Last time

- Trusted Operating System Design
  - Security Features
  - Trusted Computing Base
  - Least Privilege in Popular OSs
  - Assurance
- Security in Networks
  - Network Concepts
  - Threats in Networks

This time

- Security in Networks
  - Threats in Networks

Intelligence

- Social Engineering
  - Attacker gathers sensitive information directly from a person
  - Often, attacker pretends to be somebody within the person's organization who has a problem and exploits the person's willingness to help (or vice versa)
    - I forgot my password, I locked myself out, there's a problem with your Paypal account,...
- Dumpster diving
- Eavesdropping on oral communication between people
- Google
  - There's lots of information on the Internet that shouldn't be there
  - The right Google query will find it

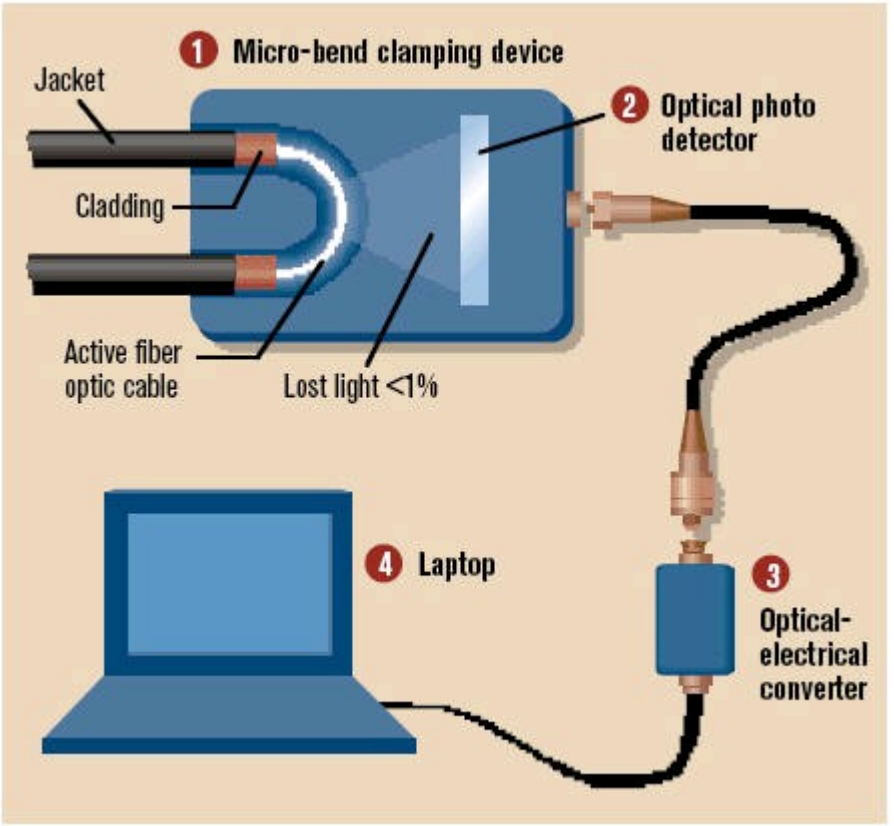
Eavesdropping and Wiretapping

- Owner of node can always monitor communication flowing through node
  - Eavesdropping or passive wiretapping
  - Active wiretapping involves modification or fabrication of communication
- Can also eavesdrop while communication is flowing across a link
  - Degree of vulnerability depends on type of communication medium
- Or when communication is accidentally sent to attacker's node
- It is prudent to assume that your communication is wiretapped

Communication Media

- Copper cable
  - Inductance allows a physically close attacker to eavesdrop without making physical contact
  - Cutting cable and splicing in secondary cable is another option
- Optical fiber
  - No inductance, and signal loss by splicing is likely detectable
  - However, just bending the fiber might work
- Microwave/satellite communication
  - Signal path at receiver tends to be wide, so attacker close to receiver can eavesdrop
- All these attacks are feasible in practice, but require physical expenses/effort

Fiber Tapping



(Sandra Kay Miller, Information Security Magazine, November 2006)

See also http://www.schneier.com/blog/archives/2007/09/eavesdropping_o_1.html

Communication Media (cont.)

- WiFi
  - Can be easily intercepted by anyone with a Wi-Fi-capable (mobile) device
    - Don't need additional hardware, which would cause suspicion
  - Maybe from kilometers away using a directed antenna
  - WiFi also raises other security problems
    - Physical barriers (walls) help against random devices being connected to a wired network, but are (nearly) useless in case of wireless network
    - Need authentication mechanism to defend against free riders

Misdelivered Information

- Local Area Network (LAN)
  - Connects all computers within a company or a university
  - Technical reasons might cause a packet to be sent to multiple nodes, not only to the intended receiver
  - By default, a network card ignores wrongly delivered packets
  - An attacker can change this and use a packet sniffer to capture these packets
- Email
  - Wrongly addressed emails, inadvertent Reply-To-All

Impersonation

- Impersonate a person by stealing his/her password
  - Guessing attack
  - Exploit default passwords that have not been changed
  - Sniff password (or information about it) while it is being transmitted between two nodes
  - Social engineering
- Exploit trust relationships between machines/accounts
  - Rhosts/rlogin mechanism allows user A on machine X to specify that user B on machine Y can act as A on X without having to re-enter password
    - shosts/slogin mechanism is similar
    - Attacker breaking into machine Y can exploit this
    - Or attacker might be able to masquerade as machine Y

Spoofing

- An object (node, person, URL, Web page, email, WiFi access point,…) masquerades as another one
- URL spoofing
  - Exploit typos: www.uwaterlo.ca
  - Exploit ambiguities: www.foobar.com or www.foo-bar.com?
  - Exploit similarities: www.paypa1.com
- Web page spoofing and URL spoofing are used in Phishing attacks
- “Evil Twin” attack for WiFi access points
- Spoofing is also used in session hijacking and man-in-the-middle attacks

Session Hijacking

- TCP protocol sets up state at sender and receiver end nodes and uses this state while exchanging packets
  - e.g., sequence numbers for detecting lost packets
  - Attacker can hijack such a session and masquerade as one of the endpoints
- Web servers sometimes have client keep a little piece of data (“cookie”) to re-identify client for future visits
  - Attacker can sniff or steal cookie and masquerade as client
- Man-in-the-middle attacks are similar; attacker becomes stealth intermediate node, not end node

Traffic Flow Analysis

- Sometimes, the mere existence of communication between two parties is sensitive and should be hidden
  - Whistleblower
  - Military environments
  - Two CEOs
- TCP/IP has each packet include unique addresses for the packet's sender and receiver end nodes
- Attacker can learn these by sniffing packets
- More on protecting yourself from this attack later

Integrity Attacks

- Attacker can modify packets while they are being transmitted
  - Change payload of packet
  - Change address of sender or receiver end node
  - Replay previously seen packets
  - Delete or create packets
- Line noise, network congestion, or software errors could also cause these problems
  - TCP/IP will likely detect environmental problems, but fail in the presence of an active attacker
  - How in the case of TCP's checksumming mechanism?

Integrity Attacks (cont.)

- DNS cache poisoning
  - Domain Name System maps hostnames (www.uwaterloo.ca) to numerical addresses (129.97.128.40), as stored in packets
  - Attacker can create wrong mappings

Protocol Failures

- TCP/IP assumes that all nodes implement protocols faithfully
- E.g., TCP includes a mechanism that asks a sender node to slow down if the network is congested
  - An attacker could just ignore these requests
- Some implementations do not check whether a packet is well formatted
  - E.g., the value in the packet's length field could be smaller than the packet's actual length, making buffer overflow possible
  - Potentially disastrous if all implementations are from the same vendor or based on the same code base
- Protocols can be very complex, behavior in rare cases might not be (uniquely) defined
- Some protocols include broken security mechanisms
  - WEP (see later)

Web Site Vulnerabilities

- Accessing a URL has a web server return HTML code
  - Tells browser how to display web page and how to interact with web server
  - Attacker can examine this code and find vulnerabilities
- Web site defacements
- Attacker crafts malicious URL and sends it to web server
  - to exploit a buffer overflow
  - to invoke a shell or some other program
  - to feed malicious input parameters to a server-side script
  - to access sensitive files
    - E.g., by including "../" in a URL or by composing URLs different from the "allowed ones" in the HTML code

Web Site Vulnerabilities (cont.)

- HTTP protocol is stateless, so web server asks client to keep state when returning a web page and to submit this state when accessing next web page
  - Cookie or URL (http://www.store.com?clientId=4342)
  - Attacker can submit modified state information
- Cross-site scripting (XSS) attacks
  - Attacker adds his/her own HTML code to somebody else's web page
    - E.g., in the comments section of a blog
    - Code could contain a virus
  - Other users download and execute this code when downloading the web page

Denial of Service (DoS)

- Cutting a wire or jamming a wireless signal
- Flooding a node by overloading its Internet connection or its processing capacity
- Ping flood
  - Node receiving a ping packet is expected to generate a reply
  - Attacker could overload victim
  - Different from “ping of death”, which is a malformatted ping packet that crashes victim’s computer
- Smurf attack
  - Spoof address of sender end node in ping packet by setting it to victim’s address
  - Broadcast ping packet to all nodes in a LAN

Denial of Service (cont.)

- Exploit knowledge of implementation details about a node to make node perform poorly
- SYN flood
  - TCP initializes state by having the two end nodes exchange three packets (SYN, SYN-ACK, ACK)
  - Server queues SYN from client and removes it when corresponding ACK is received
  - Attacker sends many SYNs, but no ACKs
- Send packet fragments that cannot be reassembled properly
- Craft packets such that they are all hashed into the same bucket in a hash table

Denial of Service (cont.)

- Black hole attack
  - Routing of packets in the Internet is based on a distributed protocol
  - Each router informs other routers of its cost to reach a set of destinations
  - Malicious router announces low cost for victim destination and discards any traffic destined for victim
  - Has also happened because of router misconfiguration
- DNS attacks
  - DNS cache poisoning can lead to packets being routed to the wrong host

Distributed Denial of Service (DDoS)

- If there is only a single attacking machine, it might be possible to identify the machine and to have routers discard its traffic (see later)
- Difficult if there are lots of attacking machines
- Most might participate without knowledge of their owners
  - Attacker breaks into machines using Trojan, buffer overflow,… and installs malicious software
  - Machine becomes a zombie/bot and waits for attack command from attacker
  - A network of bots is called a botnet
  - How would you turn off a botnet?

Botnets

- Today's botnets are very sophisticated and include
  - Virus/worm/trojan for propagation based on multiple exploits
  - Stealthiness to hide from owner of computer
  - Code morphing to make detection difficult
  - Bot usable for different attacks (spam, DDoS,...)
  - Distributed, dynamic & redundant control infrastructure
- Earlier worms (Nimda, slammer) were written by hackers for fame with the goal to spread worm as fast as possible
  - slammer infected 75,000 hosts in 10 minutes
  - Caused disruption and helped detection

Botnets (cont.)

- Botnets are controlled by hackers looking for profit, which rent them out
  - Criminal organizations
- Spread more slowly, infected machine might lie dormant for weeks
- Currently, Storm Worm botnet is expected to include millions of machines, its processing power likely makes it the world's biggest supercomputer
- We don't know when and for what it will be used and who is behind it

Active Code

- To reduce load on server, server might ask client to execute code on its behalf
  - Java, JavaScript, ActiveX
  - Invoke another application (Word, iTunes,…)
  - Maybe inadvertently (see XSS attack)
- Obviously, this can be dangerous for client
- Java 1.1 ran in a sandbox with limited capabilities, code is checked for correctness
  - No writing to a file, no talking to random network nodes
  - Similar for JavaScript
  - But it could still use up CPU or memory resources, wreak havoc with display, or play annoying music

Active Code (cont.)

- Java 1.2 can break out of sandbox if approved by user
  - What's the problem here?
- ActiveX
  - No sandbox or correctness check
  - Downloaded code is cryptographically signed, signature is verified to be from "trusted" entity before execution
- Third-party applications
  - Turn out to be a huge problem, for all browsers
  - Malicious input parameters, Word macros,…
  - Potentially disastrous if application has full access rights to a user's account

Recap

- Security in Networks
  - Threats in Networks

Next time

- Security in Networks
  - Network Security Controls
  - Firewalls
  - Honeypots
  - Intrusion Detection Systems