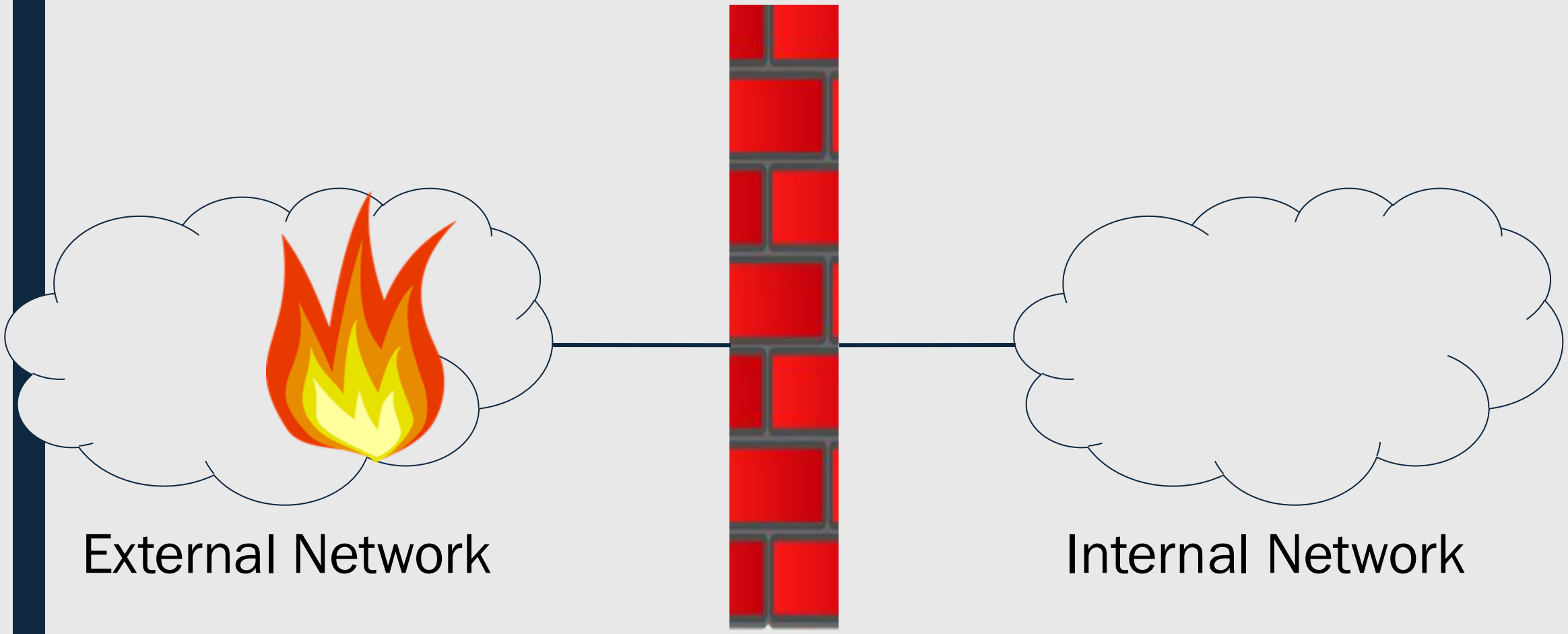
Intrusion Detection System

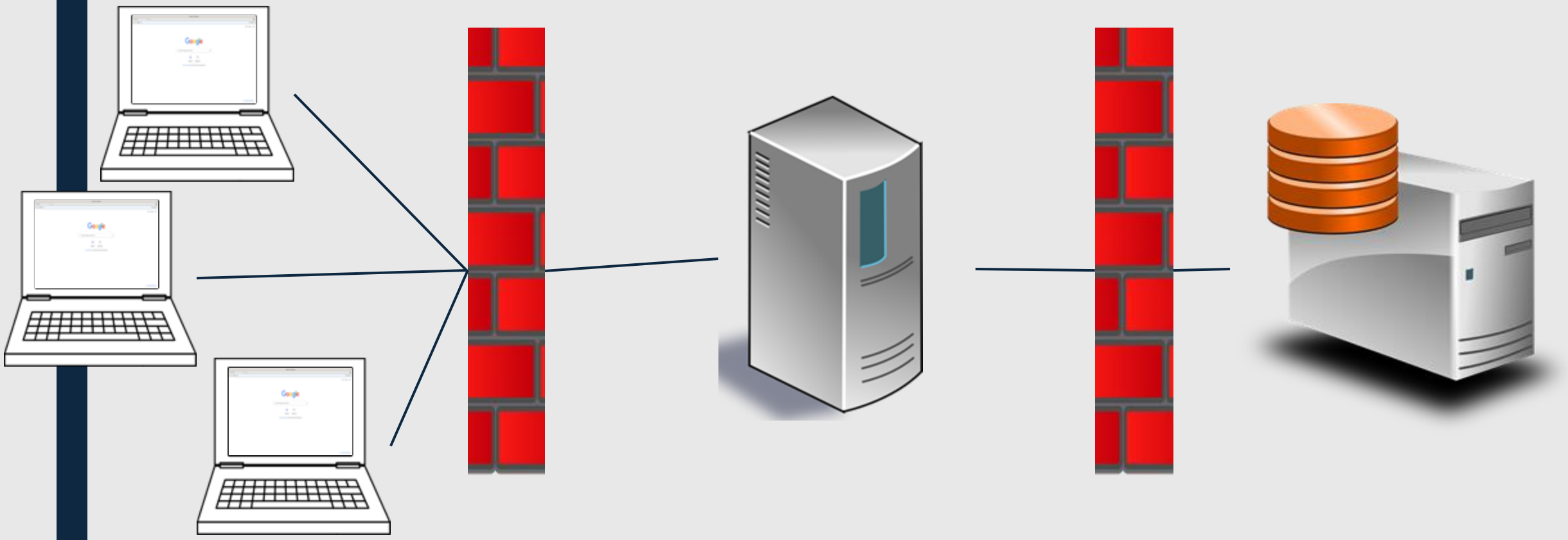


Tunnel



FIREWALLS


External Network
Internal Network



Internet

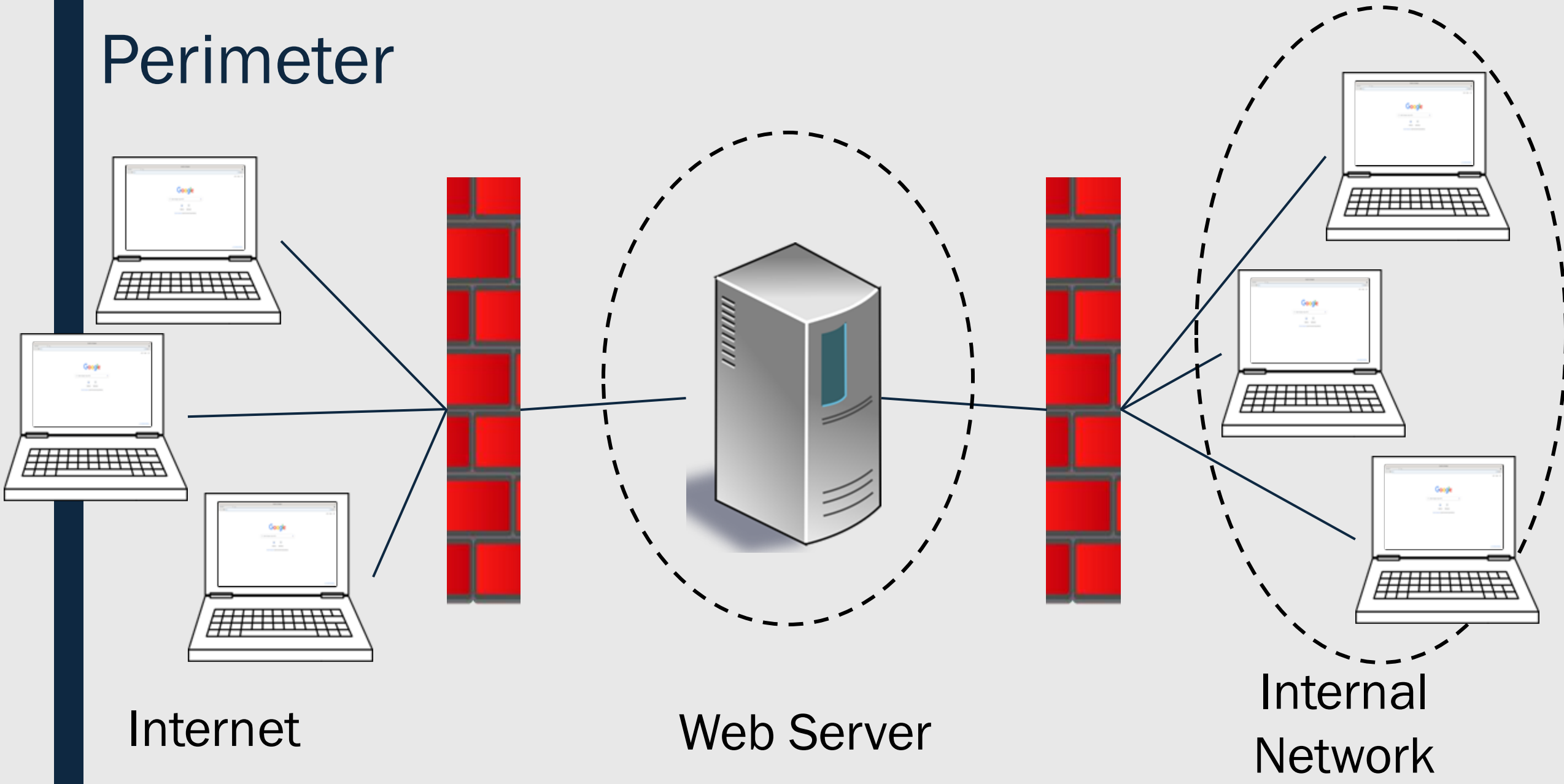
Web Server

Database Server

Firewall

Def’n: a gateway between two networks that can allow, deny, or modify data passing from one to the other

Perimeter



Firewall Properties

- security perimeter
- defense in depth: *used in conjunction w/ other methods*
- chokepoint for security analysis: *all communication funnels through*
- reference monitor
  - *complete mediation*
  - *immune to attack*
  - *proven correct*

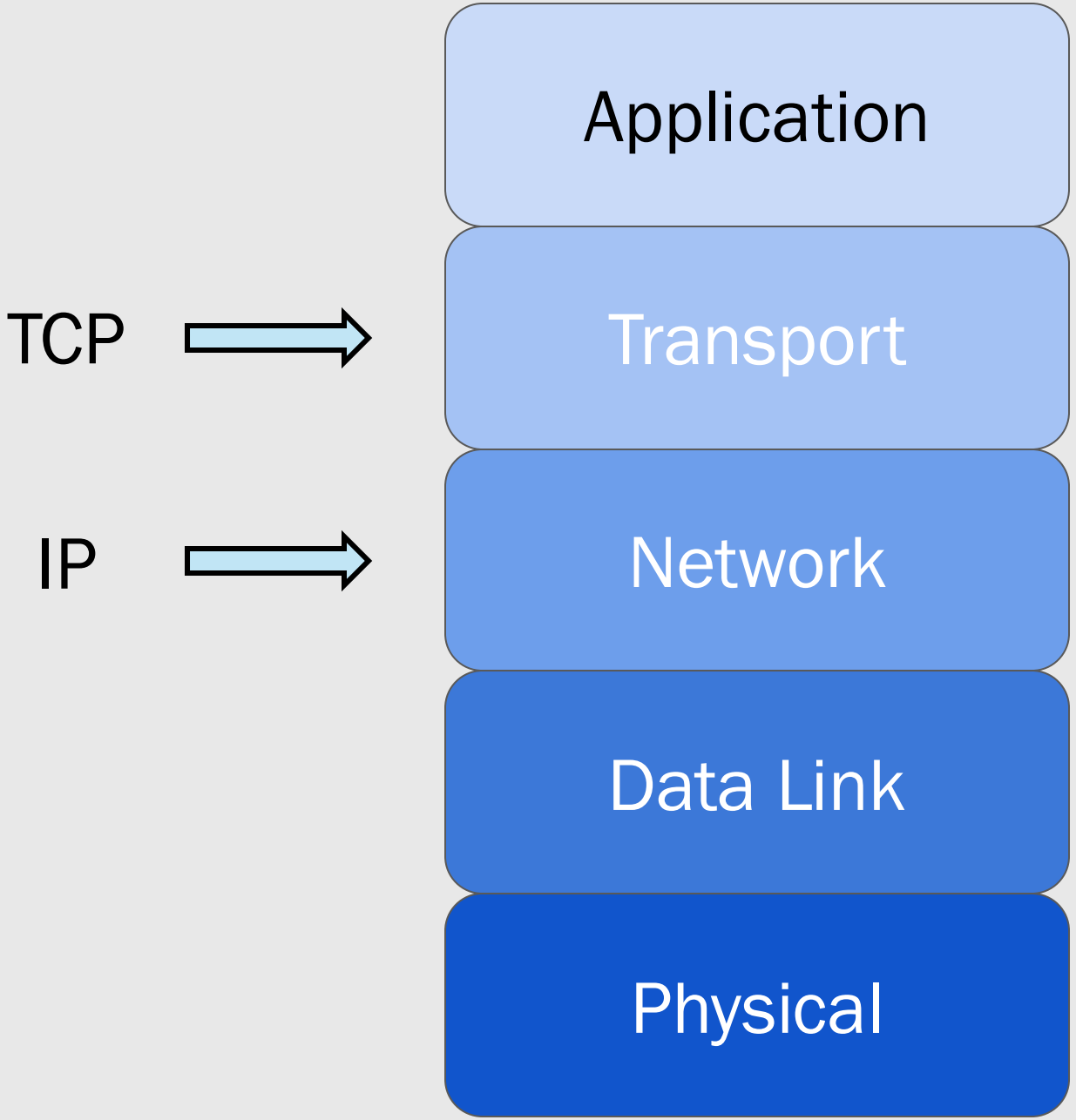
Types of Firewalls

Packet Filters

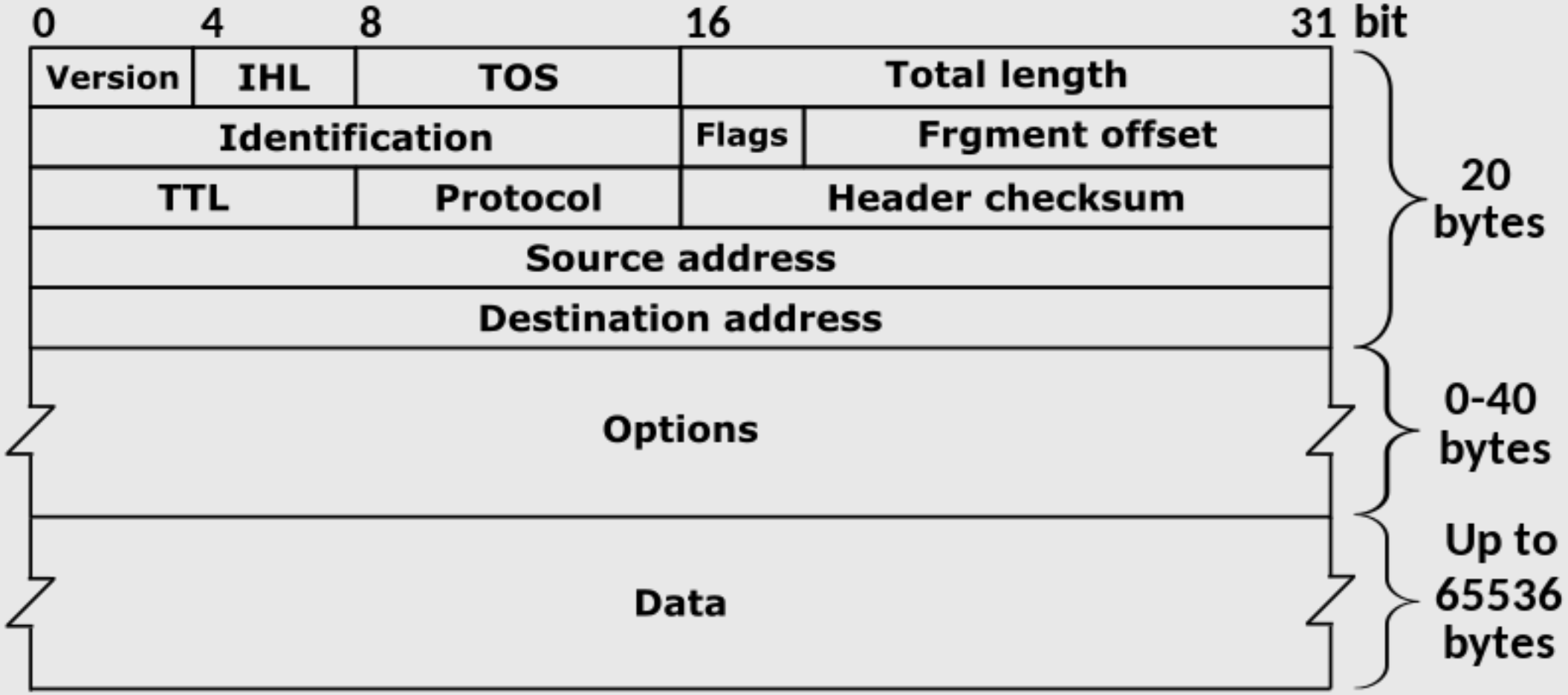
Proxy

FIRST, SOMEBACKGROUND: TCP/IP

TCP/IP

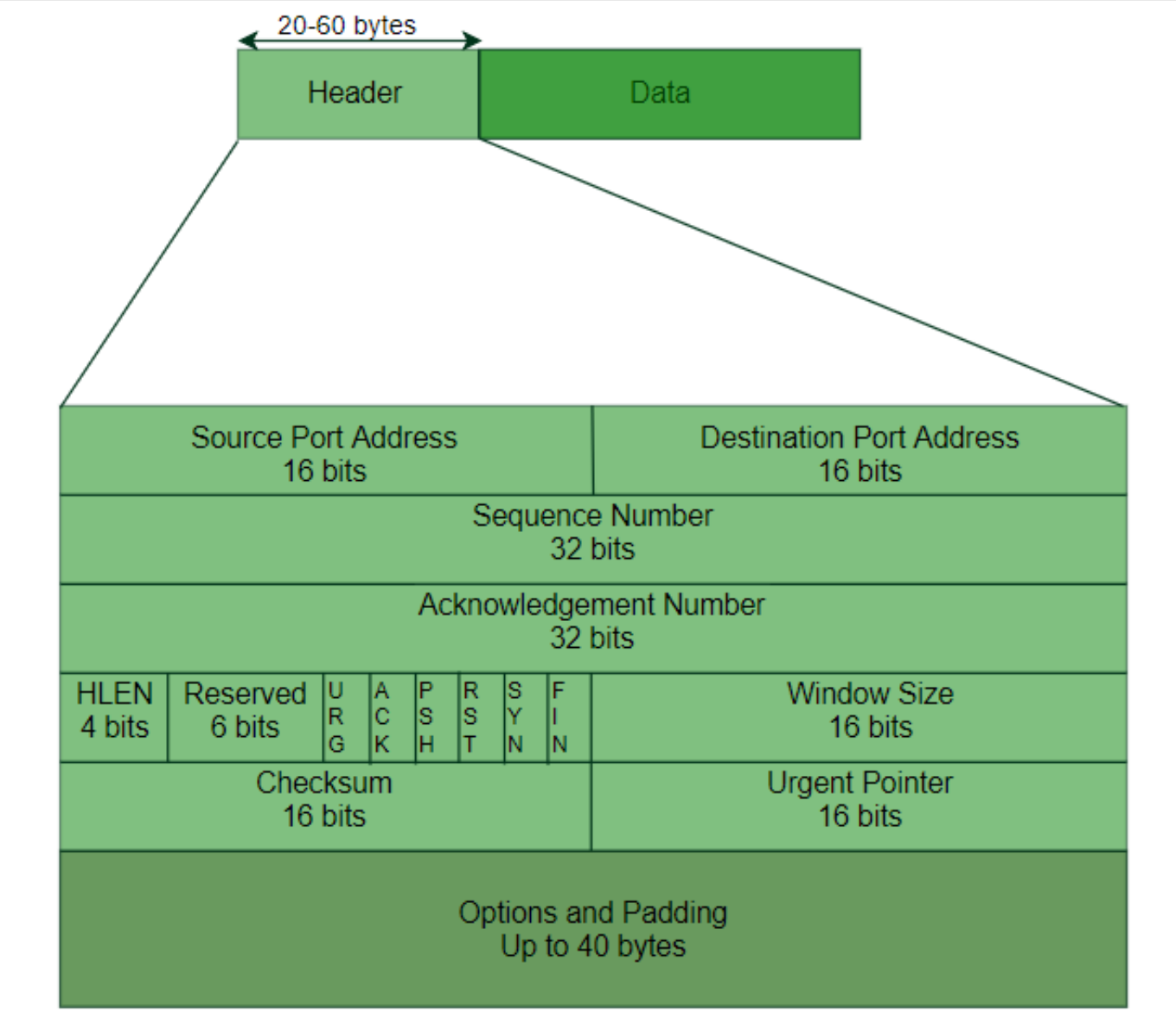


IPv4 Packet



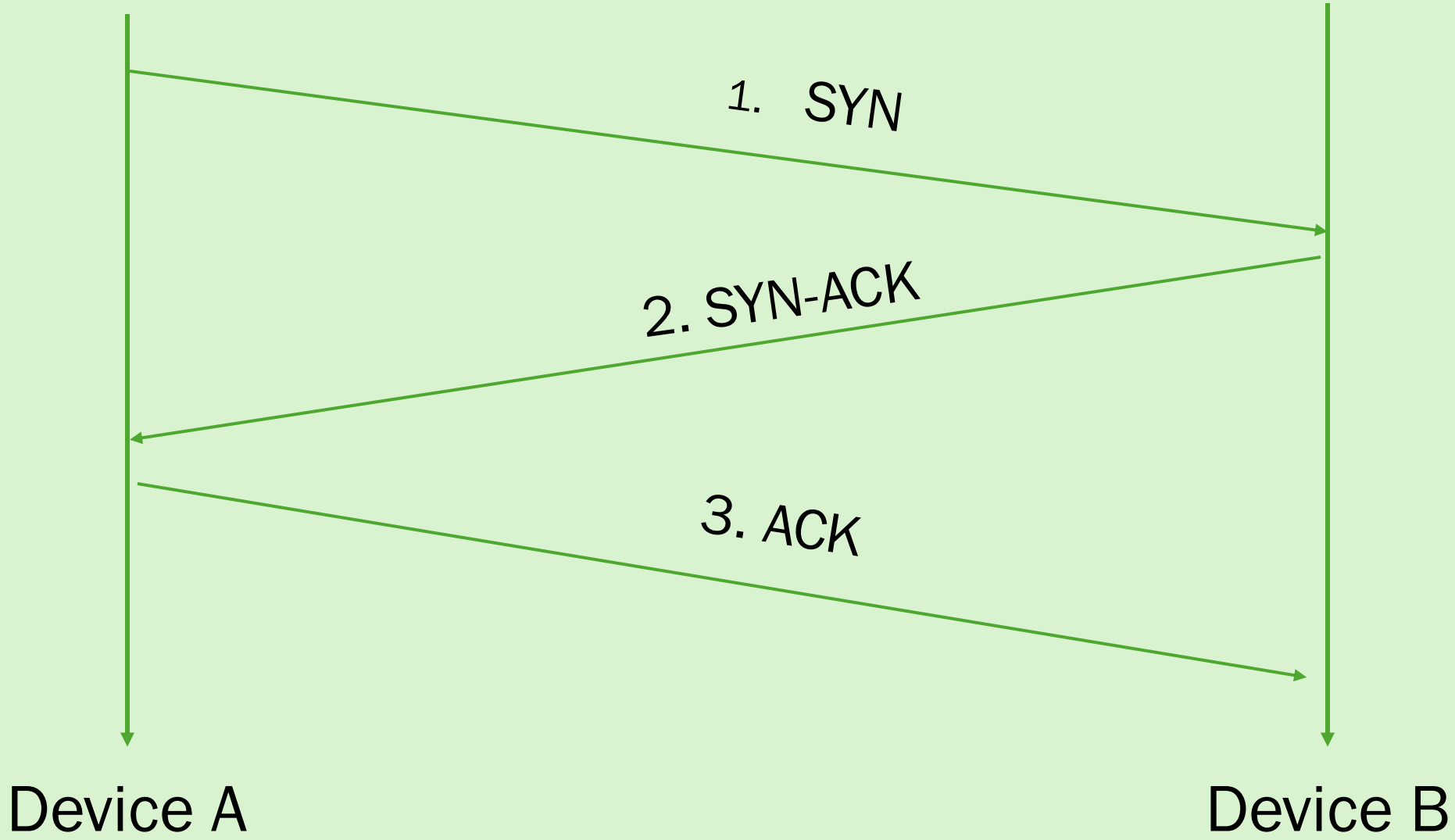
https://en.wikipedia.org/wiki/File:IPv4_Packet-en.svg

TCP Segment



https://www.geeksforgeeks.org/services-and-segment-structure-in-tcp/

TCP



PACKET FILTERS

Packet Filter

Def’n: IP packets are compared to a set of rules and either allowed, dropped, or rejected

Filtering Rules

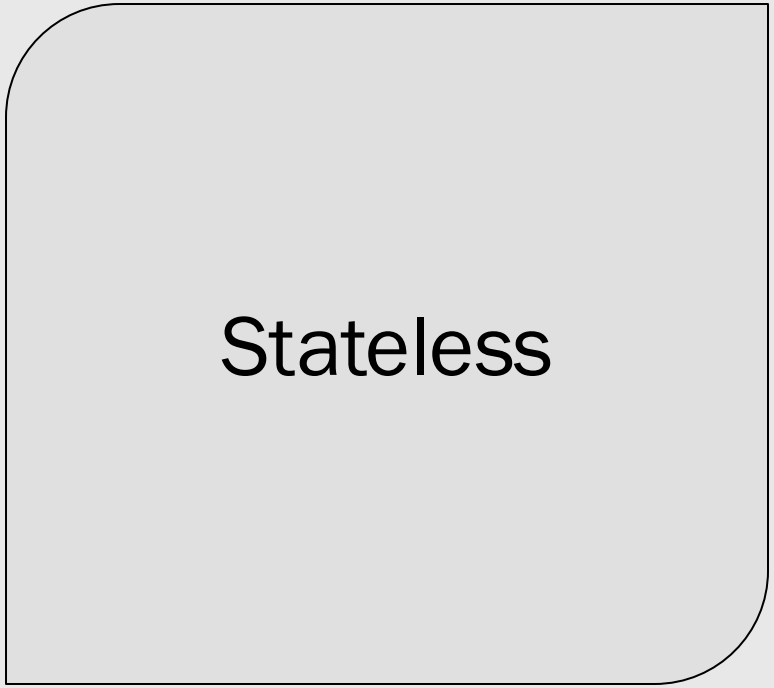
- TCP/IP header fields
- IP header protocol
- Packet size, flags
- Application protocol
- User ID
- Network activity

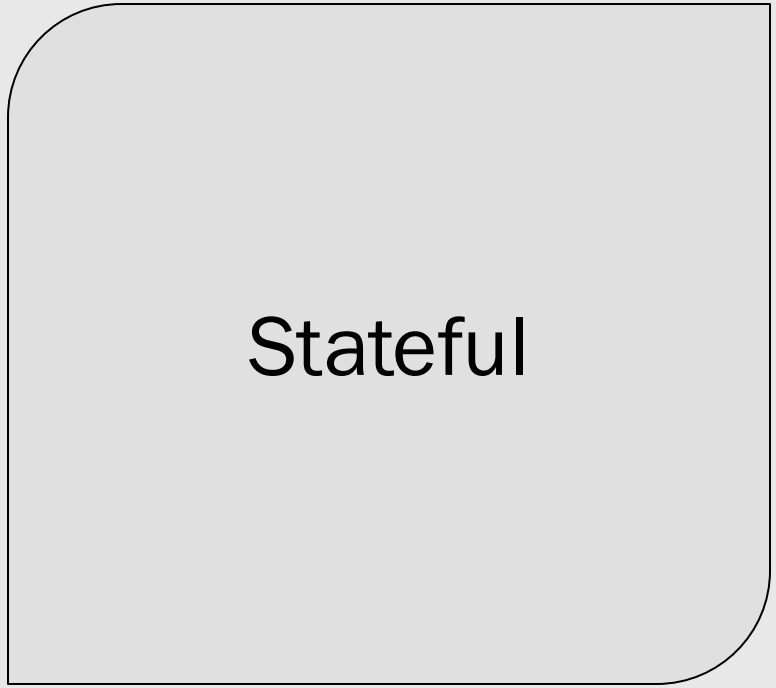
Packet Filters

Positive:
Default Deny

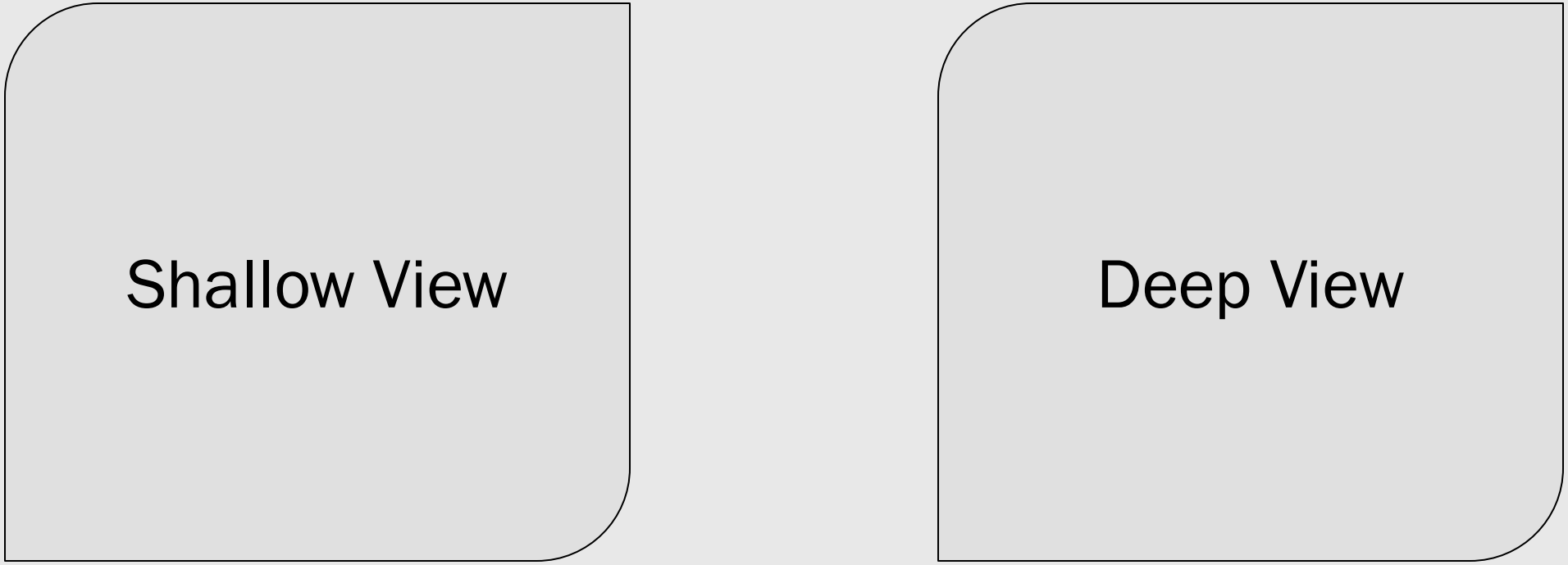
Negative: Default
Allow

Packet Filters





Packet Filters



Firewall Limitations

- reliance on topology
- untrustworthy insiders
- tunneling
- encrypted content

An Example Packet Filter

Rule	Direction	Src Addr	Dest Addr	Protocol	Dest Port	Action
A	In	External	Internal	TCP	25	Allow
B	Out	Internal	External	TCP	>1023	Allow
C	Out	Internal	External	TCP	25	Allow
D	In	External	Internal	TCP	>1023	Allow
E	Either	Any	Any	Any	Any	Deny

Building Internet Firewalls: Internet and Web Security, by Elizabeth D. Zwicky, Simon Cooper, D. Brent Chapman, ch. 8.

An Example Packet Filter

People inside the organization can **receive** mail!

Rule	Direction	Src Addr	Dest Addr	Protocol	Dest Port	Action
A	In	External	Internal	TCP	25	Allow
B	Out	Internal	External	TCP	>1023	Allow
C	Out	Internal	External	TCP	25	Allow
D	In	External	Internal	TCP	>1023	Allow
E	Either	Any	Any	Any	Any	Deny

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An Example Packet Filter

People inside the organization can **send** mail!

Rule	Direction	Src Addr	Dest Addr	Protocol	Dest Port	Action
A	In	External	Internal	TCP	25	Allow
B	Out	Internal	External	TCP	>1023	Allow
C	Out	Internal	External	TCP	25	Allow
D	In	External	Internal	TCP	>1023	Allow
E	Either	Any	Any	Any	Any	Deny

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An Example Packet Filter

Default deny!

Rule	Direction	Src Addr	Dest Addr	Protocol	Dest Port	Action
A	In	External	Internal	TCP	25	Allow
B	Out	Internal	External	TCP	>1023	Allow
C	Out	Internal	External	TCP	25	Allow
D	In	External	Internal	TCP	>1023	Allow
E	Either	Any	Any	Any	Any	Deny

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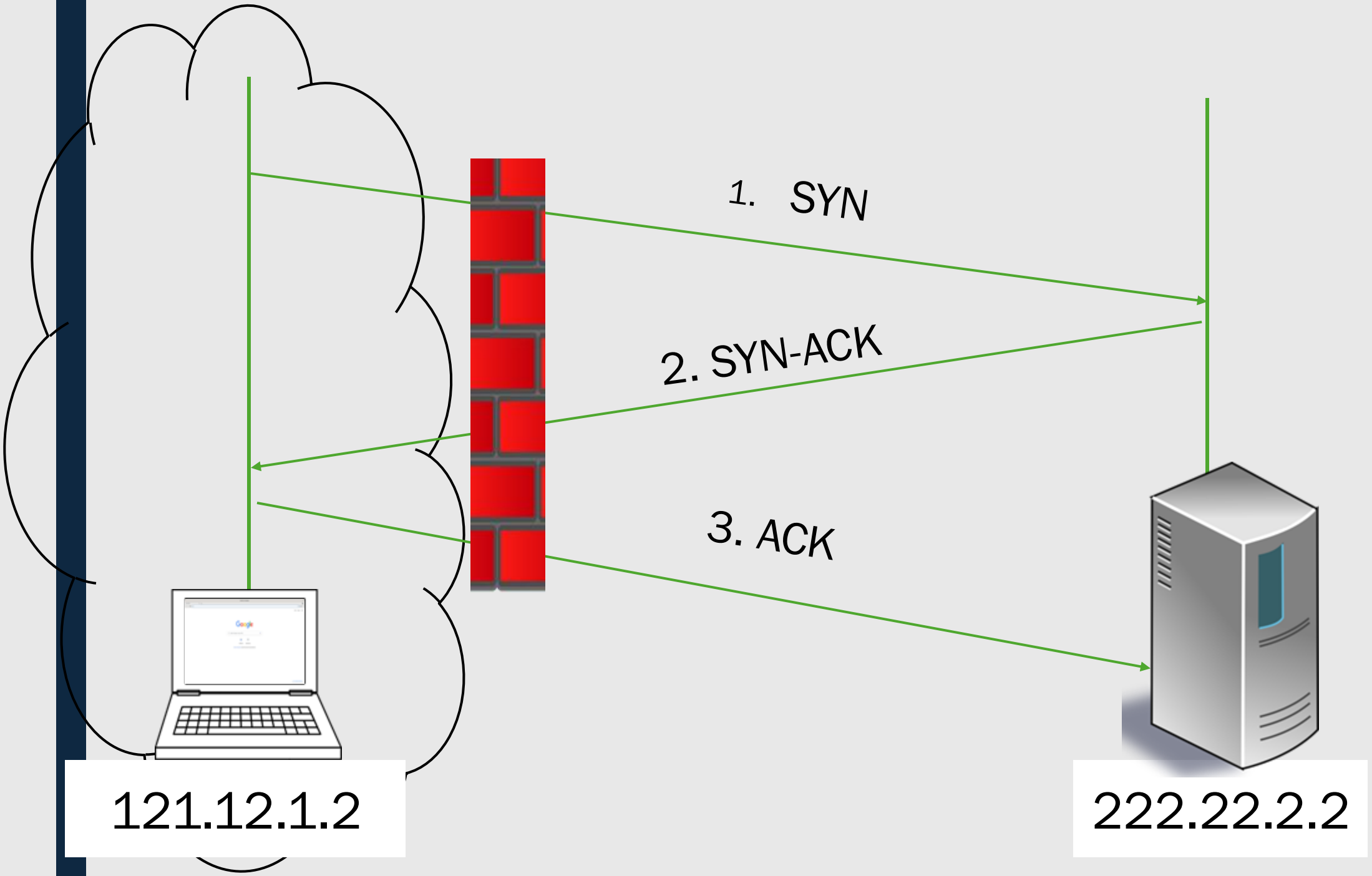
1. SYN
2. SYN-ACK
3. ACK
121.12.1.2
222.22.2.2

Rule	Dir	Src Addr	Dest Addr	Protocol	Dest Port	Action
A	In	External	Internal	TCP	25	Allow
B	Out	Internal	External	TCP	>1023	Allow
C	Out	Internal	External	TCP	25	Allow
D	In	External	Internal	TCP	>1023	Allow
E	Either	Any	Any	Any	Any	Deny

Packet	Direction	Src	Dest	Protocol	Dest Port	Action (rule)
1	In	121.12.1.2	222.2.2.2	TCP	25	Allow (A)
2	Out	222.2.2.2	121.12.1.2	TCP	5150	Allow (B)

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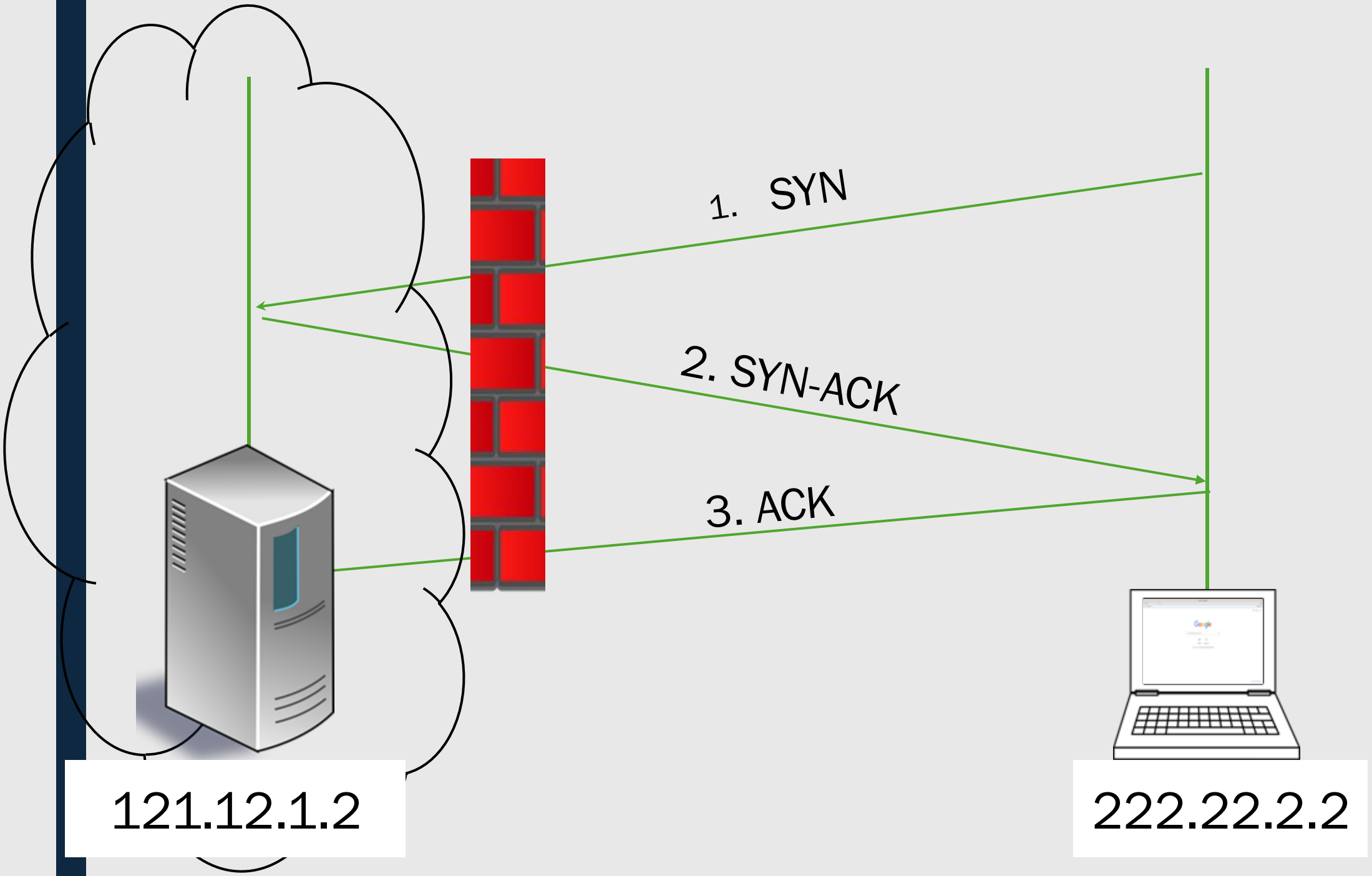
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222.22.2.2

Rule	Dir	Src Addr	Dest Addr	Protocol	Dest Port	Action
A	In	External	Internal	TCP	25	Allow
B	Out	Internal	External	TCP	>1023	Allow
C	Out	Internal	External	TCP	25	Allow
D	In	External	Internal	TCP	>1023	Allow
E	Either	Any	Any	Any	Any	Deny

Packet	Direction	Src	Dest	Protocol	Dest Port	Action (rule)
3	Out	222.22.2.2	121.12.1.2	TCP	25	Permit (C)
4	In	121.12.1.2	222.22.2.2	TCP	5150	Permit (D)

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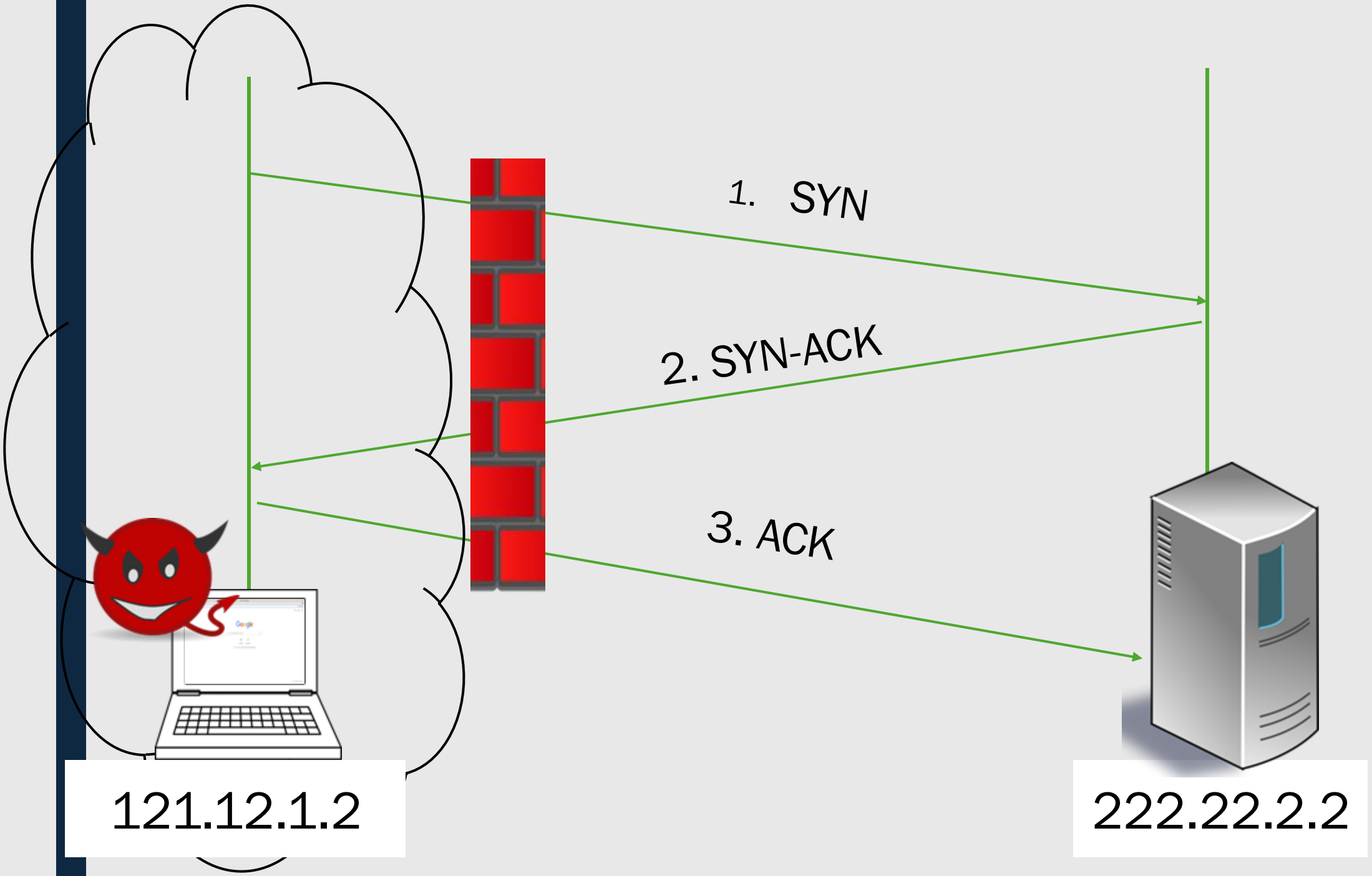
1. SYN
2. SYN-ACK
3. ACK
121.12.1.2
222.22.2.2

Rule	Dir	Src Addr	Dest Addr	Protocol	Dest Port	Action
A	In	External	Internal	TCP	25	Permit
B	Out	Internal	External	TCP	>1023	Permit
C	Out	Internal	External	TCP	25	Permit
D	In	External	Internal	TCP	>1023	Permit
E	Either	Any	Any	Any	Any	Deny

Packet	Direction	Src	Dest	Protocol	Dest Port	Action (rule)
1	In	121.12.1.2	222.2.2.2	TCP	8080	Allow (D)
2	Out	222.2.2.2	121.12.1.2	TCP	5150	Allow (B)

Updated Packet Filter

Rule	Dir	Src Addr	Dest Addr	Prot	Src Port	Dest Port	Action
A	In	External	Internal	TCP	> 1023	25	Allow
B	Out	Internal	External	TCP	25	> 1023	Allow
C	Out	Internal	External	TCP	> 1023	25	Allow
D	In	External	Internal	TCP	25	> 1023	Allow
E	Either	Any	Any	Any	Any	Any	Deny

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Rule	Dir	Src Addr	Dest Addr	Prot	Src Port	Dest Port	Action
A	In	External	Internal	TCP	> 1023	25	Allow
B	Out	Internal	External	TCP	25	> 1023	Allow
C	Out	Internal	External	TCP	> 1023	25	Allow
D	In	External	Internal	TCP	25	> 1023	Allow
E	Either	Any	Any	Any	Any	Any	Deny

Packet	Dir	Src Addr	Dest Addr	Prot	Src Port	Dest Port	Action (rule)
1	In	121.12.1.2	222.2.2.2	TCP	5150	8080	Deny (E)
2	Out	222.2.2.2	121.12.1.2	TCP	8080	5150	Deny (E)

Rule	Dir	Src Addr	Dest Addr	Prot	Src Port	Dest Port	Action
A	In	External	Internal	TCP	> 1023	25	Allow
B	Out	Internal	External	TCP	25	> 1023	Allow
C	Out	Internal	External	TCP	> 1023	25	Allow
D	In	External	Internal	TCP	25	> 1023	Allow
E	Either	Any	Any	Any	Any	Any	Deny

Packet	Dir	Src Addr	Dest Addr	Prot	Src Port	Dest Port	Action (rule)
1	In	121.12.1.2	222.2.2.2	TCP	25	8080	Allow (D)
2	Out	222.2.2.2	121.12.1.2	TCP	8080	25	Allow (C)

Rule	Dir	Src Addr	Dest Addr	Prot	Src Port	Dest Port	ACK Set	Action
A	In	External	Internal	TCP	> 1023	25	Any	Allow
B	Out	Internal	External	TCP	25	> 1023	Yes	Allow
C	Out	Internal	External	TCP	> 1023	25	Any	Allow
D	In	External	Internal	TCP	25	> 1023	Yes	Allow
E	Either	Any	Any	Any	Any	Any	Any	Deny

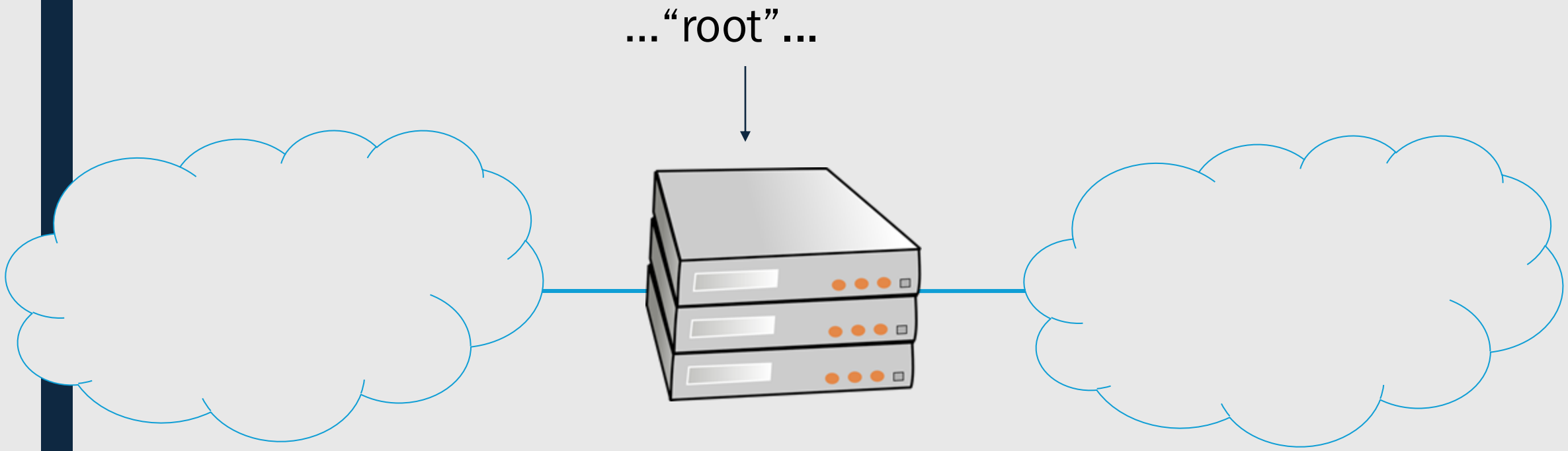
Packet	Dir	Src Addr	Dest Addr	Prot	Src Port	Dest Port	ACK Set	Action (rule)
1	In	121.12.1.2	222.2.2.2	TCP	25	8080	No	Deny (E)

Problem: packet filters have an imperfect view

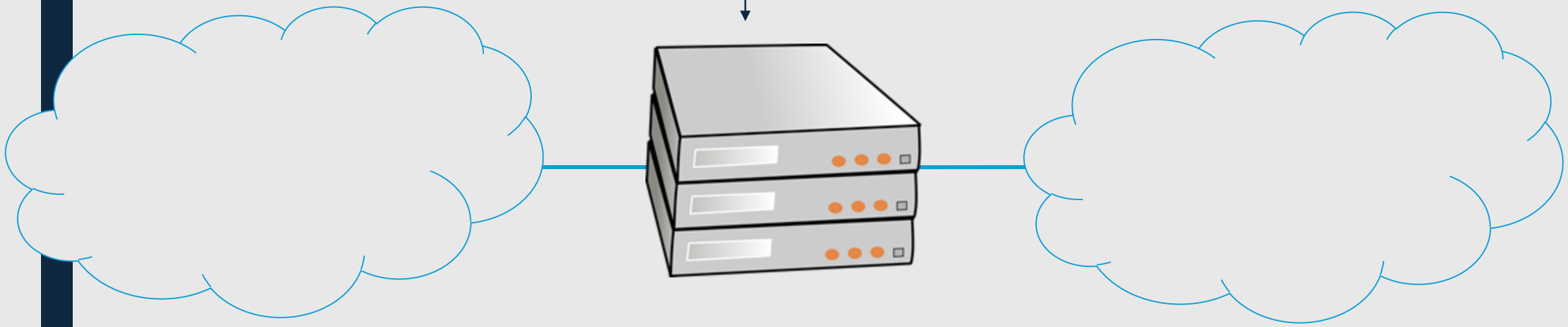
Signature-Based Filters

Def'n: a packet filter that inspects the packet payload to find patterns of known attacks

E.g., look for "root"; look for "/etc/passwd"


…“root”…
External Network
Internal Network

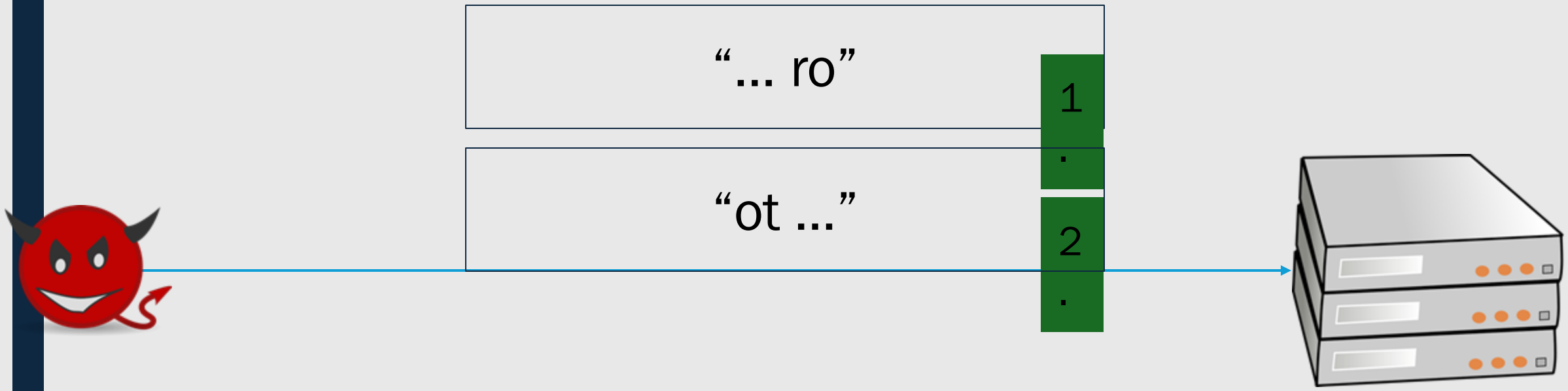
IP Header | TCP Header | “....root...”



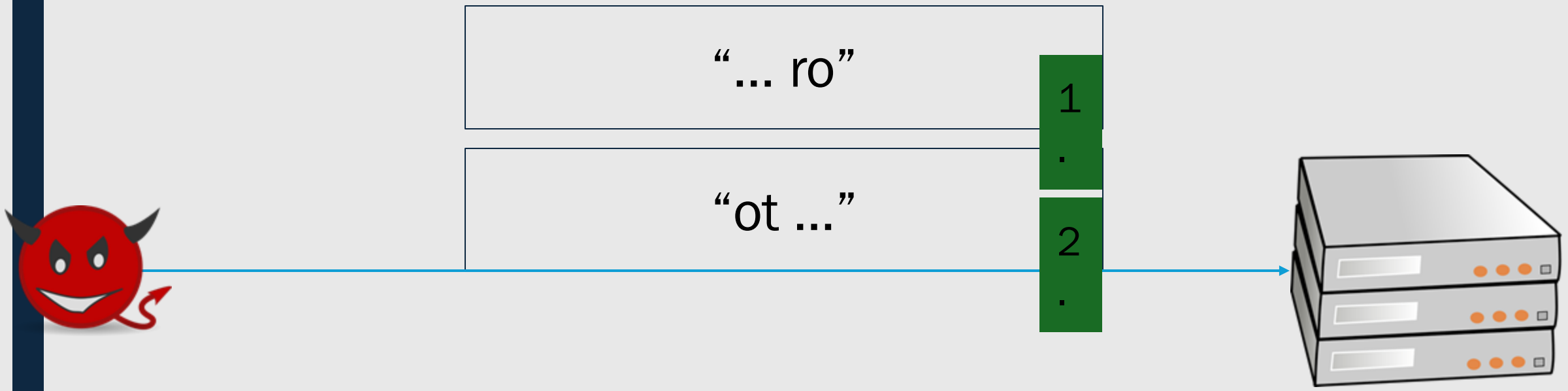
External Network

Internal Network

Attack



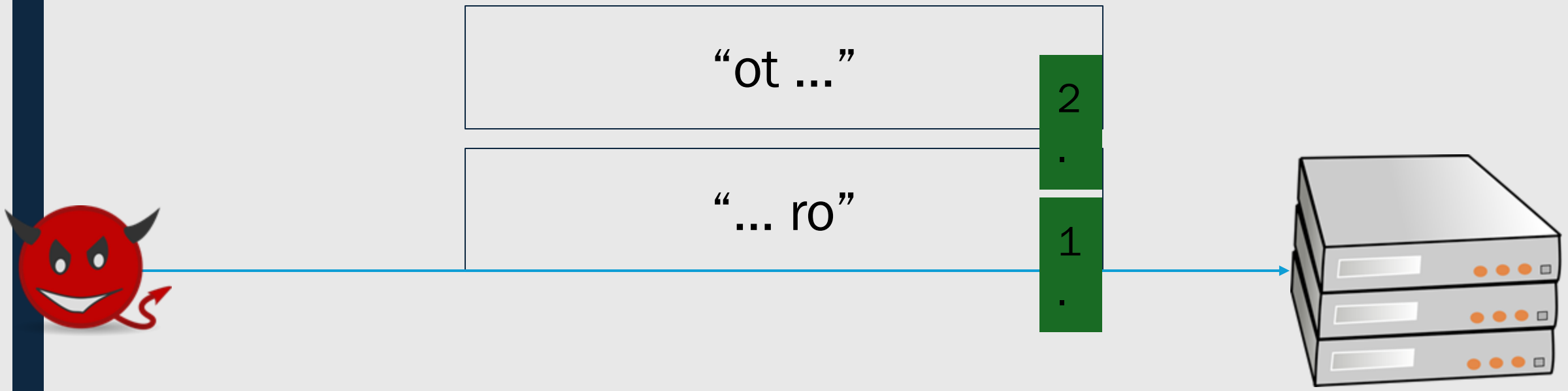
Attack



Fix: Track sequences of packets

Downside…. Have to track more state.

Attack



Attacker can easily ensure segments sent out of order.

Another Attack

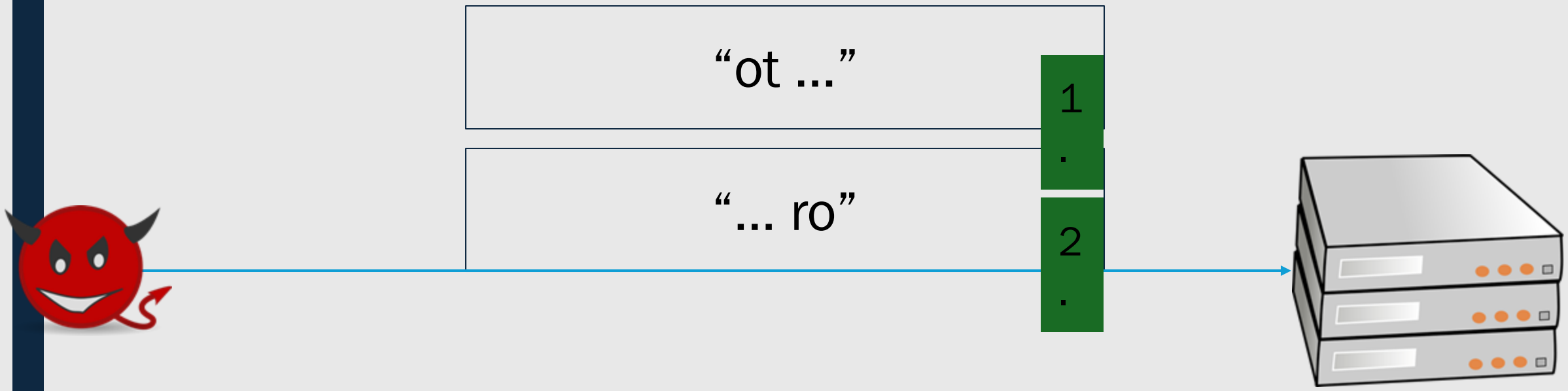
TTL=25	“r”
TTL=19	“i”
TTL=25	“o”
TTL=19	“p”
TTL=25	“o”
TTL=25	“t”

r

o

o

t



Fix: Reassemble the TCP stream