CSci 5271
Introduction to Computer Security
Day 13: Network, etc., security overview

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Outline

Brief introduction to networking

Announcements intermission

Some classic network attacks

Second half of course

More Unix access control

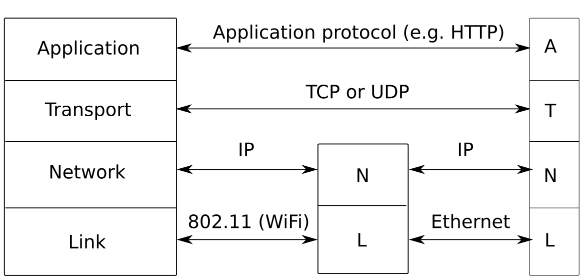
The Internet

- A bunch of computer networks voluntarily interconnected
- Capitalized because there's really only one
- No centralized network-level management
  - But technical collaboration, DNS, etc.

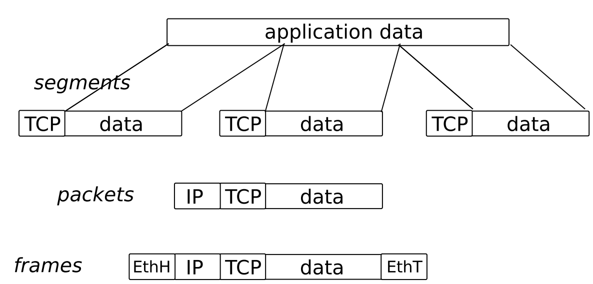
Layered model (OSI)

7. Application (HTTP)
6. Presentation (MIME?)
5. Session (SSL?)
4. Transport (TCP)
3. Network (IP)
2. Data-link (PPP)
1. Physical (10BASE-T)

Layered model: TCP/IP



Packet wrapping



IP(v4) addressing

- Interfaces (hosts or routers) identified by 32-bit addresses
  - Written as four decimal bytes, e.g. 192.168.10.2
- First k bits identify network, $32 - k$ host within network
  - Can't (anymore) tell k from the bits
- We'll run out any year now

IP and ICMP

- Internet Protocol (IP) forwards individual packets
- Packets have source and destination addresses, other options
- Automatic fragmentation (usually avoided)
- ICMP (I Control Message P) adds errors, ping packets, etc.

UDP

- User Datagram Protocol: thin wrapper around IP
- Adds source and destination port numbers (each 16-bit)
- Still connectionless, unreliable
- OK for some small messages

TCP

- Transmission Control Protocol: provides reliable bidirectional stream abstraction
- Packets have sequence numbers, acknowledged in order
- Missed packets resent later

Flow and congestion control

- Flow control: match speed to slowest link
  - "Window" limits number of packets sent but not ACKed
- Congestion control: avoid traffic jams
  - Lost packets signal congestion
  - Additive increase, multiplicative decrease of rate

Routing

- Where do I send this packet next?
  - Table from address ranges to next hops
- Core Internet routers need big tables
- Maintained by complex, insecure, cooperative protocols
  - Internet-level algorithm: BGP (Border Gateway Protocol)

Below IP: ARP

- Address Resolution Protocol maps IP addresses to lower-level address
  - E.g., 48-bit Ethernet MAC address
- Based on local-network broadcast packets
- Complex Ethernets also need their own routing (but called switches)

DNS

- Domain Name System: map more memorable and stable string names to IP addresses
- Hierarchically administered namespace
  - Like Unix paths, but backwards
- `.edu` server delegates to `.umn.edu` server, etc.

DNS caching and reverse DNS

- To be practical, DNS requires caching
  - Of positive and negative results
- But, cache lifetime limited for freshness
- Also, reverse IP to name mapping
  - Based on special top-level domain, IP address written backwards

Classic application: remote login

- Killer app of early Internet: access supercomputers at another university
- Telnet: works cross-OS
  - Send character stream, run regular login program
- rlogin: BSD Unix
  - Can authenticate based on trusting computer connection comes from
  - (Also rsh, rcp)

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What about the midterm?

- Will be graded and handed back in class Monday
- Solutions might be posted a bit earlier

Hands-on Assignment 1

- Intended possibilities remaining in week 5:
  - Format string vulnerability (exploited twice)
  - `get_line` buffer overflow (not exploited with new buffer size)
  - Negative time since modification?
- In class Monday: discussion of attacks

Project meetings schedule

- Next week, same time of week as first meeting
  - Unless we arrange otherwise
- Invitation/reminder emails out soon

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Packet sniffing

- Watch other people's traffic as it goes by on network
- Easiest on:
  - Old-style broadcast (thin, "hub") Ethernet
  - Wireless
- Or if you own the router

Forging packet sources

- Source IP address not involved in routing, often not checked
- Change it to something else!
- Might already be enough to fool a naive UDP protocol

TCP spoofing

- Forging source address only lets you talk, not listen
- Old attack: wait until connection established, then DoS one participant and send packets in their place
- Frustrated by making TCP initial sequence numbers unpredictable
  - But see Oakland'12, WOOT'12 for fancier attacks, keyword "off-path"

ARP spoofing

- Impersonate other hosts on local network level
- Typical ARP implementations stateless, don't mind changes
- Now you get victim's traffic, can read, modify, resend

rlogin and reverse DNS

- rlogin uses reverse DNS to see if originating host is on whitelist
- How can you attack this mechanism with an honest source IP address?

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- Remember, ownership of reverse-DNS is by IP address

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Cryptographic primitives

- Core mathematical tools
- Symmetric: block cipher, hash function, MAC
- Public-key: encryption, signature
- Some insights on how they work, but concentrating on how to use them correctly

Cryptographic protocols

- Sequence of messages and crypto privileges for, e.g., key exchange
- A lot can go wrong here, too
- Also other ways security can fail even with a good crypto primitive

Crypto in Internet protocols

- How can we use crypto to secure network protocols
- E.g., rsh $\rightarrow$ ssh
- Challenges of getting the right public keys
- Fitting into existing usage ecosystems

Web security: server side

- Web software is privileged and processes untrusted data: what could go wrong?
- Shell script injection (Ex. 1)
- SQL injection
- Cross-site scripting (XSS) and related problems

Web security: client side

- JavaScript security environment even more tricky, complex
- More kinds of cross-site scripting
- Possibilities for sandboxing

Security middleboxes

- Firewall: block traffic according to security policy
- NAT box: different original purpose, now de-facto firewall
- IDS (Intrusion Detection System): recognize possible attacks

Malware and network DoS

- Attacks made possible by the network
- Viruses, trojans, bot nets
  - Detection?
  - Mitigation?
- Distributed denial of service (DDoS)

Adding back privacy

- Every Internet packet has source and destination addresses on it
- So how can network traffic be private or anonymous?
- Key technique: overlay a new network
- Examples: onion routing (Tor), anonymous remailing

Usability of security

- Prevent people from being the weakest link
- Usability of authentication
- "Secure" web sites, phishing
- Making decisions about mobile apps

Electronic voting

- Challenging: hard versions of many hard problems:
  - Trust in software
  - Usability
  - Simultaneously public and private
- Some deployed systems arguably worse than paper
- Can do better with crypto and systems approaches

Electronic money (Bitcoin)

- Current payment systems have strong centralized trust
  - US Federal Reserve and mint
  - Banks, PayPal
- Could they be replaced by a peer-to-peer distributed system?
- Maybe

Outline

"POSIX" ACLs

- Based on a withdrawn standardization
- More flexible permissions, still fairly Unix-like
- Multiple user and group entries
  - Decision still based on one entry
- Default ACLs: generalize group inheritance
- Command line: `getfacl`, `setfacl`

ACL legacy interactions

- Hard problem: don't break security of legacy code
  - Suggests: "fail closed"
- Contrary pressure: don't want to break functionality
  - Suggests: "fail open"
- POSIX ACL design: old group permission bits are a mask on all novel permissions

“POSIX” “capabilities”

- Divide root privilege into smaller (~35) pieces
- Note: not real capabilities
- First runtime only, then added to FS similar to setuid
- Motivating example: `ping`
- Also allows permanent disabling

Privilege escalation dangers

- Many pieces of the root privilege are enough to regain the whole thing
  - Access to files as UID 0
  - `CAP_DAC_OVERRIDE`
  - `CAP_FOWNER`
  - `CAP_SYS_MODULE`
  - `CAP_MKNOD`
  - `CAP_PTRACE`
  - `CAP_SYS_ADMIN` (`mount`)

Legacy interaction dangers

- Former bug: take away capability to drop privileges
- Use of temporary files by no-longer setuid programs
- For more details: “Exploiting capabilities”, Emeric Nasi

Next time

- Symmetric crypto primitives