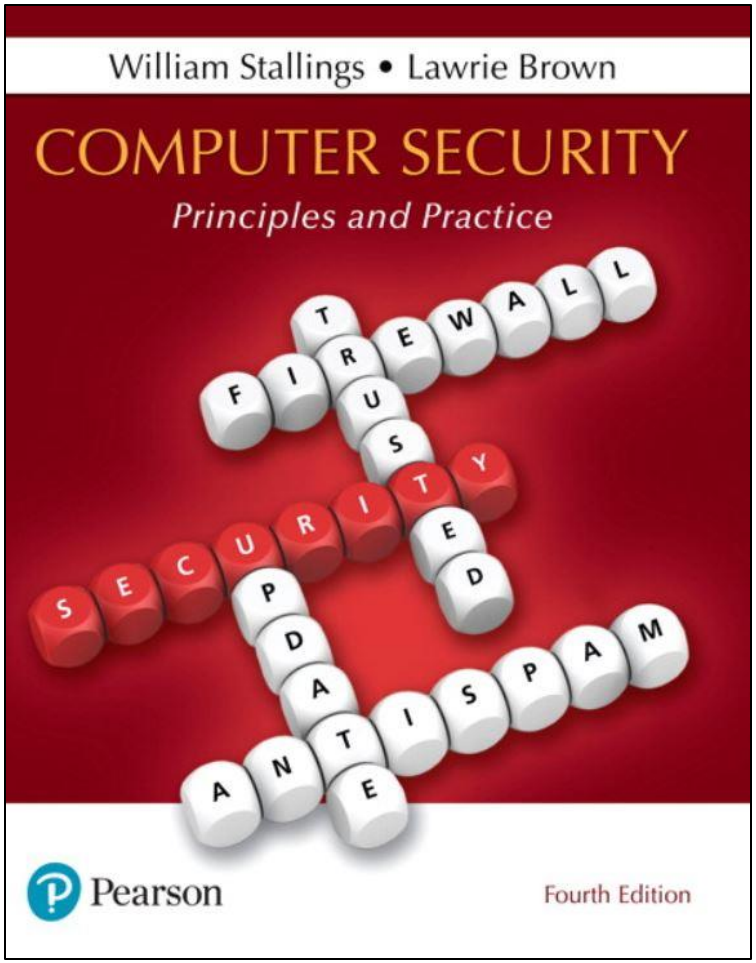
# Computer Security: Principles and Practice

Fourth Edition




## Chapter 7

Denial-of-Service Attacks

# Denial-of-Service (DoS) Attack

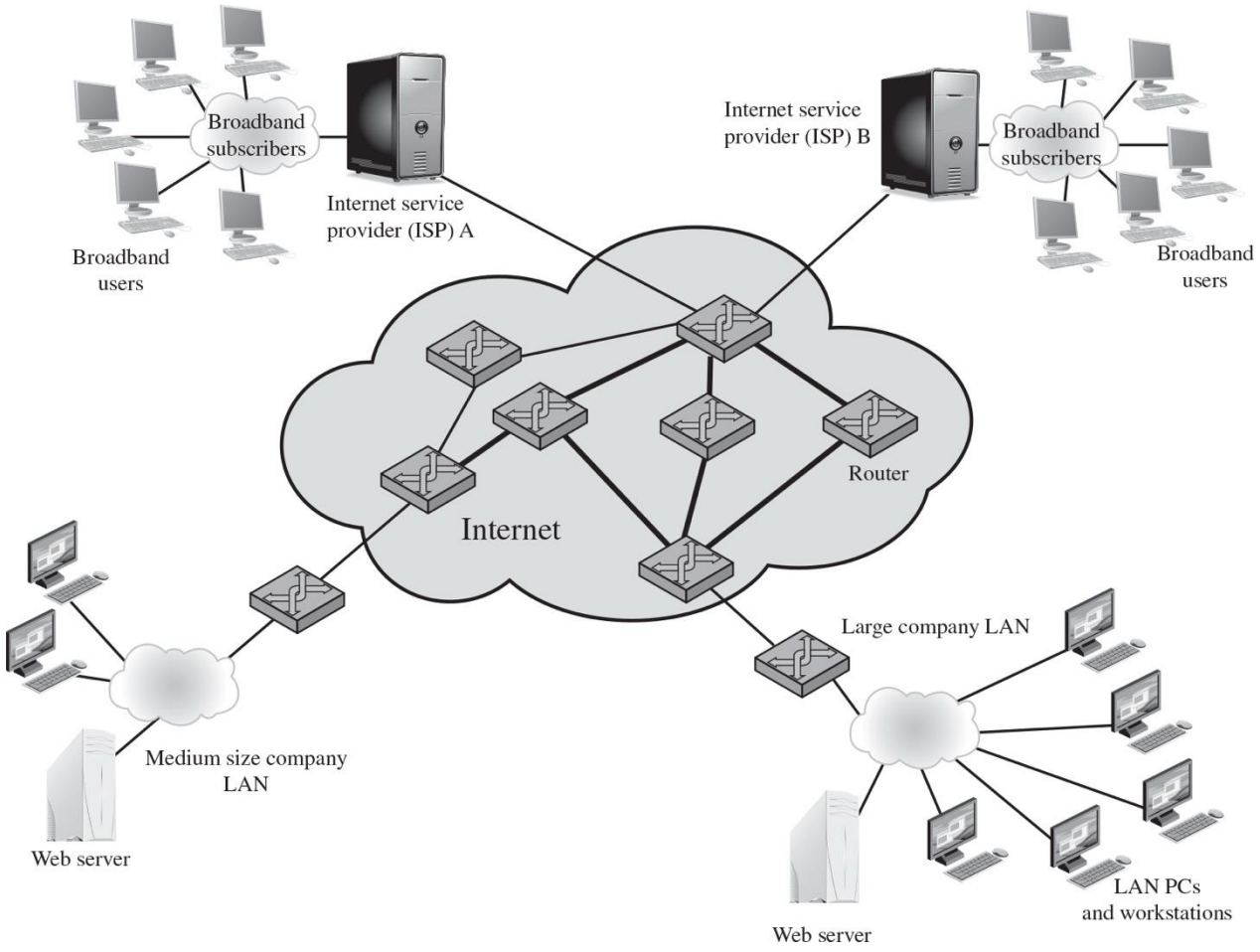
The NIST Computer Security Incident Handling Guide defines a DoS attack as:

"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

# Figure 7.1 Example Network to Illustrate DoS Attacks



# Classic DoS Attacks

- Flooding ping command
  - Aim of this attack is to overwhelm the capacity of the network connection to the target organization
  - Traffic can be handled by higher capacity links on the path, but packets are discarded as capacity decreases
  - Source of the attack is clearly identified unless a spoofed address is used
  - Network performance is noticeably affected

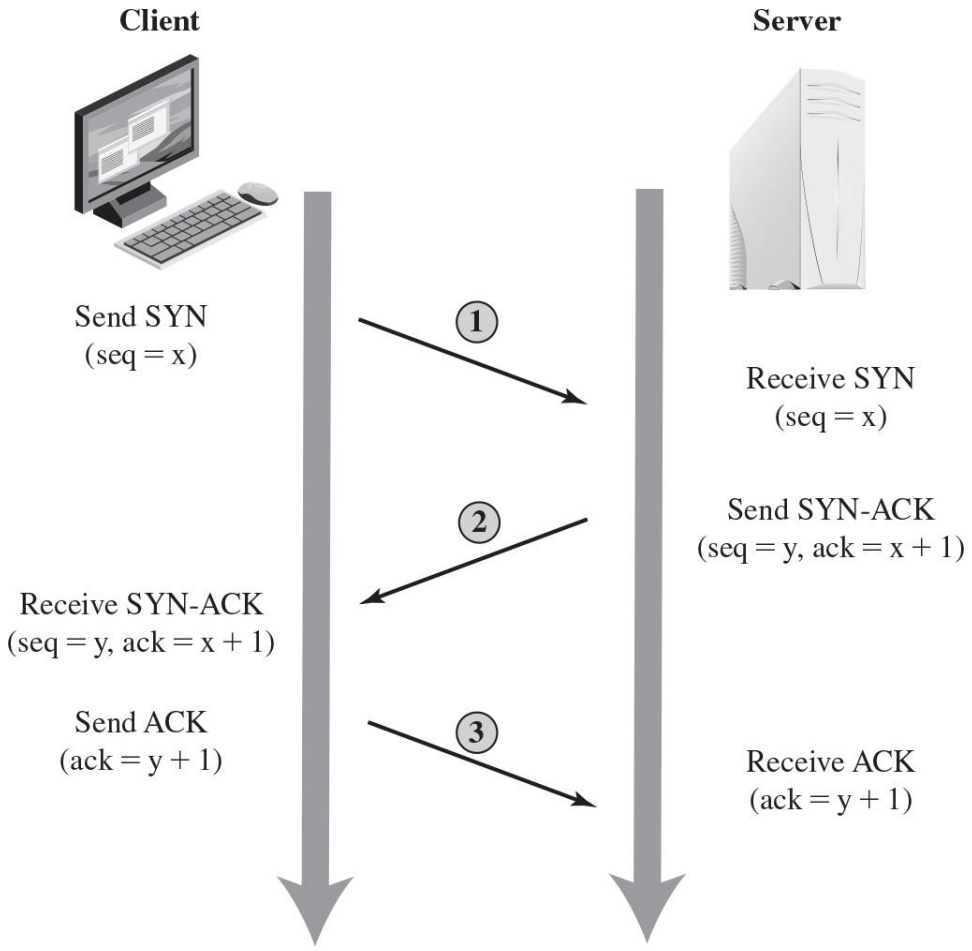
# Source Address Spoofing

- Use forged source addresses
  - Usually via the raw socket interface on operating systems
  - Makes attacking systems harder to identify
- Attacker generates large volumes of packets that have the target system as the destination address
- Congestion would result in the router connected to the final, lower capacity link
- Requires network engineers to specifically query flow information from their routers
- **Backscatter traffic**
  - Advertise routes to unused IP addresses to monitor attack traffic

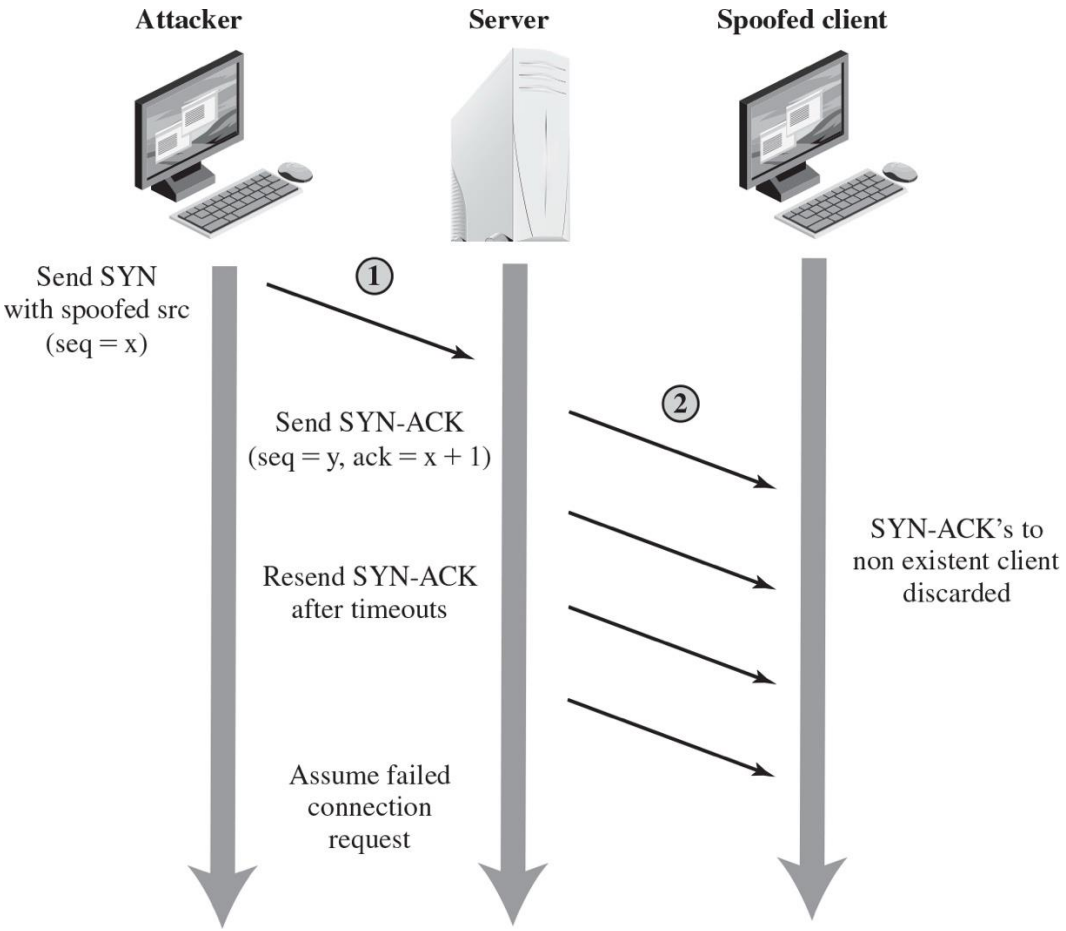
# SYN Spoofing

- Common DoS attack
- 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

# Figure 7.2 TCP Three-Way Connection Handshake



# Figure 7.3 TCP SYN Spoofing Attack



# Flooding Attacks (1 of 2)

- Classified based on network protocol used
- Intent is to overload the network capacity on some link to a server
- Virtually any type of network packet can be used

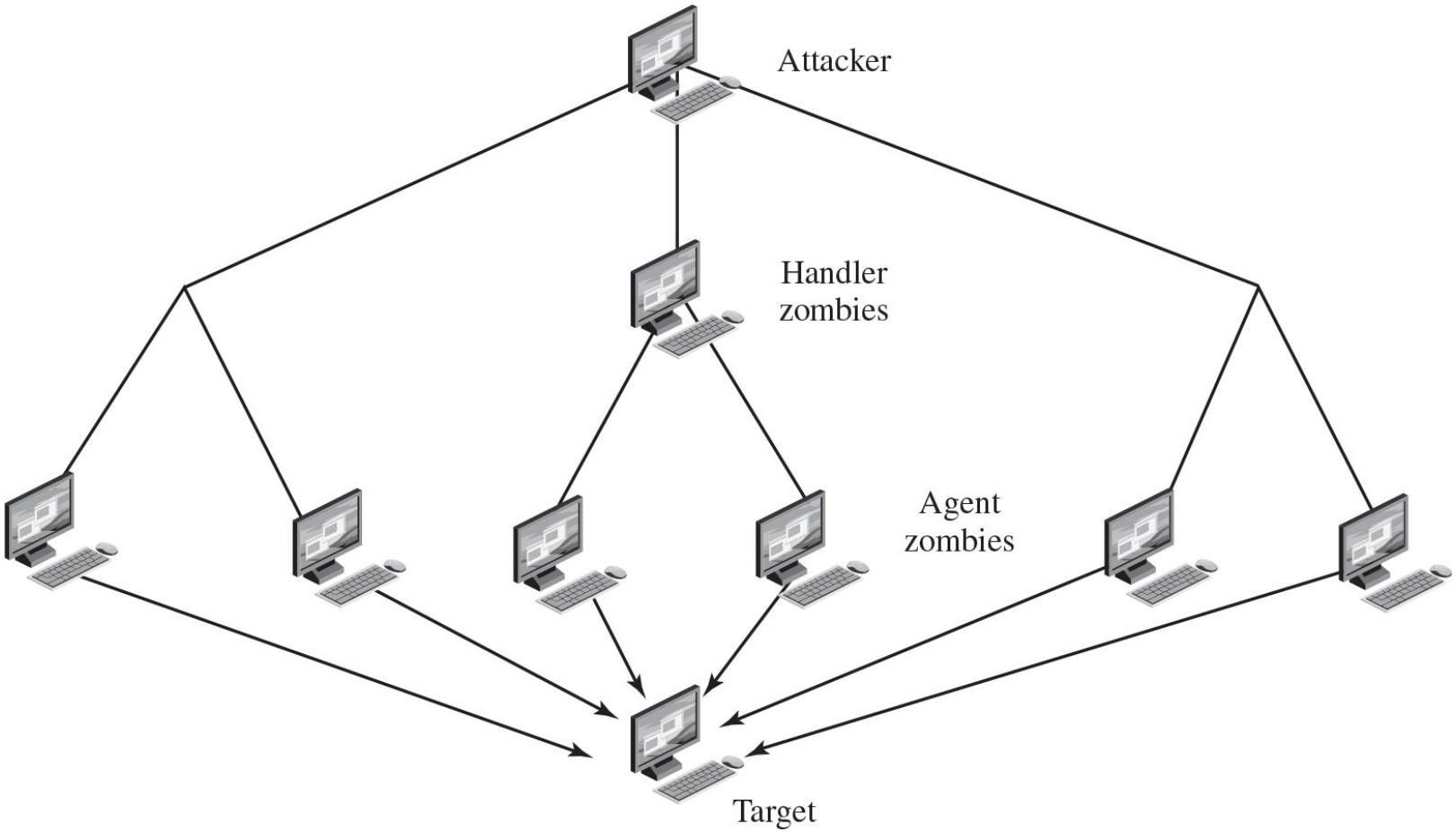
# Flooding Attacks (2 of 2)

- 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

# Distributed Denial of Service (DDoS) Attacks

- Use of multiple systems to generate attacks
- Attacker uses a flaw in operating system or in a common application to gain access and installs their program on it (zombie)
- Large collections of such systems under the control of one attacker's control can be created, forming a botnet

# Figure 7.4 DDoS Attack Architecture



# Hypertext Transfer Protocol (HTTP) Based Attacks

HTTP flood

- Attack that bombards Web servers with HTTP requests
- Consumes considerable resources
- Spidering
  - Bots starting from a given HTTP link and following all links on the provided Web site in a recursive way

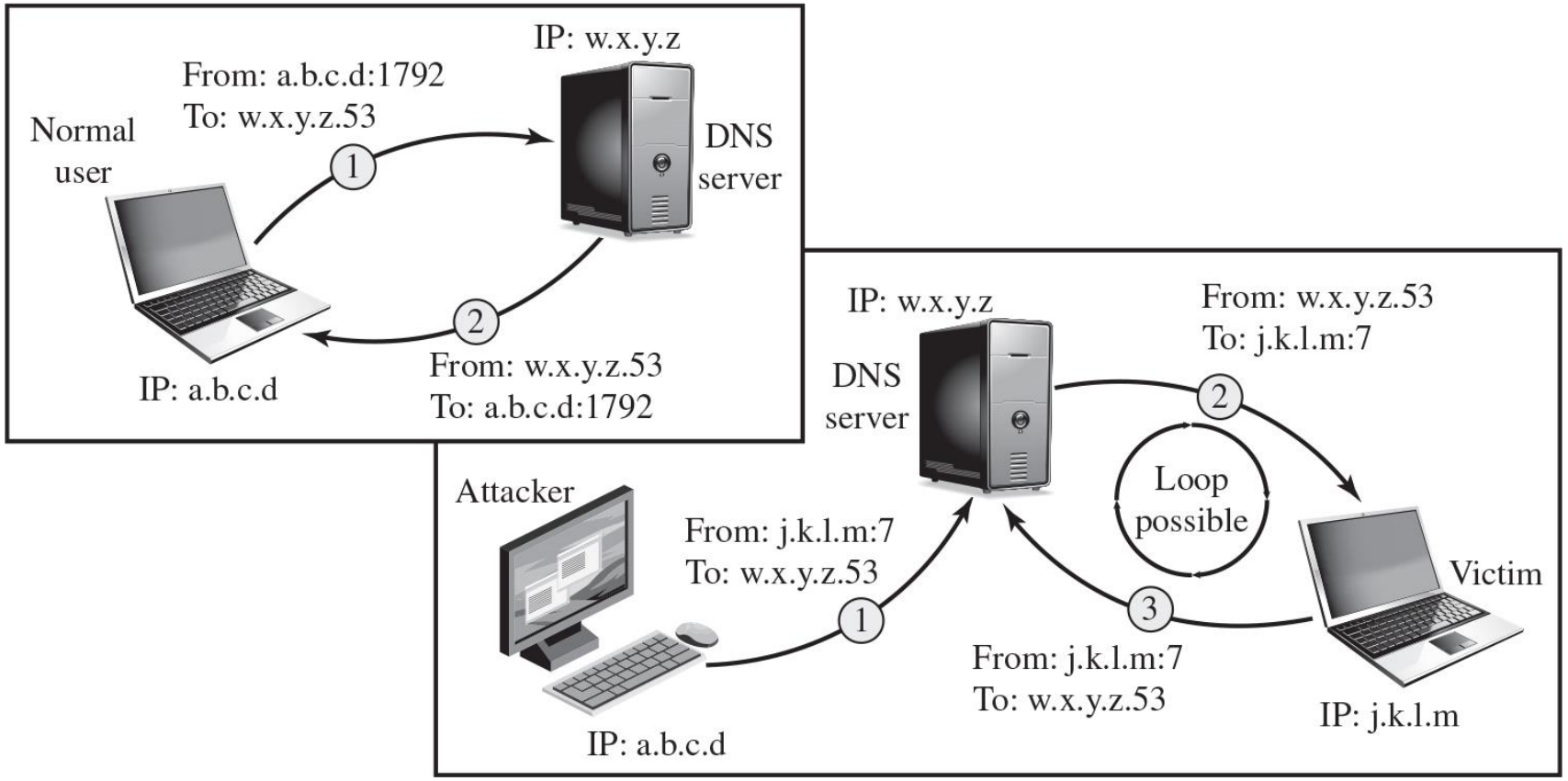
Slowloris

- Attempts to monopolize by sending HTTP requests that never complete
- Eventually consumes Web server's connection capacity
- Utilizes legitimate HTTP traffic
- Existing intrusion detection and prevention solutions that rely on signatures to detect attacks will generally not recognize Slowloris

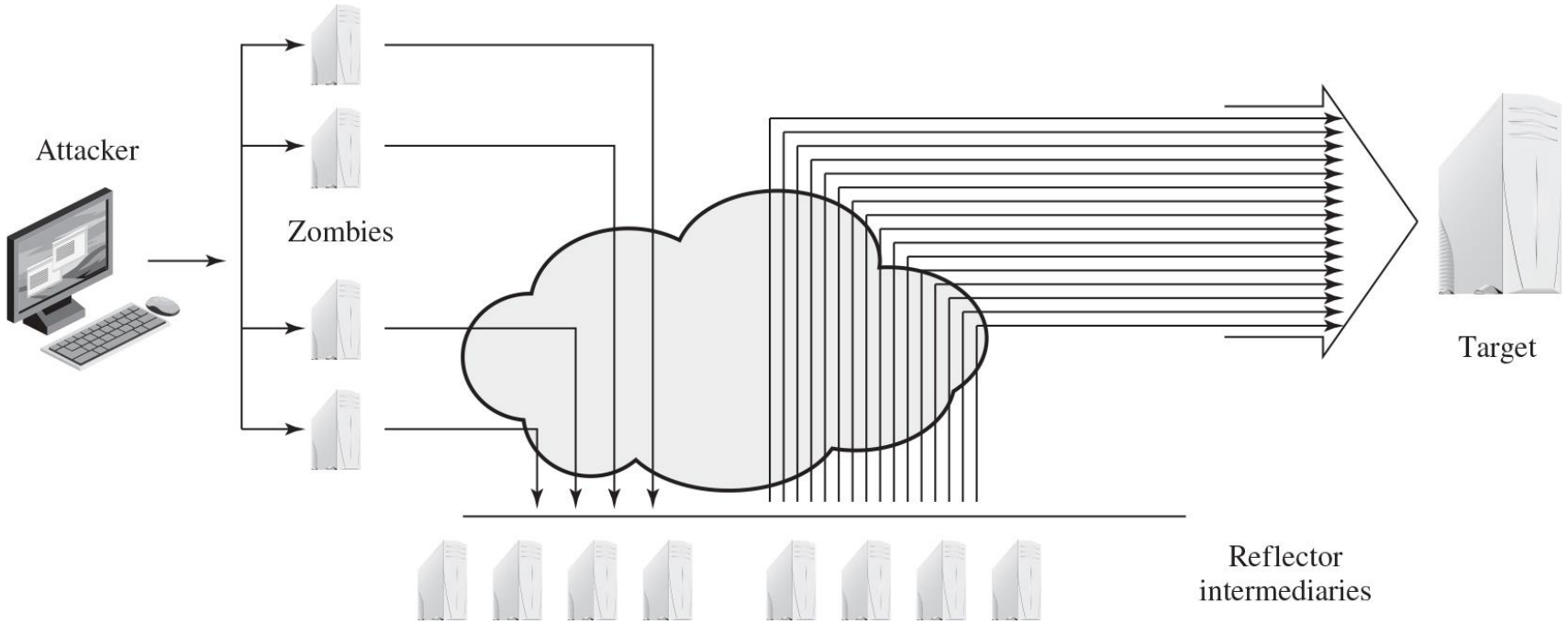
# Reflection Attacks

- 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
- “Reflects” the attack off the intermediary (reflector)
- Goal is to generate enough volumes of packets to flood the link to the target system without alerting the intermediary
- The basic defense against these attacks is blocking spoofed-source packets

# Figure 7.6 DNS Reflection Attack



# Figure 7.7 Amplification Attack



# DoS Attack Defenses

- These attacks cannot be prevented entirely
- High traffic volumes may be legitimate
  - High publicity about a specific site
  - Activity on a very popular site
  - Described as **slashdotted, flash crowd, or flash event**

Four lines of defense against DDoS attacks

- Attack prevention and preemption
  - Before attack
- Attack detection and filtering
  - During the attack
- Attack source traceback and identification
  - During and after the attack
- Attack reaction
  - After the attack

# DoS Attack Prevention (1 of 2)

- Block spoofed source addresses
  - On routers as close to source as possible
- Filters may be used to ensure path back to the claimed source address is the one being used by the current packet
  - Filters must be applied to traffic before it leaves the ISP's network or at the point of entry to their network
- Use modified TCP connection handling code
  - Cryptographically encode critical information in a cookie that is sent as the server's initial sequence number
    - Legitimate client responds with an ACK packet containing the incremented sequence number cookie
  - Drop an entry for an incomplete connection from the TCP connections table when it overflows

# DoS Attack Prevention (2 of 2)

- Block IP directed broadcasts
- Block suspicious services and combinations
- Manage application attacks with a form of graphical puzzle (captcha) to distinguish legitimate human requests
- Good general system security practices
- Use mirrored and replicated servers when high-performance and reliability is required

# Responding to DoS Attacks (1 of 2)

- Good Incident Response Plan
  - Details on how to contact technical personal for ISP
  - Needed to impose traffic filtering upstream
  - Details of how to respond to the attack
- Antispoofing, directed broadcast, and rate limiting filters should have been implemented
- Ideally have network monitors and IDS to detect and notify abnormal traffic patterns

# Responding to DoS Attacks (2 of 2)

- Identify type of attack
  - Capture and analyze packets
  - Design filters to block attack traffic upstream
  - Or identify and correct system/application bug
- Have ISP trace packet flow back to source
  - May be difficult and time consuming
  - Necessary if planning legal action
- Implement contingency plan
  - Switch to alternate backup servers
  - Commission new servers at a new site with new addresses
- Update incident response plan
  - Analyze the attack and the response for future handling

# Summary

- Denial-of-service attacks
  - The nature of denial-of-service attacks
  - Classic denial-of-service attacks
  - Source address spoofing
  - SYN spoofing
- Flooding attacks
  - ICMP flood
  - UDP flood
  - TCPSYN flood
- Defenses against denial-of-service attacks
- Responding to a denial-of-service attack
- Distributed denial-of-service attacks
- Application-based bandwidth attacks
  - SIP flood
  - HTTP-based attacks
- Reflector and amplifier attacks
  - Reflection attacks
  - Amplification attacks
  - DNS amplification attacks

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