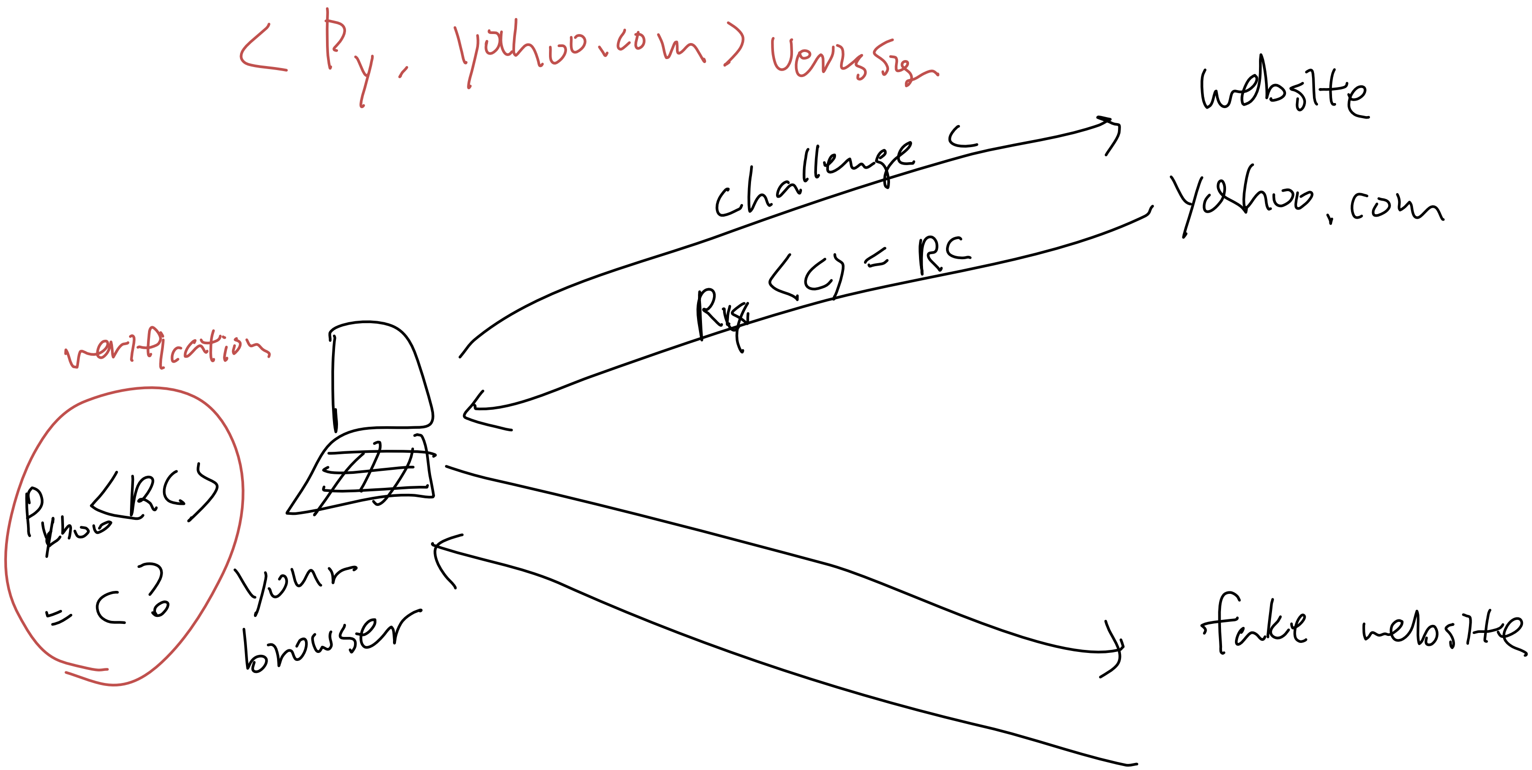
# Public Key Infrastructure (PKI) and Pretty Good Privacy (PGP)

EJ Jung



< P_Y, yahoo.com > VeriSign
website
yahoo.com
challenge C
R_Y(C) = RC
verification
P_yhoo(RC) = C?
your browser
fake website

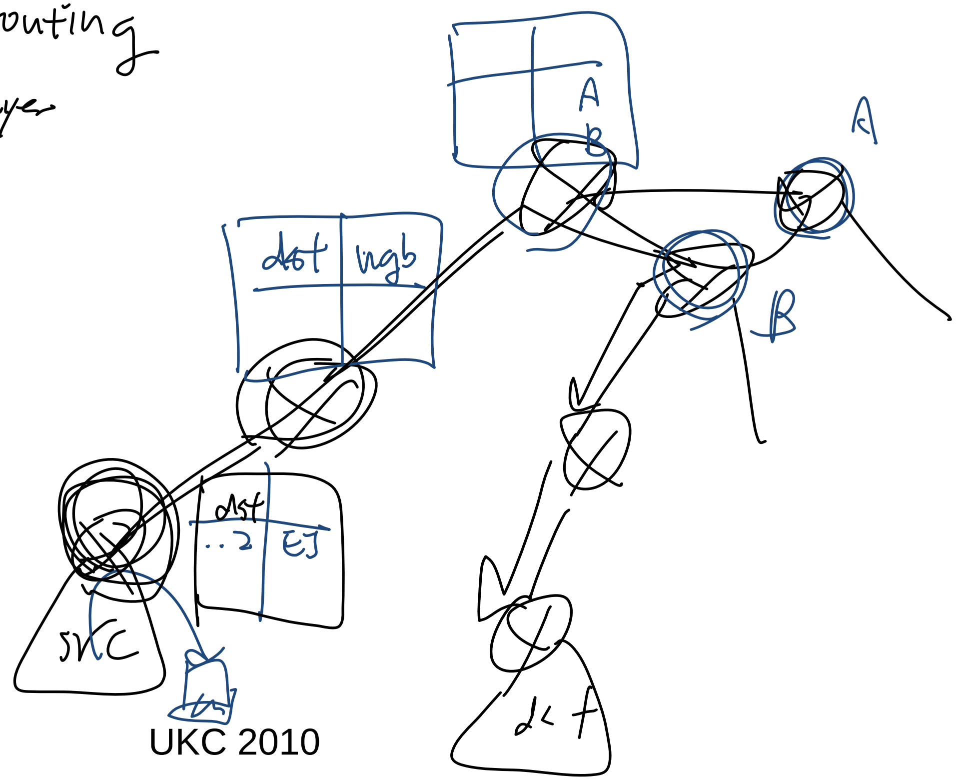
Application

Transport : src – dst   your browser ⟷ yahoo.com

Network (Internet) : routing

Access / Medium / link layer

physical



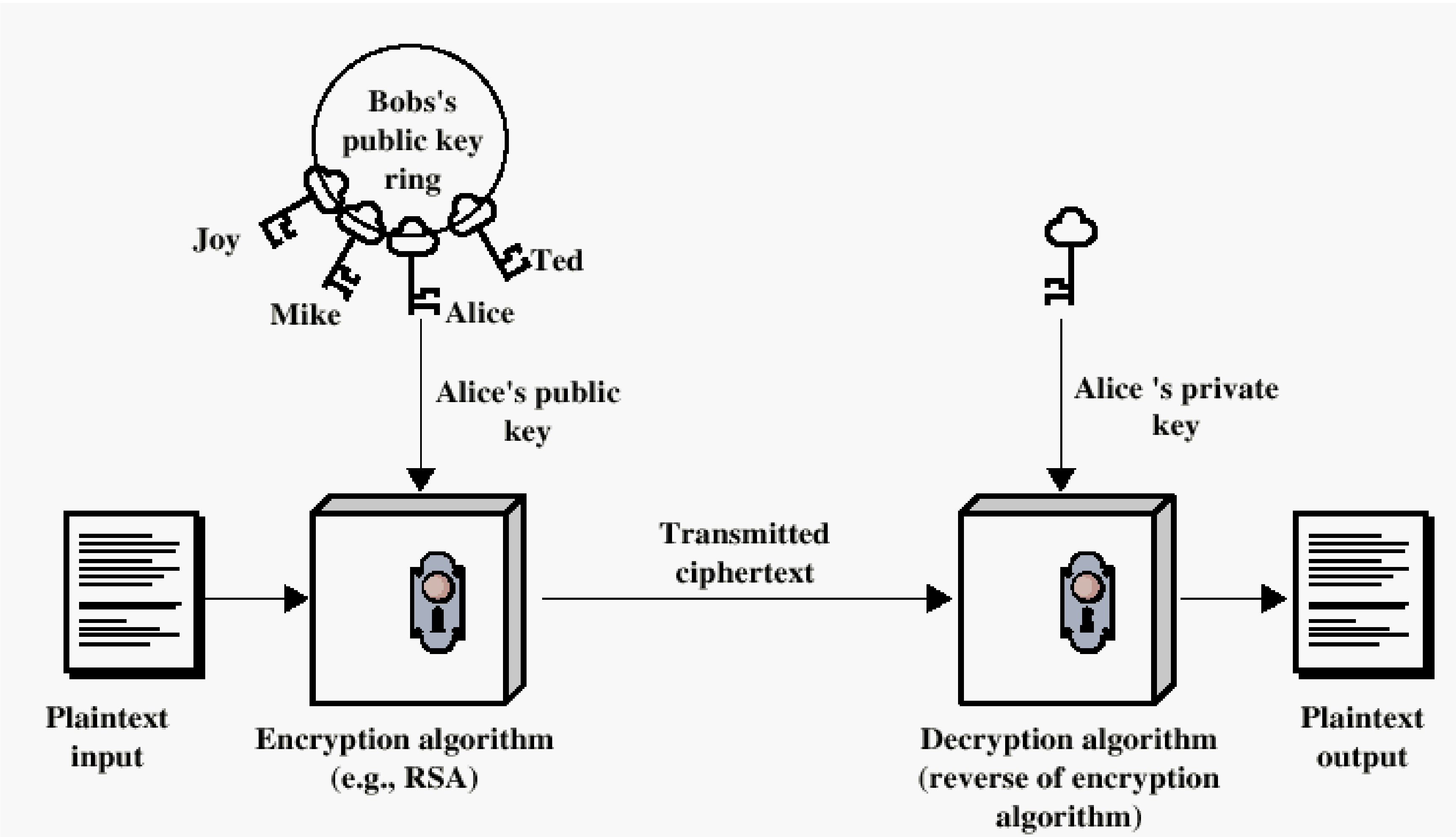
# Advantages of Public-Key Crypto

- Confidentiality without shared secrets
  - Very useful in open environments
  - No "chicken-and-egg" key establishment problem
    - With symmetric crypto, two parties must share a secret before they can exchange secret messages
- Authentication without shared secrets
  - Use digital signatures to prove the origin of messages
- Reduce protection of information to protection of authenticity of public keys
  - No need to keep public keys secret, but must be sure that Alice's public key is <u>really</u> her true public key

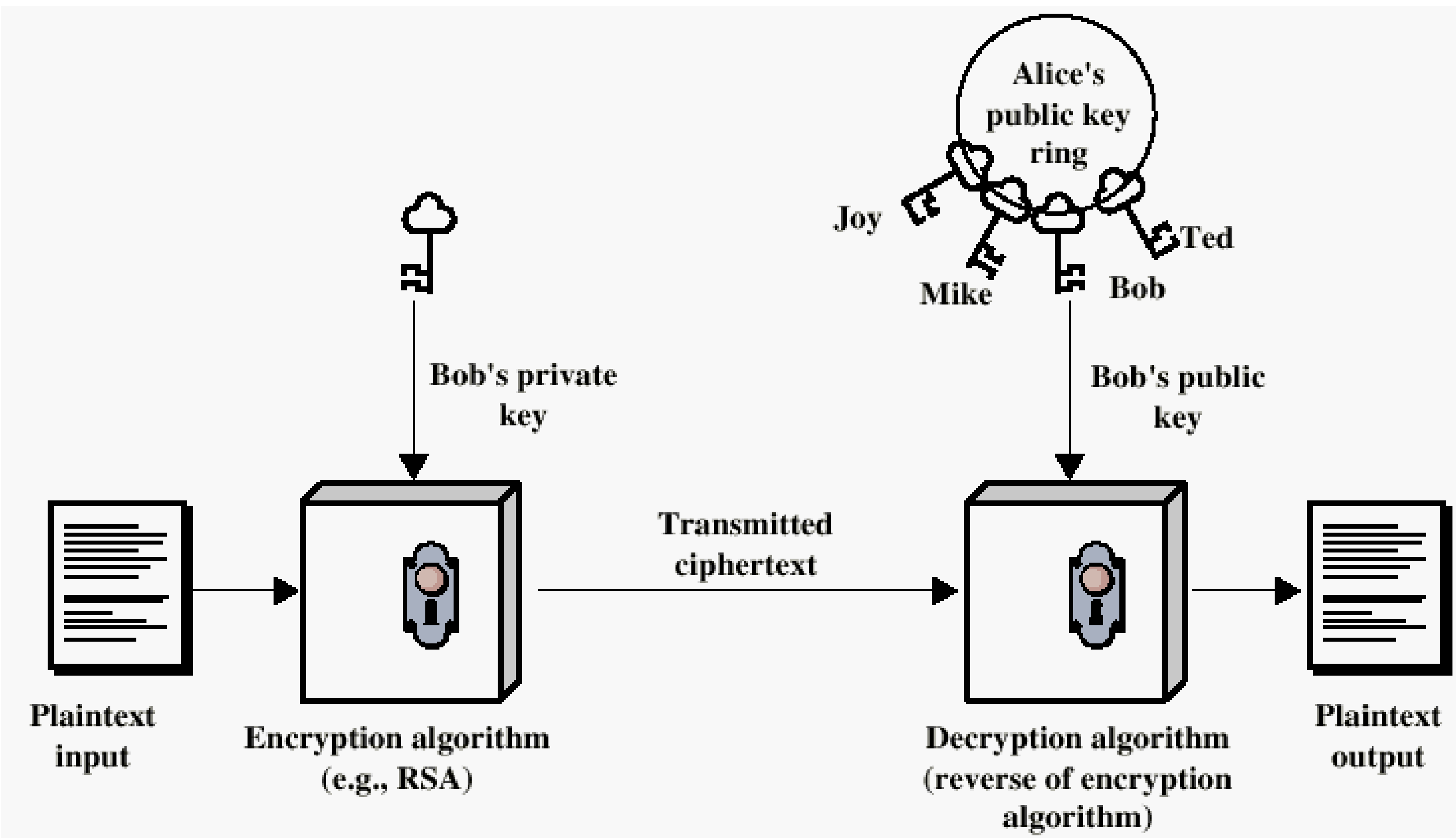
# Disadvantages of Public-Key Crypto

- Calculations are 2-3 orders of magnitude slower
  - Modular exponentiation is an expensive computation
  - Typical usage: use public-key cryptography to establish a shared secret, then switch to symmetric crypto
    - We'll see this in IPSec and SSL
- Keys are longer
  - 1024 bits (RSA) rather than 128 bits (AES)
- Relies on unproven number-theoretic assumptions
  - What if factoring is easy?
    - Factoring is believed to be neither P, nor NP-complete

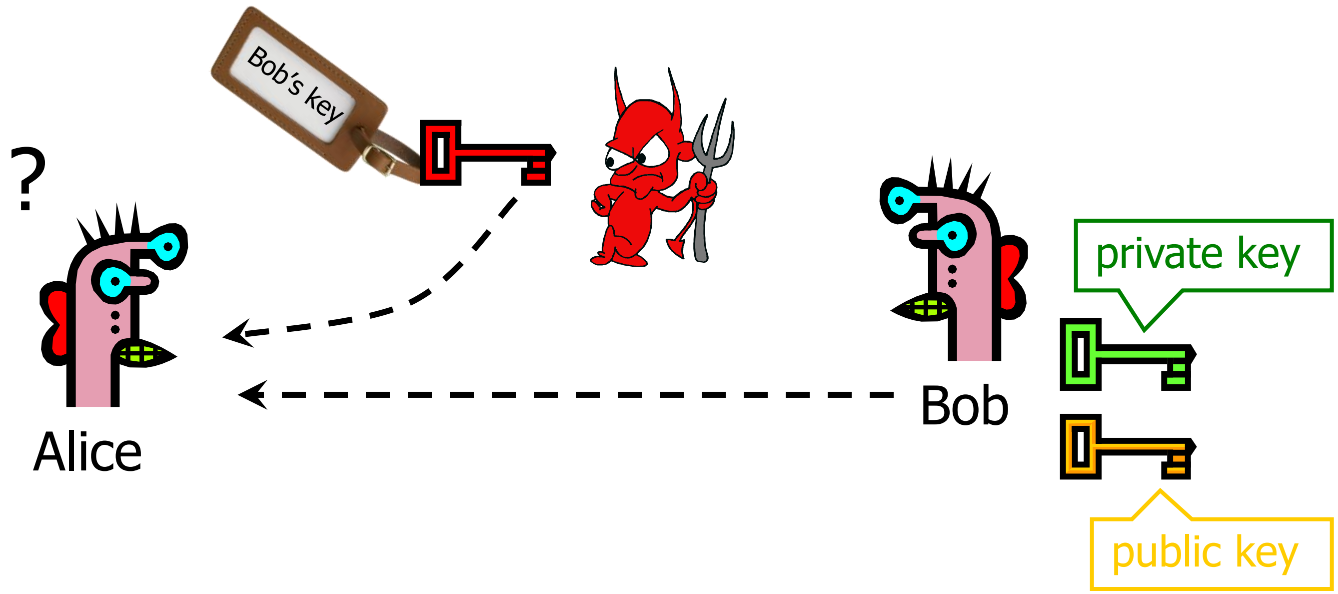
# Encryption using Public-Key system



# Authentication using Public-Key System



# Authenticity of Public Keys

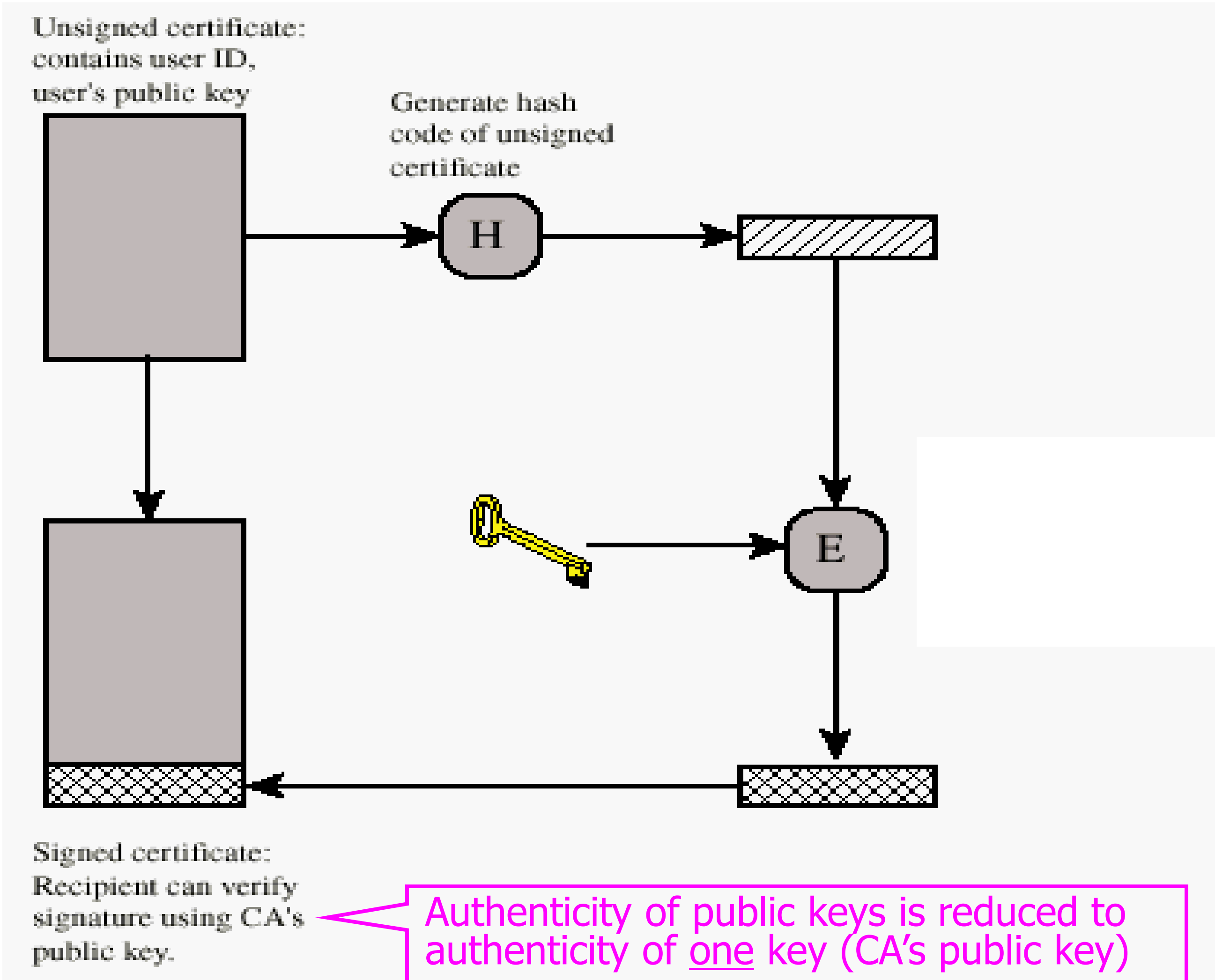



Problem: How does Alice know that the public key she received is really Bob's public key?

# Distribution of Public Keys

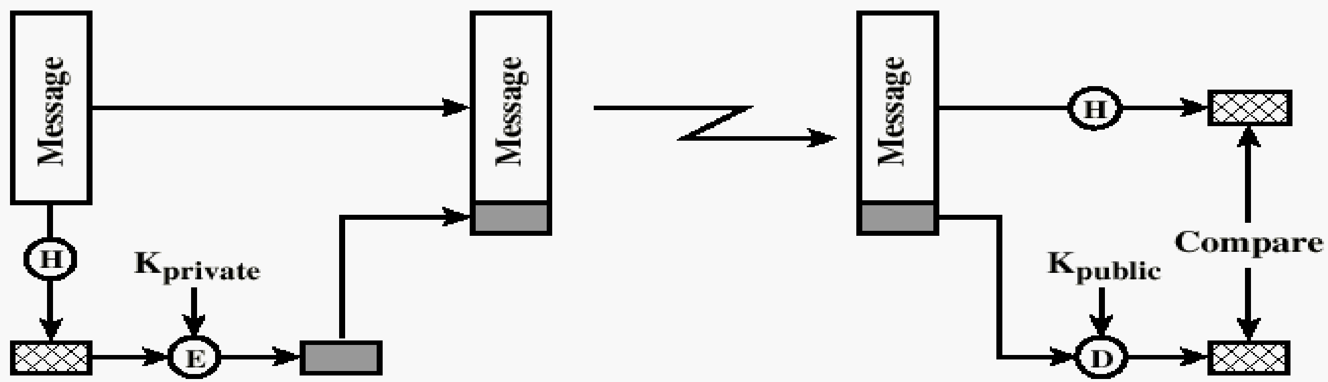
- Public announcement or public directory
  - Risks: forgery and tampering
- Public-key certificate
  - Signed statement specifying the key and identity
    - $sig_{Alice}$(“Bob”, $PK_B$)
- Common approach: certificate authority (CA)
  - Single agency responsible for certifying public keys
  - After generating a private/public key pair, user proves his identity and knowledge of the private key to obtain CA’s certificate for the public key (offline)
  - Every computer is pre-configured with CA’s public key

# Using Public-Key Certificates




Authenticity of public keys is reduced to authenticity of one key (CA's public key)

# Typical Digital Signature Approach




(b) Using public-key encryption

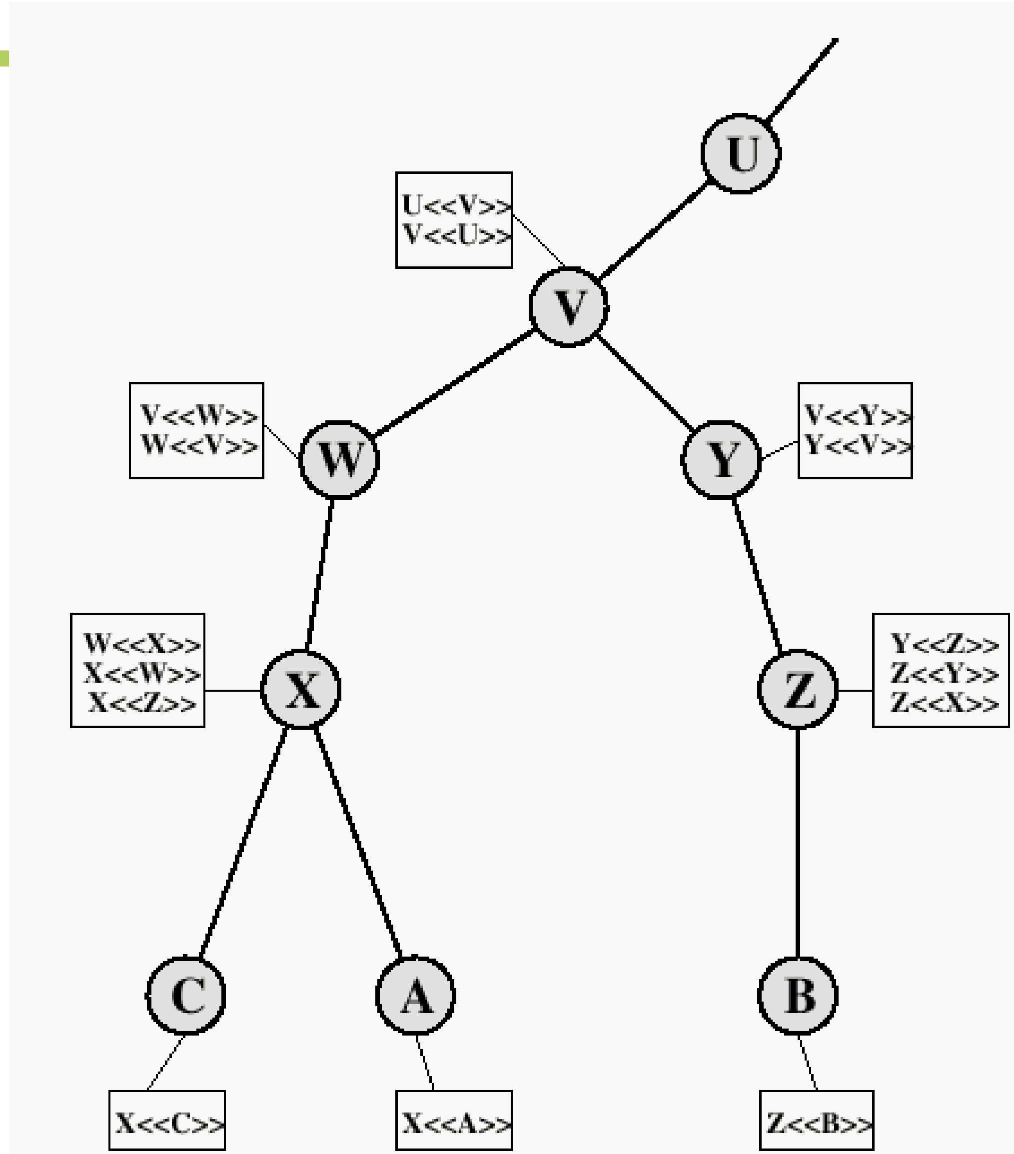
# Hierarchical Approach

- Single CA certifying every public key is impractical
- Instead, use a trusted root authority
  - For example, Verisign
  - Everybody must know the public key for verifying root authority's signatures
- Root authority signs certificates for lower-level authorities, lower-level authorities sign certificates for individual networks, and so on
  - Instead of a single certificate, use a certificate chain
    - $sig_{Verisign}$("UI", $PK_{UI}$), $sig_{UI}$("EJ Jung", $PK_E$)
  - What happens if root authority is ever compromised?

# Revocation of Certificates

- Reasons for revocation:
  - The users secret key is assumed to be compromised.
  - The user is no longer certified by this CA.
  - The CA’s certificate is assumed to be compromised.

# X.509 CA Hierarchy



# Alternative: "Web of Trust"

- Used in PGP (Pretty Good Privacy)
- Instead of a single root certificate authority, each person has a set of keys they "trust"
  - If public-key certificate is signed by one of the "trusted" keys, the public key contained in it will be deemed valid
- Trust can be transitive
  - Can use certified keys for further certification