Network Security

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- Common Network Attacks
- Security techniques: passwords, hash functions, one-time passwords, digital signatures, symmetric/asymmetric key cryptography
- IPSec, SSL, Kerberos, S/Key, (+ mention of PAP, CHAP, RADIUS, TACACS)
- Firewalls

Common Network Attacks

- ***Sniffing/Snooping* - Monitoring the network for sensitive data and passwords**
- ***Message Replays* - Sending a message repeatedly to a receiver ("replay attack")**
- ***Message Alteration* - Modifying a message and sending**
- ***Message Delay and Denial* - Lowering or removing quality of service in a network (AKA Denial-of-service)**
- ***Spoofing* - Making a packet appear to come from a location other than the one from which it was sent**

Common Network Attacks

- *SYN flooding*:

1 Z(x) ---SYN---> A ...
2 X<---SYN/ACK--- A …
3 X <---RST--- A

- **1) Attacking host sends a multitude of SYN requests to fill it's backlog queue with pending connections.**
- **2) The target responds with SYN/ACKs to what it believes is the source of the incoming SYNs. All further requests to this TCP port will be ignored. The target port is flooded.**

Common Network Attacks

- *Avarice* - a SYN,RST generator designed to disallow any TCP traffic on an Ethernet segment.
  - 1) Listen for the 3-way handshake procedure to begin
  - 2) When one is detected, immediately generate a forged RST packet and sends it back to the client
- The result is that no TCP based connections can be negotiated, and therefore no TCP traffic can flow.

Common Network Attacks

- *Sloth* - a zero TCP window generator
- 1) Detect a connection
- 2) Transmits a spoofed TCP zero-size window advertisement,
- 3) Host stops sending data, and start sending window probes
- 3) Constantly return zero-size windows

Common Network Attacks

- *Land Attack* - sends a spoofed packet with the SYN flag from the same IP and port number as the destination
- *La Tierra* - Sends the same packet used in a land attack but to more than one port and it doesn't matter (on some systems, esp. NT) if the port is opened or closed

Security Requirements

- Authentication - establishing proof of identity
- Access Control - regulating access to some object (also called "authorization")
- Integrity - detecting that the data is not tampered with.
- Confidentiality - maintaining the privacy of sensitive data
- Non-repudiation - ability to prove that the sender actually sent the data

Authentication techniques

- Weak: clear-text password
- Strong: don't send secrets on the wire
  - One-time password (Eg: S/Key. RFC 2289)
    - User remembers secret pass-phrase.
    - Server issues a challenge (random #)
    - User applies hash function to it multiple times to generate a new password.
  - Simple challenge-response: (Eg: CHAP):
    - Server encrypts a random number based upon the user's password ("challenge")
    - User decrypts & returns result ("response")

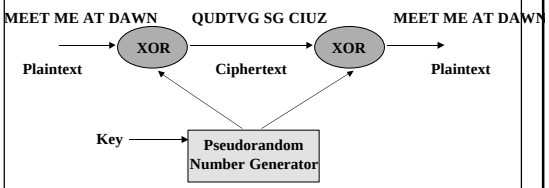
Authentication & authorization

- CHAP: also allows server-controlled "re-authentication"
- Kerberos: single sign-on to multiple servers
- Alt: digital signatures (discussed later): authenticates every message.
- Authorization:
  - Which resources can this user access ?
  - Achieved using "access control lists" (ACLs) stored in database or directory
- Client-server rather than peer-peer for better manageability (eg: RADIUS vs CHAP/PAP)

Encryption techniques

- Symmetric encryption: (Eg: DES, RC-4)
  - Share a secret ("key")
  - Encrypt text based upon the shared secret
  - Longer key (eg: 128-bits) => more secure
  - Advantages: Less CPU intensive
    - Provides integrity verification and privacy
  - Disadvantages:
    - Keys have to somehow reach receivers
    - Need one key for every receiver
    - Need separate authentication infrastructure

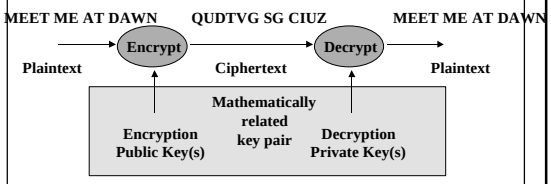
Symmetric Key Cryptography



Public Key Encryption (PKE)

- Asymmetric ("Public-key Encryption")
  - Eg: RSA, Diffie-Hellman
  - Public key; Private key
  - Data -> Public key -> private key -> Data
  - Use receiver's public key to encrypt and send data to receiver ("body")

Public Key Cryptography



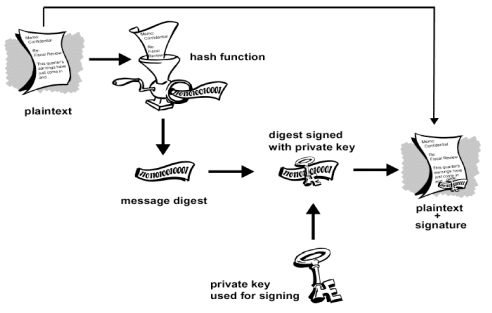
PKE (continued)

- Authentication => verify ownership of private key. Encrypt message with *sender's private* key ("signature")
- Problems:
  - Extremely CPU intensive, and slow
  - Need to secure private keys

Hash Functions, Message Digests, Digital Signatures

- Problem: The private-key based "signature" is too slow to generate & is a lot of overhead
- Solution:
  - 1. Convert the message into a smaller-sized, tough-to-guess numeric value using a "one-way hash function" (eg: MD5, SHA)
  - 2. This numeric value (16-32 bytes) is called a "message digest" or a Message Authentication Code (MAC)

Digital signatures (Contd)



Digital signatures (Contd)

- 3. Encrypt the MAC with the private key to create a "digital signature"
- 4. Receiver re-generates MAC, decrypts digital signature and compares to authenticate

PKE (contd)

- PKE slow => the text of the message is encrypted using symmetric encryption (eg: DES): integrity and confidentiality
  - Append digital signature for authentication & non-repudiation
- Another problem with PKE:
  - Anyone can create a new public key and advertise it as belonging to a third-party.
  - Need to authenticate advertiser of public key, and later verify that the sender indeed has the corresponding private key

X.509 and Certificate Authorities (CAs)

- Solution:
  - Have a trusted third-party ("certificate authority" (CA)) authenticate the advertisement of a public key. Eg: Verisign
  - The CA digitally signs the public key advertisement: creates a "X.509 certificate"

Certificate Authority (CA) - contd

- Issues: ("Public Key Infrastructure (PKI)")
  - CA should guard its private key closely
  - CA does background checks on customers.
  - CA can provide several "grades" of certificates.
  - Certificate registration (CA's public key) security
  - Scalability: need multiple, distributed CAs !

Putting it all together ...

- Server:
  - Securely *register with CA*
  - *Distribute X.509 certificates* I.e. public key
  - To send to receiver, use public key of receiver
  - For body: use symmetric encryption using shared secret (aka "cookie") which itself is exchanged using PKE initially
  - Append signature: Apply hash function to text to generate a MAC, and apply my private key

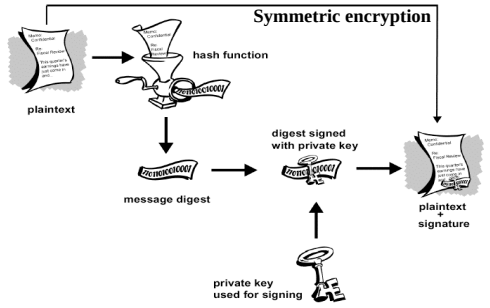
Putting it all together (contd) ...

- Client:
  - *Verify X.509 certificates* (public key) for CA signature and certification; store if ok
  - Use private key to *decrypt remote's password*, and use this to decode the text portion. This may involve matching a result with a crypto-checksum
    - If ok, then integrity, confidentiality guaranteed

Putting it together …

- Use standard hash function on text to get a MAC
- Apply sender's public key to digital signature to get a MAC value.
- Compare the two MACs. If equal, then authenticated, non-repudiable.

Recap: Central ideas...



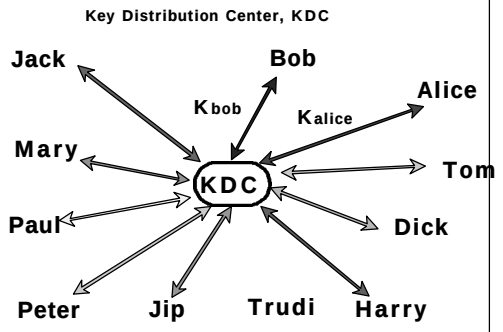
SSL

- Session oriented, stateful. Integrated w/ HTTPS
- Client may optionally have a X.509 certificate.
- Server required to have an X.509 certificate
- Client verifies server certificate; server performs optional client authentication
- Server private key verified w/ a "challenge".
- Agree to a shared secret for symmetric encryption
  - Session ID is agreed upon -- stored in server cache => not necessary to re-authenticate.
  - Data transfer using 128 bit keys

SSL (contd)

- IETF standard = TLS: transport layer security
- LDAP combined with X.509 certificates, presented through SSL can achieve single "Assign-on" access like Kerberos
- Problem: firewalls cant peek in (no "escrow")
  - Need proxy server terminates SSL sessions at the firewall and no SSL within enterprise.
    - => client authentication cannot be done (proxy server can't have client's private key)

Keberos: Mediated Authentication



Kerberos

- Single sign-on authentication/authorization for enterprise
- Kerberos V5 in Microsoft Win 2000
- Avoids hassles of CAs, and PKI, securing private keys, and private key portability
- Concepts:
  - Realms: Each realm has a master Key Distribution Center (KDC): trusted third party
  - 3 components:
    - Authentication server (AS): responsible for authenticating user

Kerberos (contd)

- Ticket granting server (TGS): gives access to specific servers to authenticated users
- Secret key database
- AS interaction:
  - User sends login name; AS sends TGT (w/ secret key based upon user's password)
  - User enters password; and workstation attempts to decrypt TGT using this password. After decryption, user gets also a session key

Kerberos (contd)

- TGS interaction:
  - Send an “authenticator” to TGS. Encrypted w/ session key (a shared secret w/ TGS), plus name of server, TGT, and timestamps.
  - TGS decrypts authenticator and gives a “service ticket”
  - Gets new session key to be shared between user and server
- Need to access more servers => connect w/ TGS to get service ticket until TGT does not expire

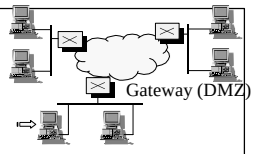
IPSec

- **IPSEC: IP-level Security Protocol**
  - **Encryption takes place between the transport and internet layers**
  - **Designed to provide privacy, forgery detection, or both for IP packets, with extensibility features.**
  - **Uses a security parameter index (SPI) to negotiate cryptographic and authentication algorithms**
  - **Authentication header (AH) and encapsulating security payload (ESP)**
- **RFC 1825, 1826, 1827 and work in IPSec working group Internet drafts**

IP Sec (contd)

- The authentication header (AH) verifies the identity of a packet's sender and the authenticity of the packet's contents.
- The encapsulating security payload (ESP) encrypts a packet before transmitting it;
  - ESP may also encapsulate the original IP packet.
- Internet key exchange (IKE) governs the transfer of security keys between senders and receivers. (IKE was formerly known as ISAKMP/Oakley)

What is a Firewall?



- A firewall is a method of achieving security between trusted and untrusted networks
- The choice, configuration and operation of a firewall is defined by policy, which determines the the services and type of access permitted
- Firewall = policy+implementation
- Firewall = “zone of risk” for the trusted network

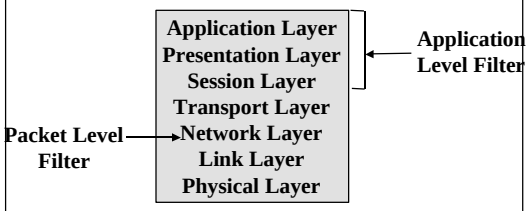
Firewalls Should…

- Support and not impose a security policy
- Use a “deny all services except those specifically permitted” policy
- Accommodate new facilities and services
- Contain advanced authentication measures
- Employ filtering techniques to permit or deny services to specific hosts and use flexible and user-friendly filtering
- Use proxy services for applications
- Handle dial-in
- Log suspicious activity

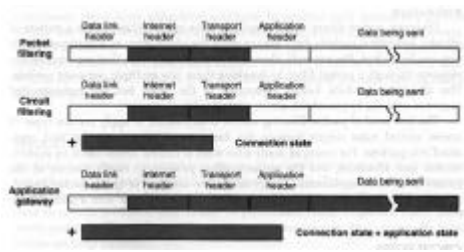
Firewalls Cannot…

- Protect against malicious insiders
- Protect against connections that do not go through them (e.g., dial-up)
- Protect against new threats or new viruses

Firewalls in Relation to 7 Layers



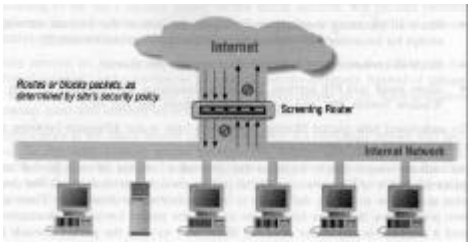
Methods: Firewalls



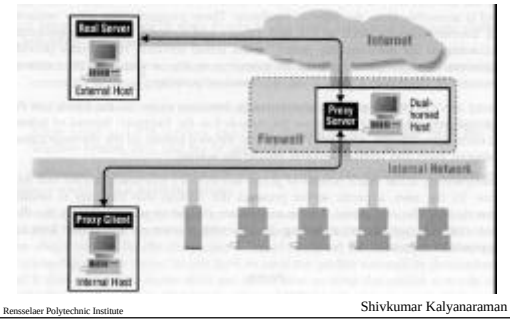
Methods: Firewalls

- Firewall control mechanisms:
  - Packet filtering - Based on the contents of individual packets
  - Circuit filtering - Controls data by controlling the flow of data and blocking if not permitted
  - Application gateway - Processes and forwards messages specific to particular TCP/IP application protocols (AKA proxy)

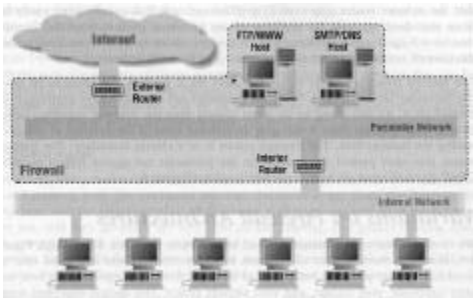
Simple Firewall Router



Firewall as a Proxy Server



Perimeter Network, Bastion Hosts



Summary

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- Security techniques: passwords, hash functions, one-time passwords, digital signatures, symmetric/asymmetric key cryptography
- IPSec, SSL, Kerberos, S/Key, (+ mention of PAP, CHAP, RADIUS, TACACS)
- Firewalls