# Lecture 12

### Public-key Cryptography

- Benefit: No longer need to assume that Alice and Bob already share a secret
- Drawback: Much slower than symmetric-key cryptography
  - Number theory calculations are much slower than XORs and bit-shifts

### Reading materials

- Encryption: Strengths and Weaknesses of Public-key Cryptography
- Public-key cryptography is a public invention due to Whitfield Diffie & Martin Hellman at Stanford Uni in 1976

#### Public-key cryptography

- public-key/two-key/asymmetric cryptography involves the use of two keys:
  - a public-key, which may be known by anybody, and can be used to encrypt messages, and verify signatures
  - a private-key, known only to the recipient, used to decrypt messages, and sign (create) signatures
- is **asymmetric** because
  - Not the same key
  - those who encrypt messages or verify signatures **cannot** decrypt messages or create signatures

### Public-Key Encryption

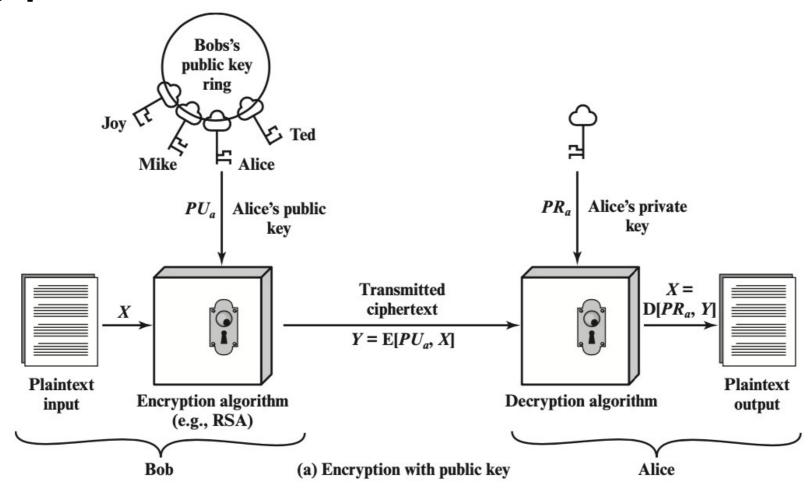
- Everybody can encrypt with the public key
- Only the recipient can decrypt with the private key







## Public-Key Cryptography -Encryption



#### **Encryption steps**

- step1: generate a pair of keys
- step2: keep the private key / secret key (SK) and distribute the public key (PK) place PK in a public register or other accessible file
- step3: Bob encrypts the message with Alice's PK
- step4: upon receiving the ciphertext (CT), Alice decrypt CT with SK

#### Public-Key Encryption: Definition

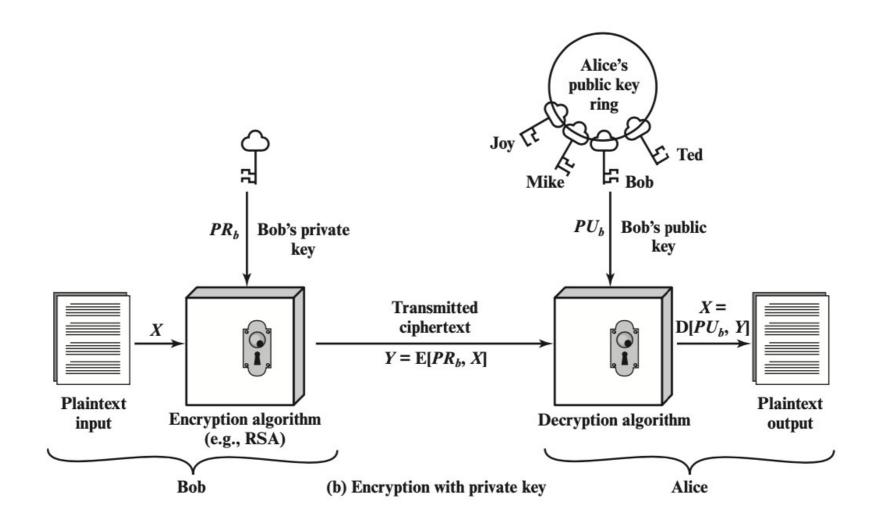
#### Three parts:

- KeyGen()  $\rightarrow$  *PK*, *SK*: Generate a public/private keypair, where *PK* is the public key, and *SK* is the private (secret) key
- Enc(PK, M) → C: Encrypt a plaintext M using public key PK to produce ciphertext C
- Dec(SK, C)  $\rightarrow M$ : Decrypt a ciphertext C using secret key SK

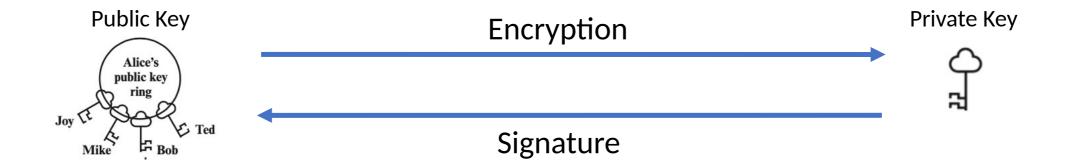
#### Properties

- **Correctness**: Decrypting a ciphertext should result in the message that was originally encrypted
  - Dec(SK, Enc(PK, M)) = M for all PK, SK  $\leftarrow$  KeyGen() and M
- Efficiency: Encryption/decryption should be fast
- **Security**: 1. Alice (the challenger) just gives Eve (the adversary) the public key, and Eve doesn't request encryptions. Eve cannot guess out anything; 2. computationally infeasible to recover M with PK and ciphertext

#### Public-Key Cryptography - Signature



#### Review



#### Public-Key application

- can classify uses into 3 categories:
  - encryption/decryption (provide secrecy)
  - digital signatures (provide authentication)
  - key exchange (of session keys)
- some algorithms are suitable for all uses; others are specific to one
- Either of the two related keys can be used for encryption, with the other used for decryption

Algorithm	Encryption/Decryption	Digital Signature	Key Exchange
RSA	Yes	Yes	Yes
Diffie-Hellman	No	No	Yes
DSS	No	Yes	No
Elliptic curve	Yes	Yes	Yes