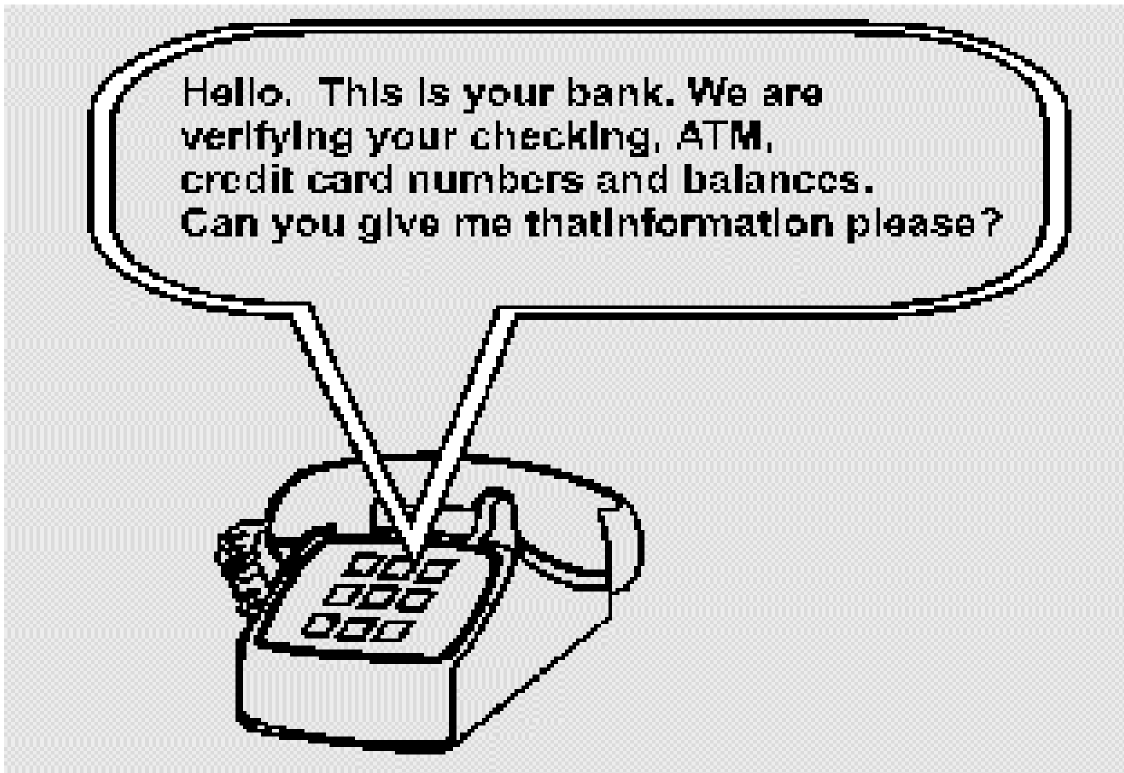
# Authentication




**Question:** how does a receiver know that remote communicating entity is who it is claimed to be?

# Authentication Protocol (ap)

- Ap 1.0
  - Alice to Bob: “I am Alice”
  - Problem: intruder “Trudy” can also send such a message
- Ap 2.0
  - Authenticate source IP address is from Alice’s machine
  - Problem: IP Spoofing (send IP packets with a false address)
- Ap 3.0: use a secret password
  - Alice to Bob: “I am Alice, here is my password” (e.g., telnet)
  - Problem: Trudy can intercept Alice’s password by sniffing packets

# Authentication Protocol

Ap 3.1: use encryption

use a symmetric key known to Alice and Bob

- Alice & Bob (only) know secure key for encryption/decryption

A to B: msg = encrypt("I am A")

B computes: if decrypt(msg)=="I am A"

then A is verified

else A is fradulent

- failure scenarios: playback attack
  - Trudy can intercept Alice's message and masquerade as Alice at a later time

# Authentication Using Nonces

Problem with ap 3.1: same password is used for all sessions

**Solution:** use a sequence of passwords

pick a "once-in-a-lifetime-only" number (nonce) for each session

**Ap 4.0**

A to B: msg = "I am A" /* note: unencrypted message! */

B to A: once-in-a-lifetime value, n

A to B: msg2 = encrypt(n) /* use symmetric keys */

B computes: if decrypt(msg2)==n

then A is verified

else A is fradulent

- note similarities to three way handshake and initial sequence number choice
- problems with nonces?

# Authentication Using Public Keys

Ap 4.0 uses symmetric keys for authentication
Question: can we use public keys?

**symmetry:** DA( EA(n) ) = EA ( DA(n) )

**AP 5.0**

A to B: msg = "I am A"
B to A: once-in-a-lifetime value, *n*
A to B: msg2 = DA(*n*)
B computes: if EA (DA(*n*))== *n*
then A is verified
else A is fradulent

# Problems with Ap 5.0

- Bob needs Alice's public key for authentication
  - Trudy can impersonate as Alice to Bob
    - Trudy to Bob: msg = "I am Alice"
    - Bob to Alice: nonce n (Trudy intercepts this message)
    - Trudy to Bob: msg2= DT(n)
    - Bob to Alice: send me your public key (Trudy intercepts)
    - Trudy to Bob: send ET (claiming it is EA)
    - Bob: verify ET(DT(n)) == n and authenticates Trudy as Alice!!
- Moral: Ap 5.0 is only as "secure" as public key distribution

# Man-in-the-middle Attack

- Trudy impersonates as Alice to Bob and as Bob to Alice
  - Alice Trudy Bob
  - "I am A" "I am A"
  - nonce n
  - DT(n)
  - send me ET
  - ET
  - nonce n
  - DA(n)
  - send me EA
  - EA
  - Bob sends data using ET, Trudy decrypts and forwards it using EA!! (Trudy *transparently* intercepts every message)

# Digital Signatures Using Public Keys

**Goals of digital signatures:**

- sender cannot repudiate message never sent ("I never sent that")
- receiver cannot fake a received message

Suppose A wants B to "sign" a message M

B sends DB(M) to A

A computes if EB ( DB(M)) == M

then B has signed M

**Question:** can B plausibly deny having sent M?

# Message Digests

- Encrypting and decrypting entire messages using digital signatures is computationally expensive
  - Routers routinely exchange data
    - Does not need encryption
    - Needs authentication and verify that data hasn't changed
- Message digests: like a checksum
  - Hash function H: converts variable length string to fixed length hash
  - Digitally sign H(M)
  - Send M, EA(H(m))
  - Can verify who sent the message and that it has been changed!
- Property of H
  - Given a digest x, it is infeasible to find a message y such that H(y) = x
  - It is infeasible to find any two messages x and y such that H(x) = H(y)

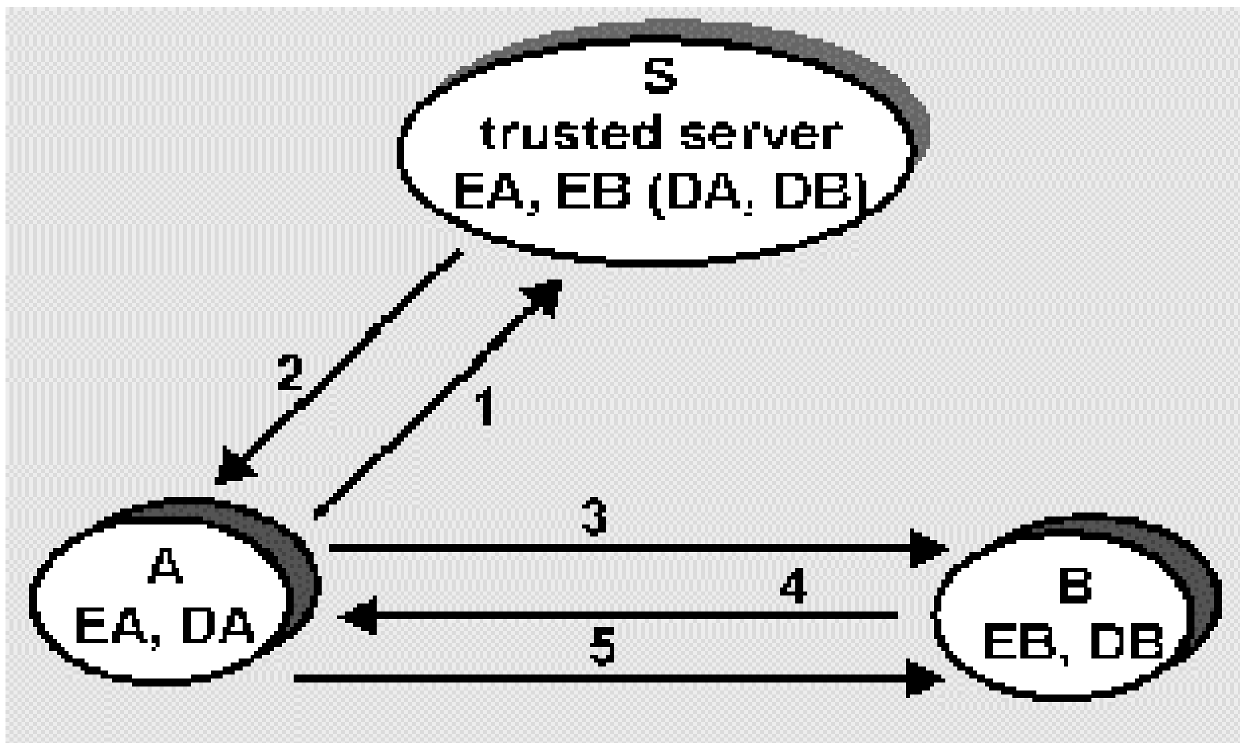
# Symmetric key exchange: trusted server

**Problem:** how do distributed entities agree on a key?

**Assume:** each entity has its own single key, which only it and trusted server know

**Server:**

- will generate a one-time session key that A and B use to encrypt communication
- will use A and B's single keys to communicate session key to A, B


S
trusted server
EA, EB (DA, DB)
2
1
A
EA, DA
3
4
5
B
EB, DB

# Symmetric Key exchange: trusted server

Preceding scenario:

**1.** A sends encrypted msg to S, containing A, B, nonce RA: EA(A,B,RA)

**2.** S decrypts using DA, generates one time session key, K, sends nonce, key, and B-encrypted encoding of key to A: EA(RA,B,K,EB(K,A))

**3.** A decrypts msg from S using DA and verifies nonce. Extracts K, saves it and sends EB(K,A) to B.

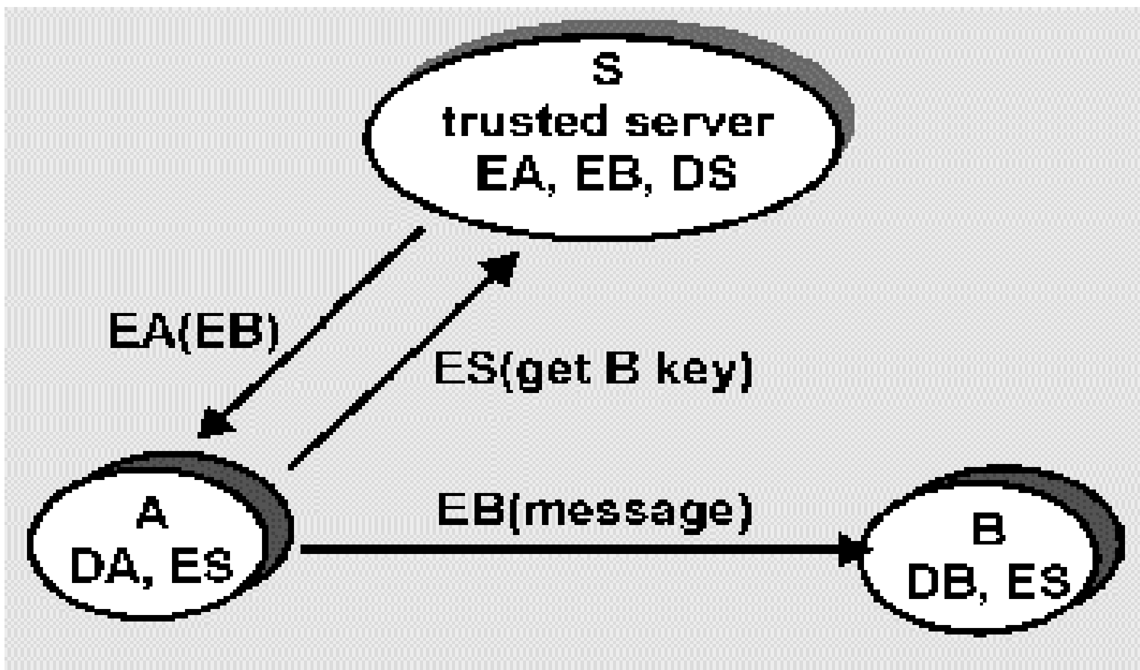
**4.** B decrypts msg using DB, extracts K, generates new nonce RB, sends EK(RB) to A

**5.** A decrypts using K, extracts RB, computes RB-1 and encrypts using K. Sends EK(RB-1) to B

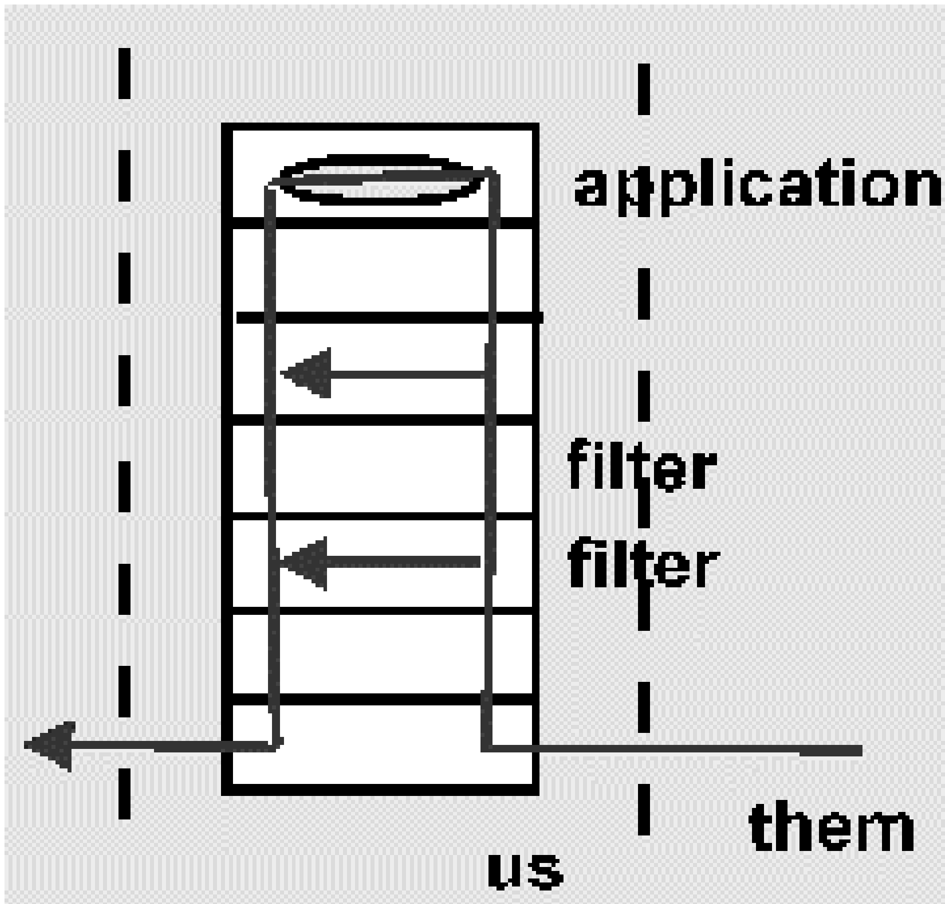
**6.** B decrypts using K and verifies RB-1

# Public key exchange: trusted server

- public key retrieval subject to man-in-middle attack
- locate all public keys in trusted server
- everyone has server's encryption key (ED public)
- suppose A wants to send to B using B's "public" key



# Protection against Intruders: Firewalls



**Firewall:** network components (host/router+software) sitting between inside ("us") and outside ("them)

**Packet filtering firewalls**: drop packets on basis of source or destination address (i.e., IP address, port)

**Application gateways:** application specific code intercepts, processes and/or relays application specific packets

- e.g., email of telnet gateways
- application gateway code can be security hardened
- can log all activity

# Secure Email

- Requirements:
  - Secrecy
  - Sender authentication
  - Message integrity
  - Receiver authentication
- Secrecy
  - Can use public keys to encrypt messages
    - Inefficient for long messages
  - Use symmetric keys
    - Alice generates a symmetric key K
    - Encrypt message M with K
    - Encrypt K with $E_B$
    - Send K(M), $E_B$(K)
    - Bob decrypts using his private key, gets K, decrypts K(M)

# Secure Email

- Authentication and Integrity (with no secrecy)
  - Alice applies hash function H to M (H can be MD5)
  - Creates a digital signature $D_A(H(M))$
  - Send M, $D_A(H(M))$ to Bob
- Putting it all together
  - Compute H(M), $D_A(H(M))$
  - M'= { H(M), $D_A(H(M))$ }
  - Generate symmetric key K, compute K(M')
  - Encrypt K as $E_B(K)$
  - Send K(M'), $E_B(K)$
- Used in PGP (pretty good privacy)

# Secure Sockets Layer (SSL)

- SSL: Developed by Netscape
  - Provides data encryption and authentication between web server and client
  - SSL lies above the transport layer
  - Useful for Internet Commerce, secure mail access (IMAP)
  - Features:
    - SSL server authentication
    - Encrypted SSL session
    - SSL client authentication

# Secure Socket Layer

- Protocol: https instead of http
  - Browser -> Server: B's SSL version and preferences
  - S->B: S's SSL version, preferences, and certificate
    - Certificate: server's RSA public key encrypted by CA's private key
  - B: uses its list of CAs and public keys to decrypt S's public key
  - B->S: generate K, encrypt K with with $E_S$
  - B->S: "future messages will be encrypted", and K(m)
  - S->B: "future messages will be encrypted", and K(m)
  - SSL session begins…

# SSL

- SET: secure electronic transactions [Visa, Mastercard]
  - Designed for secure credit card payment
  - Includes client, merchant and merchant's bank
  - Homework: read up on SET from KR 7.7.2
- Homework: get your own digital certificate
  - Click on "security" icon (next to "print" icon) in Netscape 4.7
  - Click on "Certificates" and then on "obtain your certificate"
  - Send an email to yourself signed with your certificate
  - Also examine listed of trusted CAs built into the browser

# Security: Internet activity

**IP layer:**

- authentication of header: receiver can authenticate sender using messageauthentication code (MAC)
- encryption of contents: DES, RFC 1829

**API**

- SSL - secure socket layer: support for authentication and encryption
  - port numbers: 443 for http with SSL, 465 for smtp with SSL

**Application Layer**

- Privacy Enhanced Mail (PEM)
- secure http: supports many authentication, encryption schemes

# Secure Email

**PEM :**

- operates on top of SMTP
  - ASCII
- msg authentication - MD2, MD5
- msg encryption - RSA, DES
- authenticated encrypted msgs and encrypted authenticated msgs

**PGP (Pretty Good Privacy):** secure file transfer (incl. email)

- binary files

# Security: conclusion

key concerns:

- encryption
- authentication
- key exchange

also:

- increasingly an important area as network connectivity increases
- digital signatures, digital cash, authentication, increasingly important
- an important social concern
- further reading:
  - Crypto Policy Perspectives: S. Landau et al., Aug 1994 CACM
  - Internet Security, R. Oppliger, CACM May 1997
  - www.eff.org