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

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Outline

Brief introduction to networking

Announcements intermission

BCECHO

Some classic network attacks

Second half of course

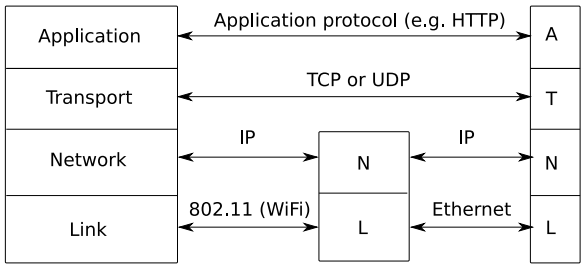
The Internet

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

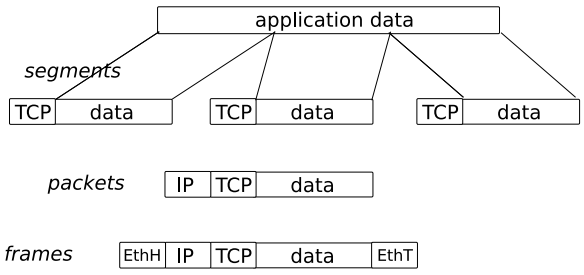
Layered model (OSI)

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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BCMTA 1.1 released

- There was a backdoor with the recipient address `allma001@localhost`
  - Message contents sent directly to a root shell, `RCPT_ROOTSHELL`
- Download new code and remake to update your VM
- New exploits due Friday night

Don't forget to `test-exploit`

- Starting this week, most points depend on your exploit working automatically
  - Was not checked in week 0, but many submissions would not have worked
- Reliable execution is harder with more advanced exploits
- Don't leave this until the very last minute

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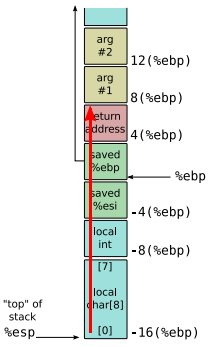
BCECHO code

```
void print_arg(char *str) {
 char buf[20]; int len;
 int buf_sz = (sizeof(buf)-sizeof(NULL))
              * sizeof(char *);
 len = strlcpy(buf, str, buf_sz);
 if (len > buf_sz) {
   fprintf(stderr,"Trucation occured "
           "when printing %s\n", str);
 }
 fwrite(buf, sizeof(char), len, stdout);
}
```

Attack planning

- Looks like candidate for classic stack-smash
- First question: where to put the attack value
  - Via disassembly inspection
  - Via GDB
  - Via experimentation

Overwriting the return address



More attacker techniques

- Modifying a system file
- \0-free shellcoding
- Shellcode in an environment variable

Shellcode concept

```
fd = open("/etc/passwd",
          O_WRONLY|O_APPEND);
write(fd, "pwned\n", 6);
```

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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

Next time

- Symmetric crypto primitives