Last Time

- Network security

- Focus
  - How do we secure distributed systems?

- Topics
  - Basic properties: privacy, authenticity
  - Cryptography
This Time

- Network security
- Focus
  - How do we secure distributed systems?
- Topics
  - Building systems w/ crypto
  - Firewalls

Authentication Protocols

- Three-way handshake for mutual authentication
  - Client and server share secrets, e.g., login password

Client

Server

ClientId, E(x, CHK)
E(x + 1, SHK), E(y, SHK)
E(y + 1, CHK)
E(SK, SHK)
Via Trusted Third Party (Kerberos)

Authentication server

A, B

E((T, L, K, B), K_A), E((T, L, K, A), K_B)

A authenticates B

E((A, T), K), E((T, L, K, A), K_B)

B authenticates A

E(T + 1, K)

Public Key Authentication

A authenticates B

E(x, Public_B)

A authenticates B

(similarly for B to authenticate A)
Message Integrity Protocols

- Sometimes we don’t care about privacy but do care about integrity/authenticity

- Digital signatures (RSA)
  - Sign message with private key (encrypt); others verify with public key (decrypt)

- MD5 with RSA
  - Send signed digest of message along with message

- Keyed MD5
  - Send digest of message plus shared secret along with message

- Last two methods increase performance

Key Distribution

- Public key systems depend on the distribution of keys!
  - Public Key Infrastructures (PKIs), e.g., Verisign
  - An Achilles heel?

- Certificates (X.509)
  - Distribute keys by trusted certification authority (CA)
    - “I swear X’s public key is Y”, signed by CA
  - Still requires bootstrapping …
  - Also allows us to can build chains of trust
    - e.g., public keys for a domain name so that “.edu” (root) certifies “washington.edu”’s key, they certify “cs…”’s key …
  - Certificate Revocation Lists needed to “undo” associations!
Example Systems

- Pretty Good Privacy (PGP)
  - For authentic and confidential email
- Secure Sockets (SSL) and Secure HTTP (HTTPS)
  - For secure Web transactions
- IP Security (IPSEC)
  - Framework for encrypting/authenticating IP packets

PGP

- Application level system
- Based on public keys and a "grass roots" Web of trust
- Sign messages for integrity/authenticity
  - Encrypt with private key of sender
- Encrypt messages for privacy
  - Could just use public key of receiver …
  - But encrypt message with secret key, and secret key with public key of receiver to boost performance
SSL/TLS and HTTPS

- Secure transport layers targeted at Web transactions
  - SSL/TLS inserted between TCP and HTTP to make secure HTTP
- Extra handshake phase to authenticate and exchange shared session parameters
  - Such as secret keys used for encryption
  - Client might authenticate Web server but not vice-versa
    - Certificate Authority embedded in Web browser
- Performance optimization
  - Refer to shared state with session id
  - Can use same parameters across connections
    - Client sends session id, allowing server to skip handshake

IPSEC

- Framework for encrypted and authenticated IP packets
  - Choice of algorithms not specified
- Uses new protocol headers inside IPv4 packets
  - Authentication header
    - For message integrity and origin authenticity
    - Optionally “anti-replay” protection (via sequence number)
  - Encapsulating Security Payload
    - Adds encryption for privacy
- Depends on key distribution (ISAKAMP)
  - Sets up security associations
- Example use: secure tunnels between corporate offices
Filter-based Firewalls

- Sit between site and rest of Internet, filter packets
  - Enforce site policy in a manageable way
  - e.g. pass (*, *, 128.7.6.5, 80), then drop (*, *, *, 80)
  - Rules may be added dynamically to pass new connections
- Sometimes called a “level 4” switch
  - Acts like a router (accepts and forwards packets)
  - But looks at information up to TCP port numbers (layer 4)

Proxy-Based Firewalls

- Problem: Filter ruleset can be complex/insufficient
  - Adequate filtering may require application knowledge
- Run proxies for Web, mail, etc. just outside firewall
  - In the “de-militarized zone” DMZ
  - External requests go to proxies, only proxies connect inside
    - External user may or may not know this is happening
  - Proxies filter based on application semantics