Cryptographic Security

Security Considerations

Factors:

- reliance on unknown, vulnerable intermediaries (e.g., Internet routers)
- parties may have no personal or organizational relationship (e.g., e-commerce)
- use of automated surrogates (e.g., agents)

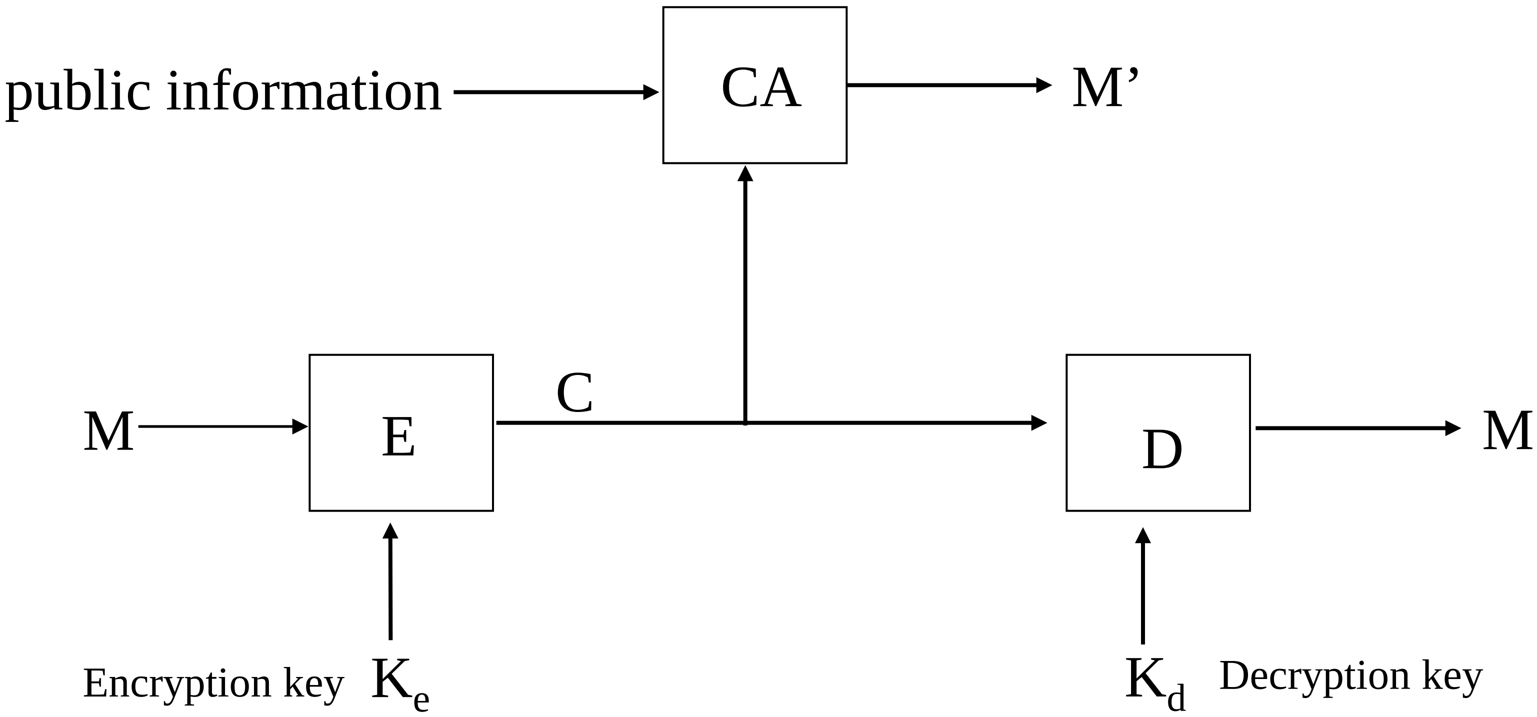
Goals:

- privacy/confidentiality - information not disclosed to unauthorized entities
- integrity - information not altered deliberately or accidentally
- authentication - validation of identity of source of information
- non-repudiation - source of information can be objectively established

Threats:

- replay of messages
- interference (inserting bogus messages)
- corrupting messages

Cryptography



Forms of attack:

- ciphertext-only
- known-plaintext
- chosen-plaintext

Forms of Cryptosystems

- **Private Key (symmetric) :**

  A single key is used for both encryption and decryption.

  Key distribution problem - a secure channel is needed to transmit the key before secure communication can take place over an unsecure channel.

- **Public Key (asymmetric):**

  The encryption procedure (key) is public while the decryption procedure (key) is private.

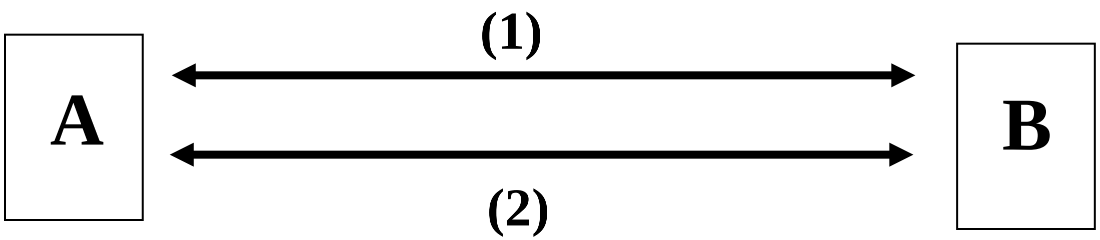
  Requirements:

  1. For every message M, D(E(M)) = M
  2. E and D can be efficiently applied to M
  3. It is impractical to derive D from E.

Combining Public/Private Key Systems

Public key encryption is more expensive than symmetric key encryption

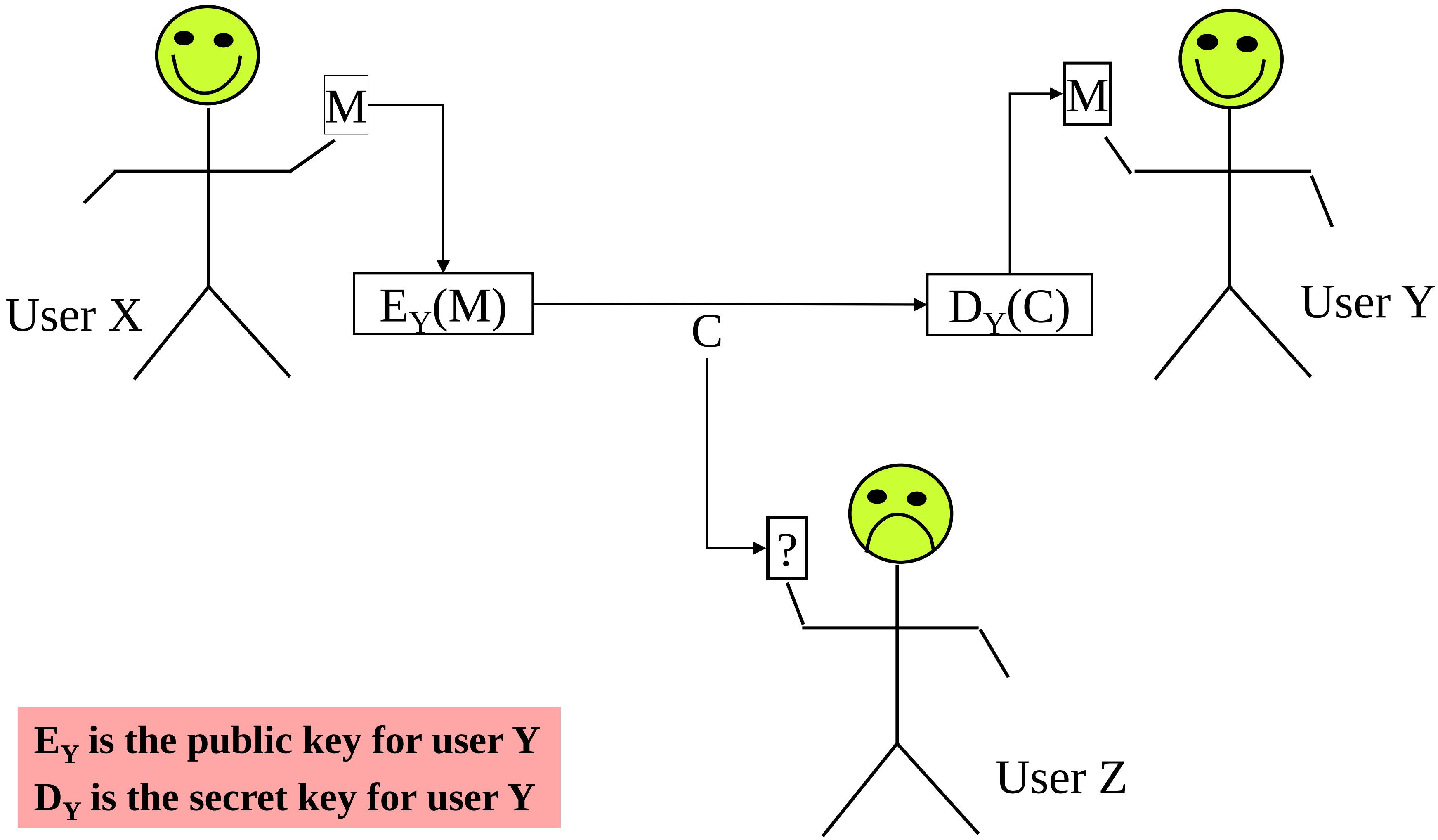
For efficiency, combine the two approaches



(1) Use public key encryption for authentication; once authenticated, transfer a shared secret symmetric key

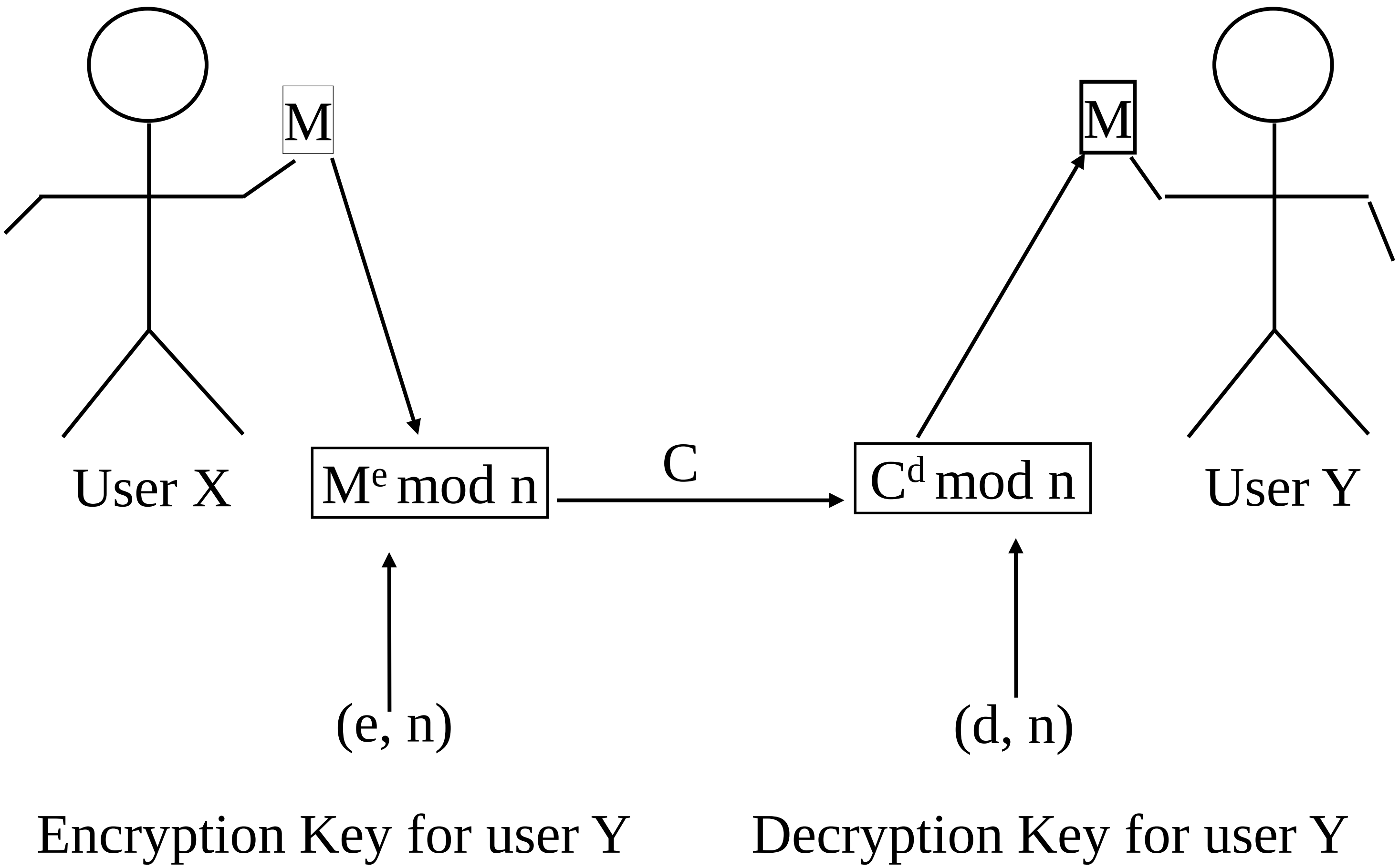
(2) Use symmetric key for encrypting subsequent data transmissions

Secure Communication - Public Key System



E_Y is the public key for user Y
D_Y is the secret key for user Y

Rivest-Shamir-Adelman (RSA) Method



RSA Method

1. Choose two large (100 digit) prime numbers, p and q,and set n = p x q

2. Choose any large integer, d, so that: GCD(d, ((p-1)x(q-1)) = 1

3. Find e so that: e x d = 1 (modulo (p-1)x(q-1))

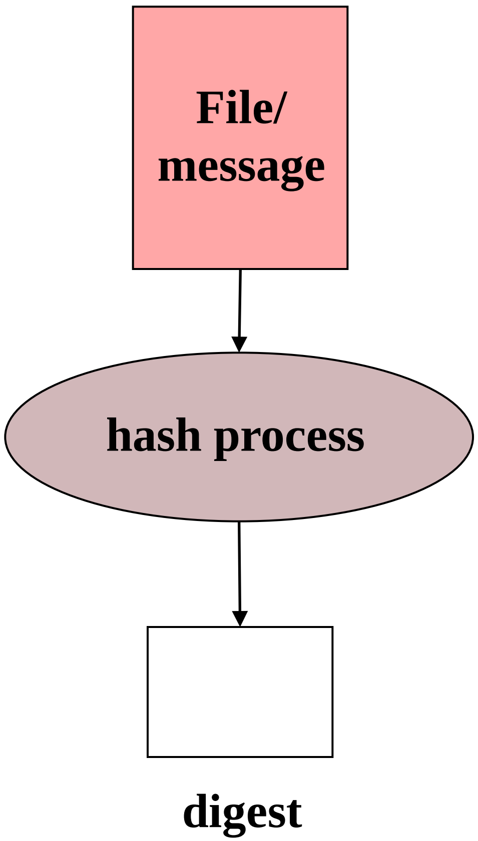
<u>Example:</u>

1. p = 5, q = 11 and n = 55.
   (p-1)x(q-1) = 4 x 10 = 40

2. A valid d is 23 since GCD(40, 23) = 1

3. Then e = 7 since:
   23 x 7 = 161 modulo 40 = 1

(Large) Document Integrity



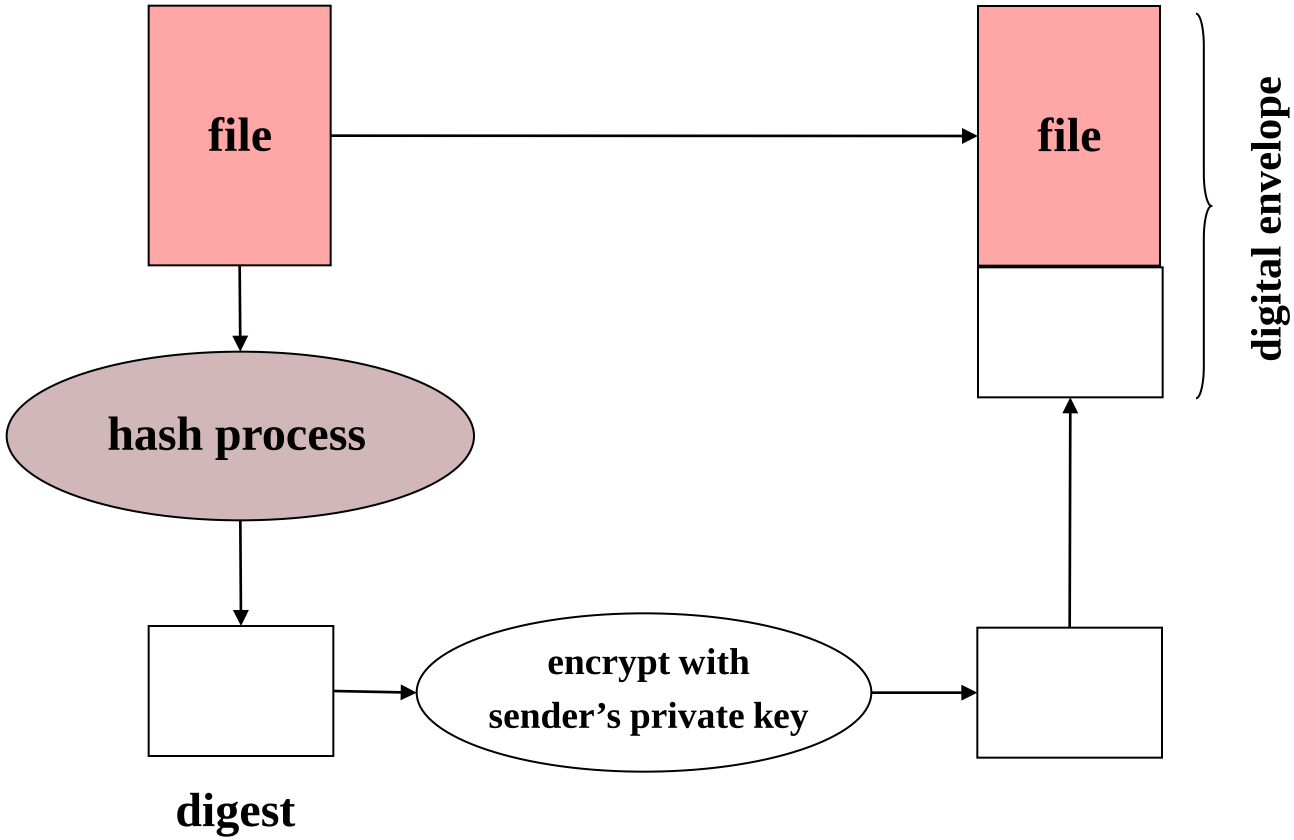
<u>Digest properties</u>:

- **fixed-length, condensation of the source**
- **efficient to compute**
- **irreversible - computationally infeasible for the original source to be reconstructed from the digest**
- **unique - difficult to find two different sources that map to the same digest (collision resistance)**

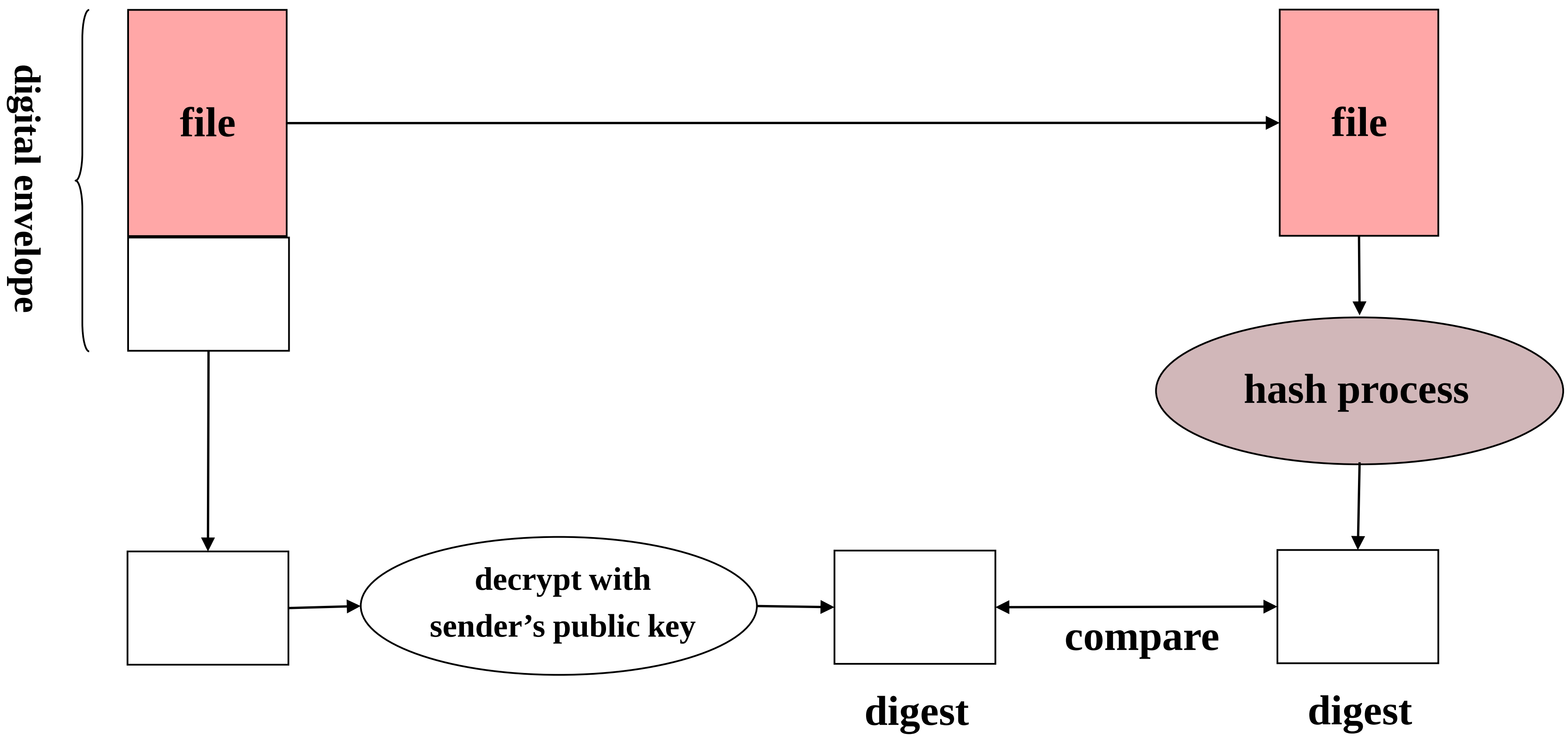
Also know as: fingerprint

Examples: MD5 (128 bits), SHA-1 (160 bits)

(Large)Document Integrity



Guaranteeing Integrity



Digital Signatures (Public Key)

Requirements:

unforgable and unique

receiver: knows that a message came from the sender (authenticity)

sender: cannot deny authorship(non-repudiation)

message integrity

sender & receiver: message contents preserved (integrity)

(e.g., cannot cut-and-paste a signature into a message)

Public Key System:

sender, A: (E_A : public, D_A : private)

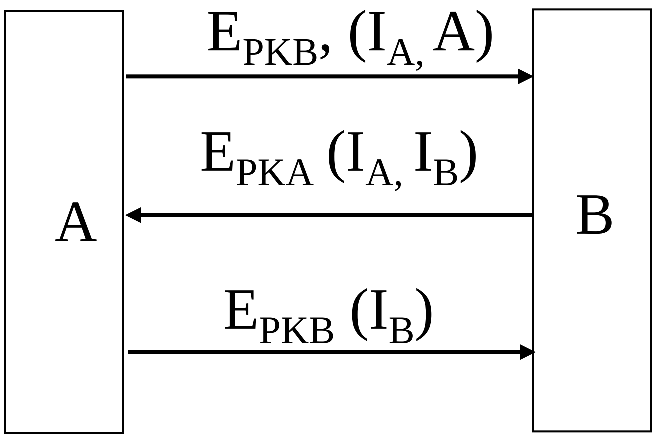
receiver, B: (E_B : public, D_B : private)

sender(A) ---- C= E_B (D_A (M)) ---> receiver(B)

receiver(B) -- M = E_A (D_B (C)) ---> M

Secure Communication (Public Key)

Handshaking



I_A, I_B are "nonces"
nonces can be included in each subsequent message
PKB: public key of B; PKA: public key of A;