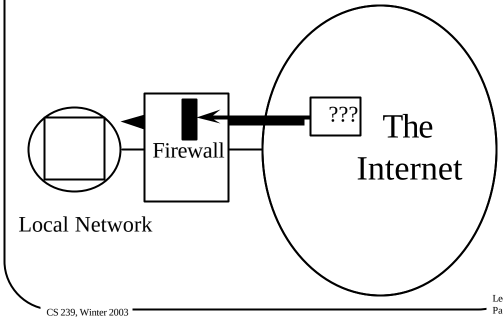
Network Security: Firewalls and Virtual Private Networks
CS 239
Computer Software
March 3, 2003

Firewalls

- "A system or combination of systems that enforces a boundary between two or more networks" - NCSA Firewall Functional Summary
- Usually, a computer that keeps the bad guys out

Typical Use of a Firewall



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The Internet

Firewall

Local Network

What Is a Firewall, Really?

- Typically a machine that sits between a LAN/WAN and the Internet
- Running special software
- That somehow regulates network traffic between the LAN/WAN and the Internet

Firewalls Today

- A standard piece of equipment for all installations that care about security
- At minimum, prevent information coming into a network on "bad" ports
- Often implement ingress/egress filtering
- Many high-quality commercial products available

Types of Firewalls

- Filtering gateways
  - AKA screening routers
- Circuit gateways
  - Also a kind of screening router
- Application level gateways
  - AKA proxy gateways
- Hybrid (complex) gateways

Filtering Gateways

- Based on packet routing information
- Look at information in the incoming packets’ headers
- Based on that information, either let the packet through or reject it

Example Use of Filtering Gateways

- Allow particular external machines to telnet into specific internal machines
  - Denying telnet to other machines
- Or allow full access to some external machines
- And none to others

A Fundamental Problem

- Today’s IP packet headers aren’t authenticated
  - And are pretty easy to forge
- If your filtering firewall trusts packet headers, it offers little protection
- Situation may be improved by IPSEC
  - But hasn’t been yet

Filtering Based on Ports

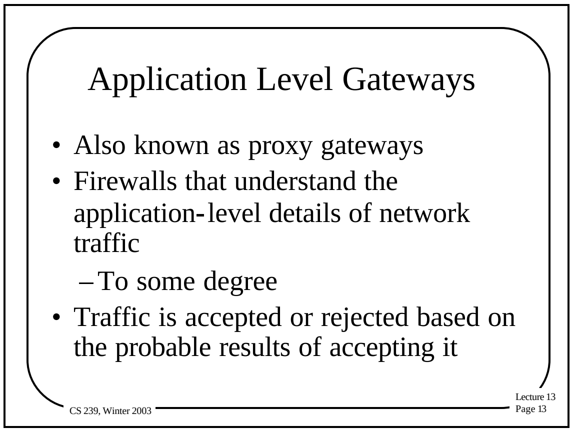
- Most incoming traffic is destined for a particular machine and port
  - Which can be derived from the IP and TCP headers
- Only let through packets to select machines at specific ports
- Makes it impossible to externally exploit flaws in little-used ports
  - If you configure the firewall right . . .

Pros and Cons of Filtering Gateways

+ Fast
+ Cheap
+ Flexible
+ Transparent
– Limited capabilities
– Dependent on header authentication
– Generally poor logging
– May rely on router security

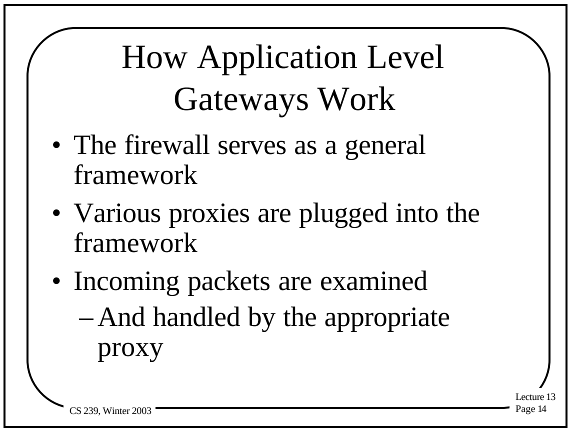
Circuit Gateways

- Another kind of filtering firewall
- Used when internal machines request service from machines outside the firewall
- Makes it look like the request came from the firewall
  - Concealing internal system details



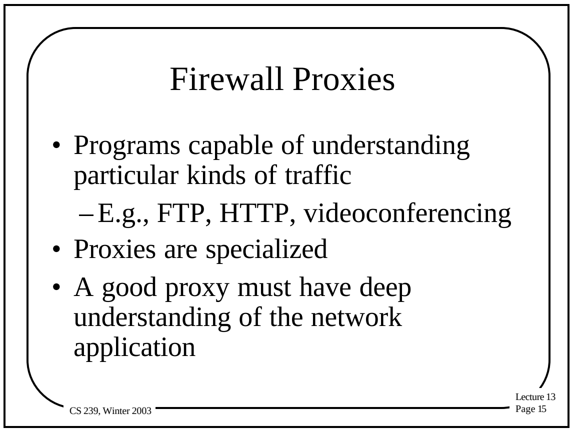
Application Level Gateways

- Also known as proxy gateways
- Firewalls that understand the application-level details of network traffic
  - To some degree
- Traffic is accepted or rejected based on the probable results of accepting it



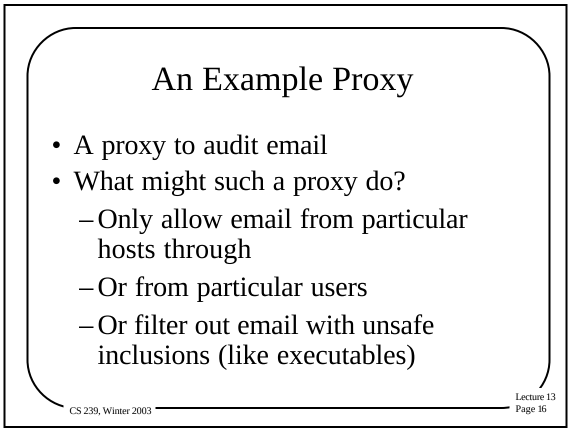
How Application Level Gateways Work

- The firewall serves as a general framework
- Various proxies are plugged into the framework
- Incoming packets are examined
  - And handled by the appropriate proxy



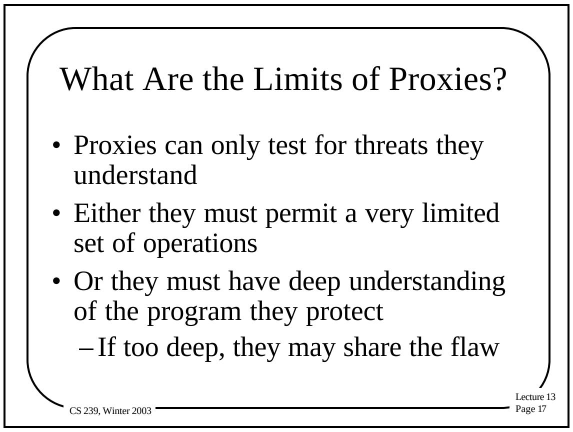
Firewall Proxies

- Programs capable of understanding particular kinds of traffic
  - E.g., FTP, HTTP, videoconferencing
- Proxies are specialized
- A good proxy must have deep understanding of the network application



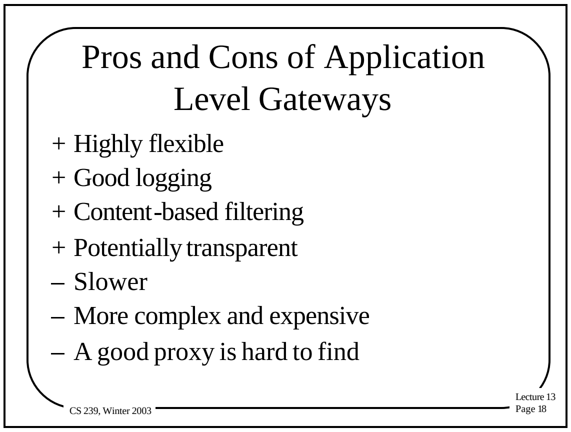
An Example Proxy

- A proxy to audit email
- What might such a proxy do?
  - Only allow email from particular hosts through
  - Or from particular users
  - Or filter out email with unsafe inclusions (like executables)



What Are the Limits of Proxies?

- Proxies can only test for threats they understand
- Either they must permit a very limited set of operations
- Or they must have deep understanding of the program they protect
  - If too deep, they may share the flaw



Pros and Cons of Application Level Gateways

+ Highly flexible
+ Good logging
+ Content-based filtering
+ Potentially transparent
– Slower
– More complex and expensive
– A good proxy is hard to find

Hybrid Gateways

- A combination of two or more other types
  - Typically filtering gateways and proxy gateways
- Are they better?
  - If in parallel, no
  - If in series, maybe

Firewall Characteristics

- Statefulness
- Transparency
- Firewalls and authentication
- Firewalls and encryption
- Firewalls and viruses

Stateful Firewalls

- Much network traffic is connection-oriented
  - E.g., telnet and videoconferencing
- Proper handling of that traffic requires the firewall to maintain state
- But handling information about connections is more complex

Firewalls and Transparency

- Ideally, the firewall should be invisible
  - Except when it vetoes access
- Users inside should be able to communicate outside without knowing about the firewall
- External users should be able to invoke internal services transparently

Firewalls and Authentication

- Many systems want to allow specific sites or users special privileges
- Firewalls can only support that to the extent that strong authentication is available
  - At the granularity required
- For general use, may not be possible
  - In current systems

Firewalls and Encryption

- Firewalls provide no confidentiality
  - For data they pass back and forth
- Unless the data is encrypted
- But if the data is encrypted, the firewall can’t examine it
- So typically the firewall must be able to decrypt
  - Or only work on unencrypted parts of packets

Firewalls and Link Encryption

- Inter-firewall encryption is essentially link level encryption
  - With all inherent problems
  - Except (presumably) that only trusted machines encrypt and decrypt
- More encryption can be applied at the application level
  - Limiting the firewall’s options

Firewalls and Viruses

- Firewalls are an excellent place to check for viruses
- Virus detection software can be run on incoming executables
- Requires that firewall knows when executables come in
- And must be reasonably fast

Firewall Configuration and Administration

- Again, the firewall is the point of attack for intruders
- Thus, it must be extraordinarily secure
- How do you achieve that level of security?

Firewall Hardening

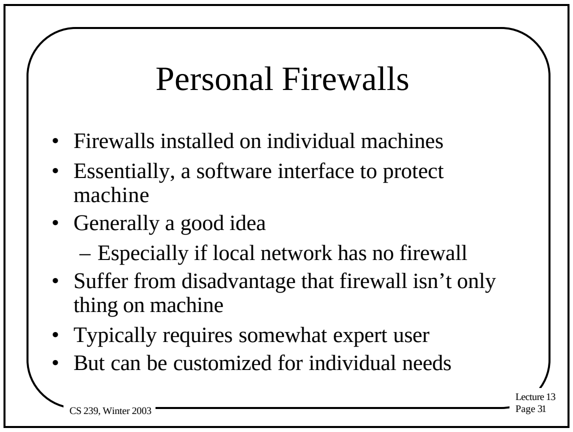
- Devote a special machine only to firewall duties
- Alter OS operations on that machine
  - To allow only firewall activities
  - And to close known vulnerabilities
- Strictly limit access to the machine
  - Both login and remote execution

Firewalls and Logging

- The firewall is the point of attack for intruders
- Logging activities there is thus vital
- The more logging, the better
- Should log what the firewall allows
- And what it denies
- Tricky to avoid information overload

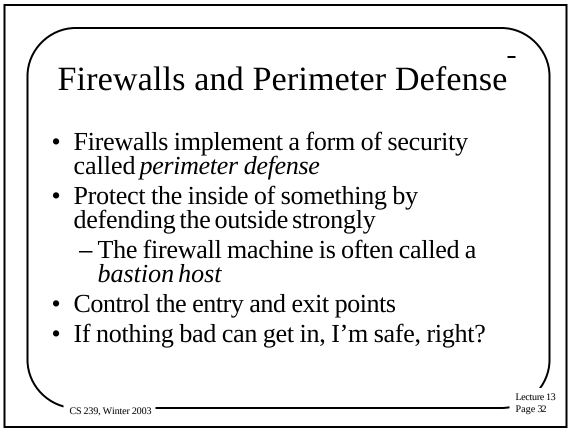
Closing the Back Doors

- Firewall security is based on assumption that all traffic goes through the firewall
- So be careful with:
  - Modem connections
  - Wireless connections
  - Portable computers
- Put a firewall at every entry point to your network
- And make sure all your firewalls are up to date



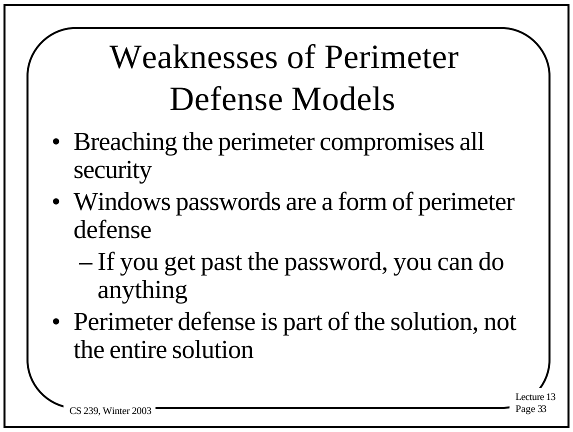
Personal Firewalls

- Firewalls installed on individual machines
- Essentially, a software interface to protect machine
- Generally a good idea
  - Especially if local network has no firewall
- Suffer from disadvantage that firewall isn't only thing on machine
- Typically requires somewhat expert user
- But can be customized for individual needs



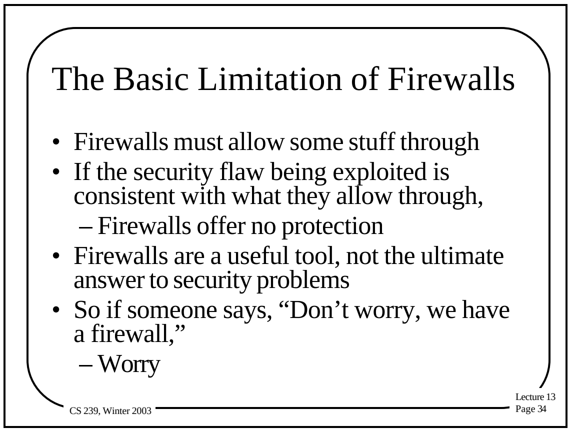
Firewalls and Perimeter Defense

- Firewalls implement a form of security called *perimeter defense*
- Protect the inside of something by defending the outside strongly
  - The firewall machine is often called a *bastion host*
- Control the entry and exit points
- If nothing bad can get in, I'm safe, right?



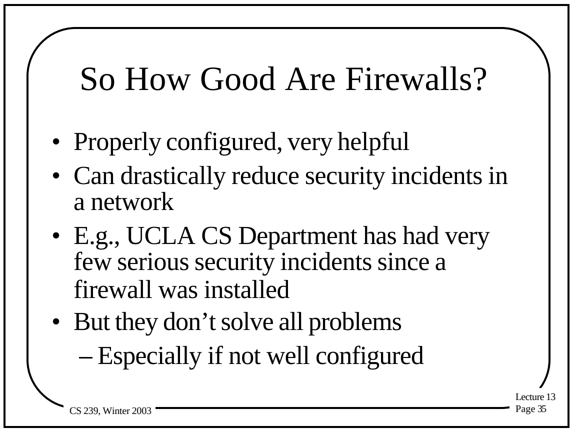
Weaknesses of Perimeter Defense Models

- Breaching the perimeter compromises all security
- Windows passwords are a form of perimeter defense
  - If you get past the password, you can do anything
- Perimeter defense is part of the solution, not the entire solution



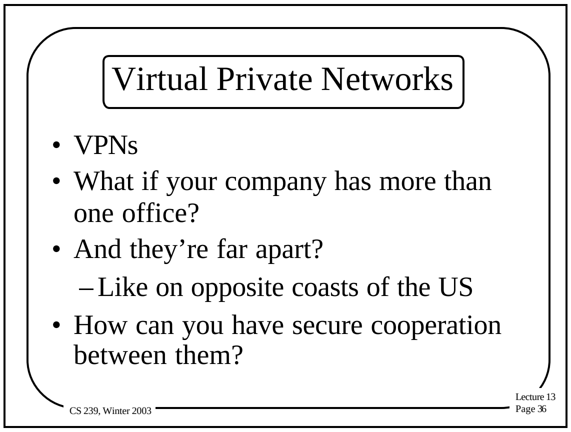
The Basic Limitation of Firewalls

- Firewalls must allow some stuff through
- If the security flaw being exploited is consistent with what they allow through,
  - Firewalls offer no protection
- Firewalls are a useful tool, not the ultimate answer to security problems
- So if someone says, "Don't worry, we have a firewall,"
  - Worry



So How Good Are Firewalls?

- Properly configured, very helpful
- Can drastically reduce security incidents in a network
- E.g., UCLA CS Department has had very few serious security incidents since a firewall was installed
- But they don't solve all problems
  - Especially if not well configured



Virtual Private Networks

- VPNs
- What if your company has more than one office?
- And they're far apart?
  - Like on opposite coasts of the US
- How can you have secure cooperation between them?

Hope For the Best

- Internet lines aren’t easy to tap
  - Though redirecting traffic is sometimes possible
- Backbone carriers are probably trustworthy
- Most traffic isn’t that important
- Maybe just encrypt the critical stuff?

Leased Line Solutions

- Lease private lines from some telephone company
- The phone company ensures that your lines cannot be tapped
  - To the extent you trust in phone company security
- Can be expensive and limiting

Another Solution

- Communicate via the Internet
  - Getting full connectivity, bandwidth, reliability, etc.
  - At a lower price, too
- But how do you keep the traffic secure?
- Encrypt everything!

Encryption and Virtual Private Networks

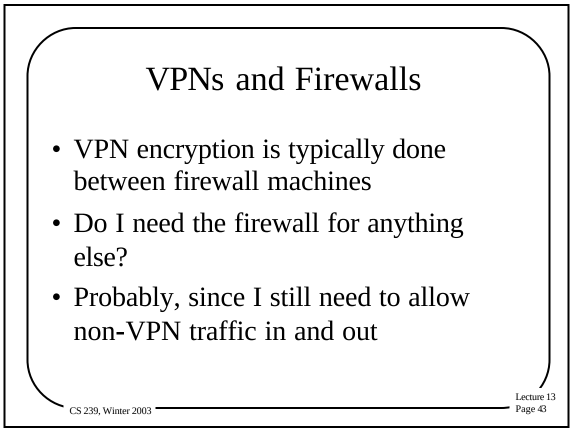
- Use encryption to convert a shared line to a private line
- Set up a firewall at each installation’s network
- Set up shared encryption keys between the firewalls
- Encrypt all traffic using those keys

Is This Solution Feasible?

- A VPN can be half the cost of leased lines (or less)
- And give the owner more direct control over the line’s security
- IPsec might make deployment and interoperation easy

Key Management and VPNs

- All security of the VPN relies on key secrecy
- How do you communicate the key?
  - In early implementations, manually
  - Modern VPNs use something like IKE
- How often do you change the key?
  - IKE allows frequent changes



VPNs and Firewalls

- VPN encryption is typically done between firewall machines
- Do I need the firewall for anything else?
- Probably, since I still need to allow non-VPN traffic in and out