ECS 235B Module 26
Network Flooding
Availability and Network Flooding

• Access over Internet must be unimpeded
  • Context: flooding attacks, in which attackers try to overwhelm system resources

• If many sources flood a target, it’s a *distributed denial of service attack*
TCP 3-Way Handshake and Availability

- Normal three-way handshake to initiate connection
- Suppose source never sends third message (the last ACK)
  - Destination holds information about pending connection for a period of time before the space is released

\[
\text{source} \xrightarrow{\text{SYN}(s)} \text{destination} \xrightarrow{\text{SYN}(t)\text{ACK}(s+1)} \text{destination} \xleftarrow{\text{ACK}(t+1)} \text{source}
\]
Analysis

• Consumption of bandwidth
  • If flooding overwhelms capacity of physical network medium, SYNs from legitimate handshake attempts may not be able to reach the target

• Absorption of resources on destination host
  • Flooding fills up memory space for pending connections, causing SYNs from legitimate handshake attempts to be discarded

• In terms of the models:
  • Waiting time is the time that destination waits for ACK from source
  • Fairness policy must assure host waiting for ACK (resource) will receive (acquire) it
Analysis in Terms of Model

• Waiting time is the time that destination waits for ACK from source
• Fairness policy must assure host waiting for ACK (resource) will receive (acquire) it
  • But goal of attack is to make sure it never arrives
• Yu-Gligor model: finite wait time does not hold
  • So model says denial of service can occur
• Millen model: $T_p(ACK) > max(ACK)$
  • $max(ACK)$ is the time-out period for pending connections
  • So model says denial of service can occur
Countermeasures

• Focus on ensuring resources needed for legitimate handshakes to complete are available
  • So every legitimate client gets access to server

• First approach: manipulate opening of connection at end point
  • If focus is to ensure connection attempts will succeed at some time, focus is really on waiting time
  • Otherwise, focus is on user agreement

• Second approach: control which packets, or rate at which packets, sent to destination
  • Focus is on implicit user agreements
Intermediate Systems

- Approach is to reduce consumption of resources on destination by diverting or eliminating illegitimate traffic so only legitimate traffic reaches destination
  - Done at infrastructure level

- Example: Cisco routers try to establish connection with source (TCP intercept mode)
  - On success, router does same with intended destination, merges the two
  - On failure, short time-out protects router resources and target never sees flood
Track Connection Status

• Use network monitor to track status of handshake

• Example: `synkill` monitors traffic on network
  • Classifies IP addresses as not flooding (good), flooding (bad), unknown (new)
  • Checks IP address of SYN
    • If good, packet ignored
    • If bad, send RST to destination; ends handshake, releasing resources
    • If new, look for ACK or RST from same source; if seen, change to good; if not seen, change to bad

• Periodically discard stale good addresses
Intermediate Systems near Sources

- D-WARD relies on routers close to the sources to block attack
  - Reduces congestion in network without interfering with legitimate traffic
- Placed at gateways of possible sources to examine packets leaving (internal) network and going to Internet
- Deployed on systems in research lab for 4 months
  - First month: large number of false alerts
  - Tuning D-WARD parameters reduced this number
D-WARD: Observation Component

• Has set of legitimate internal addresses
• Gathers statistics on packets leaving network, discarding packets without legitimate addresses
• Tracks number of simultaneous connections to each remote destination
  • Unusually large number may indicate attack from this network
• Examines connections with large amount of outgoing traffic but little incoming (response) traffic
  • May indicate destination host is overwhelmed
D-WARD: Observation Component

- Also aggregates traffic statistics to each remote address
- Classifies flows as attack, suspicious, normal
  - Normal: statistics match legitimate traffic model
  - Attack: if not
- Once traffic classified as attack begins to match legitimate traffic model, indicates attack has ended, so flow reclassified as suspicious
  - If it stays suspicious for predetermined time, reclassified as normal
D-WARD: Rate-Limiting Component

• When attack detected, this component limits amount of packets that can be sent

• This reduces volume of traffic going from this network to destination

• How it limits rate is based on D-WARD’s best guess of amount of traffic destination can handle
  • When flow reclassified as normal, D-WARD raises rate limit until sending rate is as before
D-WARD: Traffic-Policing Component

• Component obtains information from other 2 components
• Based on this, decides whether to drop packets
  • Packets for normal connections always forwarded
  • Packets for other flows may be forwarded provided doing so does not exceed rate limit associated with flow
Endpoint Protection

• Control how TCP state is stored
  • When SYN received, entry in queue of pending connections created
    • Remains until an ACK received or time-out
    • In first case, entry moved to different queue
    • In second case, entry made available for next SYN
  • In SYN flood, queue is always full
    • So, assure legitimate connections space in queue to some level of probability
    • Two approaches: SYN cookies or adaptive time-outs
SYN Cache

• Space allocated for each pending connection
  • But much less than for a full connection

• How it works on FreeBSD
  • On initialization, hash table \((\text{syncache})\) created
  • When SYN packet arrives, system generates hash from header and uses that to determine which bucket to store enough information to be able to send SYN/ACK on the pending connection (and does so)
    • If bucket full, oldest element dropped
  • If peer returns ACK, entry removed and connection created
  • If peer returns RST, entry removed
  • If no response, repeat fixed number of times; if no responses, remove entry
SYN Cookies

• Source keeps state

• How it works
  • When SYN arrives, generate number (syncookie) from header data and random data; use as ACK sequence number in SYN/ACK packet
    • Random data changes periodically
    • When reply ACK arrives, recompute syncookie from information in header

• FreeBSD uses this technique when pending connection cannot be inserted into syncache
Adaptive Time-Out

• Change time-out time as space available for pending connections decreases

• Example: modified SunOS kernel
  • Time-out period shortened from 75 to 15 sec
  • Formula for queueing pending connections changed:
    • Process allows up to $b$ pending connections on port
    • $a$ number of completed connections but awaiting process
    • $p$ total number of pending connections
    • $c$ tunable parameter
    • Whenever $a + p > cb$, drop current SYN message
Other Flooding Attacks

• These use *reflectors* (typically, infrastructure systems) to augment traffic, creating flooding
  • Attacker need only send small amount of traffic; reflectors create the rest
  • Called *amplification attack*

• Hides origin of attack, which appears to come from reflectors
Smurf Attack

- Relies on router forwarding ICMP packets to all hosts on network
- Attacker sends ICMP packet to router with destination address set to broadcast address of network
- Router sends copy of packet to each host on network
  - If attacker sends steady stream of packets, has the effect of sending that stream to all hosts on network
- Example of an *amplification attack*
DNS Amplification Attack

• Uses DNS resolvers that are configured to accept queries from any host rather than only hosts on their own network

• Attacker sends packet with source address set to that of target
  • Packet has query that causes DNS resolver to send large amount of information to target
  • Example: zone transfer query is a small query, but typically sends large amount of data to target, typically in multiple packets, each larger than a query packet
Pulse Denial of Service Attack

• Like flooding, but packets sent in pulses
  • May only degrade target’s performance, but that may be enough of a denial of service

• Induces 3 anomalies in traffic to target
  • Ratio of incoming TCP packets to outgoing ACKs increases dramatically
    • Rate of incoming packets much higher than system can send ACKs
  • When attacker reduces number of packets to target, number of ACKs drop
  • Distribution of incoming packet interarrival time will be anomalous

• Vanguard detection scheme uses these 3 anomalies to detect pulse denial-of-service attack
Quiz

Does synkill protect against a distributed denial of service attack?

• Yes, as it blocks initial SYN packets and, if a second SYN comes from the same source, assumes it is a bad connection.

• No, because if there are too many SYNs from different sources, the internal table will overflow and some SYN packets will get through.

• Yes, because it sends an RST to the destination, releasing the resources being held for the connection.

• No, because if the attacker sends a SYN/ACK and then does nothing, the resources at the destination remain allocated for some time.