18734: Foundations of Security and Privacy

A Quick Tour of Cryptographic Primitives

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Basic Cryptographic Concepts

- Encryption scheme (symmetric and public key)
- Signature scheme
- Message authentication code
- Hash function

Symmetric Encryption Scheme

- *Key generation* algorithm
  - Produces a key that is used for encryption and decryption
- Algorithm to *encrypt* a message
- Algorithm to *decrypt* a ciphertext
- Correctness:
  - Decrypting a ciphertext obtained by encrypting message m with the corresponding key k returns m

$$dec(enc(m,k),k) = m$$

- (Symbolic) Security:
  - A ciphertext cannot be decrypted without access to the key

Can you think of a stronger security property?

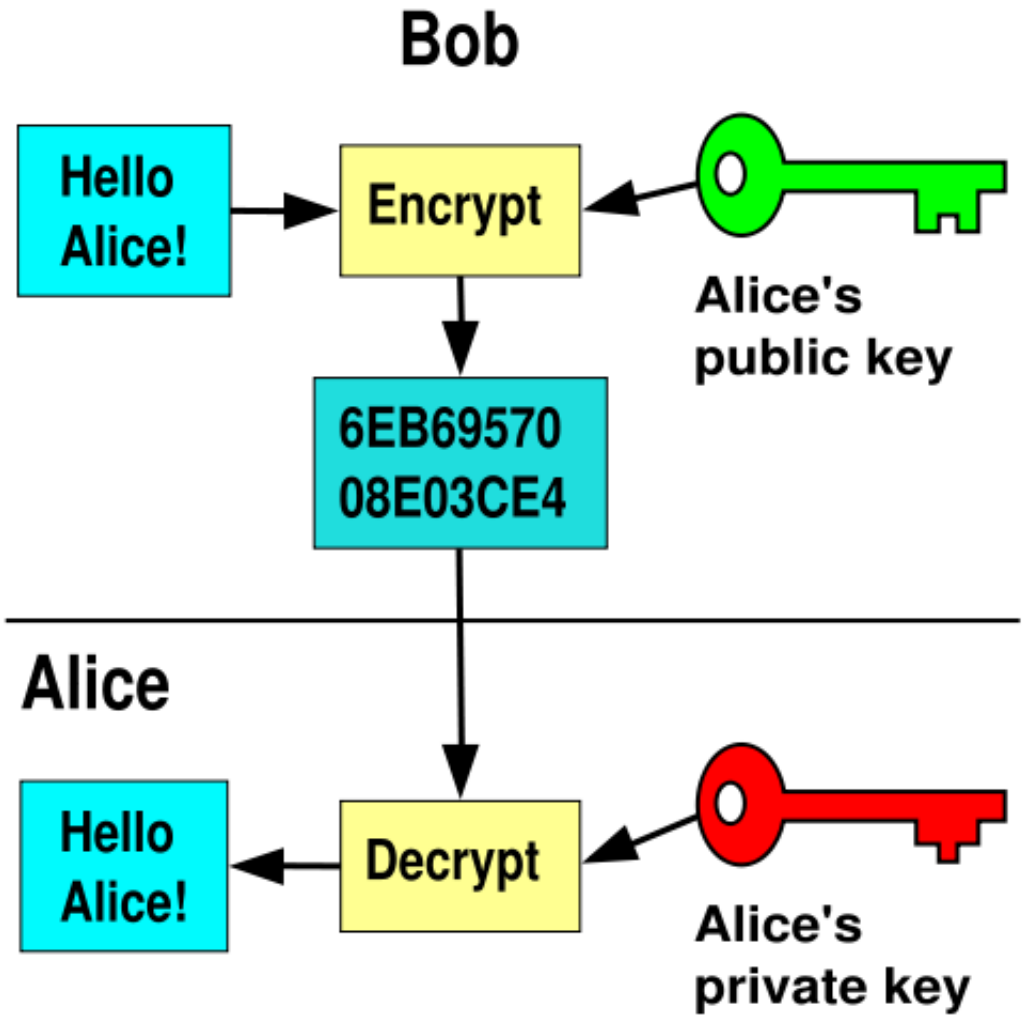
Public-Key Encryption Scheme

- *Key generation* algorithm
  - Produces private decryption & public encryption key pair
- Algorithm to *encrypt* a message
- Algorithm to *decrypt* a ciphertext
- Correctness:
  - Decrypting a ciphertext obtained by encrypting message m with the corresponding encrytion key returns m

$$dec(enc(m,pk(A)), sk(A)) = m$$

- (Symbolic) Security:
  - A ciphertext cannot be decrypted without access to the private decryption key

Why would you want public key encryption?


Bob
Hello Alice!
Encrypt
Alice's public key
6EB69570 08E03CE4
Alice
Hello Alice!
Decrypt
Alice's private key

Signature Scheme

- *Key generation* algorithm
  - Produces private signing & public verification key pair
- Algorithm to *sign* data
- Algorithm to *verify* signature
- Correctness:
  - Message signed with a signing key verifies with the corresponding verification key

$$verify(m, sign(m, sk(A)), pk(A)) = ok$$

- Security:
  - A signature cannot be produced without access to the private signing key

Can you think of a scenario where you may not want non-repudiation?

Message Authentication Code (MAC)

- *Key generation* algorithm
  - Produces a key
- Algorithm to *mac a* message
- Algorithm to *verify* a mac on a message
- Correctness:
  - Message mac-ed with key verifies with the same key

$$verify(k, m, mac(k,m)) = ok$$

- Security:
  - A MAC cannot be produced without access to the key

Similar to signature, but uses symmetric key

What property does a signature have, but a MAC does not?

Hash Functions

- *Key generation* algorithm
  - Produces a key
- Algorithm to *hash a* message m, given a key k to a fixed length output *hash(k, m)*

- Security (Collision resistance)

Given hash function *hash:* $X \rightarrow Y$ and key *k*, cannot find a collision, i.e. $x, x' \in X$ s.t. $x \neq x'$ and hash(k,x) = hash(k,x')

What is the difference between a MAC and a hash function?

Cryptographic Constructions

- Signature scheme
  - DSS, RSA-FDH,…
- Hash function
  - SHA-1, MD5,…
- Message Authentication Code (MAC)
  - HMAC, CBC-MAC, NBAC…
- Encryption scheme
  - Asymmetric (public key): RSA, Diffie-Hellman, El Gamal,… (distinct keys for encryption and decryption)
  - Symmetric: DES, 3DES, AES, RC4,… (same key for encryption and decryption)

Want to know more?
18-733: Applied Cryptography