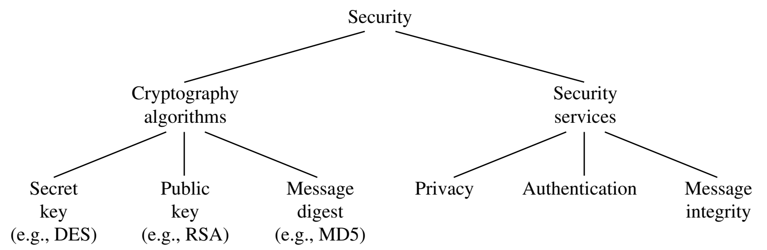
Security

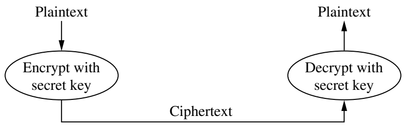
- Outline
  - Encryption Algorithms
  - Authentication Protocols
  - Message Integrity Protocols
  - Firewalls

Overview

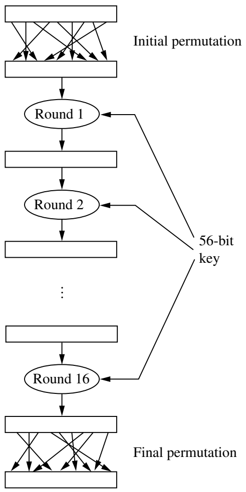
- Cryptography functions
  - Secret key (e.g., DES)
  - Public key (e.g., RSA)
  - Message digest (e.g., MD5)
- Security services
  - Privacy: preventing unauthorized release of information
  - Authentication: verifying identity of the remote participant
  - Integrity: making sure message has not been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



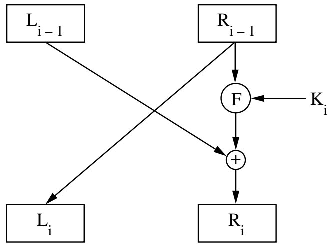
Secret Key (DES)



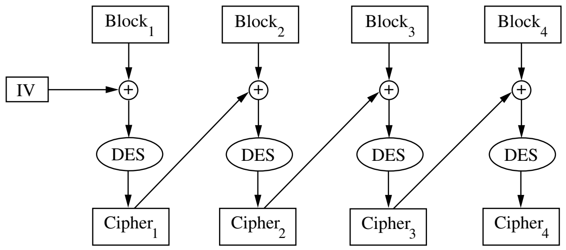
- 64-bit key (56-bits + 8-bit parity)
- 16 rounds



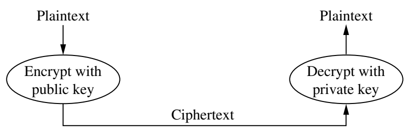
- Each round



- Function F and generation of K_i for each round not shown
- Repeat for larger messages



Public Key (RSA)



- Generate a public and private key
  - choose two large prime numbers p and q (each 256 bits)
  - multiply p and q together to get n
  - chose the encryption key e, such that e and $(p-1) \times (q-1)$ are relatively prime.
  - two numbers are relatively prime if they have no common factor greater than one.
  - compute decryption key d such that

$$d = e^{-1} mod \; ((p-1) \times (q-1))$$

  - construct public key as $\langle e, n \rangle$
  - construct private key as $\langle d, n \rangle$
  - discard (do not disclose) original primes p and q
- Encryption & Decryption

$$c = m^e mod \; n$$

$$m = c^d mod \; n$$

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

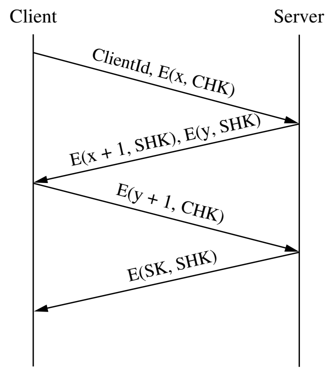
  given a cryptographic checksum for a message, it is virtually impossible to figure out what message produced that checksum; it is not computationally feasible to find two messages that hash to the same cryptographic checksum.

- Relevance

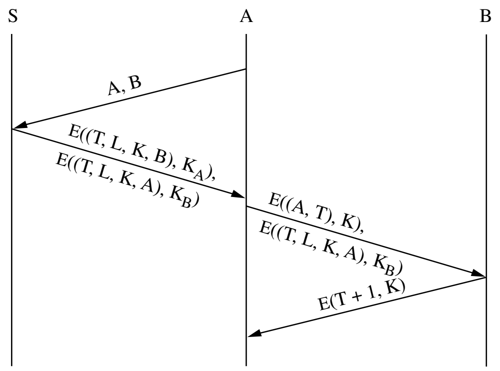
  if you are given a checksum for a message and you are able to compute exactly the same checksum for that message, then it is highly likely this message produced the checksum you were given.

Authentication Protocols

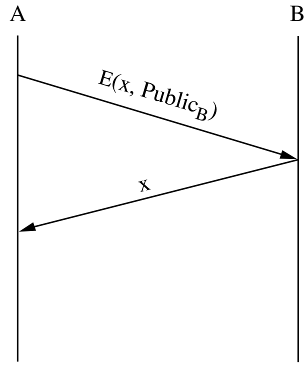
- Three-way handshake



- 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 signiture 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
    * compares result with checksum sent with message
- MD5 with RSA signature
  - sender

    m `+ MD5(`m`) + E(MD5(`m`),` *private*`)`
  - receiver
    * decrypts signature with sender's pubic key
    * compares result with MD5 checksum sent with message

Key Distribution

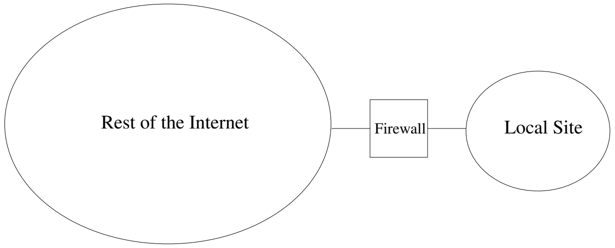
- Certificate

  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 certificate authority;
  - a digital signature.
- Certificate Authority (CA)

  an administrative entity in the business of issuing certificates; useful only to someone that already holds the CA's public key.
- 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

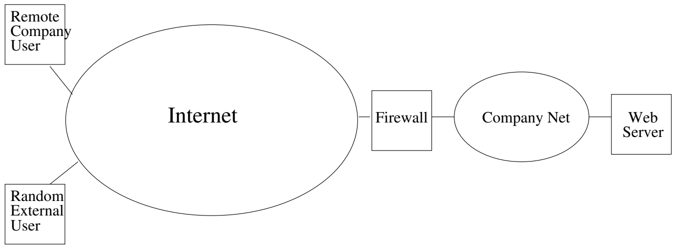
Firewalls



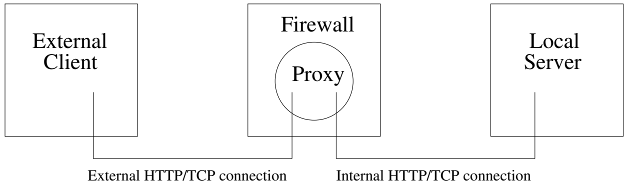
- Filter-Based Solution
  - Example
    ⟨ 192.12.13.14, 1234, 128.7.6.5, 80 ⟩
    ⟨ *, *, 128.7.6.5, 80 ⟩
  - Default: forward or not forward?
  - How Dynamic?

Proxy-Based Firewalls

- Problem: complex policy
- Example: web server



- Solution: Proxy



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