(Distributed) Denial of Service

CS-576 Systems Security

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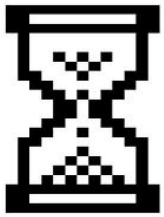
Denial-of-Service (DoS) Attack

"An action that prevents or impairs the authorized use of networks, systems, or applications by exhausting resources such as central processing units (CPU), memory, bandwidth, and disk space."



Denial-of-Service (DoS)

A form of attack on the availability of some service

Categories of resources that could be attacked are:

Network bandwidth

- Relates to the capacity of the network links connecting a server to the Internet
- For most organizations this is their connection to their Internet Service Provider (ISP)

System resources

- Aims to overload or crash the network handling software

Application resources

- Typically involves a number of valid requests, each of which consumes significant resources, thus limiting the ability of the server to respond to requests from other users

Network Flooding Attacks

Attacker generates large volumes of packets that have the target system as the destination address

Intent is to overload the network capacity on some link to a server

Congestion would result in the router connected to the final, lower capacity link

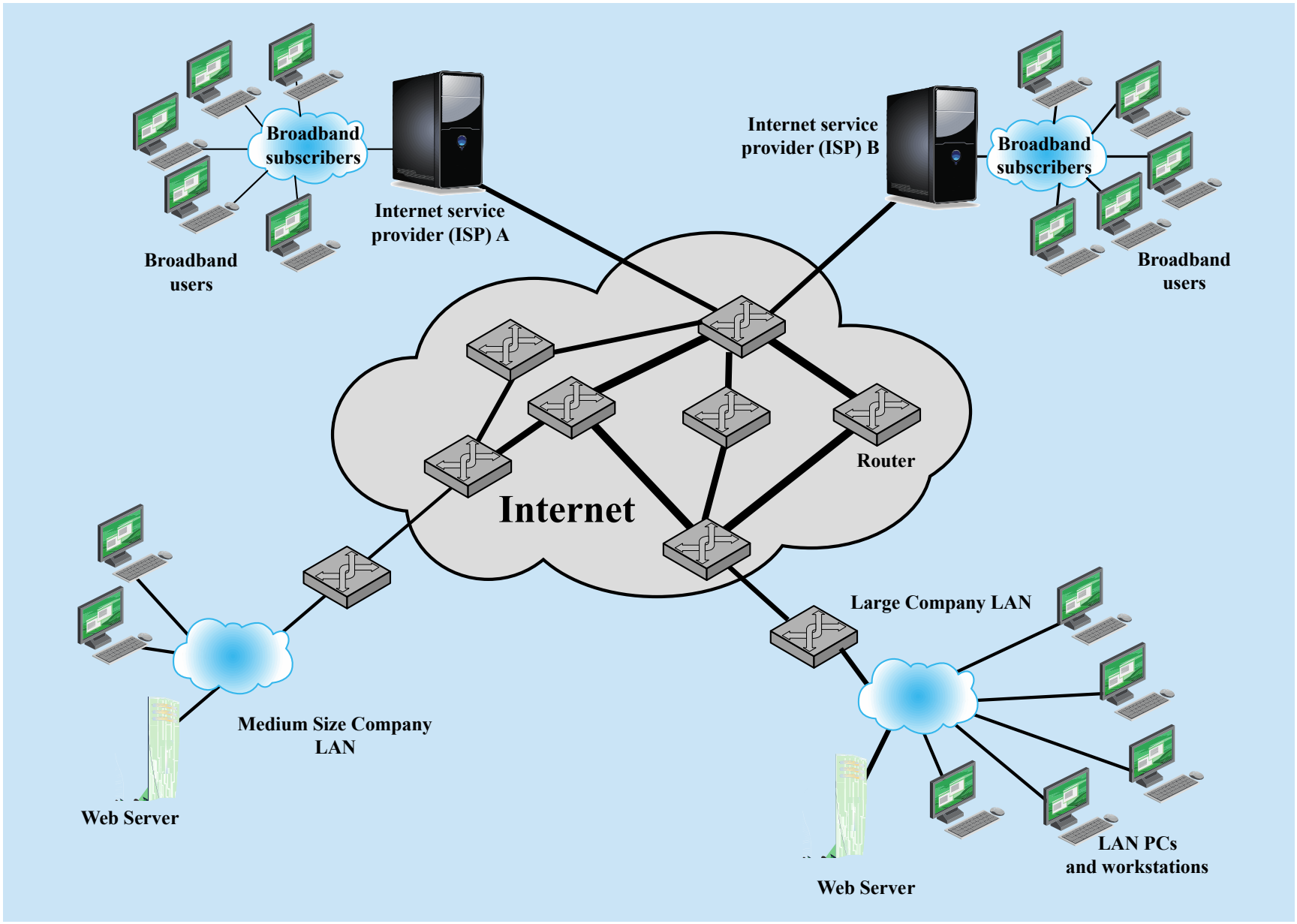
Virtually any type of network packet can be used

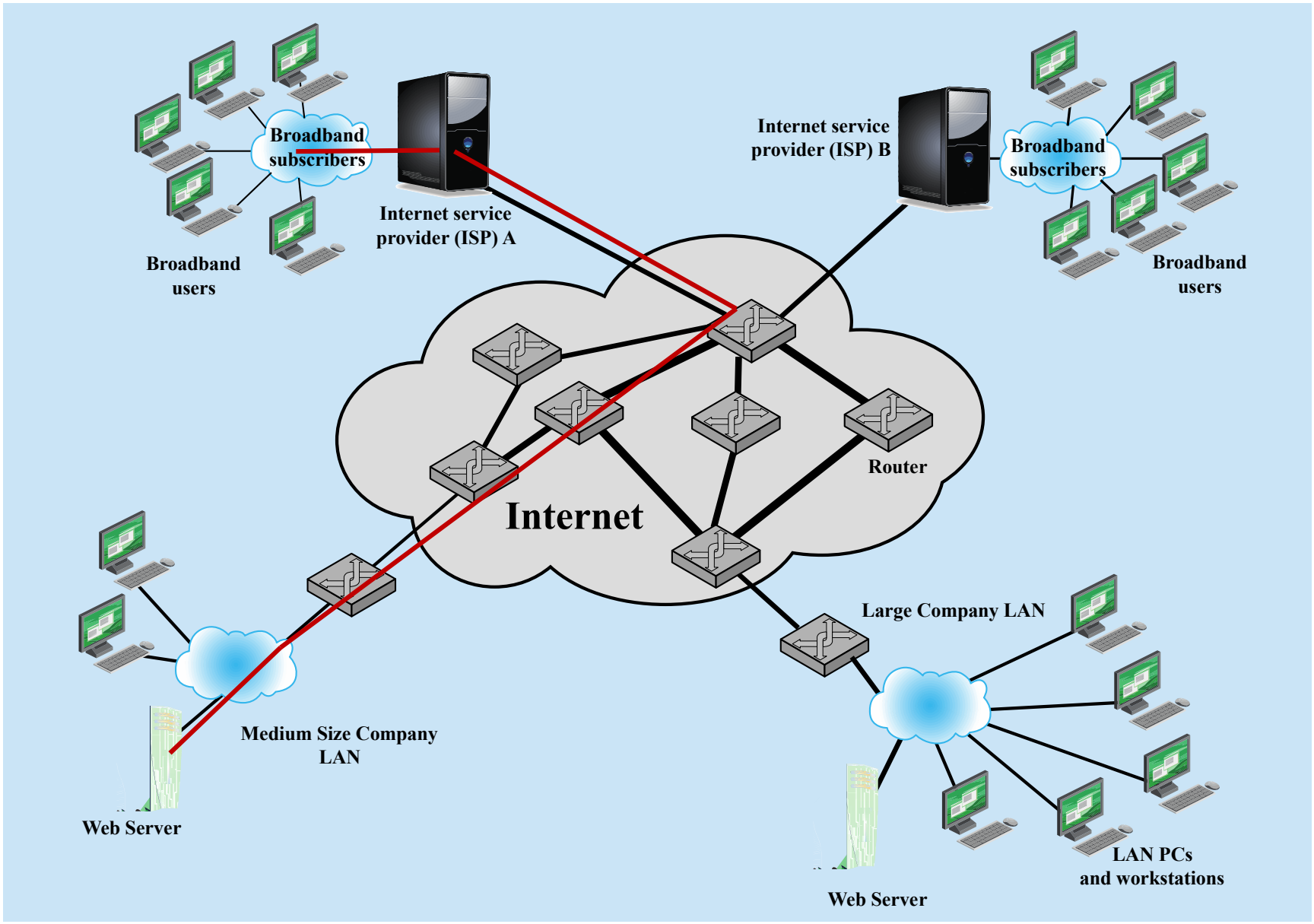
Network Flooding Attacks

Classified based on network protocol used

Virtually any type of network packet can be used

ICMP flood	• Ping flood using ICMP echo request packets • Traditionally network administrators allow such packets into their networks because ping is a useful network diagnostic tool
UDP flood	• Uses UDP packets directed to some port number on the target system
TCP SYN flood	• Sends TCP packets to the target system • Total volume of packets is the aim of the attack rather than the system code


Broadband subscribers
Broadband users
Internet service provider (ISP) A
Internet service provider (ISP) B
Broadband subscribers
Broadband users
Internet
Router
Medium Size Company LAN
Web Server
Large Company LAN
Web Server
LAN PCs and workstations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Internet service provider (ISP) A
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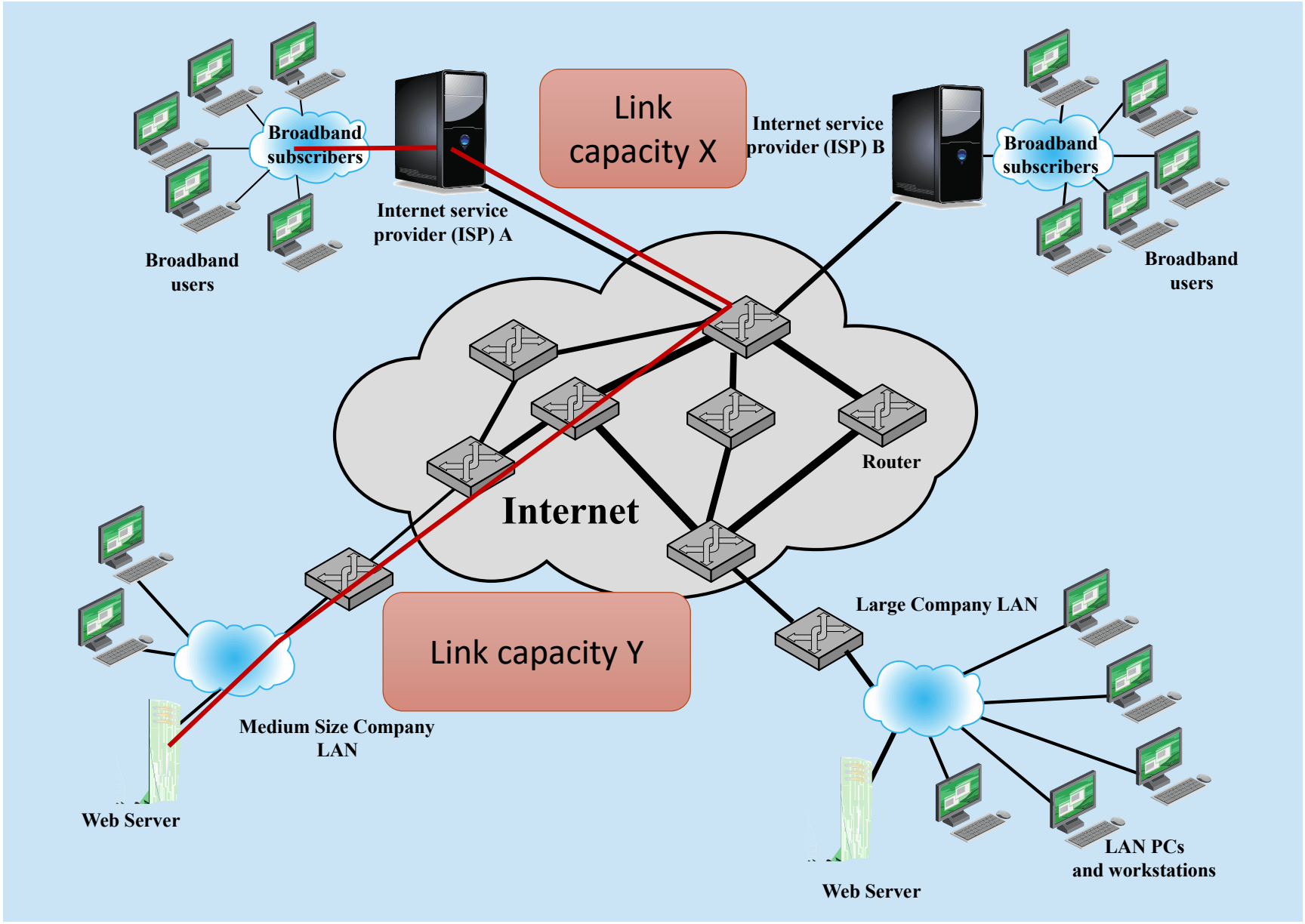
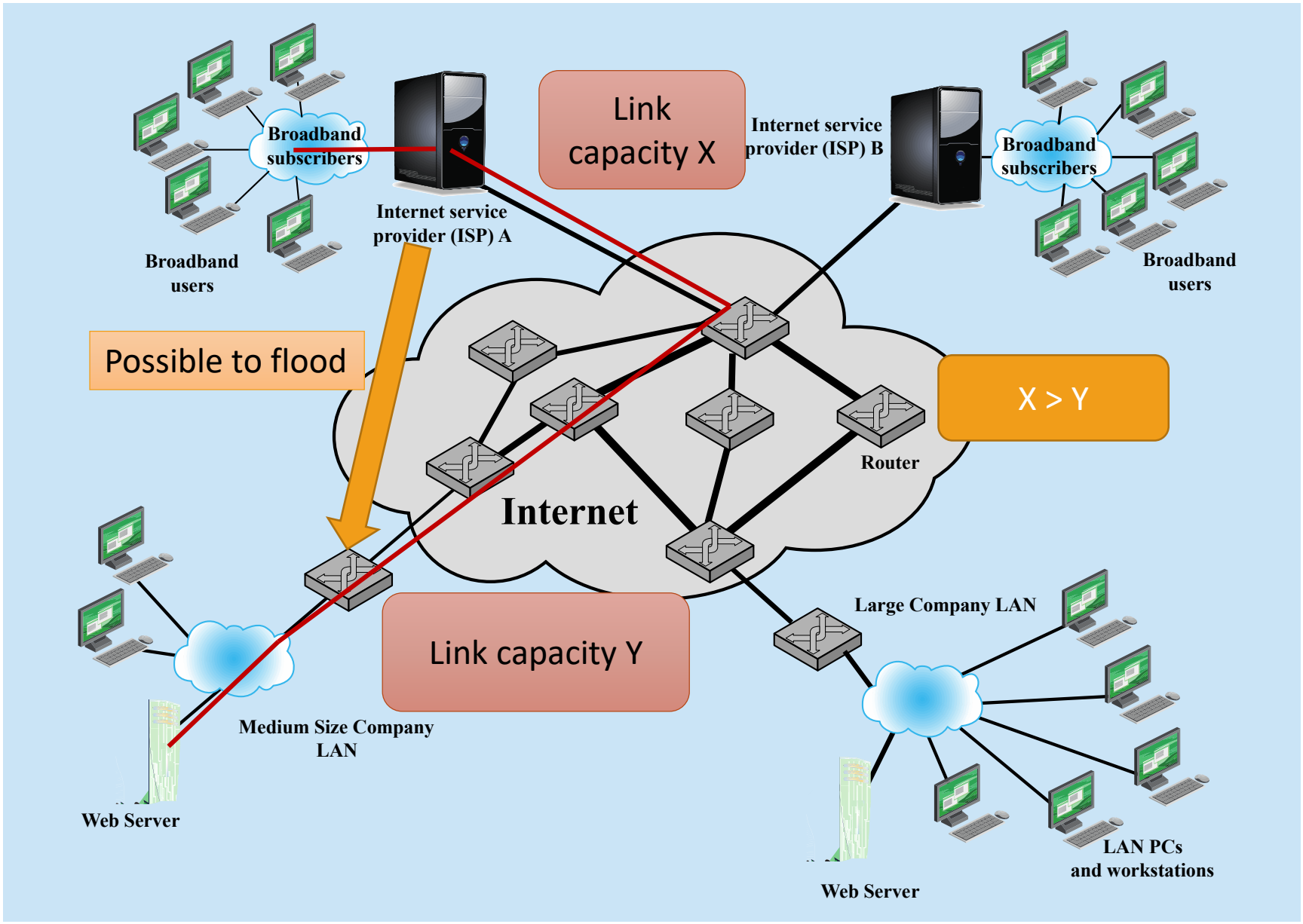
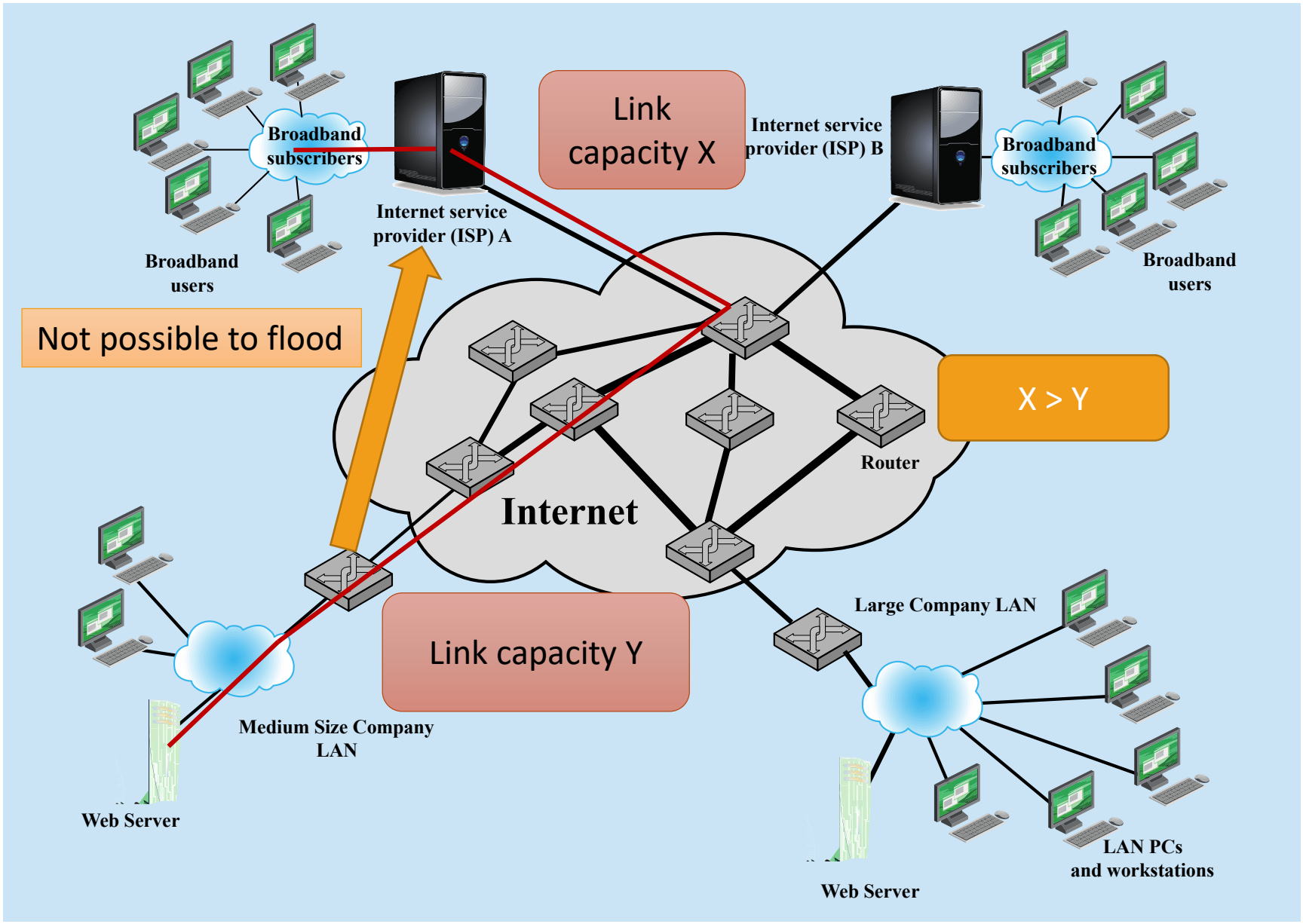
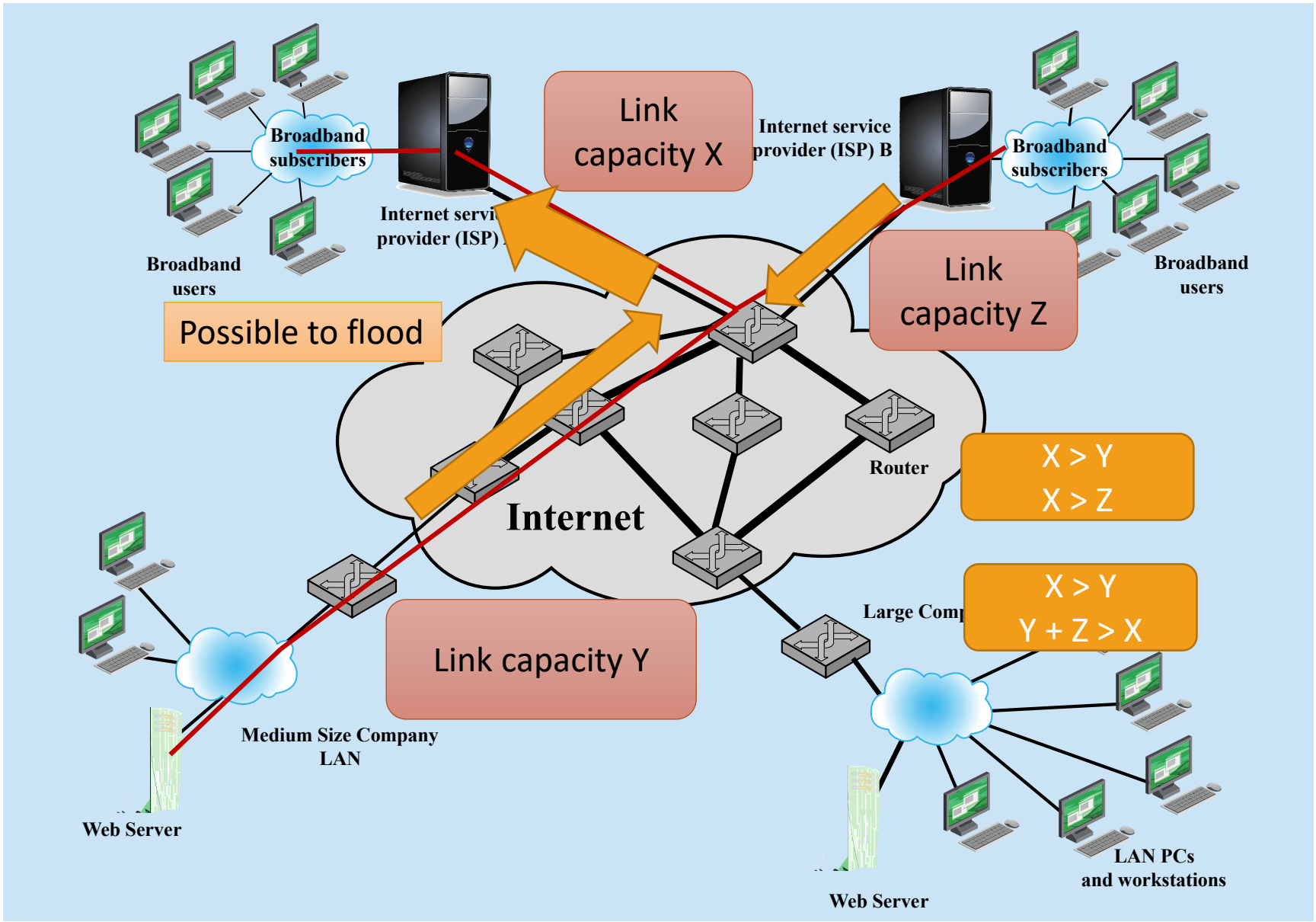

Broadband subscribers
Broadband users
Internet service provider (ISP) A
Link capacity X
Internet service provider (ISP) B
Broadband subscribers
Broadband users
Router
Internet
Link capacity Y
Large Company LAN
Medium Size Company LAN
Web Server
Web Server
LAN PCs and workstations

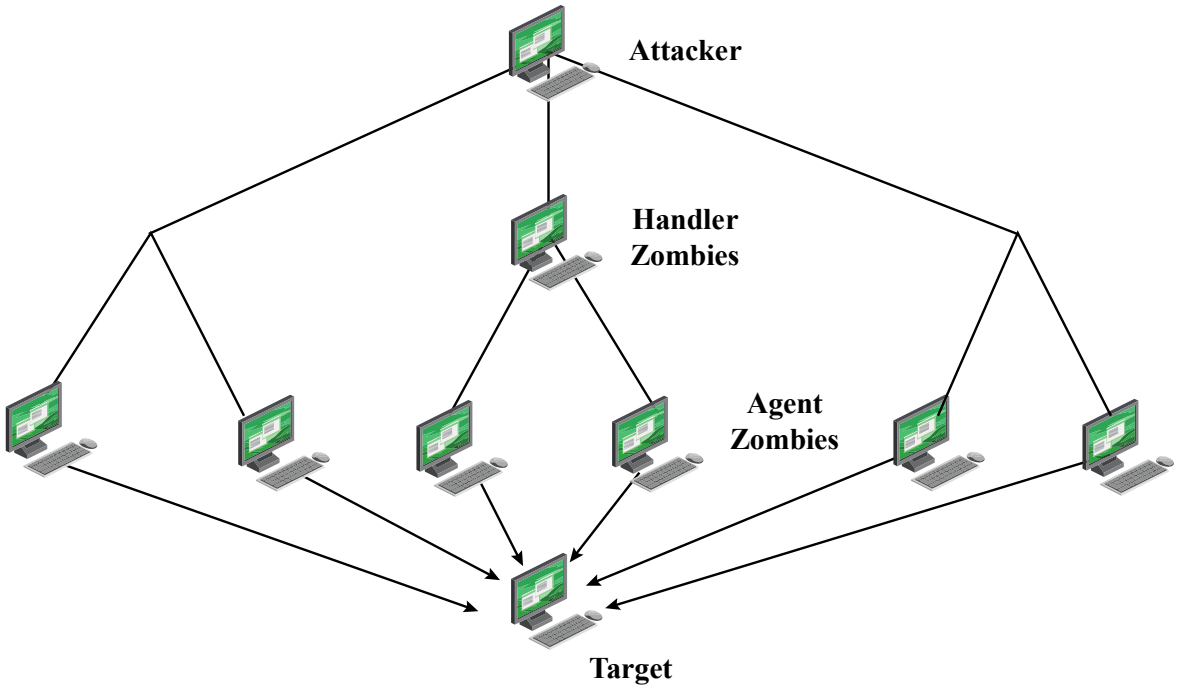

Broadband subscribers
Broadband users
Internet service provider (ISP) A
Link capacity X
Internet service provider (ISP) B
Broadband subscribers
Broadband users
Possible to flood
X > Y
Router
Internet
Link capacity Y
Large Company LAN
Medium Size Company LAN
Web Server
Web Server
LAN PCs and workstations


Broadband subscribers
Broadband users
Internet service provider (ISP) A
Link capacity X
Internet service provider (ISP) B
Broadband subscribers
Broadband users
Not possible to flood
X > Y
Router
Internet
Link capacity Y
Large Company LAN
Medium Size Company LAN
Web Server
Web Server
LAN PCs and workstations


Broadband subscribers
Broadband users
Internet service provider (ISP) B
Broadband subscribers
Broadband users
Link capacity X
Link capacity Z
Possible to flood
Internet
Router
X > Y
X > Z
X > Y
Y + Z > X
Link capacity Y
Medium Size Company LAN
Web Server
Web Server
LAN PCs and workstations

Distributed Denial-of-Service

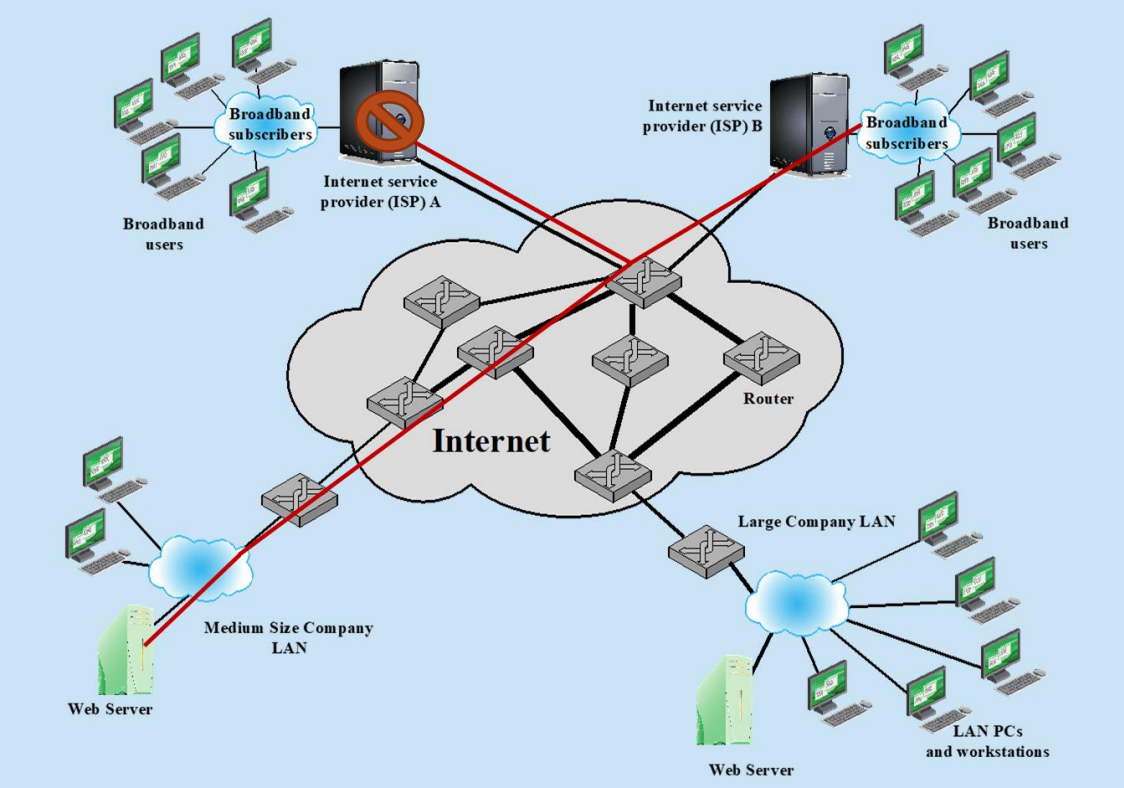
Botnets are frequently used to perform network-based DDoS attacks



Simple Solution

Block subnets participating in DDoS

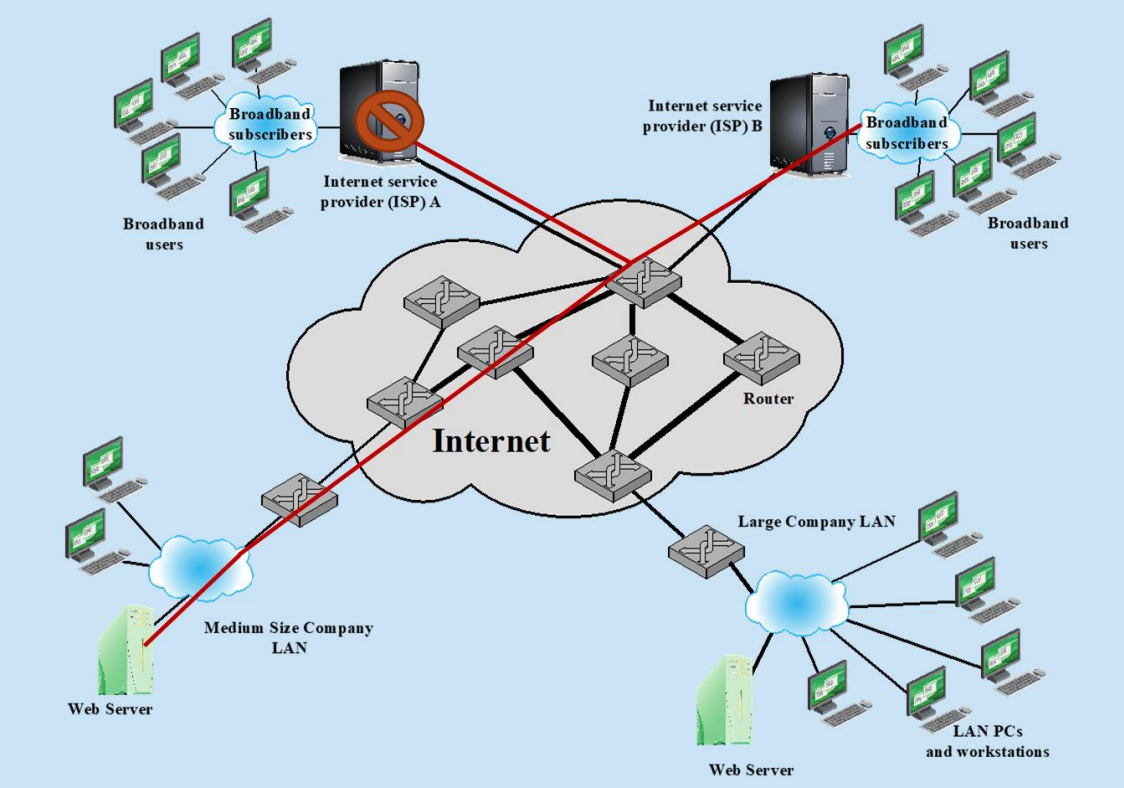
- Can affect many non-participating nodes



Less Simple Solution

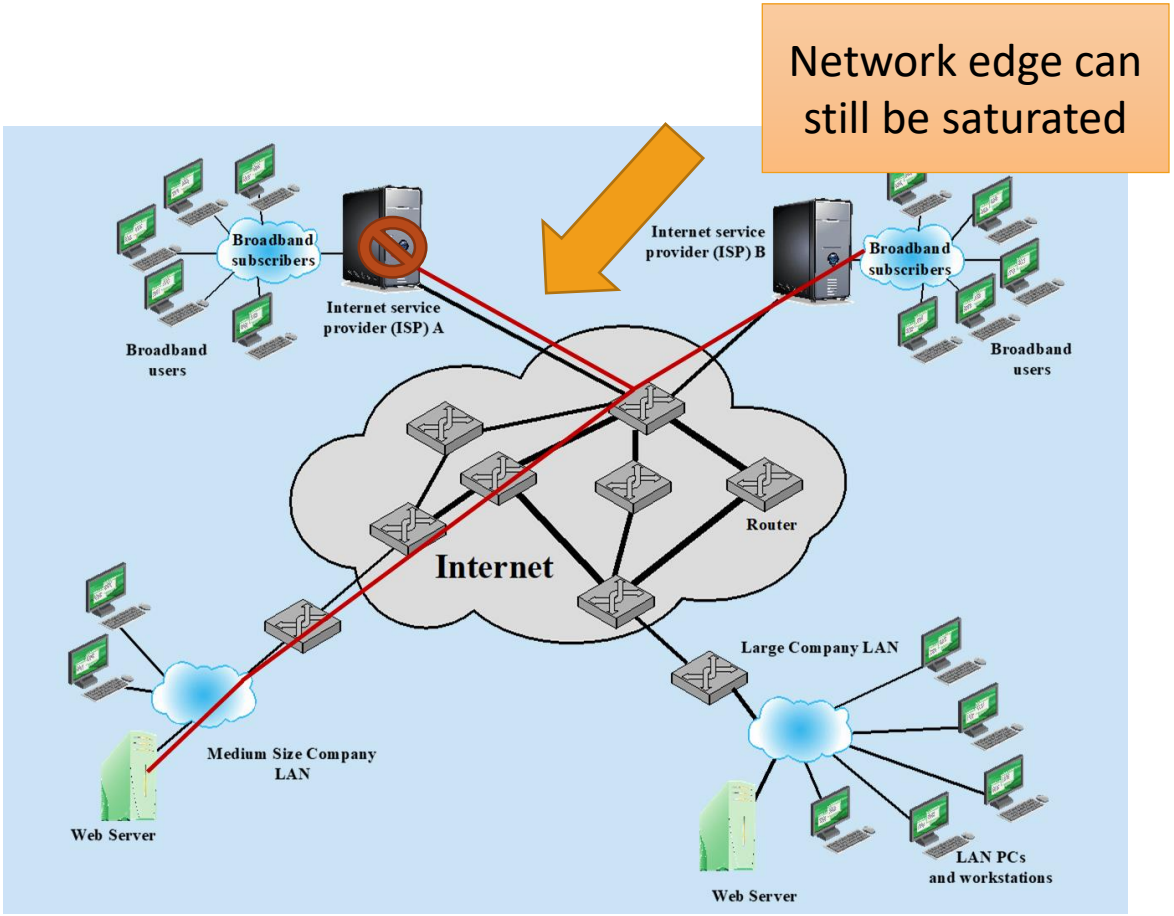
Block individual IPs participating in DDoS

- Can still affect infected and, otherwise, innocent users
- Maintaining large lists of IPs is cumbersome



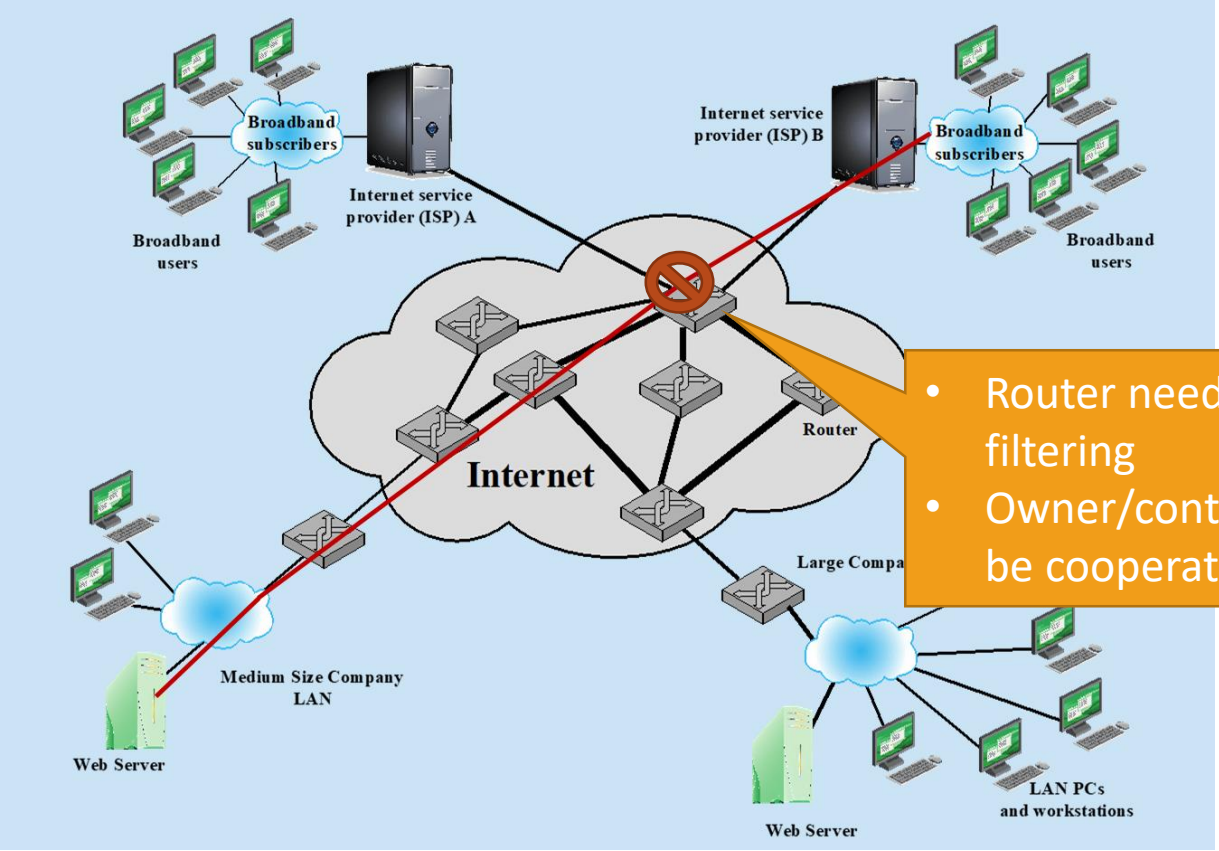
Where to Block?

Blocking near the target does not solve the problem



Where to Block?

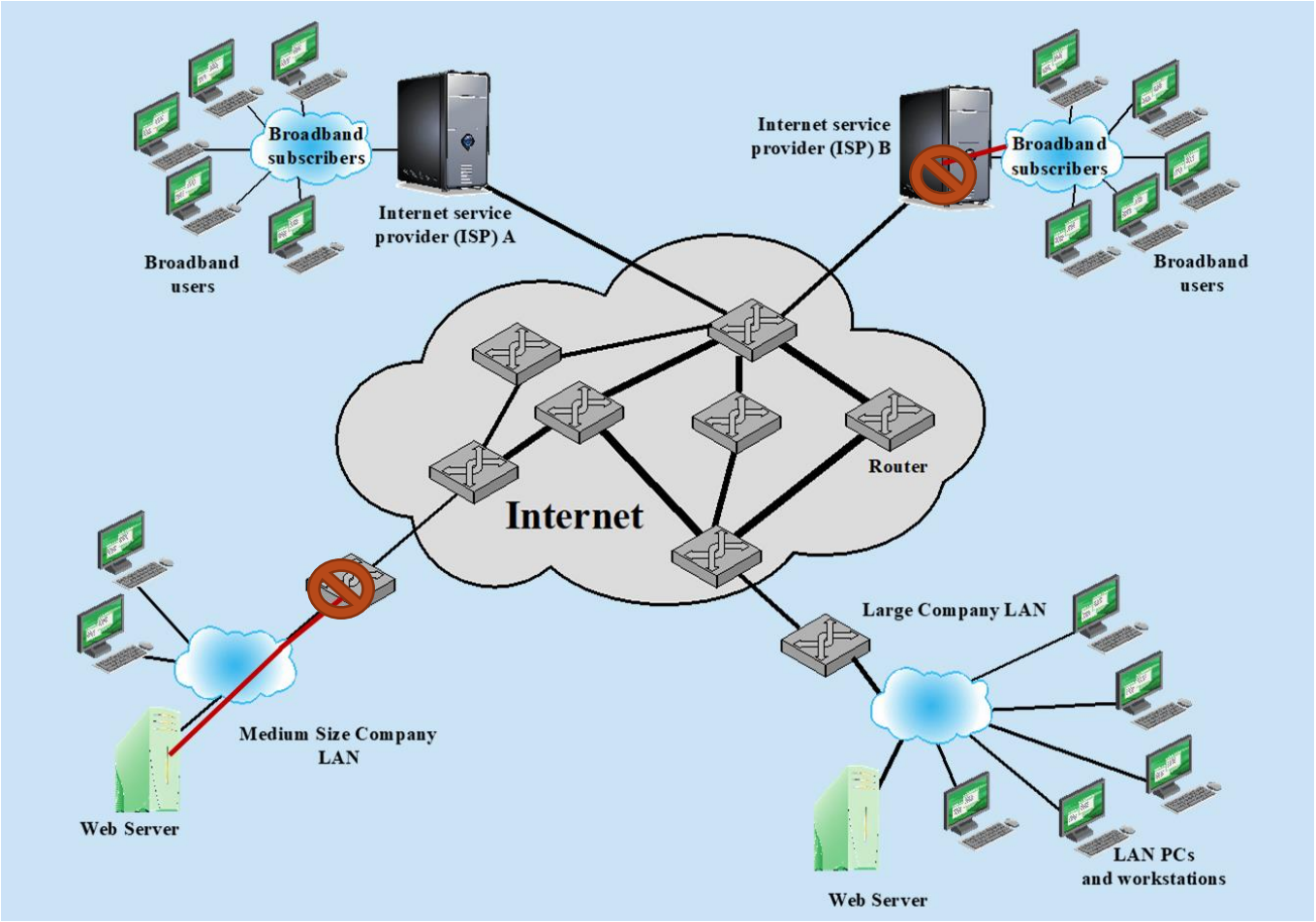
It is better to clock closer to the source



- Router needs to support filtering
- Owner/controller needs to be cooperative

Where to Block?

Best case scenario (but probably unrealistic)



Source Address Spoofing

Use forged source addresses

- E.g., via the raw socket interface

Identifying culprits and blocking IPs is harder

Local routers can potentially filter such packets

- For example, by checking that the packets' IPs match the one given to the host
  - Not done my many networks

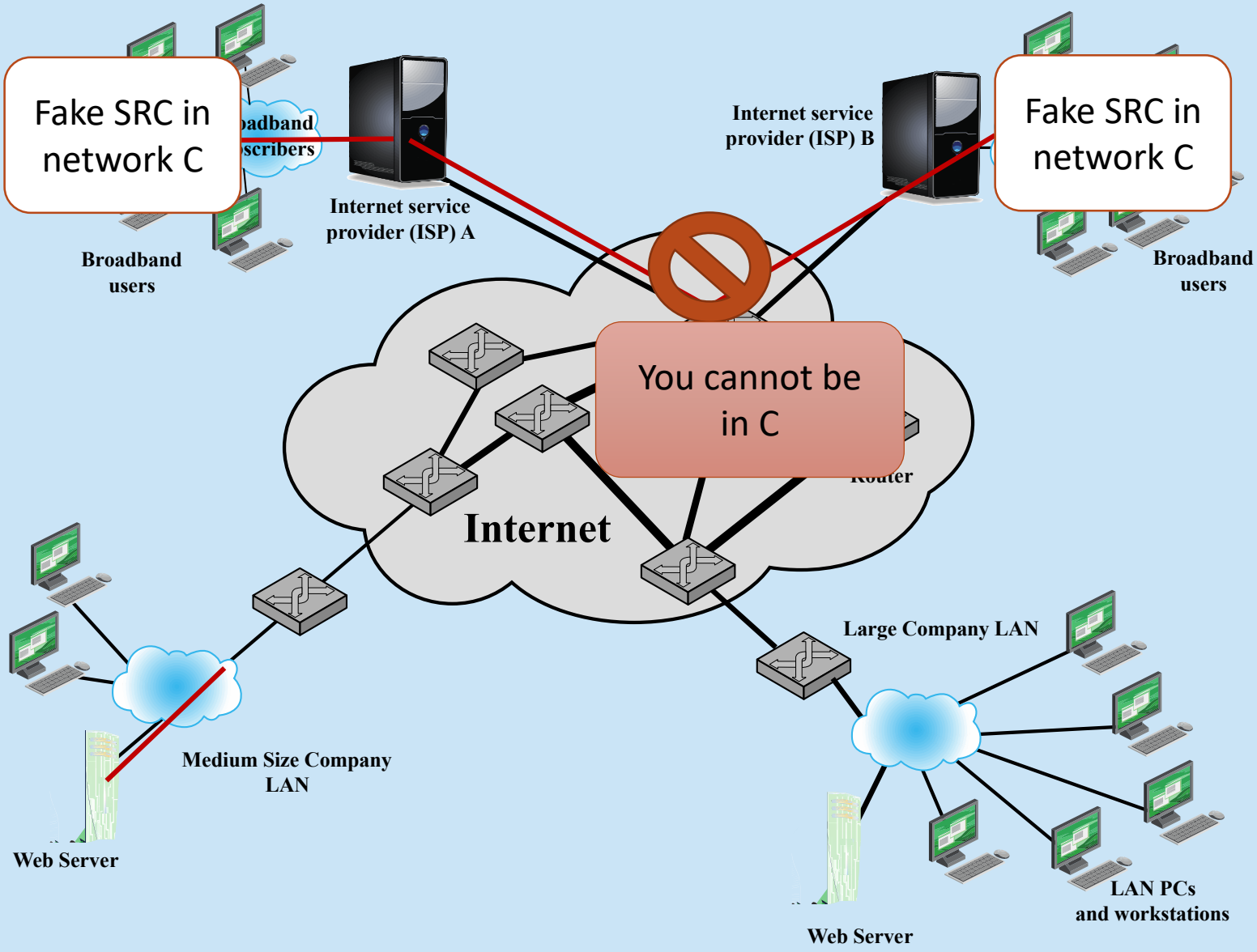
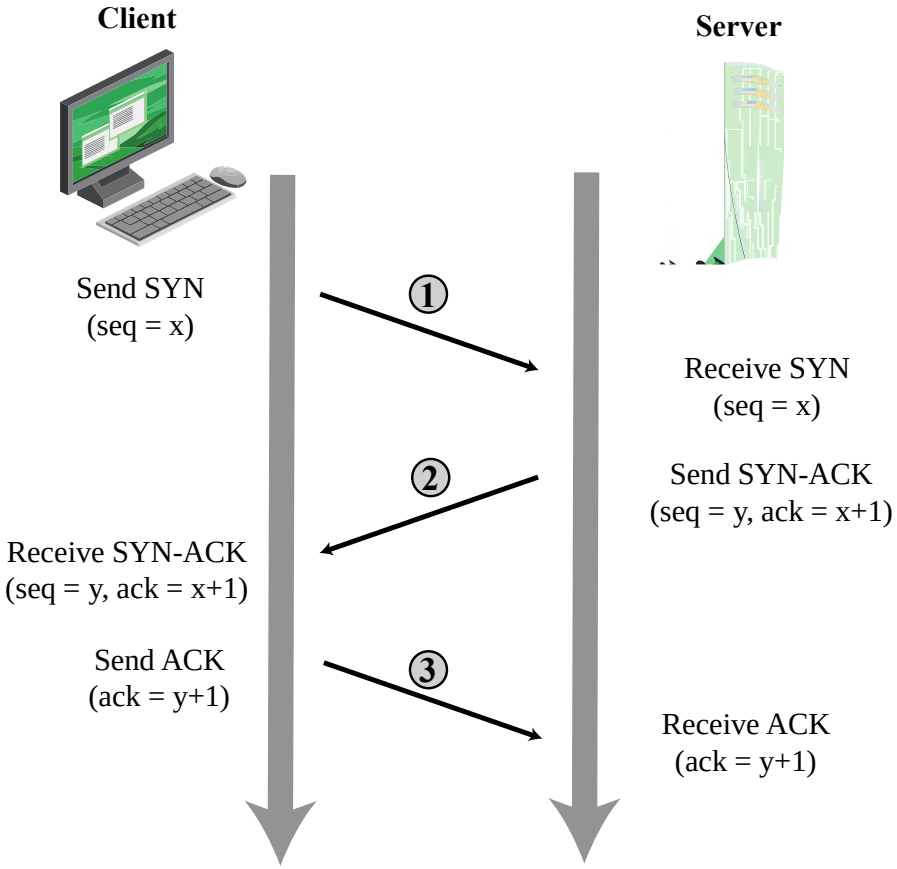


Figure 7.1 Example Network to Illustrate DoS Attacks

SYN Packet Tricks

SYN is one of the first packets sent to establish a TCP connection

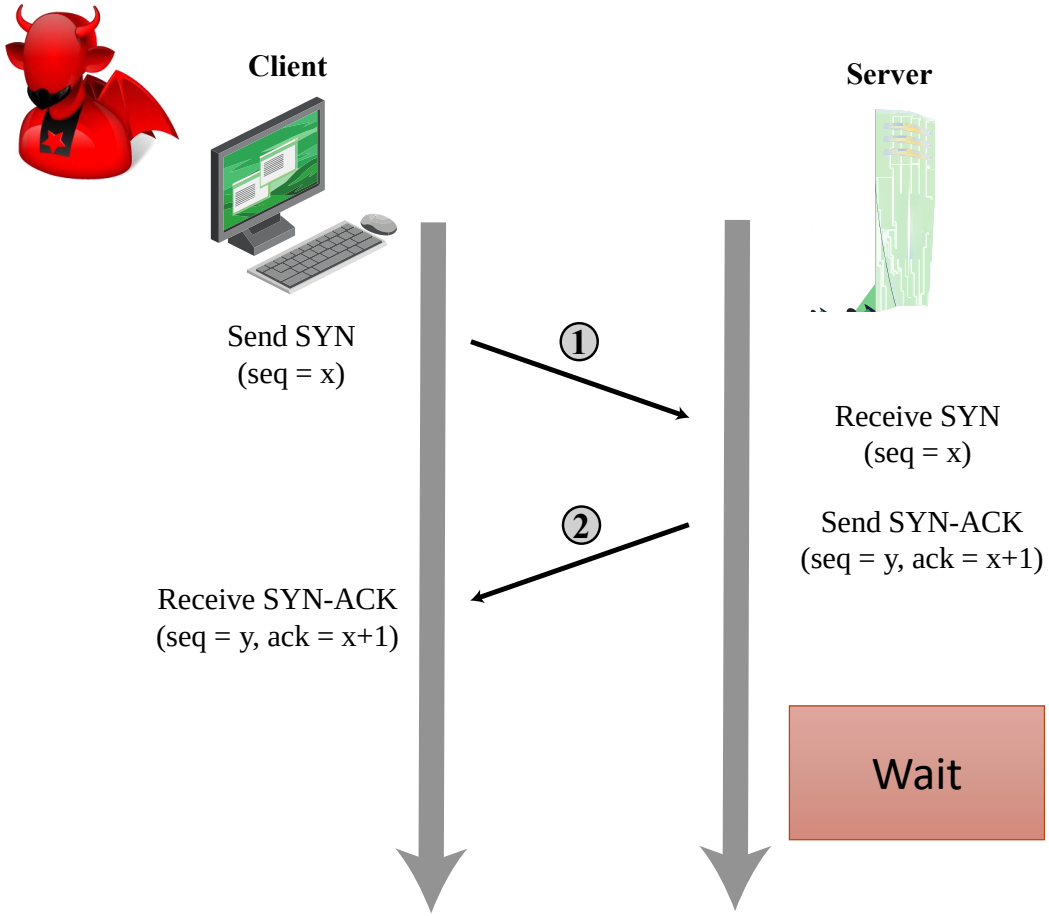


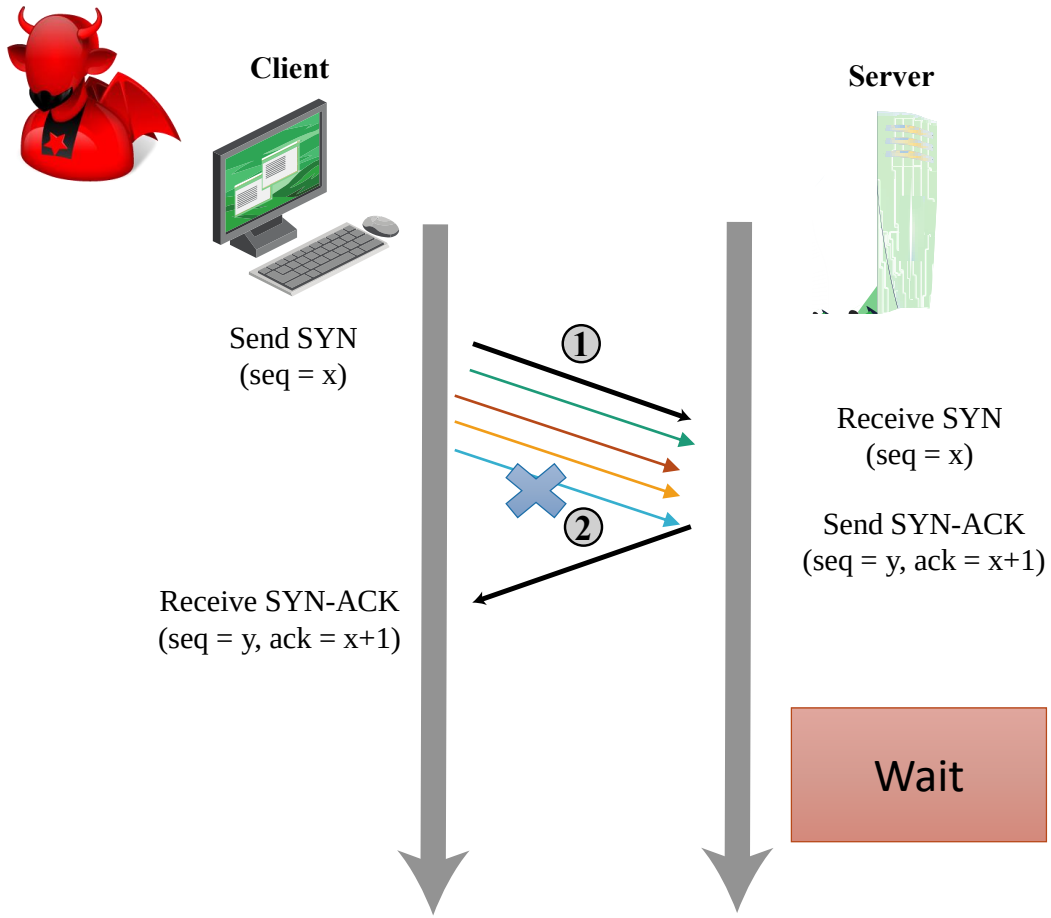
SYN Floods Targeting the System

Attacks the ability of a server to respond to future connection requests by overflowing the tables used to manage them

Thus legitimate users are denied access to the server

Hence an attack on system resources, specifically the network handling code in the operating system


Client
Server
Send SYN
(seq = x)
1
Receive SYN
(seq = x)
2
Send SYN-ACK
(seq = y, ack = x+1)
Receive SYN-ACK
(seq = y, ack = x+1)
Wait


Client
Server
Send SYN
(seq = x)
1
Receive SYN
(seq = x)
Send SYN-ACK
(seq = y, ack = x+1)
2
Receive SYN-ACK
(seq = y, ack = x+1)
Wait

SYN Spoofing

Spoof the source address of the SYN packet

- It can hide the true sender of a packet

The destination will try to establish a connection with the spoofed address

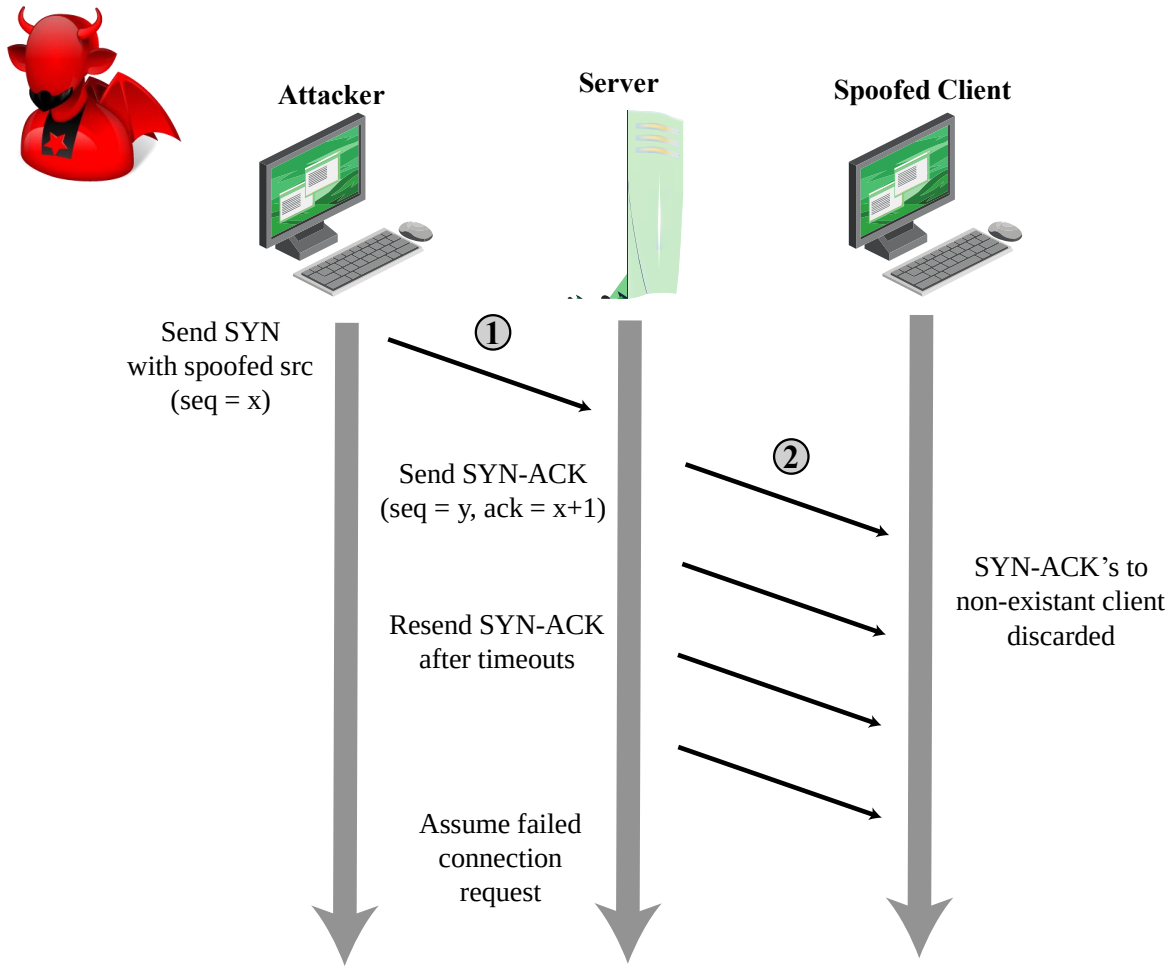


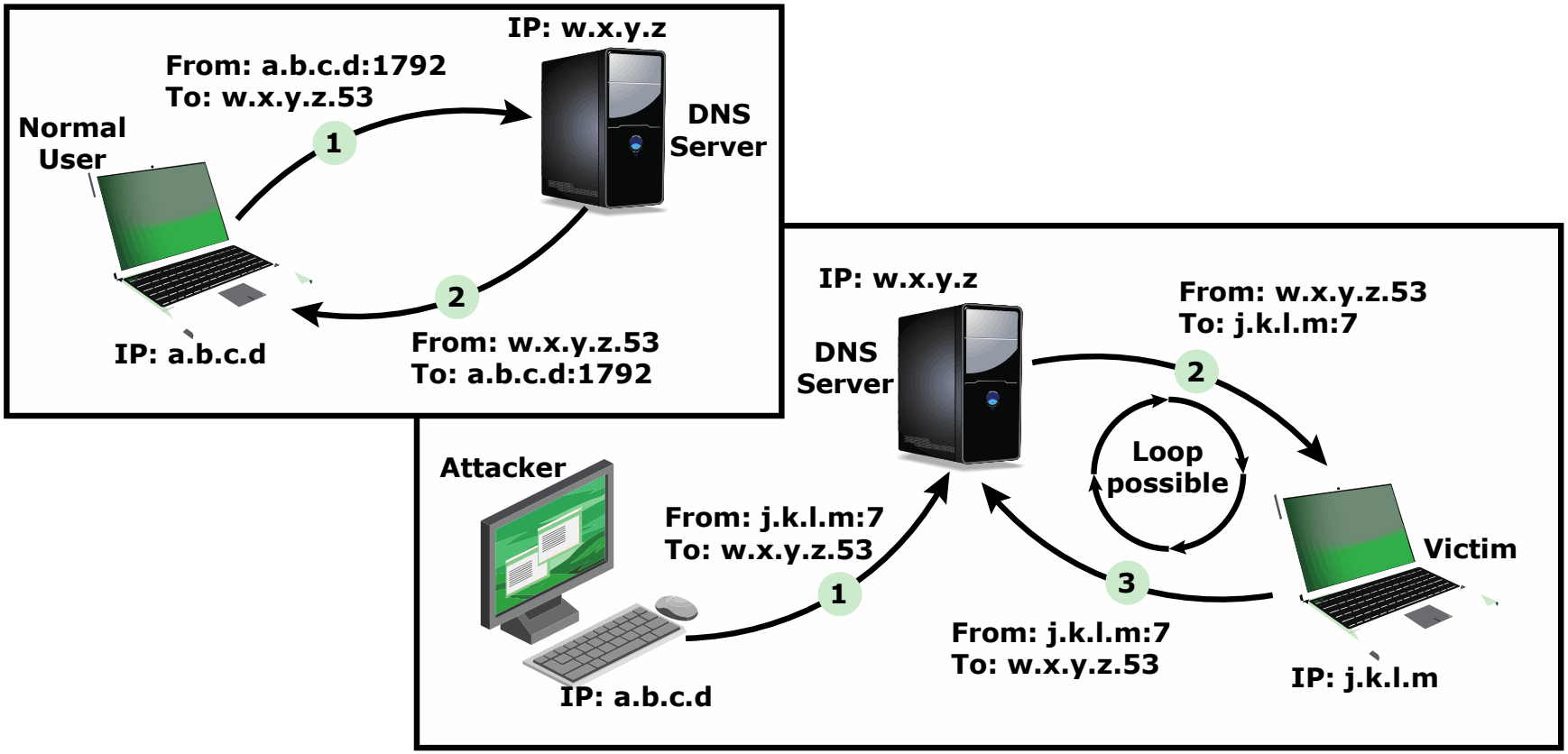
Figure7.3 TCP SYN Spoofing Attack

Reflection Attacks

Attacker sends packets to a known service on the intermediary with a spoofed source address of the actual target system

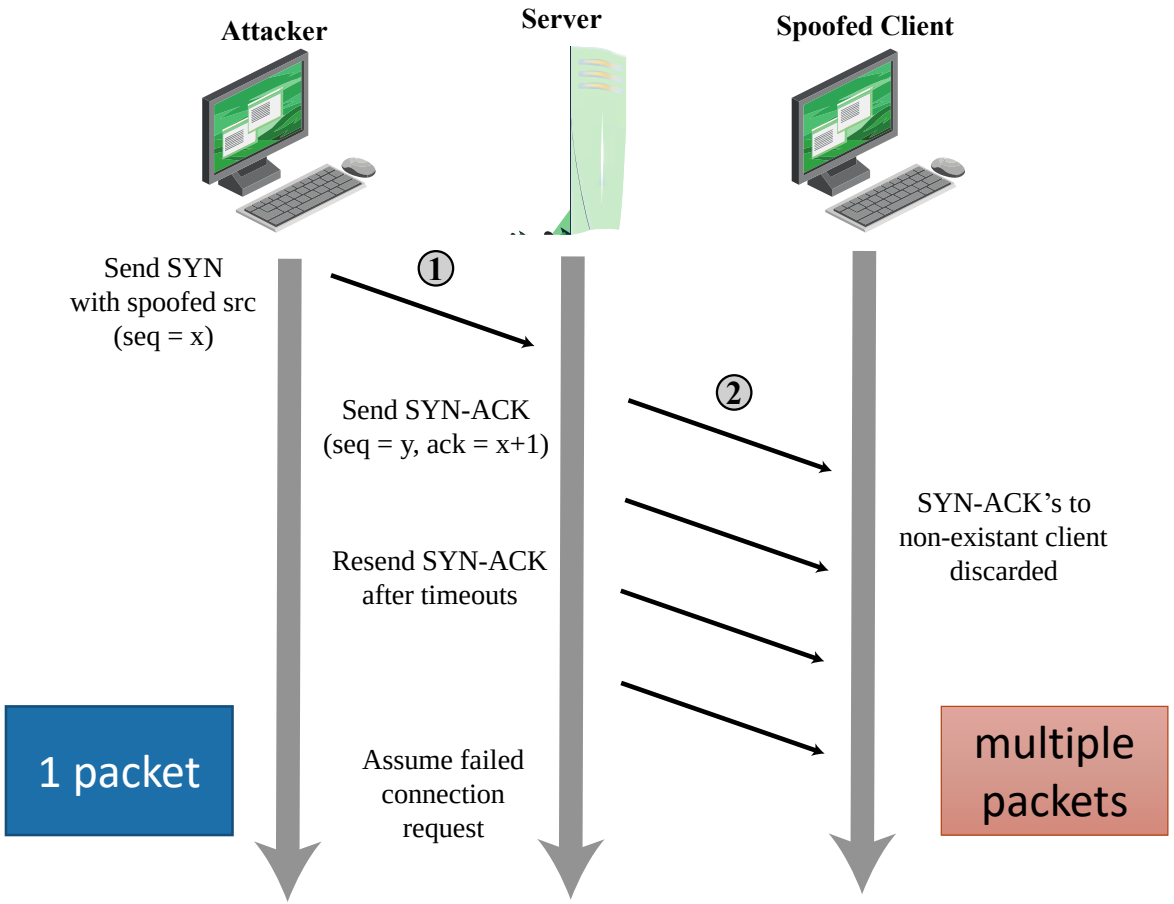
When intermediary responds, the response is sent to the target → It **"Reflects"** the attack off the intermediary (reflector)

Reflection Through DNS



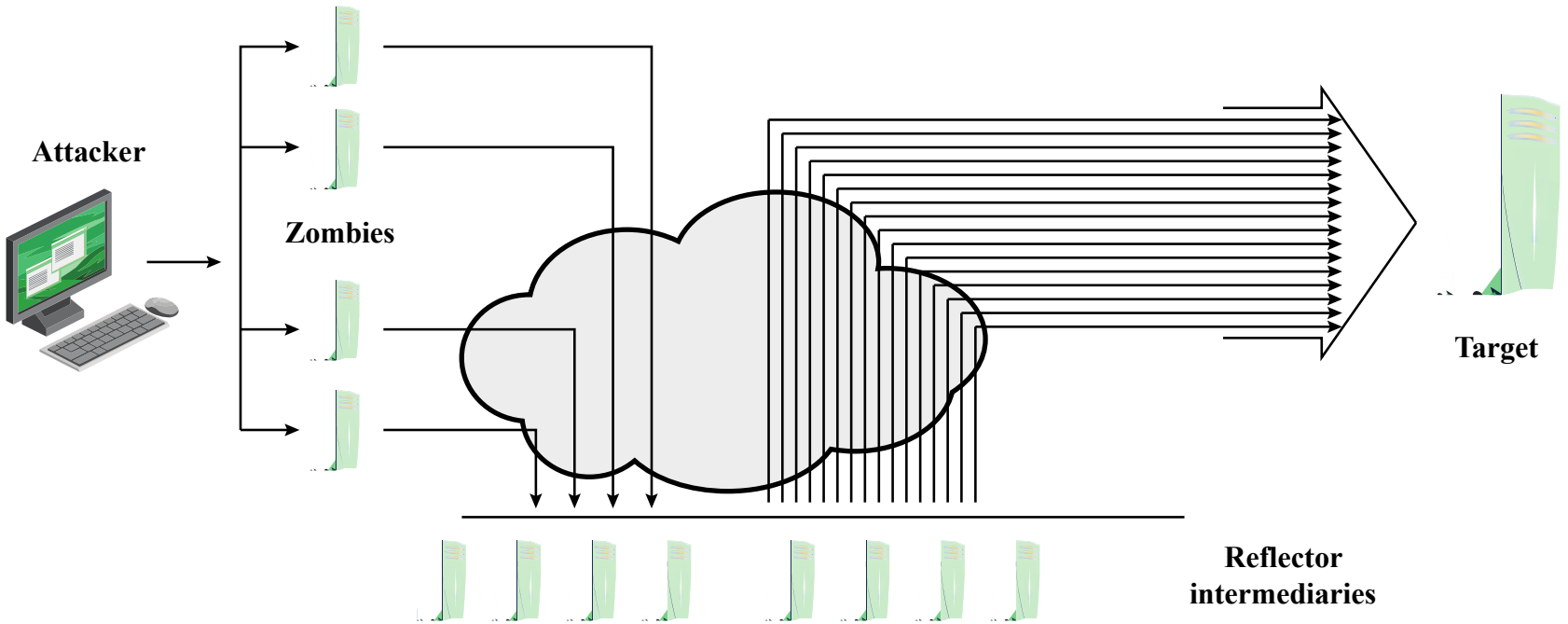
Amplification Attacks

Single spoofed packet results in multiple packets to target



Amplification Attacks

Higher-layer protocols, like DNS, can also be used



DNS Amplification Attacks

Spoofed DNS query packets are sent to legitimate DNS server

DNS generates one larger packet which it sends to the spoofed address

Amplification occurs because response is larger in size than the original query

HTTP-Based Attacks

HTTP flood

Attack that bombards Web servers with HTTP requests

Consumes considerable resources

Slowloris

Create many HTTP requests to server that never complete

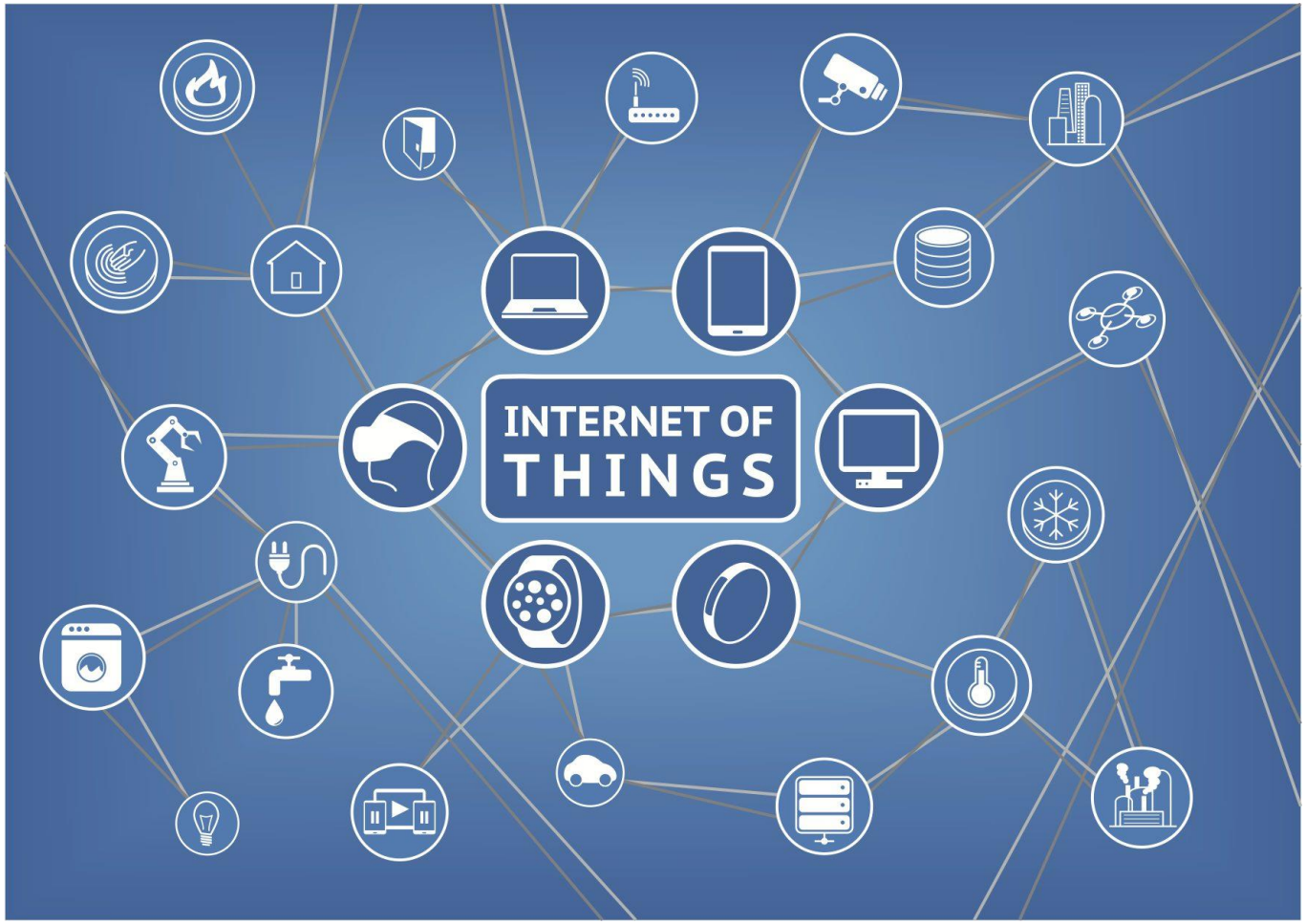
- Send partial requests as slowly as possible

Consumes Web server's connection capacity

Hard to differentiate from client with limited connectivity

Internet of Things

Internet connected devices/objects



Mirai Botnet

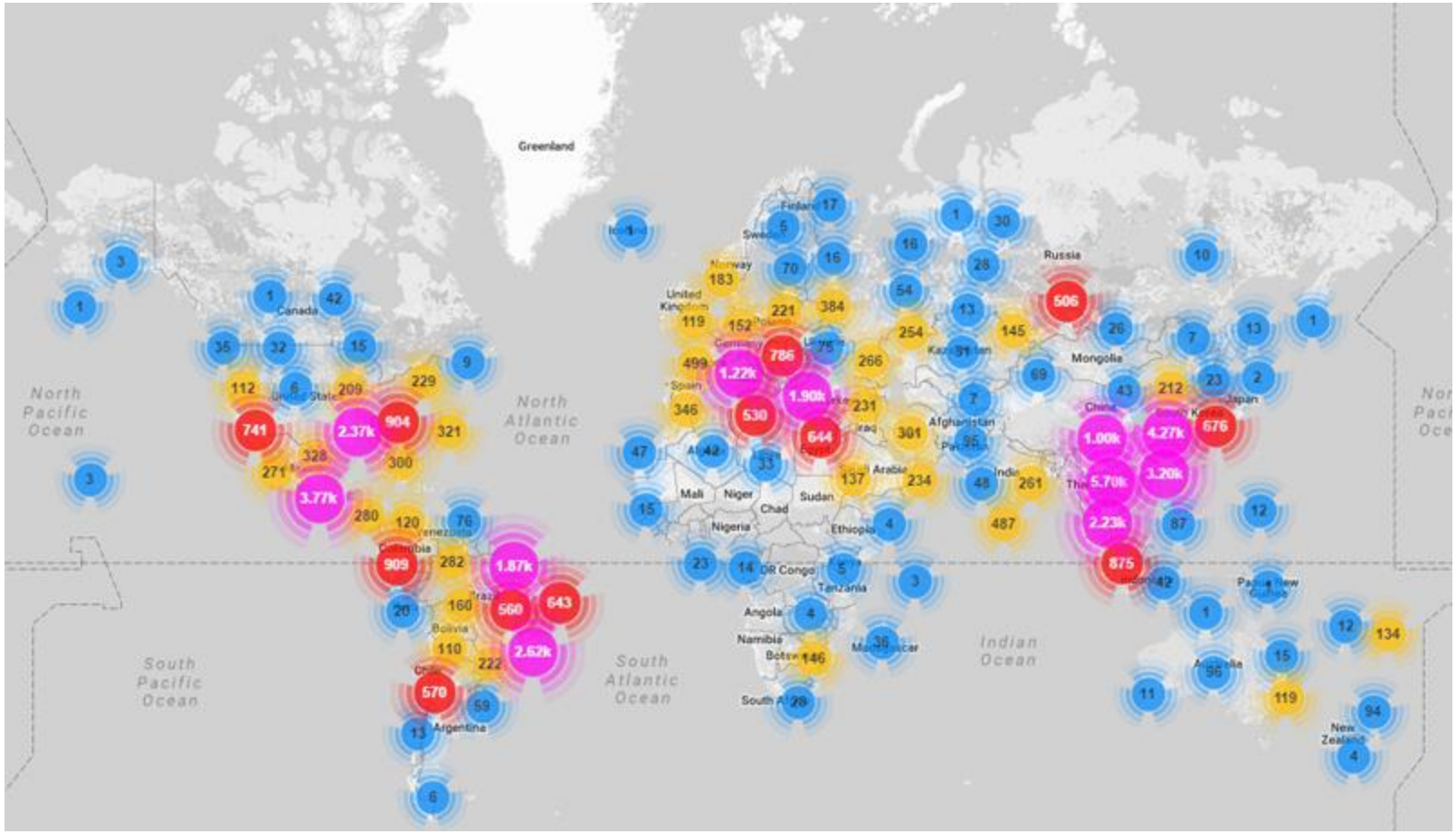
Exploited vulnerable CCTV cameras

Multiple vulnerabilities found on CCTV cameras:

- Weak authentication, stack overflow, etc.

Estimated to control more than 100k devices

IoT Botnet-Driven DDoS



Reading: https://www.incapsula.com/blog/malware-analysis-mirai-ddos-botnet.html