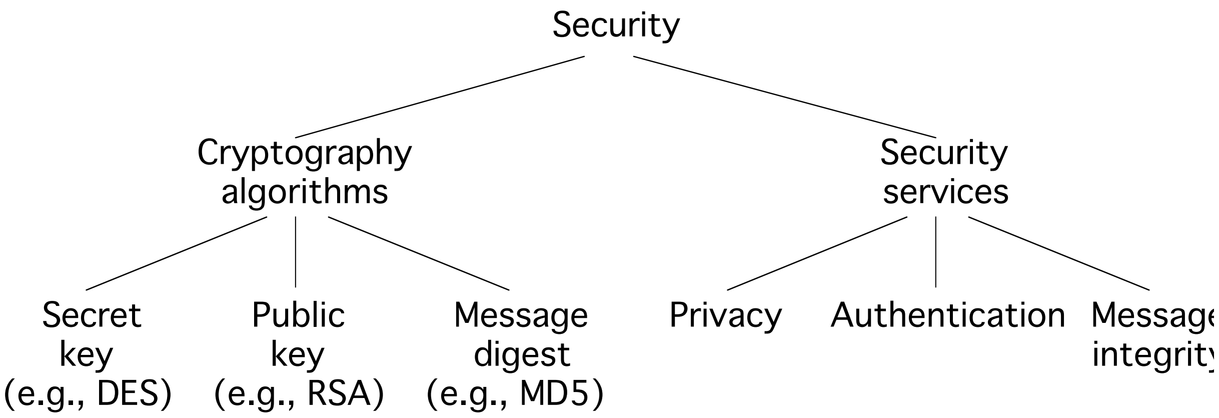
Chapter 8: Security

- Outline
  - Encryption Algorithms - only recipient can open message
  - Authentication Protocols - only sender could've sent it
  - Message Integrity Protocols - message was not tampered
  - Key Distribution - how to trust entities
  - Firewalls - devices to filter unwanted traffic

Overview

- Cryptography functions
  - Secret key (e.g., DES)
  - Public key (e.g., RSA)
  - Message digest (e.g., MD5)
- Security services
  - Privacy: preventing unauthorized release of information
  - Authentication: verifying identity of the remote participant
  - Integrity: making sure message has not been altered



Security

Cryptography algorithms

Security services

Secret key (e.g., DES)

Public key (e.g., RSA)

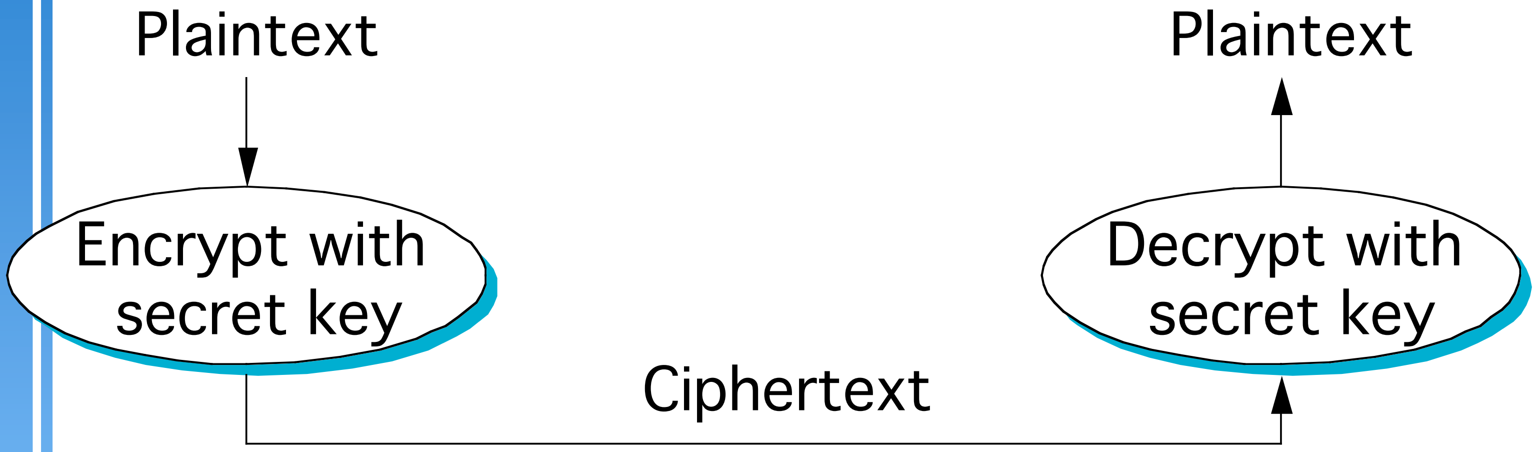
Message digest (e.g., MD5)

Privacy

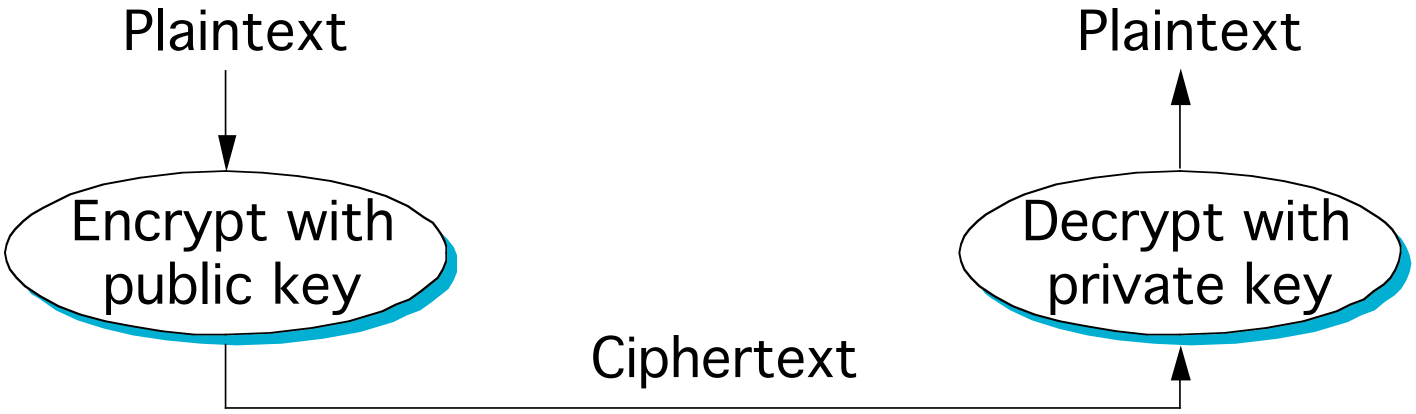
Authentication

Message integrity

Secret Key (DES)



Public Key (RSA)



- Encryption & Decryption

$c = m^e \bmod n$

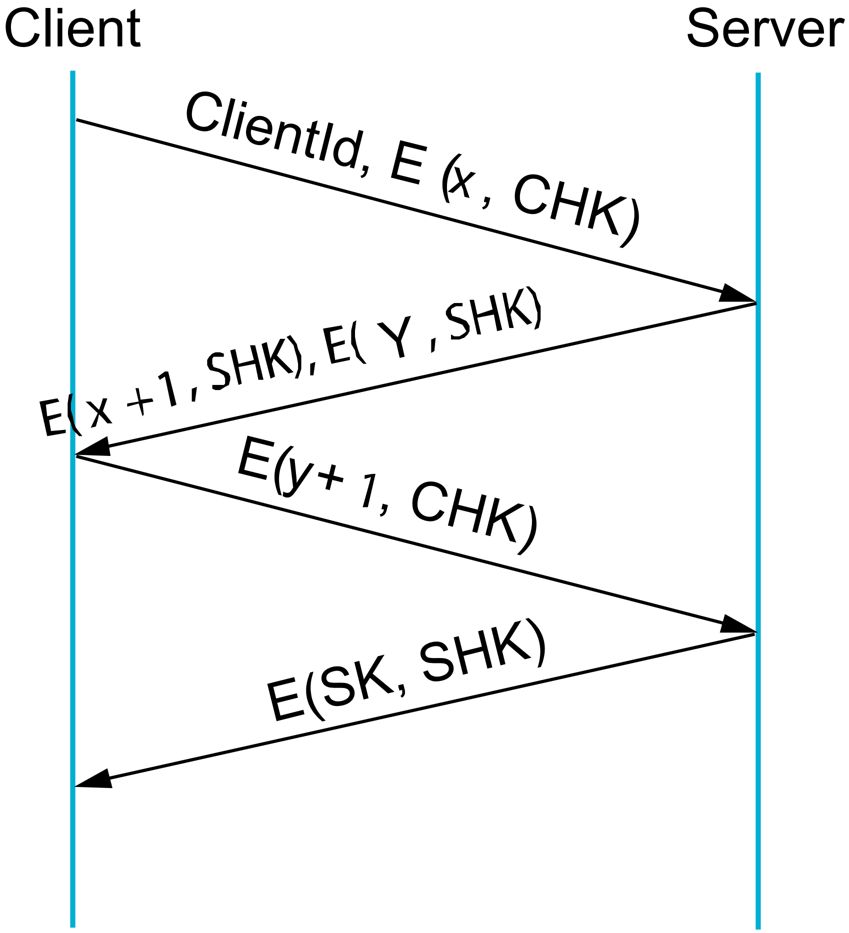
$m = c^d \bmod n$

Message Digest

- Cryptographic checksum
  - just as a regular checksum protects the receiver from accidental changes to the message, a cryptographic checksum protects the receiver from malicious changes to the message.
- One-way function
  - given a cryptographic checksum for a message, it is virtually impossible to figure out what message produced that checksum; it is not computationally feasible to find two messages that hash to the same cryptographic checksum.
- Relevance
  - if you are given a checksum for a message and you are able to compute exactly the same checksum for that message, then it is highly likely this message produced the checksum you were given.

Authentication Protocols

- Three-way handshake



Client

Server

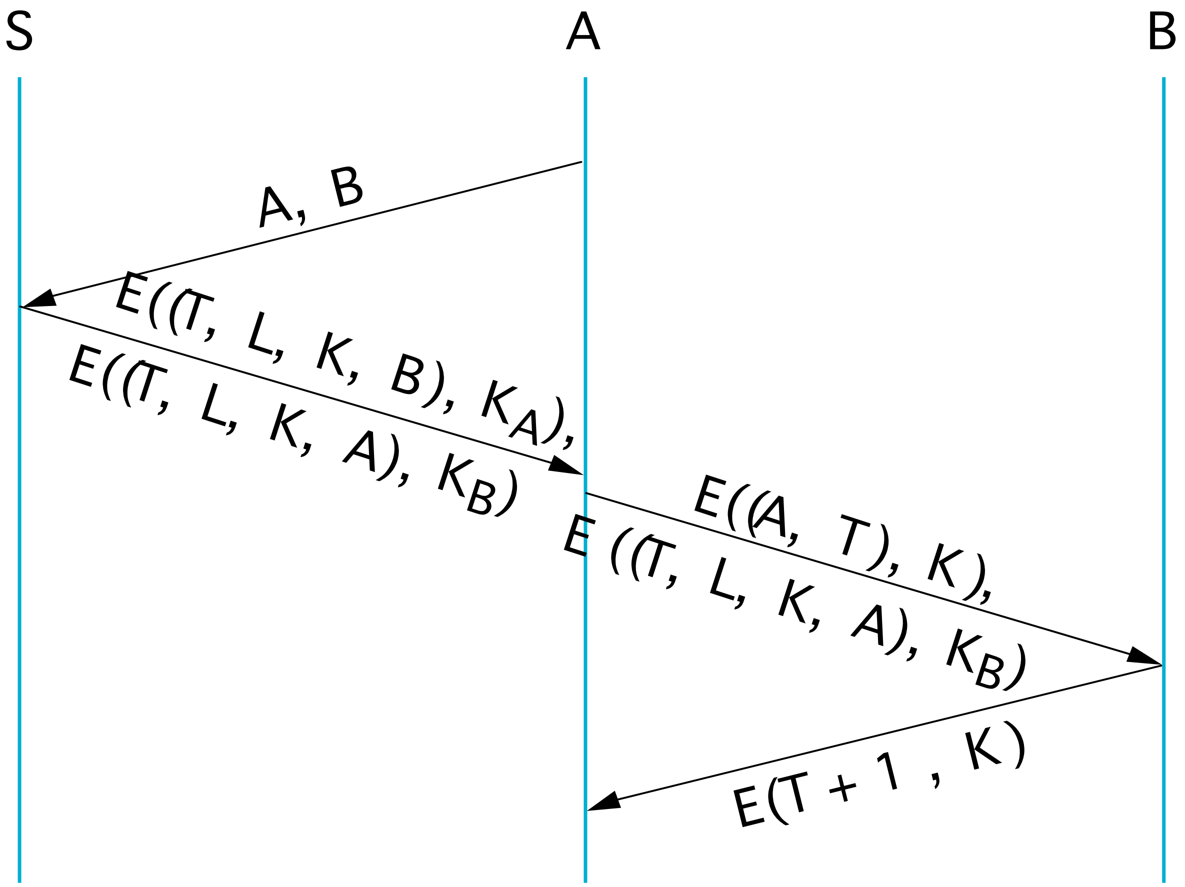
ClientId, E (x, CHK)

E(x +1, SHK), E(Y, SHK)

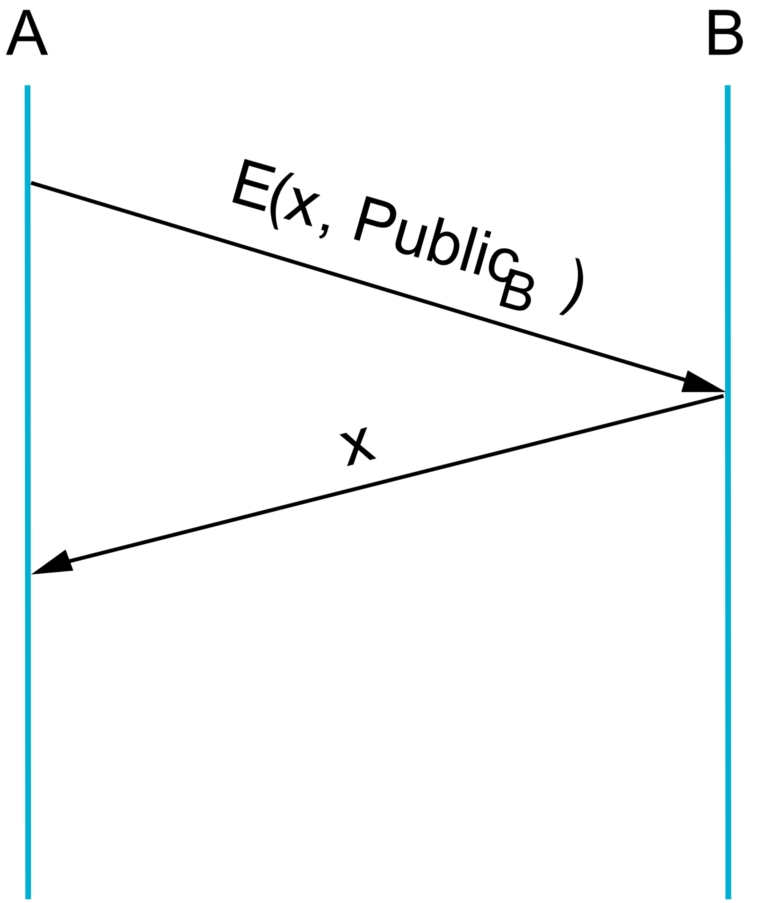
E(y+ 1, CHK)

E(SK, SHK)

- Trusted third party (Kerberos)



- Public key authentication



Message Integrity Protocols

- Digital signature using RSA
  - special case of a message integrity where the code can only have been generated by one participant
  - compute signature with private key and verify with public key
- Keyed MD5
  - sender: m + MD5(m + k) + E(k, private)
  - receiver
    - recovers random key using the sender’s public key
    - applies MD5 to the concatenation of this random key message
- MD5 with RSA signature
  - sender: m + E(MD5(m), private)
  - receiver
    - decrypts signature with sender’s public key
    - compares result with MD5 checksum sent with message

Key Distribution

- Certificate
  - special type of digitally signed document:
    - “I certify that the public key in this document belongs to the entity named in this document, signed X.”
  - the name of the entity being certified
  - the public key of the entity
  - the name of the certified authority
  - a digital signature
- Certified Authority (CA)
  - administrative entity that issues certificates
  - useful only to someone that already holds the CA’s public key.

Key Distribution (cont)

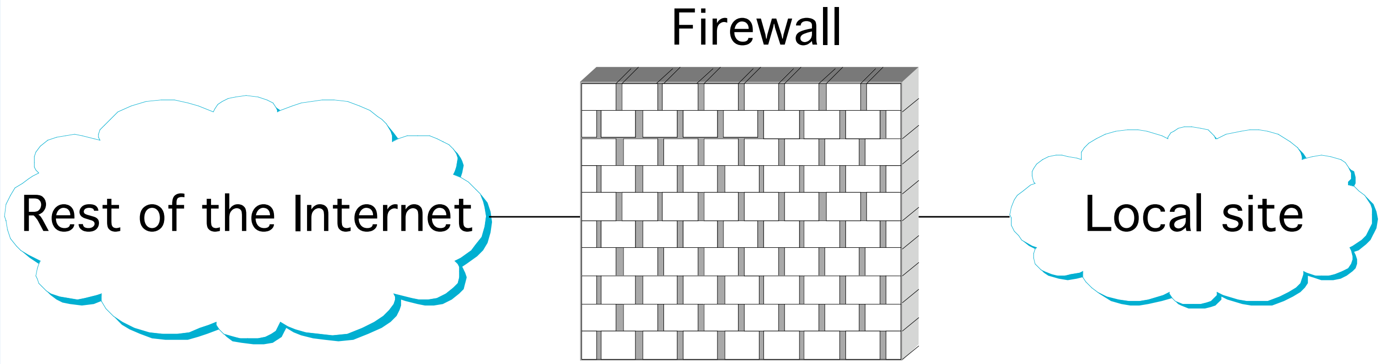
- Chain of Trust
  - if X certifies that a certain public key belongs to Y, and Y certifies that another public key belongs to Z, then there exists a chain of certificates from X to Z
  - someone that wants to verify Z’s public key has to know X’s public key and follow the chain
- Certificate Revocation List

IPSEC - Secure communications in IP

IPSec comes in two forms

- AH provides a keyed hash and authentication data
  - Ensures data comes from peer router (authentication)
  - Detects alterations (keyed hash)
  - But does not encrypt for confidentiality
- ESP encrypts
  - Two sub-modes: tunnel and transport
  - In tunnel mode, the new IP header hides source and destination addresses: keeps server address confidential
  - Keyed hash for detecting alterations
  - Authentication
  - Encryption

Firewalls



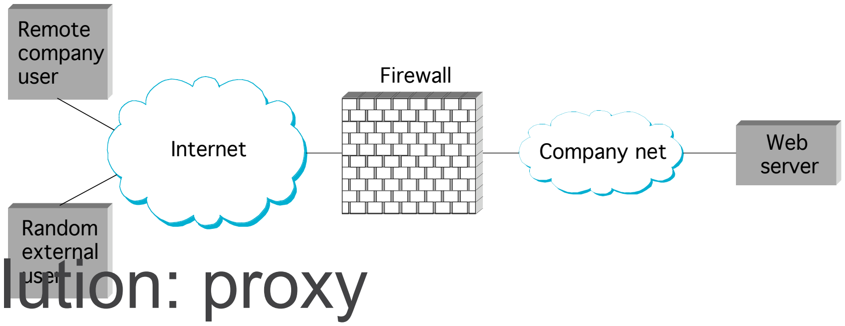
- Filter-Based Solution
  - example

    (192.12.13.14, 1234, 128.7.6.5, 80)

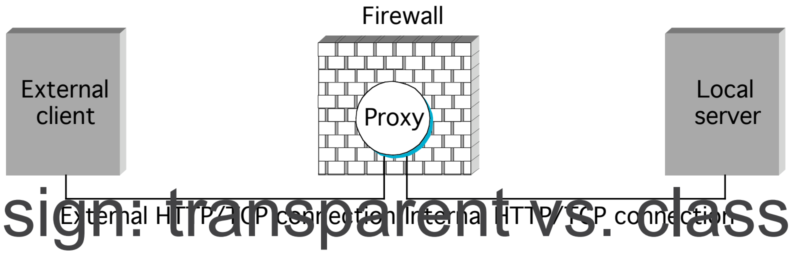
    (*,*, 128.7.6.5, 80)
  - default: forward or not forward?
  - how dynamic?
  - stateful

Proxy-Based Firewalls

- Problem: complex policy
- Example: web server



- Solution: proxy



- Design: transparent vs. classical
- Limitations: attacks from within

Denial of Service

- Attacks on end hosts
  - SYN attack
- Attacks on routers
  - pollute route cache
- Authentication attacks
- Distributed DoS attacks