Network Security
CS 239
Computer Software
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Outline

- Basics of network security
- Definitions
- Sample attacks
- Defense mechanisms

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
  - Only handles a small number of machines, mostly related ones
- Other networks are very non-local
  - E.g., the Internet backbone
  - Vast numbers of users/sites share bandwidth

Implications of Locality

- Truly local networks may gain from physical security
- Relative trustworthiness of all participants may help
- Common interests of all on a local network may be helpful, too
- Wide area networks generally harder

Network Media

- Some networks are wires or cables
- Other networks run over the telephone lines
- Other networks are radio links to satellites
- Other networks are broadcast radio links

Implications of Media Type

- Wires can sometimes be physically protected
- Radio links generally can't
  - Though power and technology requirements for satellite links may provide some help

Protocol Types

- TCP/IP is probably the most widespread
  - But it only specifies some common intermediate levels
  - Other protocols exist above and below it
- And, in places, other protocols replace TCP/IP
- And there are lots of supporting protocols
  - Routing protocols, naming and directory protocols, network management protocols

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 Network Security

- Pretty much the usual suspects:
  - Wiretapping
  - Impersonation
  - Message confidentiality
  - Message integrity
  - Denial of service

Why Are Networks Especially Threatened?

- Many "moving parts"
- Many different administrative domains
- Everyone can get some access
- In some cases, trivial for attacker to get a foothold on the network
- Networks encourage sharing
- Networks often allow anonymity

What Can Attackers Attack?

- The media connecting the nodes
- Nodes that are connected to them
- Routers that control the traffic
- The protocols that set the rules for communications

Wiretapping

- An obvious network vulnerability
  - But don't forget, "wiretapping" is a general term
    - Not just networks are vulnerable
- **Passive wiretapping** is listening in illicitly on conversations
- **Active wiretapping** is injecting traffic illicitly

Wiretapping on Wires

- Signals can be trapped at many points
- Actually tapping into some physical wires is possible
- Other "wires" are broadcast media
  - **Packet sniffers** can listen to all traffic
- Subverted routers and gateways also offer access

Wiretapping on Wireless

- Often just a matter of putting an antenna up
  - Though position may matter a lot
  - Generally not even detectable that it's happening
- Active threats are easier to detect
  - And, for satellites, technically challenging

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

Methods of Network Impersonations

- Even in standard protocols, often easy to change fields in a header
  - When created or later
  - E.g., IP allows forging "from" addresses
- Existing networks have little or no built-in authentication

Authentication to Foil Impersonation

- Higher level protocols often require authentication of transmissions
- Much care required to ensure proper authentication
- And not having authentication underneath can cause many problems
- Authentication schemes are rarely perfect

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

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

Methods of Attacks on Message Integrity

- Replacing part of a packet
- Changing headers to alter destination of a packet
  - Or its source
- Inserting improper packets into a proper packet stream

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

Some Sample Attacks

- Smurf attacks
- SYN flood
- Ping of Death

Smurf Attacks

- Attack on vulnerability in IP broadcasting
- Send a ping packet to IP broadcast address
  - With forged "from" header of your target
- Resulting in a flood of replies from the sources to the target
- Easy to fix at the intermediary
  - Don't allow IP broadcasts to originate outside your network
- No good solutions for victim

SYN Flood

- Based on vulnerability in TCP
- Attacker uses initial request/response to start TCP session to fill a table at the server
- Preventing new real TCP sessions
- SYN cookies and firewalls with massive tables are possible defenses

Normal SYN Behavior

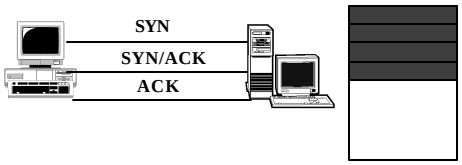
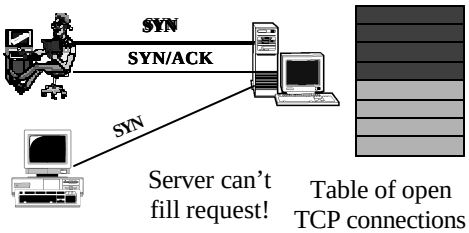


Table of open TCP connections

A SYN Flood

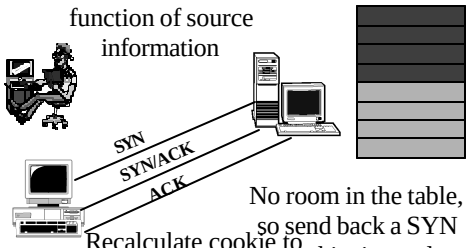


Server can't fill request!

Table of open TCP connections

SYN Cookies

SYN/ACK number is function of source information



No room in the table, so send back a SYN cookie, instead

Recalculate cookie to determine if proper response

The Ping of Death

- IP packets are supposed to be no longer than 65,535 bytes long
- Can improperly send longer IP packets
- Some OS networking software wasn't prepared for that
  - Resulting in buffer overflows and crashes
- Can filter out pings, but other IP packets can also cause problem
- OS patches really solve the problem

Network Security Mechanisms

- Again, the usual suspects -
  - Encryption
  - Authentication
  - Access control
  - Data integrity mechanisms
  - Traffic control

Encryption for Network Security

- Relies on the kinds of encryption algorithms and protocols discussed previously
- But network security tends to only worry about the data transport issues
- Which leads to an important question -

Authentication for Network Security

- Various entities need to be authenticated
  - Hosts to hosts
  - Users to hosts
  - Hosts to users
- Because of inherent insecurities of networks, cryptographic methods used

Access Control

- When a node is put on a network, potentially all its resources become available over the network
- How do we control who can access resources?
- And how?

Data Integrity Mechanisms

- Bad things can happen if attackers can change data values
  - Either while in transit in the net
  - Or by remotely accessing a machine
- How do we keep our data intact?

Checksums, Secure Hashes, and Digital Signatures

- Checksums can tell us if the data has changed
  - If the checksum hasn't been altered
- Secure hashes use cryptographic techniques
  - If the hash is protected
- Digital signatures provide full protection
  - At full cryptographic costs

Traffic Control Mechanisms

- Filtering
  - Ingress filtering
  - Egress filtering
- Protection against traffic analysis
  - Padding
  - Routing control
- Rate Limits

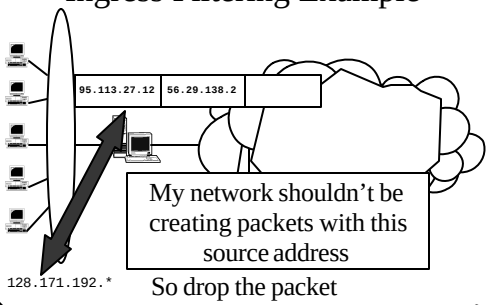
Ingress Filtering

- Different definitions apply
- Most common one is that ingress filtering is done as packets leave local networks and enter the Internet
- Can be filtered in various ways

Ingress Filtering for Address Assurance

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

Ingress Filtering Example



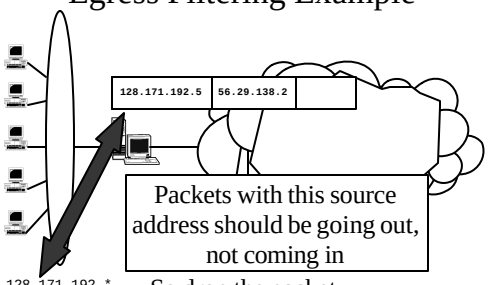
Egress Filtering

- Again, definitions vary
- Most common definition is that egress filtering occurs as packets leave the Internet and enter a border router
  - On way to that router's network
- Again, can filter on multiple criteria

Egress Filtering for Address Assurance

- Packets coming from outside your router shouldn't have source addresses of your local network
- Filter any that do
- If local network performs some access control based on IP address, very important

Egress Filtering Example



Padding

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

Routing Control

- Use ability to control message routing to conceal the traffic in the network
- Especially important when trying to handle **covert channels**
  - Encapsulated users or programs trying to leak information out

Rate Limits

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