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

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Review question

What's "common" about the Common Criteria?

A. Every kind of product is evaluated against the same "protection profile."
B. Anyone can perform the certification, without special government approval.
C. The certification applies to devices used in everyday civilian life, rather than in government or the military.
D. A single certification is recognized by the governments of many countries.
E. A single certification can be used for products from different vendors.

Outline

Brief introduction to networking

Announcements intermission

Some classic network attacks

Second half of course

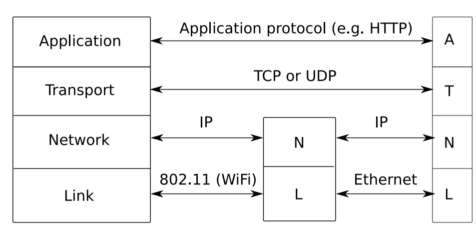
The Internet

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

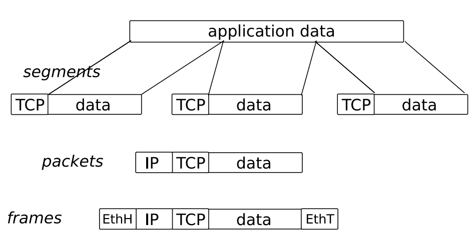
Layered model (OSI)

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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Payment app

```
void payment(char *name, int amount_cny,
             char *purpose, int purpose_len) {
    float amount_usd = amount_cny/6.466;
    char memo[32];
    strcpy(memo, "Payment for: ");
    memcpy(memo + strlen(memo), purpose,
           purpose_len);
    write_check(name, amount_usd, memo);
}
```

Reverse range

```
void reverse_range(int *a, int from,
                   int to) {
    unsigned *p = &a[from];
    unsigned *q = &a[to];
    while (!(p == q + 1 || p == q + 2)) {
        *p += *q;
        *q = *p - *q;
        *p = *p - *q;
        p++; q--;
    } }
```

Multiplication with overflow

- What 32-bit `int`, when multiplied by 7, gives 20?

Exercise Set 2 reminders

- Due 11:59pm tonight
- Different, PDF-based submission on Gradescope
- Unrestricted discussion allowed from Sunday

Midterm exam Monday

- Arrive slightly early to start exam promptly at 2:30pm
- Erasable writing instrument recommended
  - E.g., mechanical pencil with separate eraser
- Write on front sides of pages only
- Open book, notes, printouts, but no electronics
- Today's material is not covered

Sample midterms posted

- For use in studying, I have posted samples of 6 previous midterm exams on the course schedule page
- Will also post corresponding solutions on Friday

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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?

rlogin and reverse DNS

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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 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

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