Digital Signatures

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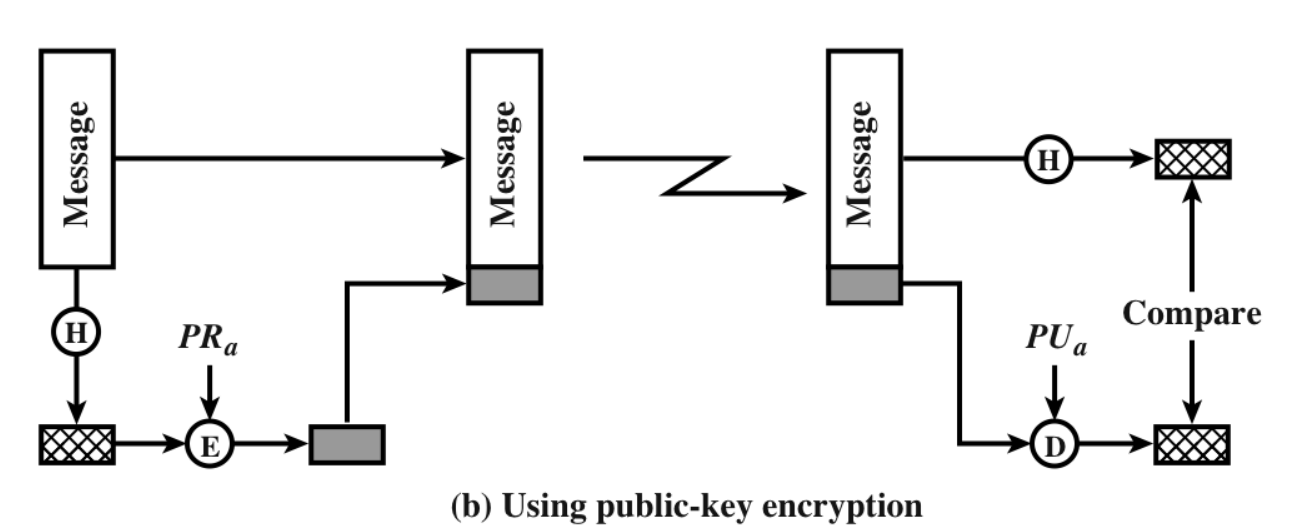
Digital Signatures

- How is a digital signature constructed?
  - Why should we use a hash?



(b) Using public-key encryption

Digital Signatures

- What assurances do we get?
  - Authentication?
  - Confidentiality?
  - Integrity?
  - Non-repudiation?
- MAC vs. Signature
  - What are the differences?
- What do we sign?

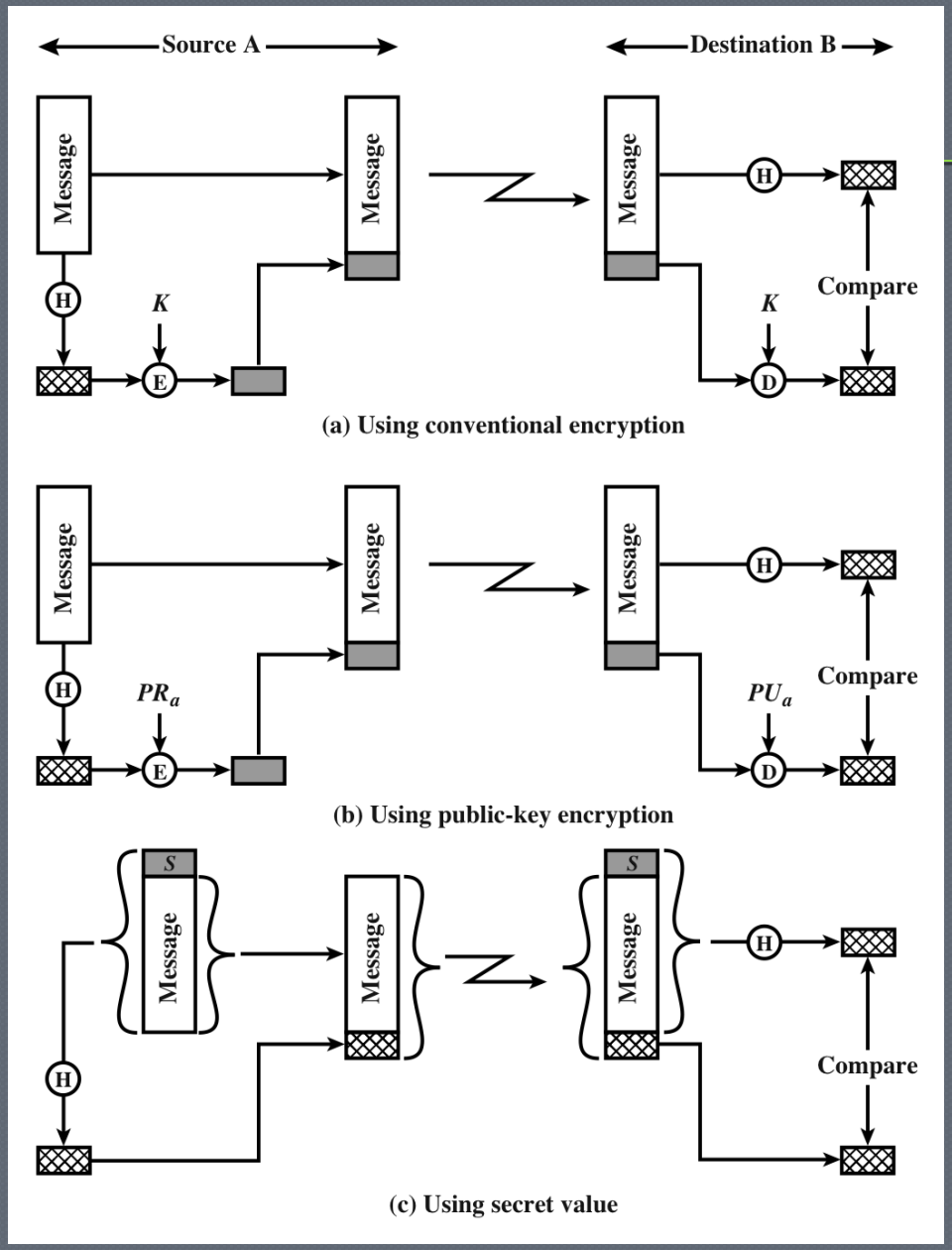
Digital Signatures

- When do we sign?
  - Sign-then-Encrypt (common)
    - Surreptitious forwarding attack
  - Encrypt-then-Sign
    - Authorship claim attack

Order of Authentication/Encryption

- Encrypt then Authenticate (Sign/MAC)
  - More secure (in theory)
  - More efficient to discard bogus messages
- Authenticate (Sign/MAC) then Encrypt
  - Harder to attack the MAC, not visible
  - Disclosing data is less severe than accepting modified data
  - Horton Principle – authenticate what you mean, not what you say
- Encrypt and Authenticate
  - Process in parallel
  - MAC protect authenticity, not privacy
- All choices can be used securely and insecurely

Message Authentication



- Three approaches
  - Benefits of each?
  - Drawbacks?
  - Third option broken, use HMAC

Digital Certificates

- Who has a digital certificate?
- What is the most common use for certificates?

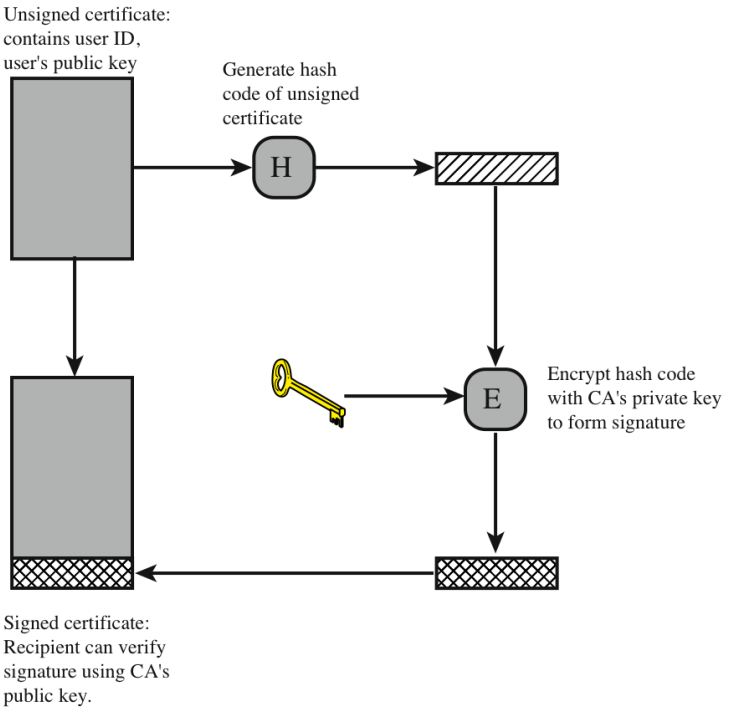


Figure 3.12 Public-Key Certificate Use

Performance Test

- Goal: figure out the relative computing time for algorithms (one block)
  - SHA-1
  - AES
  - RSA Encrypt
  - RSA Signature
- Order the above, fastest to slowest

Performance Test

- Average of 10,000 iterations
- SHA-1 – 0.0017 ms
- AES – 0.0142 ms

8x slower than a hash

- RSA encrypt – 0.3647 ms

215x slower than a hash
26x slower than AES

- RSA signature – 5.9751 ms

3515x slower than a hash
421x slower than AES
16x slower than RSA enc.

RSA Padding

Or: "How RSA should really be used"
(See PKCS #1)

RSA Primitives

- RSA Encryption
  - $m^e = c \pmod n$
- RSA Decryption
  - $c^d = m \pmod n$
- Pitfalls of using RSA
  - Mathematical structure – m3=m1*m2, multiply sigs
  - What if m is very small? Take the e'th root
- Use RSA Padding
- RSA Labs publishes the standards for using RSA
  - Public Key Cryptography Standard #1 (PKCS #1)
    - Current version: 2.1

Overview of PKCS #1

- Good cryptographic practice
  - Employ a key pair in only one scheme
    - One pair for signatures, one for encryption
- Provides 2 approaches for using the RSA primitives
  - Legacy
    - PKCS1-v1_5
  - Recommended
    - OAEP, PSS

PKCS1-v1_5 Encryption

- Encryption
  - Message m becomes EM
    - EM = 0x00 || 0x02 || PS || 0x00 || M
  - EM is then used with the encryption primitive
- Decryption
  - Ensure that the decrypted message conforms to the expected structure above, remove padding, etc

PS is randomly generated, non-zero, bytes
- PS must be at least 8 bytes
- Why must PS have a minimum length?

- How does this scheme affect the size of the message to be encrypted?
- When does this approach produce identical ciphertexts?

PKCS1-v1_5 Signatures

- Signature
  - Hash message m, pre-pend the digestID to create T
    - EM = 0x00 || 0x01 || PS || 0x00 || T
  - EM is then used with the signature primitive
- Verification
  - Use public key to obtain EM
  - Ensure that EM conforms to the expected structure above, remove padding, etc

PS is the byte 0xff repeated over and over

- How does this scheme affect the size of the message digests that can be used?
- When does this approach produce identical signatures?

PKCS1-v1_5

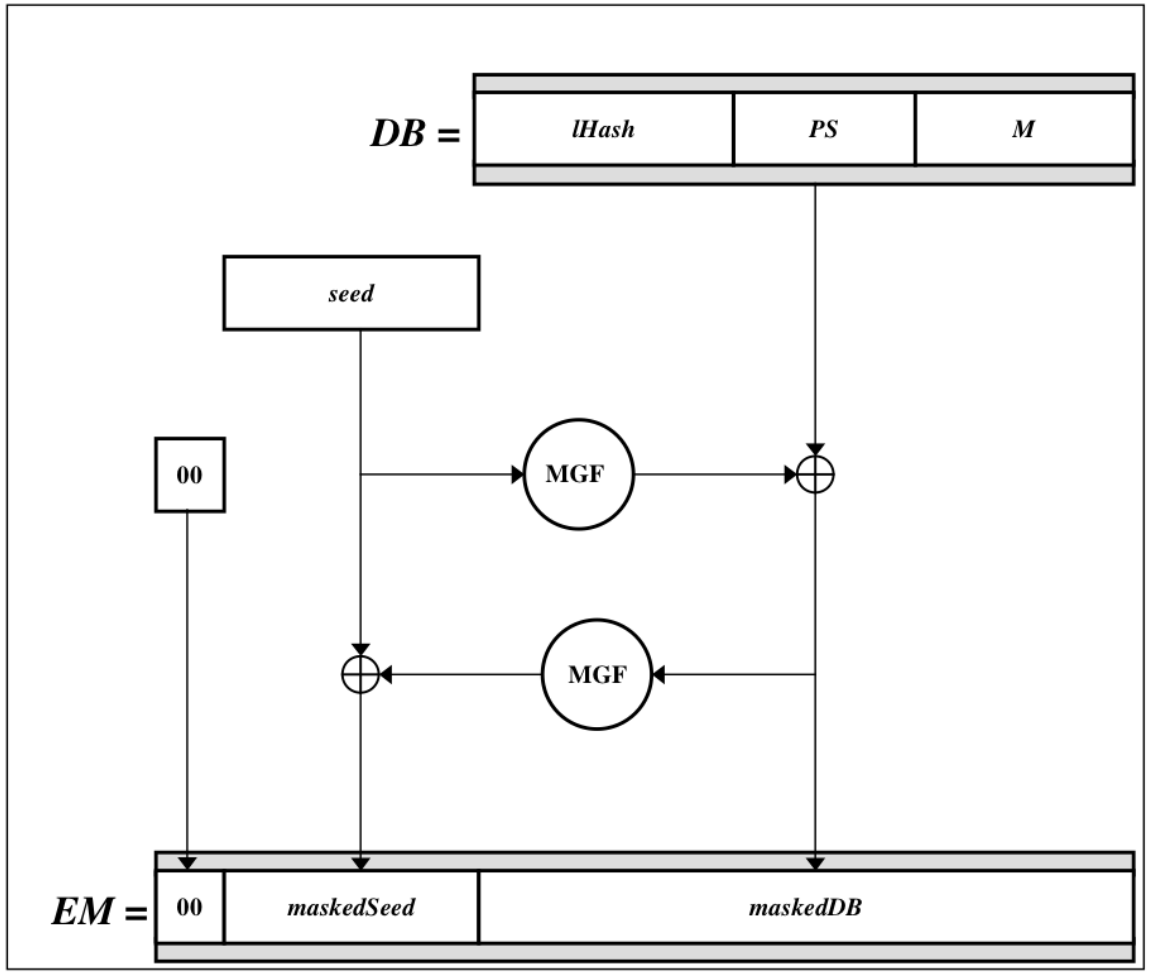
- Encryption
  - EM = 0x00 || 0x02 || PS || 0x00 || M
- Signature
  - EM = 0x00 || 0x01 || PS || 0x00 || T

- Why do both start with 0x00?

RSA Encryption with OAEP

- OAEP
  - Optimal Asymmetric Encryption Padding
  - In addition to being more secure adds the ability to associate a label with the message
- Encrypt(M, L (optional), n, e)

RSA Encryption with OAEP



PS is the byte 0x00 repeated over and over

seed is a random series of bytes

How does this scheme affect the size of the message to be encrypted?

When does this approach produce identical ciphertexts?

RSA Signatures with PSS

- PSS
  - Probabilistic Signature Scheme
- $Padding_1$ and $Padding_2$ are bytes of 0x00
- Salt is random
- bc is 0xbc
- When does this approach produce identical signatures?