Denial of Service attacks

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2005-04-12

Lecture topics

- Types of denial of service
- How to mitigate attacks
- How to find out senders

What is Denial of Service

> The prevention of authorized access to a system resource or the delaying of system operations and functions[10]

- System is *unavailable* or *unusable*
- Unavailable
  - system crashed
  - route unavailable
- Unusable
  - responses too slow
    - protocol timers fire
    - users are impatient
  - high packet loss

Why anybody wants to DoS

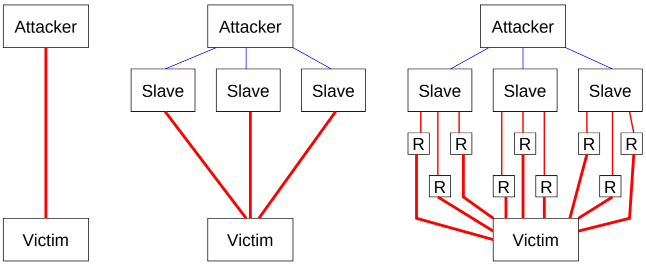
- Extortion
  - a large crime
  - aimed on bookies, online casinos and other e-Commerce sites
- Disabling some services
  - spam blacklist services
- Enabling other attacks
  - overloading firewall, IDS
- Revenge or hate
  - SCO, RIAA, . . .
- Damaging competitors
- Last resort attack

How to DoS

- Just send lots of packets
  - works best with distributed DoS
  - also amplification attacks
- Use protocol properties
  - TCP 3-way handshake, connection resets
- Use implementation vulnerabilities
  - send malformed data
- Use algorithmic complexity
  - exploit worst-case
- Attack on infrastructure
  - routers
  - support services (DNS, other directories, registries)
  - electrical power, air conditioning, physical cables

DoS attack types

- Single-source
- Multi-source
- Reflection attacks (amplification)



SYN flooding

- Send lot of TCP SYN packets
- Possibly fake source address
- Large number of half-open connections
  ⇒ kernel structures exhausted
- New legitimate connections cannot be established
- Use of SYN cookies
- Even low rate of packets is sufficient

Smurf attack

- Send ICMP echo request to broadcast address
- Use victim's address as source address
- All hosts in subnet answer (even hundreds)
  ⇒ amplification of messages
- Disallow directed broadcasts to network
  `no ip directed-broadcast`

LAND attack

- Send TCP SYN with source address same as destination address
  - ip address
  - ports
- Host ends to send packets to itself
  ⇒ Exhausts CPU
- Do not allow packets with source address in LAN from outside
- Protecting by source address filtering
  - do not accept a packet with your address as sender from outside
  - network, host-based filtering

TCP connection resets

- TCP connection aborts if receives SYN or RST with
  - right 5-tuple (source IP, destination IP, proto, src port, dst port)
  - ACK field within window
    - the larger window, the less tries needed
    - 64 KiB window ⇒65536 tries
- Can be used to DoS if connection setup expensive
- MD5 option to protect [6]

Common code bugs

- Many code fragments used in multiple implementations
  - e.g. reference code in standard
- Teardrop
  - exploited bug in IP fragment reassembly
  - two packets may crash computer
- ASN.1 parser
  - SNMP, X.509 certificates

Routing attacks

- Blackhole
  - cause traffic directed wrong destination
  - drop packets
- Eavesdropping
  - receive data and record
  - resend data to right destination
- Network hijacking
  - steal network addresses
  - to send spam, other attacks

Routing protocols

- Path vector protocols (RIP, BGP)
  - each router informs neighbours about its routing table
  - (destination, cost)
  - not possible to verify data
- Link state protocols (OSPF, IS-IS)
  - network topology flooded
  - independent verification of data (all neighbours must be evil)
- Attacks
  - compromised router
  - message injection
  - message modification
- May require physical access to link

BGP security

- Internet runs on BGP4
- Should one trust for *ALL* ISPs?
  - small configuration error can lead to problems [1]
  - how about malicious user

  ⇒Use policy filters
- BGP connection resets
  - needs to establish a new session
    ⇒ uses router resources
  - use TCP MD5 extension to protect malicious resets [6]
  - TTL protection [5]
- Filter BGP (port 179) on edges

DNS cache poisoning

- Can be used to "hijack" sites
  1. trick server to resolve address (reverse lookup, try to send email, etc.)
  2. return extra information

  ns.innocent.example: `1.0.0.10.in-addr.arpa IN PTR ?` ⇒ns.evil.example
  ns.evil.example ⇒ns.innocent.example:

1.0.0.10.in-addr.arpa	IN	PTR	trap.evil.example
bank.example	IN	NS	ns.evil.example
www.bank.example	IN	A	middlebox.evil.example
company.example	IN	NS	ns.evil.example
company.example	IN	MX	1 mailrecord.evil.example

- DNS server must verify that response is what is asked

Algorithmic complexity

- Algorithms may have very different normal- and worst case complexity[2]
  - binary tree: $O(n \log n) \ldots O(n^2)$
  - hash table: $O(1) \ldots O(n^2)$
  - quicksort: $O(n \log n) \ldots O(n^2)$
- For small values of n, no difference (the normal case)
  ⇒ exploit with exceptional values
  - apache header concatenation had $O(n^2)$: For normal case when there was at most two or three same headers this made no big difference. If there were thousands of headers (no more than few tens KiBs of data), this results $O(n^2)$ memory and CPU consumption. [11]
- If hash function is known, cause collisions
  - collision values stored linked list

Protecting from DoS using BGP

[14]

- Possible to null route attacked network on edge
  - protects other traffic
  - complete DoS
- If attack comes only some directions
  - null route on attack directions (iBGP communities)
  - other traffic unaffected
- Use MPLS TE tunnels
  - possible to monitor traffic
  - QoS methods to protect part of traffic

DoS in ad-hoc networks

- Routing attacks
- Watching misbehaving nodes
- packet disordering, delay (exploiting TCP retransmission=
- MAC level attacks
- Problems with power control

Is it DDoS attack?

- Identifying sources
  - IP fragment ID
  - TTL field
- Ramp-up time
  - distributed attack starts slower
- Spectral analysis
- Flash crowd (slashdot effect)

Botnets

- What to use botnets for

  1. DDoS
  2. spamming
  3. traffic sniffing
  4. keylogging
  5. spreading new malware
  6. automated advertisisement clicks to get revenue on click-through adverisiment such as Google AdSense
  7. attacking on IRC networks
  8. manipulating polls and games
  9. large-scale identity theft by sending phishing spam and hosting phishing web sites; also computer user's information may be captured using keylogging or file search

- How to build a botnet

  – direct attacks (ports 445, 139, 137, 135, 5000)

  – browser, email exploits

  – p2p networks

- How much of bots

  – tens of active botnets

  – hundreds to tens of thousands bots in each net
    ⇒ total *million bots*

  – 1000 bots with 256k upstream
    ⇒ 256 Mbit/s attack speed: normal business have access speed a lot less

- Mostly controlled by IRC

  – provides quite scalable infrastructure

  – any communication possible, like using NNTP news

  – p2p networks

  – trin00, TFN: UDP-based (Tribe Flood Network)

Traffic traceback

- Problem: where incoming attack traffic originates

- Source IP cannot be trusted

  – sender can put it to any address

  – ingress filtering not deployed universally

- Should not need additional hardware or load on routers

- Scalability problems, few proposals [8, 12, 13]

Network administrator checklist

1. Check that your users cannot fake source address

   - ingress filtering [3]
   - `ip verify unicast reverse-path`

> It's better than a sharp stick in the eye, I'll tell ya, lad.
>
> Listen to me: It's called a "best current practice" for a reason – people should do it. Not sit and around and endlessly discuss it (we've already done that a thousand times).
>
> I wrote it, I stand beside it. I'm sick of hearing why people haven't implemented it yet – it's almost five years later and there's simply no excuse. It's sickening.
>
> - fergie[4]

2. Check source IP for forgery
   - don't accept local address from outside
   - packet filter or reverse-path verification
3. Do not accept directed broadcasts [9]
   - `no ip directed-broadcast`

   Note, that you cannot just drop any packet which destination address has low byte 255:
   - it may be destined to /23 (or shorter prefix) network
   - it does not help for /25 (and longer prefix) networks
4. Filter for bogons (unallocated or private-use address space) [7] `http://www.cymru.com/Bogons/`

Summary

- Denial of service many times hardest part
- Outer defences most vulnerable
- Designing the right failure model important
  - allow authorised users
  - deny unauthorised users
- Which one is the most important?
- Know your adversary

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