CS 640 Introduction to Computer Networks

Lecture29

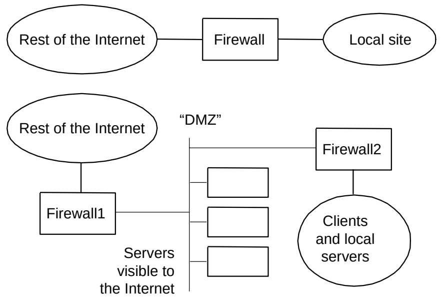
Network security (continued)

- Network perimeter defenses
  - Firewalls
  - Network intrusion detection/prevention
- Denial of service attacks

Firewalls – overview

- Firewalls restrict communication between an organization’s computers and the outside world
  - Keep the bad guys on the outside from exploiting vulnerabilities on the inside
  - Without restricting legitimate traffic
- NAT boxes implement a popular firewall policy
  - Allow internal clients to connect to outside servers
  - Do not allow inbound connections
- Two types of firewalls
  - Filter based (layer 4)
  - Proxy based (application layer)

Two classical layouts



Defense in depth

- Separate large network into smaller networks
  - Different parts of the organization have different protection needs / exposure / tolerance to lost functionality
    - E.g. laptops bring in trojans/viruses they catch while on the road
  - Different departments run different software packages with different vulnerabilities
  - Users in different departments need access to different servers / data sources
- Use multiple layers of firewalls (and other defenses)
  - Attacker must bypass multiple defenses

Firewalls

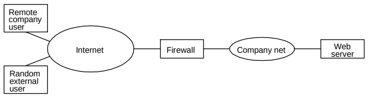
- Filter-Based Solution
  - Apply a set of rules to packets (based on headers)
  - Example of rules

action	ourhost	port	theirhost	port	comment
block	*	*	BLASTER	*	We don't trust this system
allow	OUR_GW	25	*	*	Connects to our SMTP srvr

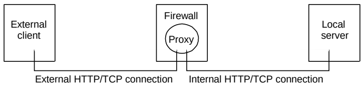
  - Default: forward or not forward?
  - Filtering on TCP flags can block connection from outside
  - How dynamic?
- Access control rules (ACLs) also available in highest speed routers (but used differently)

Proxy-Based Firewalls

- Problem: complex policy
- Example: web server



- Solution: proxy



- Design: transparent vs. classical
- Limitations: attacks from within

Intrusion detection/prevention systems

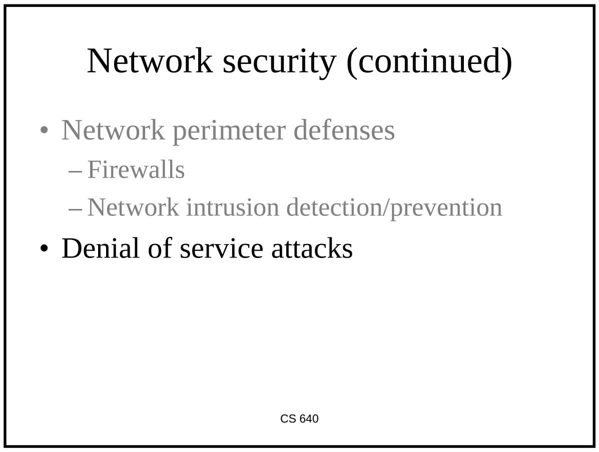
- Main role: inspect packet payloads to detect attacks (e.g. buffer overflow) based on attack signatures
  - When match found, IDS logs alert, IPS drops packet
  - Thousands of signatures catch thousands of attacks against hundreds of applications for dozens of protocols
    - Needs defragmentation, stream reassembly, some L7 parsing
  - Legitimate traffic largely unaffected
  - IPS transparent to protocol endpoints
- Other roles: detect/block scans and various anomalies

Many IPSes out there

- Snort – most widely used, open source, developed by Sourcefire (makes money by selling GUI & services)
- Cisco IPS (formerly NetRanger)
  - IPS/IDS functionality present in many Cisco devices
- TippingPoint (now 3Com)

Signature with simplified Snort syntax describing fictitious vulnerability

```
alert tcp $EXT NET any -> $HOME NET 99
(msg:"AudioPlayer jukebox exploit";
content:"fmt="; pcre:"/^(mp3|ogg)/Ri";
content:"player="; pcre:"/.exe|.com/"; distance:5;
sid:5678)
```



Network security (continued)

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  - Network intrusion detection/prevention
- Denial of service attacks

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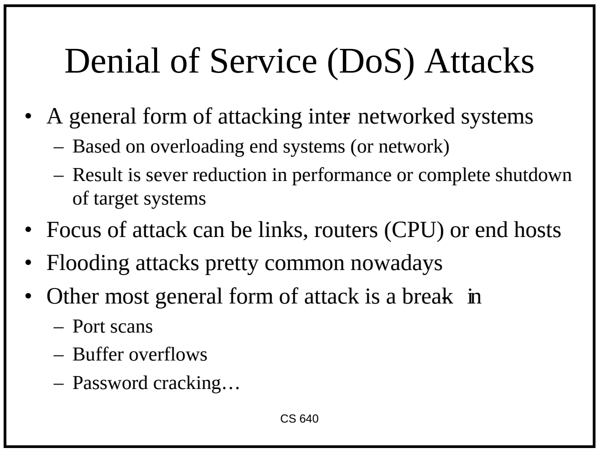

Denial of Service (DoS) Attacks

- A general form of attacking inter-networked systems
  - Based on overloading end systems (or network)
  - Result is sever reduction in performance or complete shutdown of target systems
- Focus of attack can be links, routers (CPU) or end hosts
- Flooding attacks pretty common nowadays
- Other most general form of attack is a break-in
  - Port scans
  - Buffer overflows
  - Password cracking…

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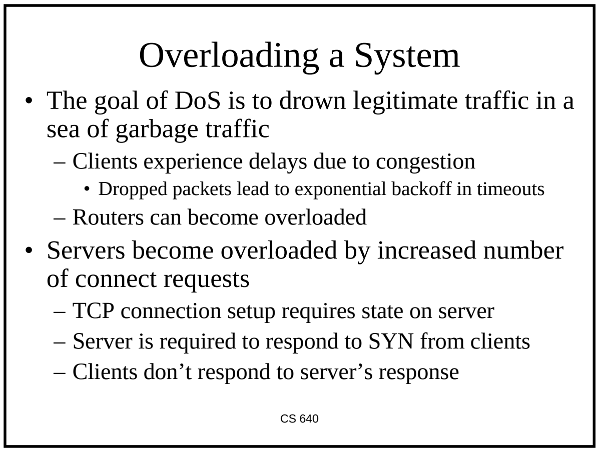

Overloading a System

- The goal of DoS is to drown legitimate traffic in a sea of garbage traffic
  - Clients experience delays due to congestion
    - Dropped packets lead to exponential backoff in timeouts
  - Routers can become overloaded
- Servers become overloaded by increased number of connect requests
  - TCP connection setup requires state on server
  - Server is required to respond to SYN from clients
  - Clients don’t respond to server’s response

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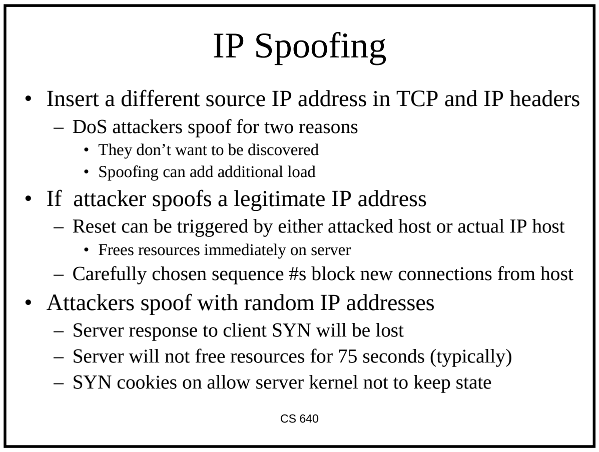

IP Spoofing

- Insert a different source IP address in TCP and IP headers
  - DoS attackers spoof for two reasons
    - They don’t want to be discovered
    - Spoofing can add additional load
- If attacker spoofs a legitimate IP address
  - Reset can be triggered by either attacked host or actual IP host
    - Frees resources immediately on server
  - Carefully chosen sequence #s block new connections from host
- Attackers spoof with random IP addresses
  - Server response to client SYN will be lost
  - Server will not free resources for 75 seconds (typically)
  - SYN cookies on allow server kernel not to keep state

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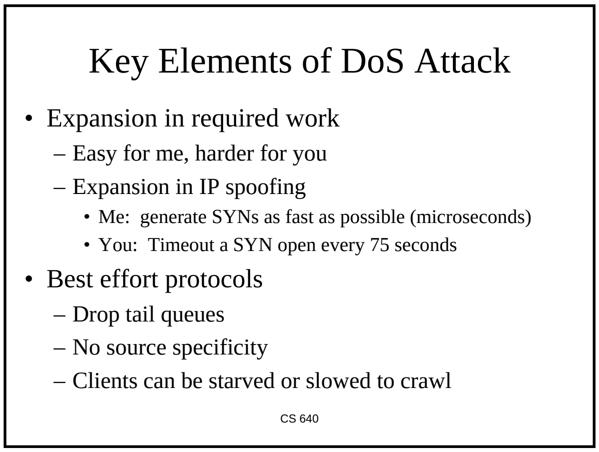

Key Elements of DoS Attack

- Expansion in required work
  - Easy for me, harder for you
  - Expansion in IP spoofing
    - Me: generate SYNs as fast as possible (microseconds)
    - You: Timeout a SYN open every 75 seconds
- Best effort protocols
  - Drop tail queues
  - No source specificity
  - Clients can be starved or slowed to crawl

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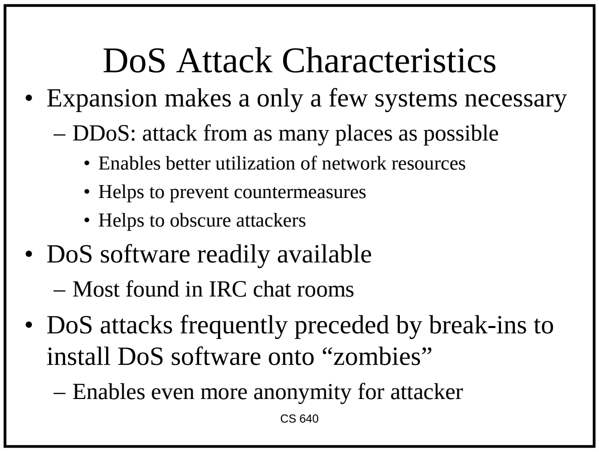

DoS Attack Characteristics

- Expansion makes a only a few systems necessary
  - DDoS: attack from as many places as possible
    - Enables better utilization of network resources
    - Helps to prevent countermeasures
    - Helps to obscure attackers
- DoS software readily available
  - Most found in IRC chat rooms
- DoS attacks frequently preceded by break-ins to install DoS software onto “zombies”
  - Enables even more anonymity for attacker

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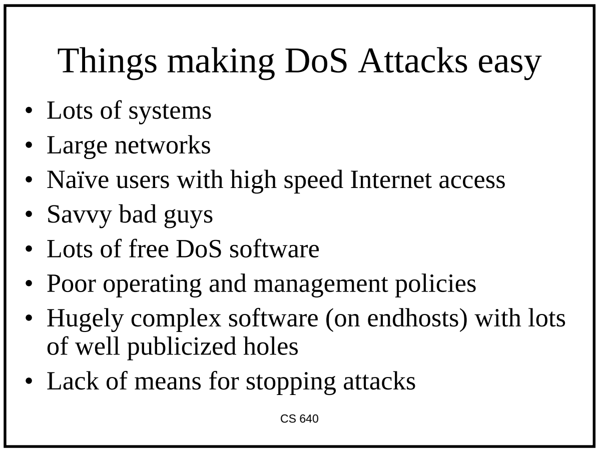
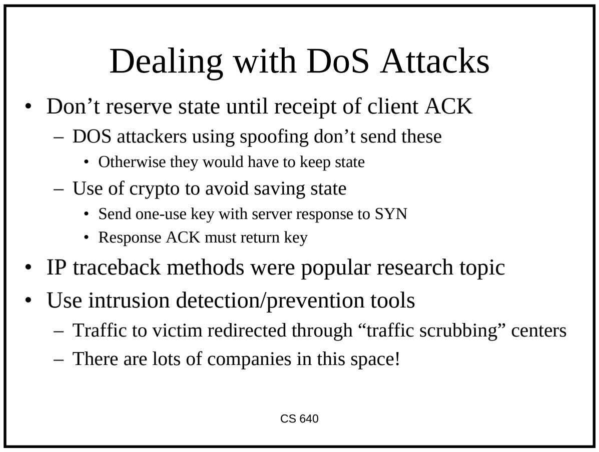


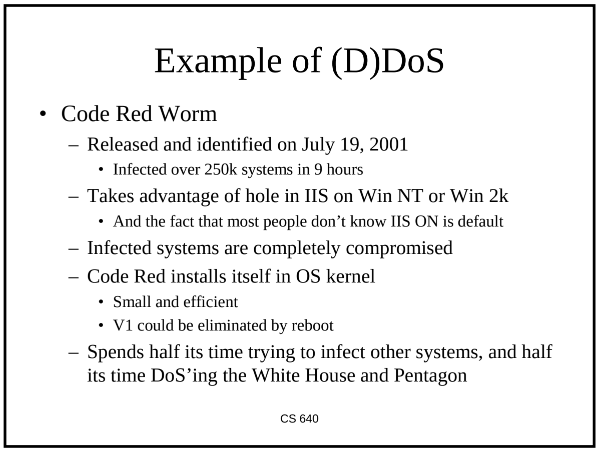
Things making DoS Attacks easy

- Lots of systems
- Large networks
- Naïve users with high speed Internet access
- Savvy bad guys
- Lots of free DoS software
- Poor operating and management policies
- Hugely complex software (on endhosts) with lots of well publicized holes
- Lack of means for stopping attacks



Dealing with DoS Attacks

- Don’t reserve state until receipt of client ACK
  - DOS attackers using spoofing don’t send these
    - Otherwise they would have to keep state
  - Use of crypto to avoid saving state
    - Send one-use key with server response to SYN
    - Response ACK must return key
- IP traceback methods were popular research topic
- Use intrusion detection/prevention tools
  - Traffic to victim redirected through “traffic scrubbing” centers
  - There are lots of companies in this space!



Example of (D)DoS

- Code Red Worm
  - Released and identified on July 19, 2001
    - Infected over 250k systems in 9 hours
  - Takes advantage of hole in IIS on Win NT or Win 2k
    - And the fact that most people don’t know IIS ON is default
  - Infected systems are completely compromised
  - Code Red installs itself in OS kernel
    - Small and efficient
    - V1 could be eliminated by reboot
  - Spends half its time trying to infect other systems, and half its time DoS’ing the White House and Pentagon