BK TP.HCM

Cryptography and Network Security

Chapter 5

Digital Signatures

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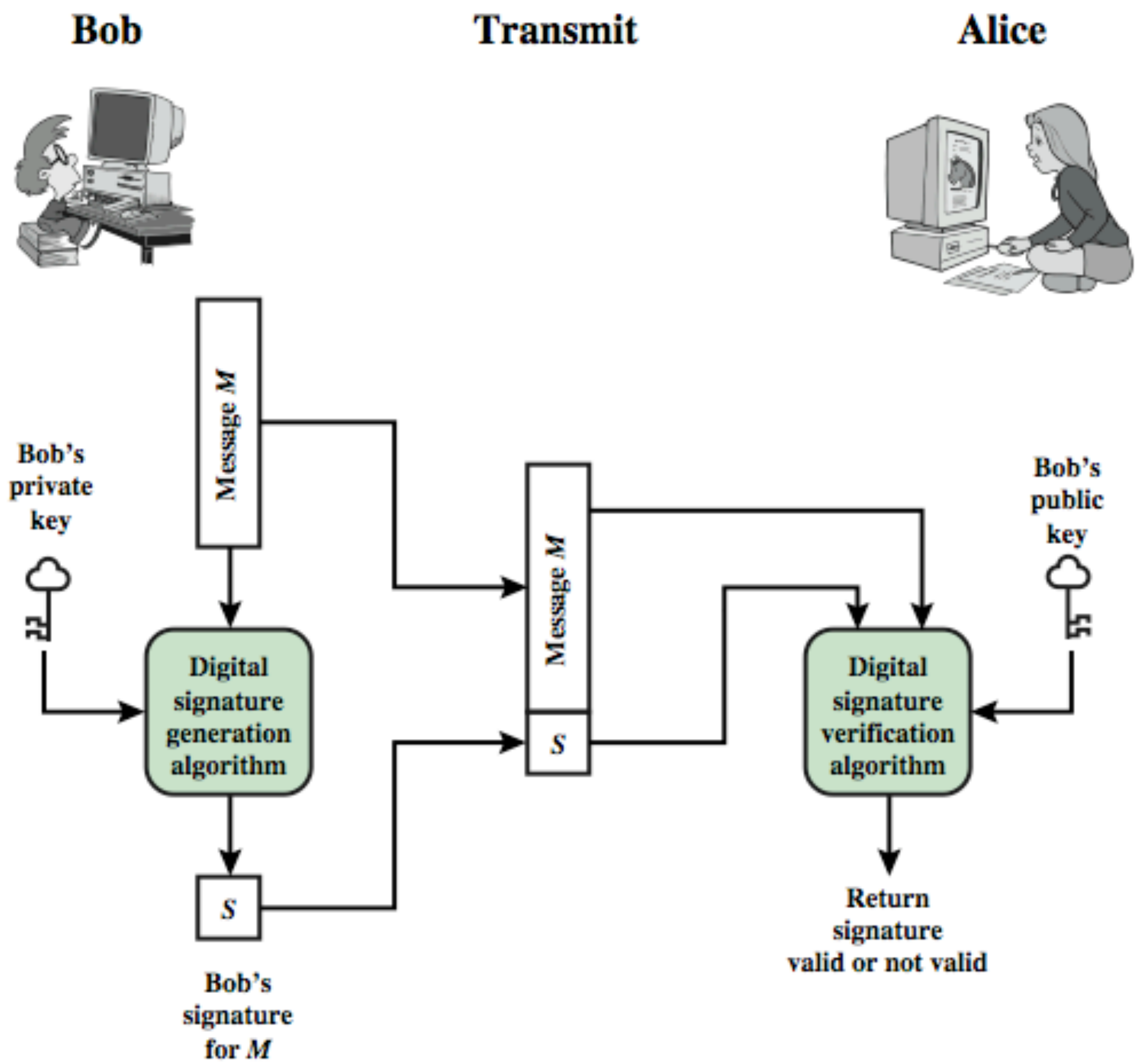
Outline

- Digital Signatures
- Digital Signature Algorithm and Standard

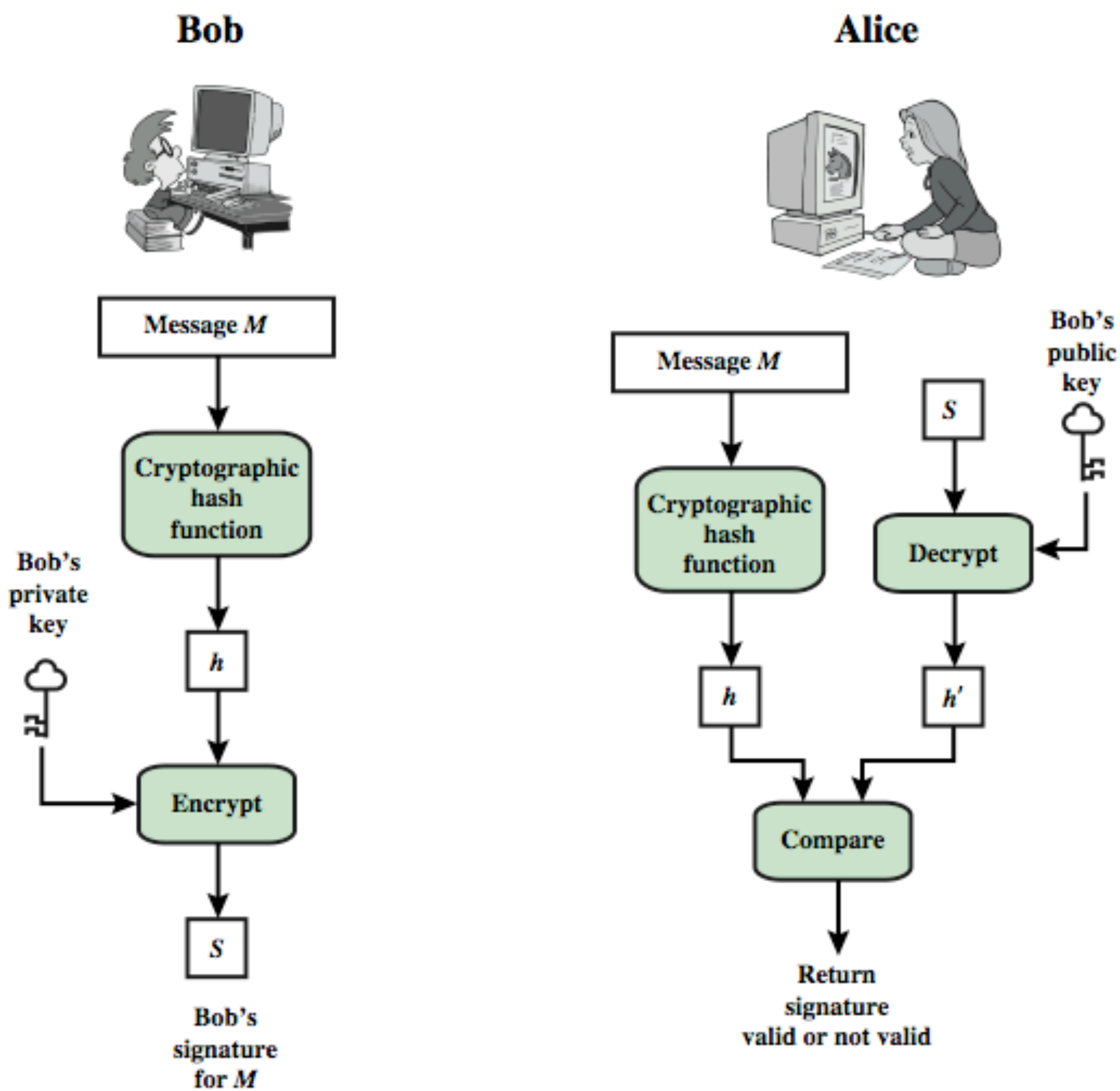
Digital Signatures

- A ***digital signature*** is an ***authentication mechanism*** that enables the creator of a message to attach a code that acts as a signature.
- Typically the signature is formed by taking the ***hash of the message*** and ***encrypting the message with the creator's private key***.
- The signature guarantees the ***source*** and ***integrity*** of the message.
- The digital signature standard (DSS) is an NIST standard that uses the ***secure hash algorithm*** (SHA).

Digital Signature Model



Digital Signature Model



Attacks and Forgeries

- **attacks**
  - key-only attack
  - known message attack
  - generic chosen message attack
  - directed chosen message attack
  - adaptive chosen message attack
- **break success levels**
  - total break
  - selective forgery
  - existential forgery

Digital Signature Requirements

- must depend on the message signed
- must use information unique to sender
  - to prevent both forgery and denial
- must be relatively easy to produce
- must be relatively easy to recognize & verify
- be computationally infeasible to forge
  - with new message for existing digital signature
  - with fraudulent digital signature for given message
- be practical save digital signature in storage

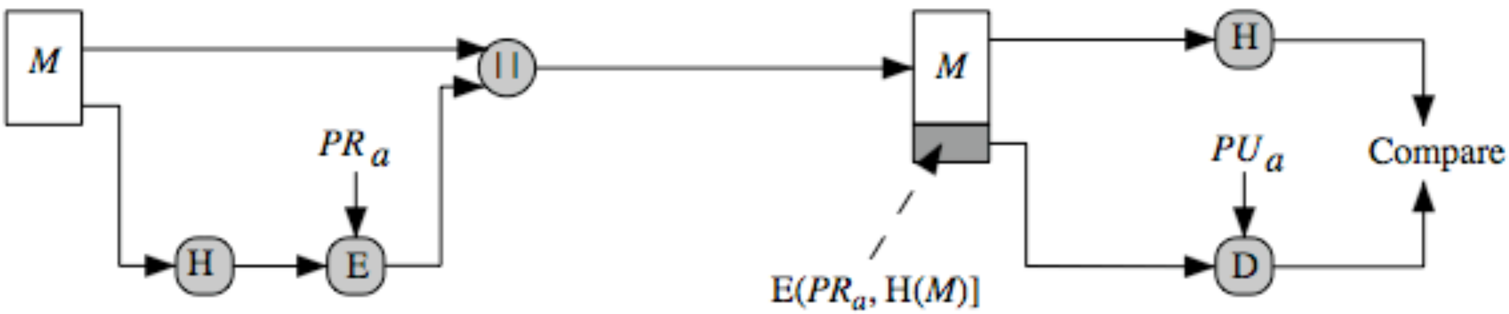
Direct Digital Signatures

- involve only sender & receiver
- assumed receiver has sender’s public-key
- digital signature made by sender signing entire message or hash with private-key
- can encrypt using receivers public-key
- important that ***sign first*** then encrypt message & signature
- security depends on sender’s private-key

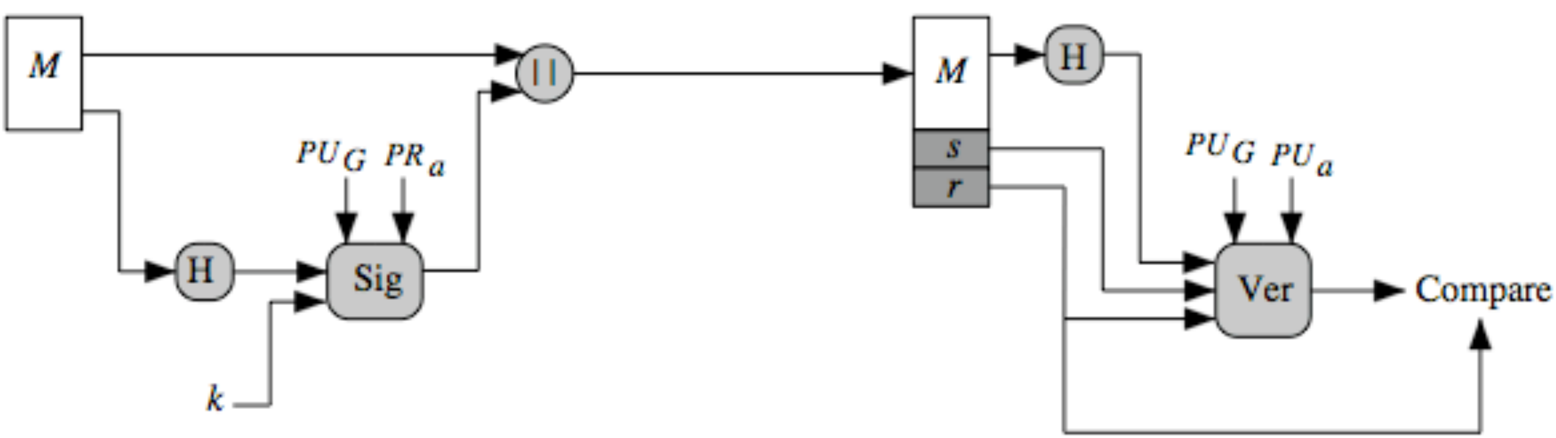
Digital Signature Standard (DSS)

- US Govt approved signature scheme
- designed by NIST & NSA in early 90's
- published as FIPS-186 in 1991
- revised in 1993, 1996 & then 2000
- uses the SHA hash algorithm
- DSS is the standard, DSA is the algorithm
- FIPS 186-2 (2000) includes alternative RSA & elliptic curve signature variants
- DSA is digital signature only unlike RSA
- is a public-key technique

DSS vs. RSA Signatures



(a) RSA Approach



(b) DSS Approach

Digital Signature Algorithm (DSA)

- creates a 320 bit signature
- with 512-1024 bit security
- smaller and faster than RSA
- a digital signature scheme only
- security depends on difficulty of computing discrete logarithms
- variant of ElGamal & Schnorr schemes

DSA Key Generation

- **have shared global public key values (p,q,g):**
  - choose 160-bit prime number q
  - choose a large prime p with $2^{L-1} < p < 2^L$
    - where L= 512 to 1024 bits and is a multiple of 64
    - such that q is a 160 bit prime divisor of (p-1)
  - choose $g = h^{(p-1)/q}$
    - where $1<h<p-1$ and $h^{(p-1)/q} \bmod p > 1$
- **users choose private & compute public key:**
  - choose random private key: $x<q$
  - compute public key: $y = g^x \bmod p$

DSA Signature Creation

- **to sign a message M the sender:**
  - generates a random signature key k, $k<q$
  - Note: k must be random, be destroyed after use, and never be reused
- **then computes signature pair:**

  $r = (g^k \bmod p) \bmod q$

  $s = [k^{-1}(H(M) + xr)] \bmod q$
- **sends signature (r,s) with message M**

DSA Signature Verification

- **having received M & signature (r,s)**
- **to verify a signature, recipient computes:**

$$w = s^{-1} \bmod q$$

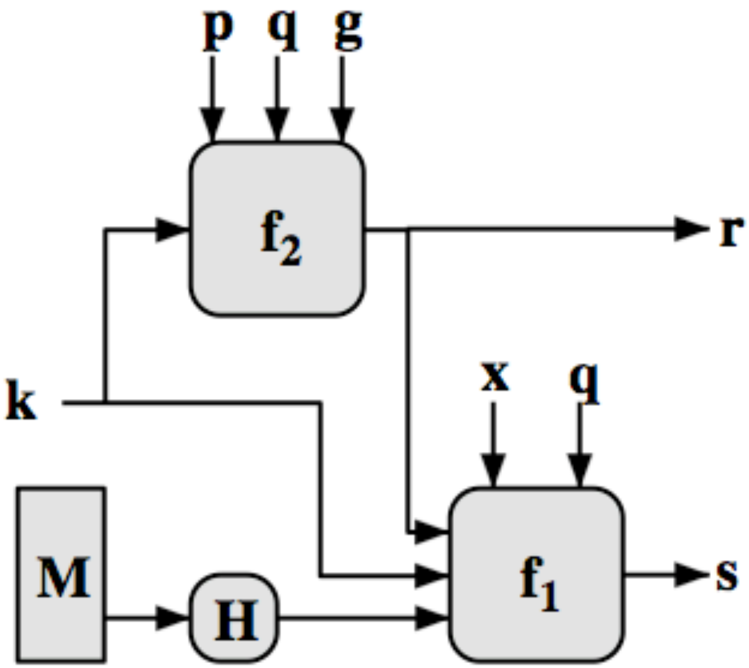
$$u1 = [H(M)w] \bmod q$$

$$u2 = (rw) \bmod q$$

$$v = [(g^{u1}\, y^{u2}) \bmod p] \bmod q$$

- **if v=r then signature is verified**
- **see Appendix A for details of proof why**

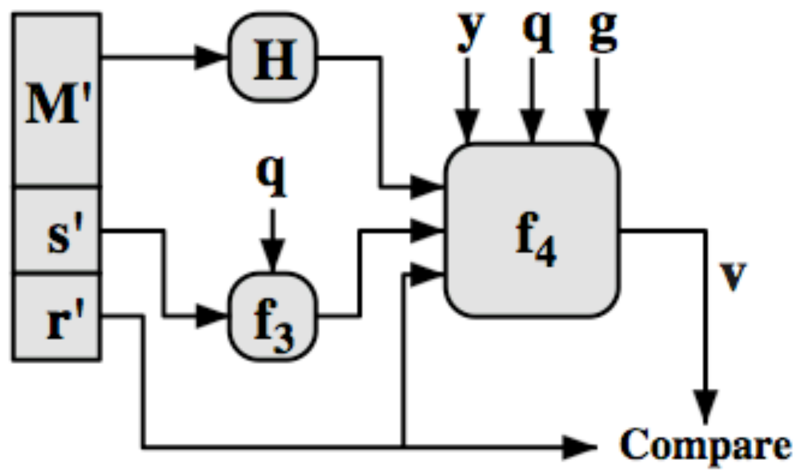
DSS Overview



$$s = f_1(H(M), k, x, r, q) = (k^{-1}\,(H(M) + xr)) \bmod q$$

$$r = f_2(k, p, q, g) = (g^k \bmod p) \bmod q$$

(a) Signing



$$w = f_3(s', q) = (s')^{-1} \bmod q$$

$$v = f_4(y, q, g, H(M'), w, r')$$

$$= ((g^{(H(M')w) \bmod q}\, y^{r'w \bmod q}) \bmod p) \bmod q$$

(b) Verifying

Summary

We have discussed:

- Digital Signatures
- Digital Signature Algorithm and Standard

References

- *Cryptography and Network Security*, Principles and Practice, William Stallings, Pearson, 7th Edition, 2017