# COMP 424
# Computer System Security

11/08/16
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# *Security in Networks*

# Some Important Network Characteristics for Security

- Degree of locality
- Media used
- Protocols used

# Degree of Locality

- Some networks are very local
  - E.g., an Ethernet
  - Benefits from:
    - Physical locality
    - Small number of users and machines
    - Common goals and interests
- Other networks are very non-local
  - E.g., the Internet backbone
  - Many users/sites share bandwidth

# Network Media

- Some networks are wires, cables, or over telephone lines
  - Can be physically protected
- Other networks are satellite links or other radio links
  - Physical protection possibilities more limited

# Protocol Types

- TCP/IP is the most used
  - But it only specifies some common intermediate levels
  - Other protocols exist above and below it
- In places, other protocols replace TCP/IP
- And there are lots of supporting protocols
  - Routing protocols, naming and directory protocols, network management protocols
  - And security protocols (IPSec, ssh, ssl)

# Implications of Protocol Type

- The protocol defines a set of rules that will always be followed
  - But usually not quite complete
  - And they assume everyone is at least trying to play by the rules
  - What if they don't?
- Specific attacks exist against specific protocols

# Threats To Networks

- Wiretapping
- Impersonation
- Attacks on message
  - Confidentiality
  - Integrity
- Denial of service attacks

# Wiretapping

- **Passive wiretapping** is listening in illicitly on conversations
- **Active wiretapping** is injecting traffic illicitly
- **Packet sniffers** can listen to all traffic on a broadcast medium
  - Ethernet or 802.11, e.g.
- Wiretapping on wireless often just a matter of putting up an antenna

# Impersonation

- A packet comes in over the network
  - With some source indicated in its header
- Often, the action to be taken with the packet depends on the source
- But attackers may be able to create packets with false sources

# Violations of Message Confidentiality

- Other problems can cause messages to be inappropriately divulged
- Misdelivery can send a message to the wrong place
  - Clever attackers can make it happen
- Message can be read at an intermediate gateway or a router
- Sometimes an intruder can get useful information just by traffic analysis

# Traffic Analysis

- ***Traffic analysis*** is the process of intercepting and examining messages in order to deduce information from patterns in communication. It can be performed even when the messages are encrypted and cannot be decrypted.

# Message Integrity

- Even if the attacker can't create the packets he wants, sometimes he can alter proper packets
- To change the effect of what they will do
- Typically requires access to part of the path message takes

# Denial of Service

- Attacks that prevent legitimate users from doing their work
- By flooding the network
- Or corrupting routing tables
- Or flooding routers
- Or destroying key packets

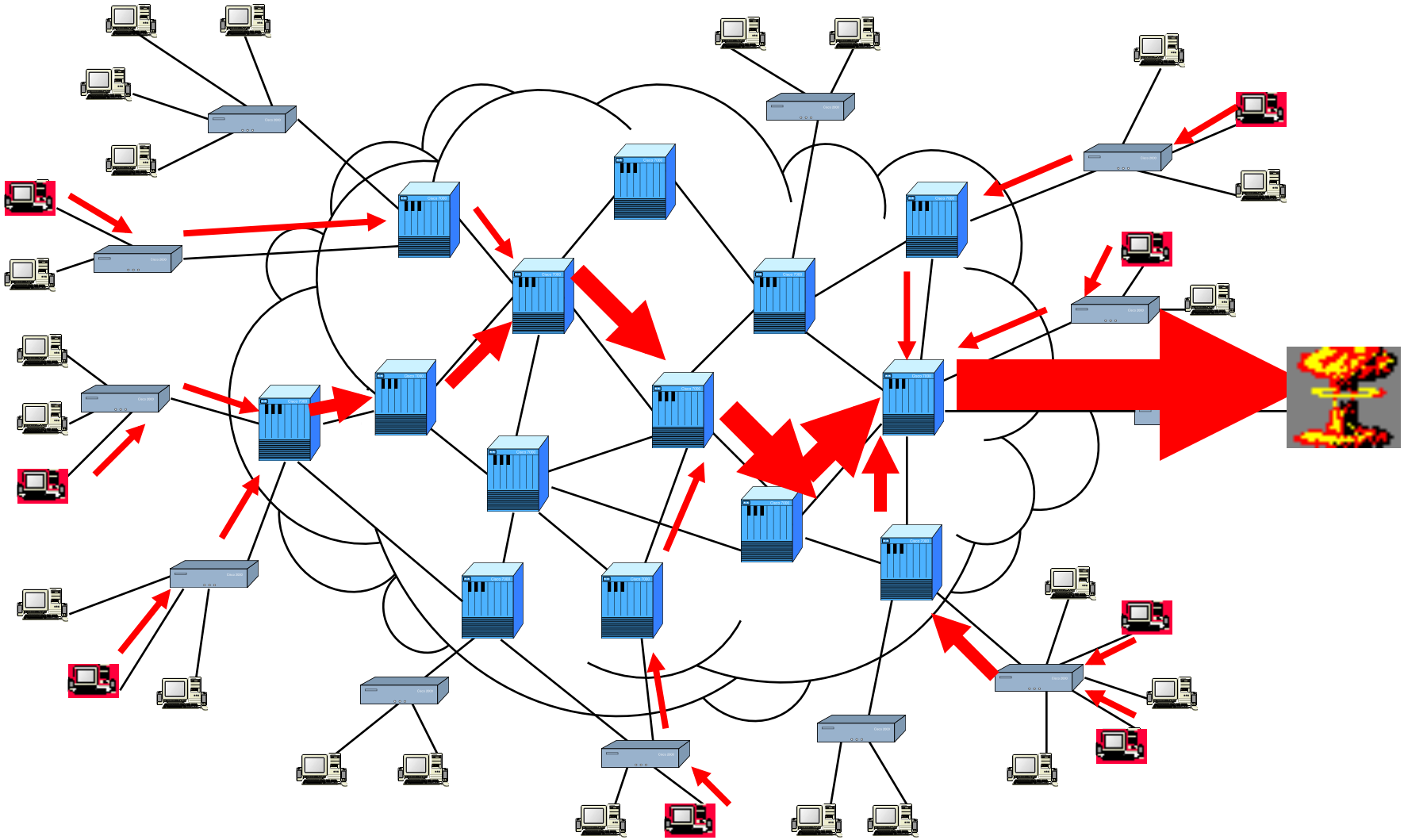
# How Do Denial of Service Attacks Occur?

- Basically, the attacker injects some form of traffic
- Most current networks aren't built to throttle uncooperative parties very well
- All-inclusive nature of the Internet makes basic access trivial
- Universality of IP makes reaching most of the network easy

# Distributed Denial of Service Attacks

- Goal: Prevent a network site from doing its normal business
- Method: overwhelm the site with attack traffic
- Response: ?

# The Problem



# Why Are These Attacks Made?

- Generally to annoy
- Sometimes for extortion
- Sometimes to prevent adversary from doing something important
- If directed at infrastructure, might cripple parts of Internet

# Attack Methods

- Pure flooding
  - Of network connection
  - Or of upstream network
- Overwhelm some other resource
  - SYN flood
  - CPU resources
  - Memory resources
  - Application level resource

# Why “Distributed”?

- Targets are often highly provisioned servers
- A single machine usually cannot overwhelm such a server
- So harness multiple machines to do so
- Also makes defenses harder

# How to Defend?

- A vital characteristic:
  - Don’t just stop a flood
  - ENSURE SERVICE TO LEGITIMATE CLIENTS!!!
- If you deliver a manageable amount of garbage, you haven’t solved the problem
- Nor have you if you prevent a flood by dropping all packets

# Complicating Factors

- High availability of compromised machines
  - Millions of zombie machines out there
- Internet is designed to deliver traffic
  - Regardless of its value
- IP spoofing allows easy hiding
- Distributed nature makes legal approaches hard
- Attacker can choose all aspects of his attack packets
  - Can be a lot like good ones

# Traffic Control Mechanisms

- Filtering
  - Source address filtering
  - Other forms of filtering
- Rate limits
- Protection against traffic analysis
  - Padding
  - …

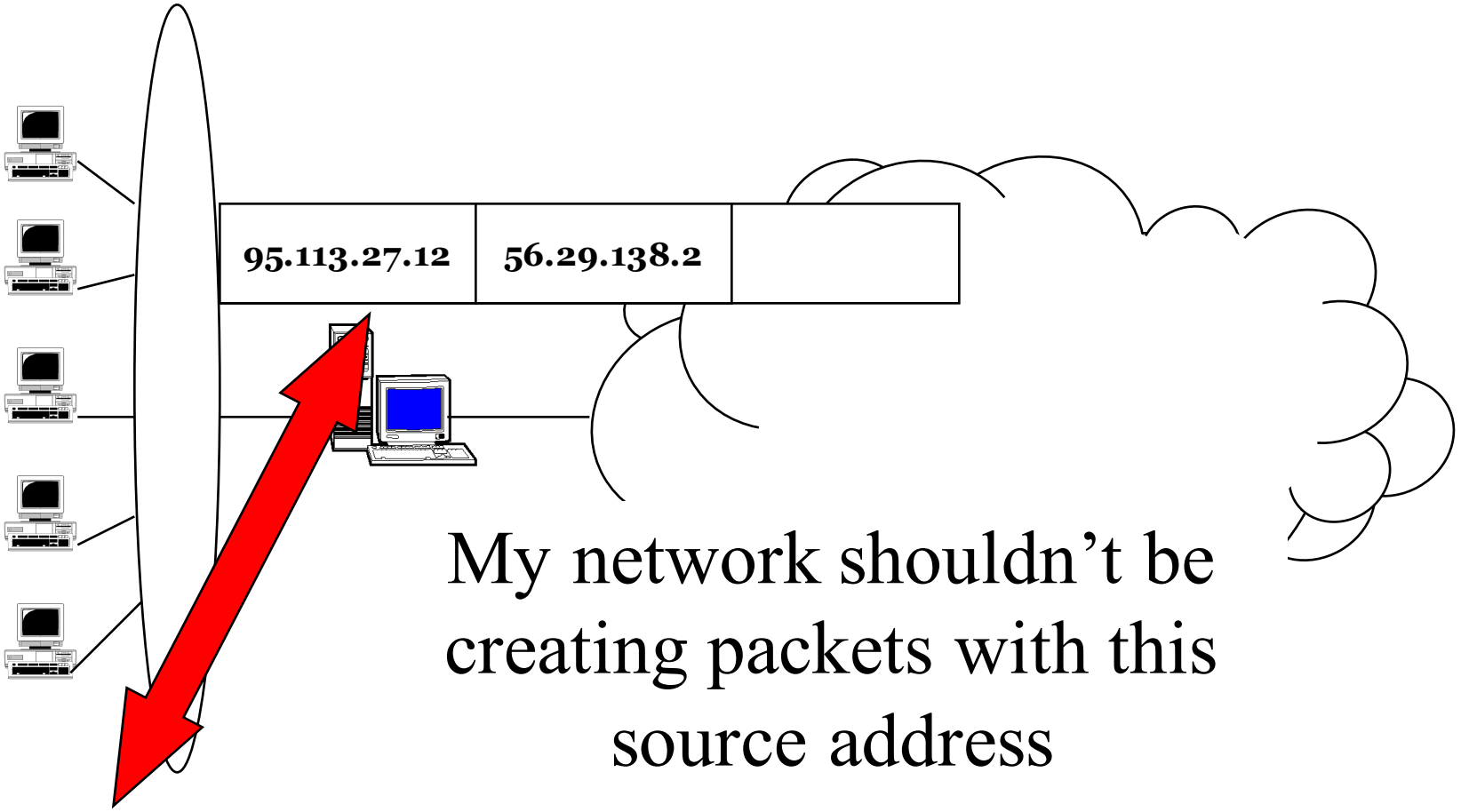
# Source Address Filtering

- Filtering out some packets because of their source address value
  - Usually because you believe their source address is spoofed
- Often called ingress filtering
  - Or egress filtering . . .

# Source Address Filtering for Address Assurance

- Router "knows" what network it sits in front of
  - In particular, knows IP addresses of machines there
- Filter outgoing packets with source addresses not in that range
- Prevents your users from spoofing other nodes' addresses
  - But not from spoofing each other's

# Source Address Filtering Example



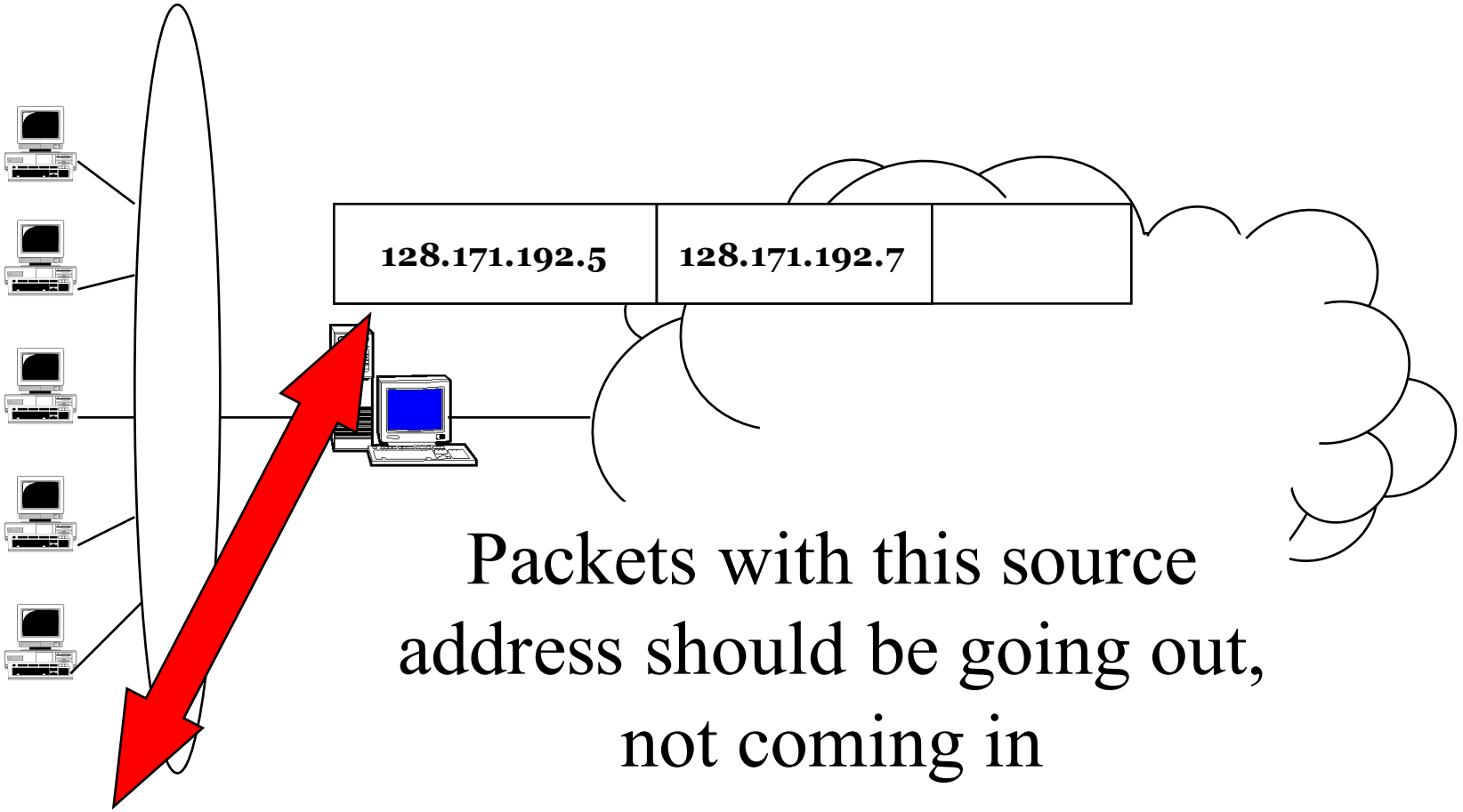

My network shouldn't be creating packets with this source address

So drop the packet

# Source Address Filtering in the Other Direction

- Often called egress filtering
  - Or ingress filtering . . .
- Occurs as packets leave the Internet and enter a border router
  - On way to that router's network
- What addresses shouldn't be coming into your local network?

# Filtering Incoming Packets




Packets with this source address should be going out, not coming in

So drop the packet

# Other Forms of Filtering

- One can filter on things other than source address
  - Such as worm signatures, unknown protocol identifiers, etc.
- Also, there are unallocated IP addresses in IPv4 space
  - Can filter for packets going to or coming from those addresses
- Some source addresses for local use only
  - Internet routers can drop packets to/from them

# Realistic Limits on Filtering

- Little filtering possible in Internet core
  - Packets being handled too fast
  - Backbone providers don't want to filter
  - Damage great if you screw it up
- Filtering near edges has its own limits
  - In what's possible
  - In what's affordable
  - In what the router owners will do

# Rate Limits

- Many routers can place limits on the traffic they send to a destination
- Ensuring that the destination isn't overloaded
  - Popular for denial of service defenses
- Limits can be defined somewhat flexibly
- But often not enough flexibility to let the good traffic through and stop the bad

# Padding

- Sometimes you don't want intruders to know what your traffic characteristics are
- Padding adds extra traffic to hide the real stuff
- Fake traffic must look like real traffic
  - Usually means encrypt it all
- Must be done carefully, or clever attackers can tell the good stuff from the noise

# Firewalls

- What is a firewall?
- A machine to protect a network from malicious external attacks
- Typically a machine that sits between a LAN/WAN and the Internet
- Running special software to regulate network traffic

# 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

# Defense in Depth

- An old principle in warfare
- Don’t rely on a single defensive mechanism or defense at a single point
- Combine different defenses
- Defeating one defense doesn’t defeat your entire plan

# So Are Firewalls Any Use?

- Definitely!
- They aren't the full solution, but they are absolutely part of it
- Anyone who cares about security needs to run a decent firewall
- They just have to do other stuff, too

# The Brass Tacks of Firewalls

- What do they really do?
- Examine each incoming packet
- Decide to let the packet through or drop it
  - Criteria could be simple or complex
- Perhaps log the decision
- Maybe send rejected packets elsewhere
- Pretty much all there is to it

# Types of Firewalls

- Filtering gateways
  - AKA screening routers
- Application level gateways
  - AKA proxy gateways
- Reverse firewalls

# Filtering Gateways

- Based on packet header information
  - Primarily, IP addresses, port numbers, and protocol numbers
- Based on that information, either let the packet through or reject it
- *Stateless* firewalls

# 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

- IP addresses can be spoofed
- If your filtering firewall trusts packet headers, it offers little protection
- Situation may be improved by IPsec
  - But hasn't been yet
- Firewalls can perform the ingress/egress filtering discussed earlier

# 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
- – Generally poor logging

# 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
- *Stateful* firewalls

# How Application Level Gateways Work

- The firewall serves as a general framework
- Various proxies are plugged into the framework
- Incoming packets are examined
  - Handed to the appropriate proxy
- Proxy typically accepts or rejects

# Deep Packet Inspection

- Another name for typical activity of application level firewalls
- Looking into packets beyond their headers
  - Especially the IP header
- “Deep” sometimes also means deeper understanding of what’s going on
  - Though not always

# Firewall Proxies

- Programs capable of understanding particular kinds of traffic
  - E.g., FTP, HTTP, videoconferencing
- Proxies are specialized
- A good proxy has deep understanding of the network application
- Typically limited by complexity and performance issues

# Pros and Cons of Application Level Gateways

+ Highly flexible
+ Good logging
+ Content-based filtering
+ Potentially transparent
– Slower
– More complex and expensive

# Reverse Firewalls

- Normal firewalls keep stuff from the outside from getting inside
- Reverse firewalls keep stuff from the insider from getting outside
- Often colocated with regular firewalls
- Why do we need them?

# Possible Uses of Reverse Firewalls

- Concealing details of your network from attackers
- Preventing compromised machines from sending things out
  - E.g., intercepting bot communications or stopping DDoS
  - Preventing data exfiltration

# Firewall Characteristics

- Statefulness
- Transparency
- Handling authentication
- Handling encryption

# 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 Encryption

- Firewalls provide no confidentiality
- 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
- Can decrypt, analyze, and re-encrypt