Digital Signatures

Signatures

We use signatures because a signature is:

- Authentic
- Not reusable
- Renders document unalterable
- Unforgeable
- Non repudiatable

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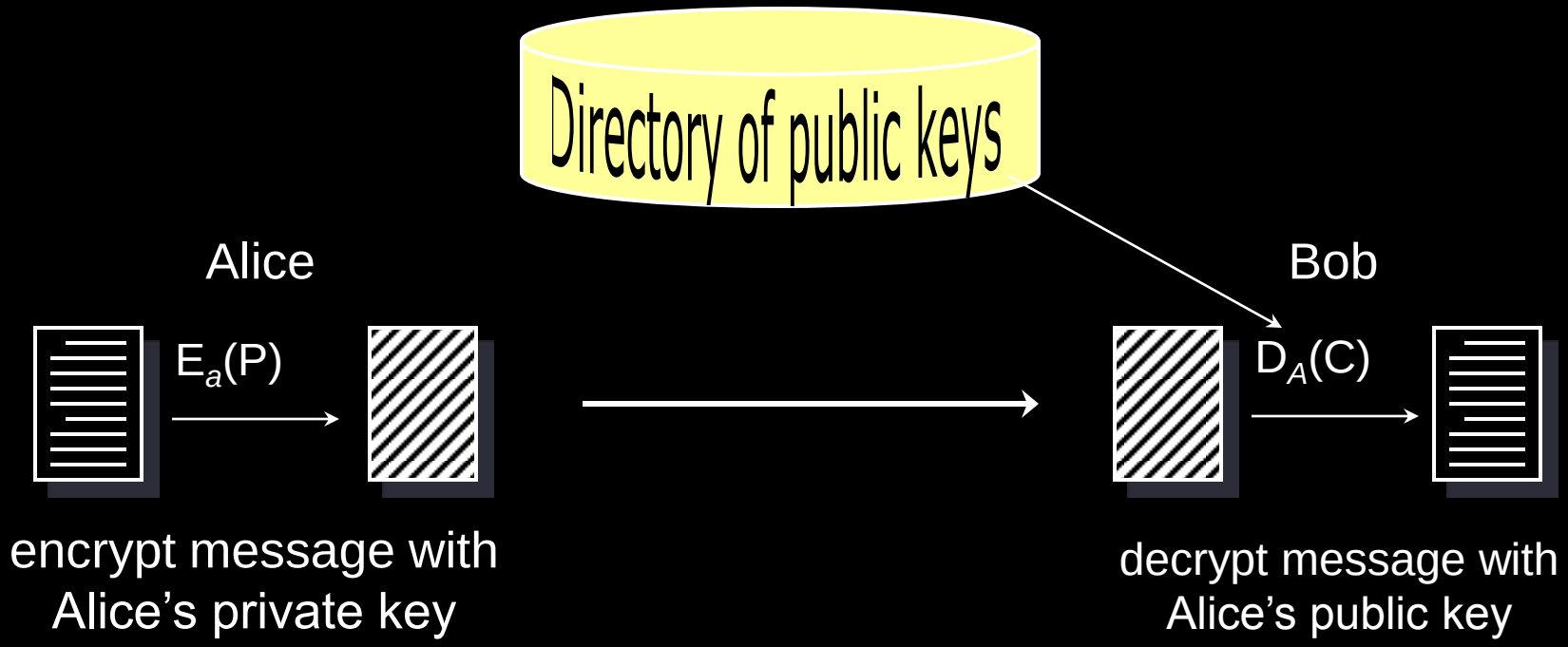
ALL UNTRUE!

Can we do better with **digital signatures**?

Digital signatures - public key cryptography

Encrypting a message with a private key is the same as signing!



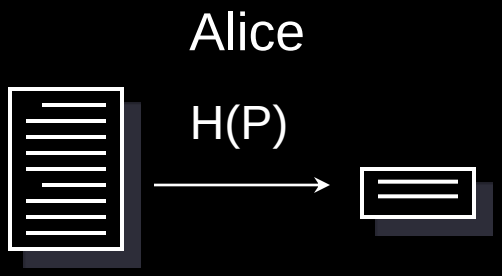
Digital signatures - public key cryptography

- What if Alice was sending Bob binary data?
  - Bob might have a hard time knowing whether the decryption was successful or not
- Public key encryption is considerably slower than symmetric encryption
  - what if the message is very large?
- What if we don't want to hide the message, yet want a valid signature?

Digital signatures - public key cryptography

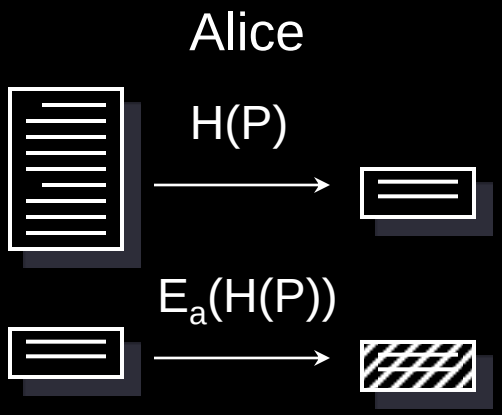
- Create a **hash** of the message
- **Encrypt the hash** and send it with the message
- Validate the hash by decrypting it and comparing it with the hash of the received message

Digital signatures - public key cryptography



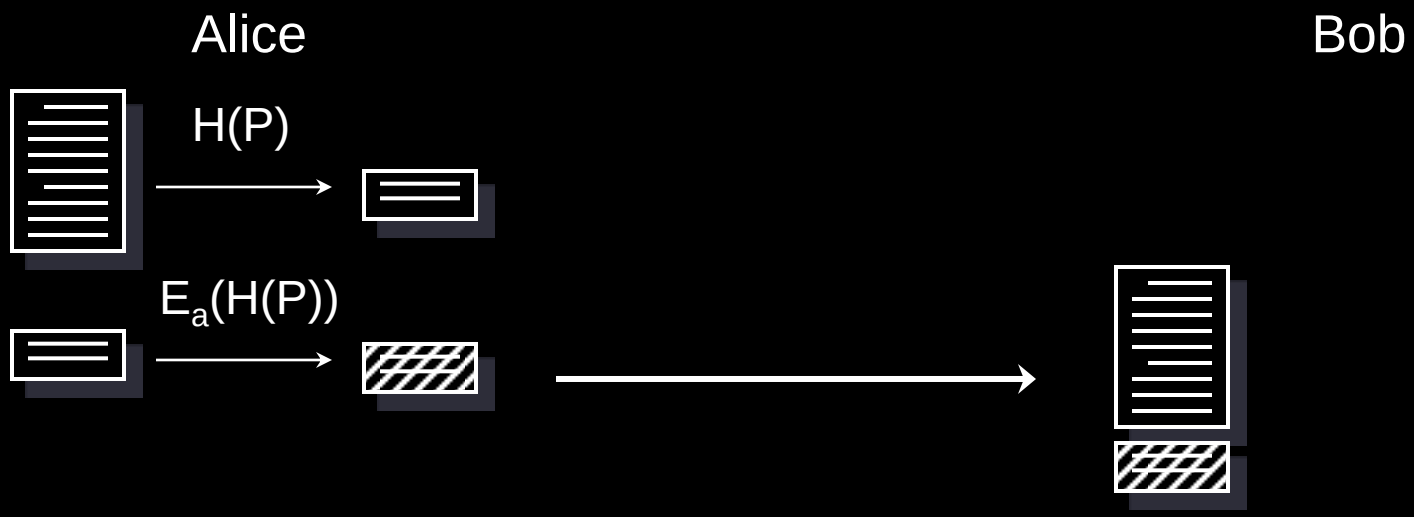
Alice generates a hash of the message

Digital signatures - public key cryptography



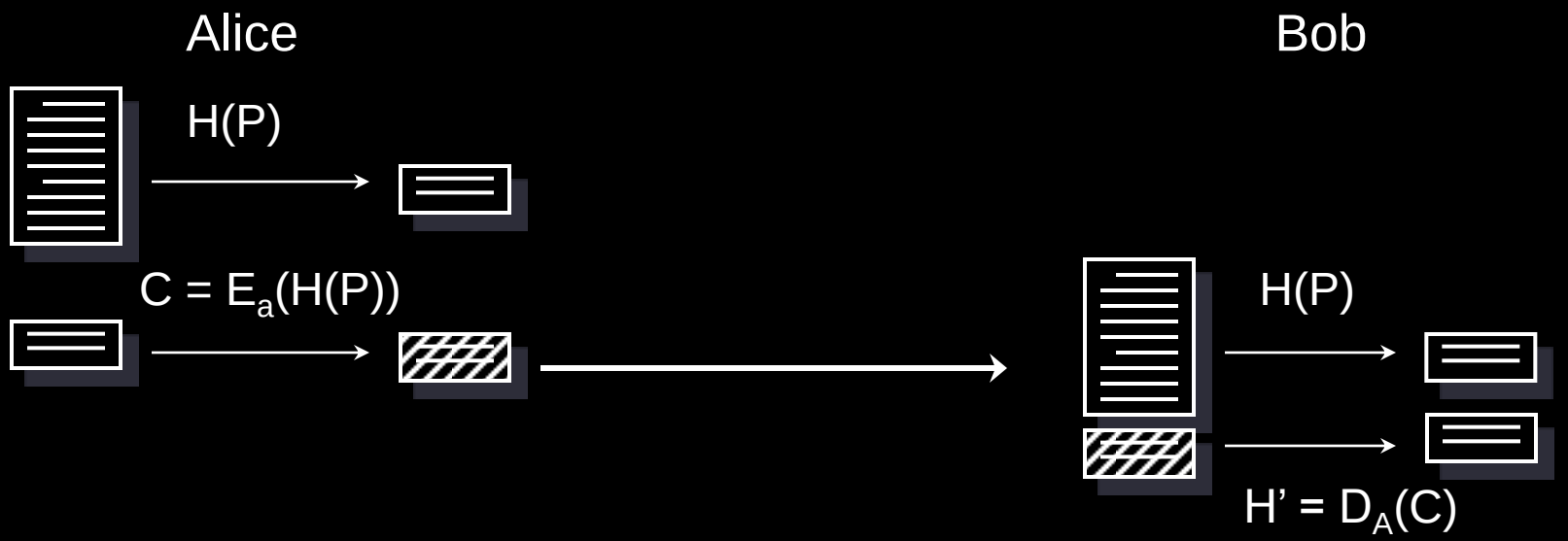
Alice encrypts the hash with her private key

Digital signatures - public key cryptography



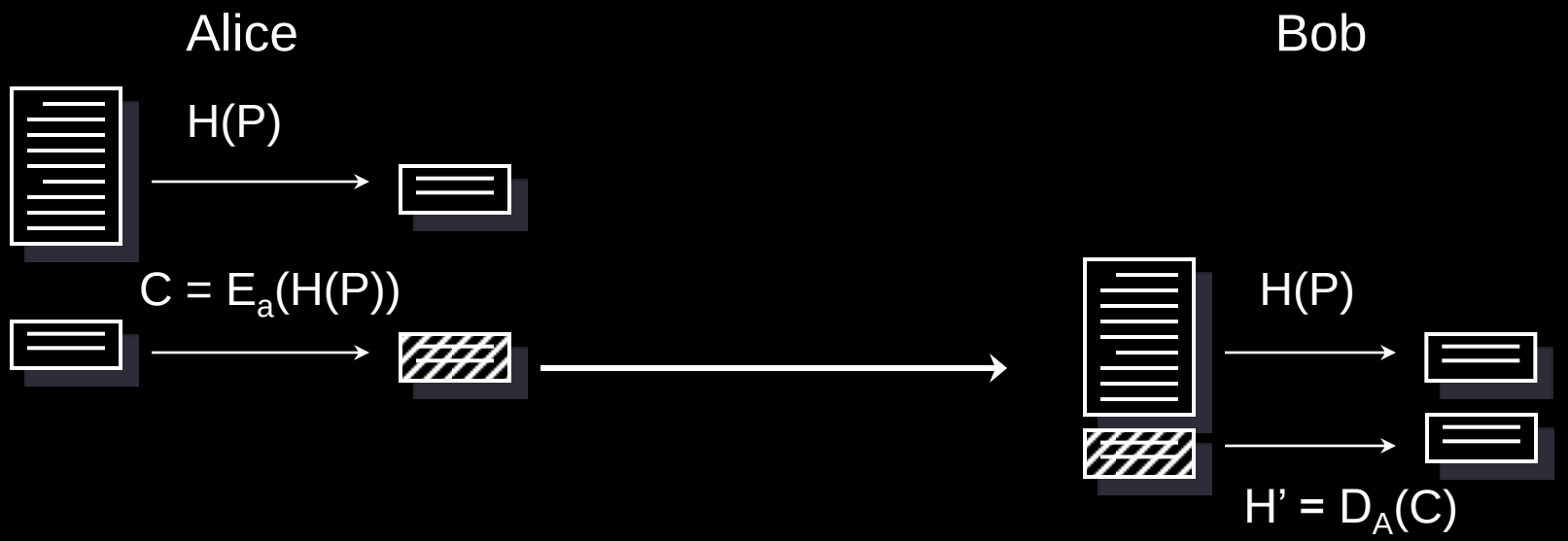
Alice sends Bob the message and the encrypted hash

Digital signatures - public key cryptography



1. Bob decrypts the has using Alice's public key
2. Bob computes the hash of the message sent by Alice

Digital signatures - public key cryptography



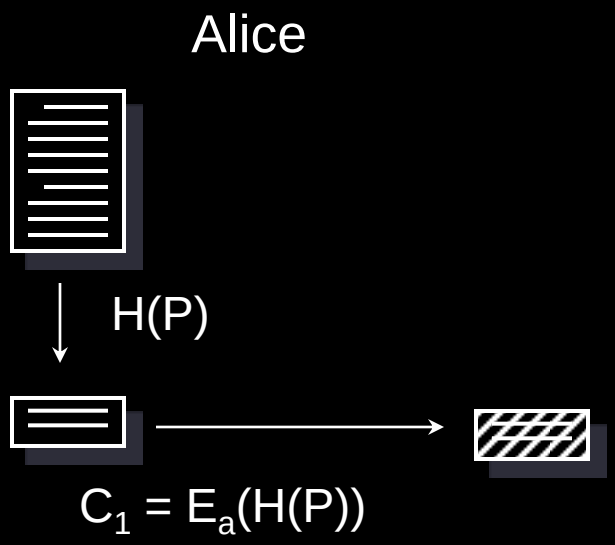
If the hashes match
- the encrypted hash *must* have been generated by Alice
- the signature is valid

Secure and authenticated messaging

If we want secrecy of the message

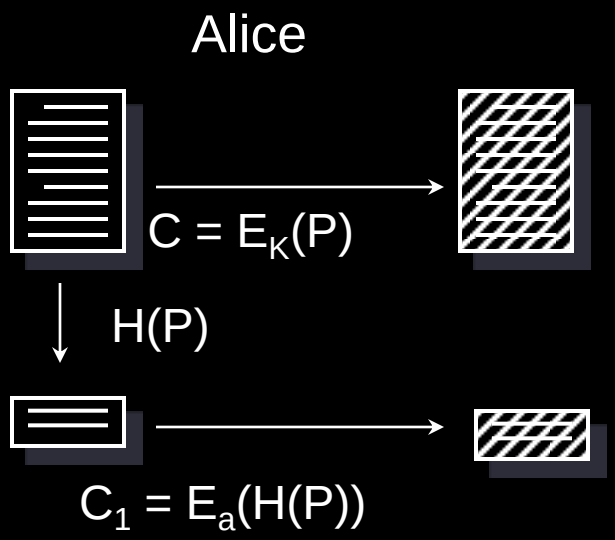
- combine encryption with a digital signature
- use a session key:
  pick a random key, *K*, to encrypt the message with a symmetric algorithm
- encrypt *K* with the public key of each recipient
- for signing, encrypt the hash of the message with sender's private key

Secure and authenticated messaging



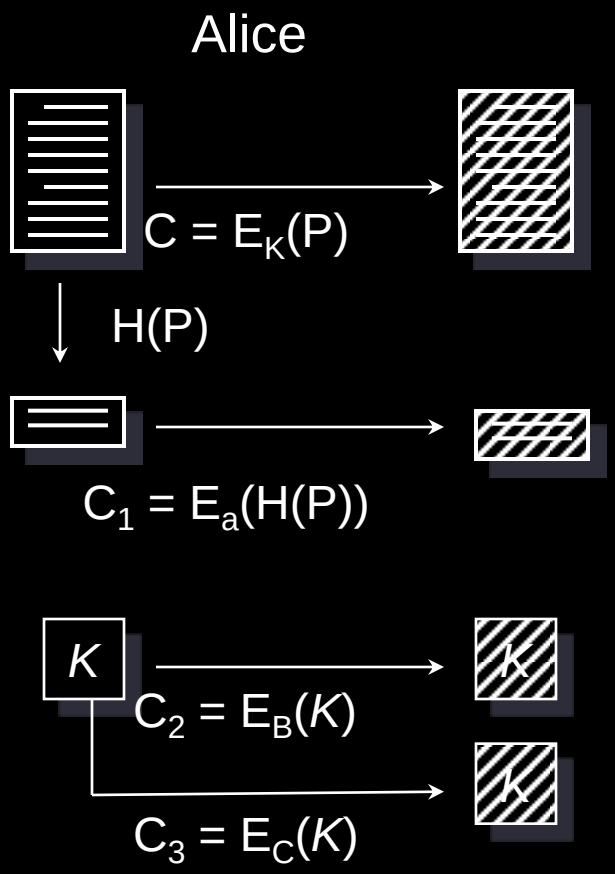
Alice generates a digital signature by encrypting the message digest with her private key.

Secure and authenticated messaging



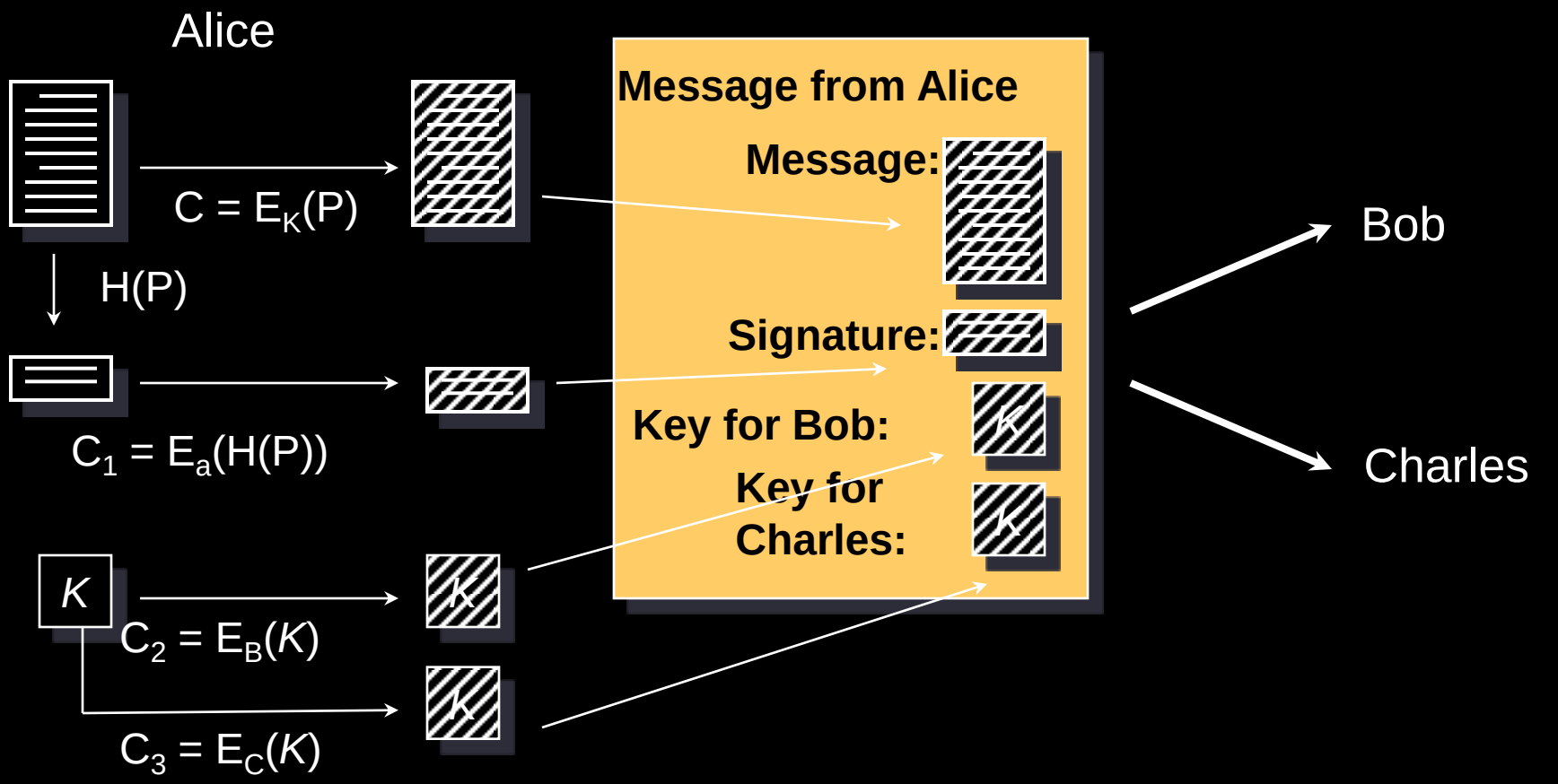
Alice picks a random key, *K*, and encrypts the message (P) with it using a symmetric algorithm.

Secure and authenticated messaging



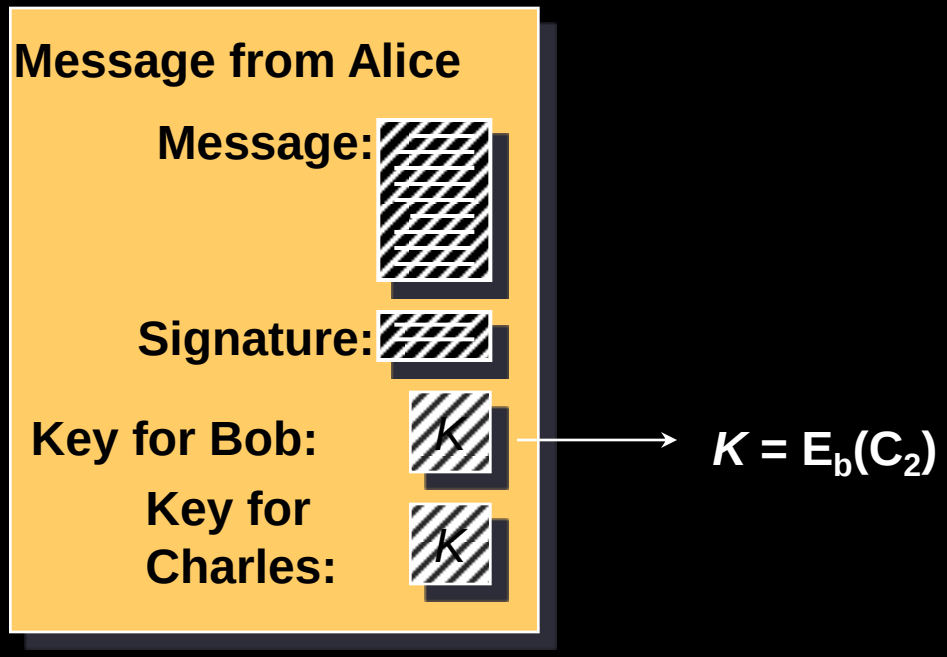
Alice encrypts the session key for each recipient of this message: Bob and Charles using their public keys.

Secure and authenticated messaging



The aggregate message is sent to Bob and Charles

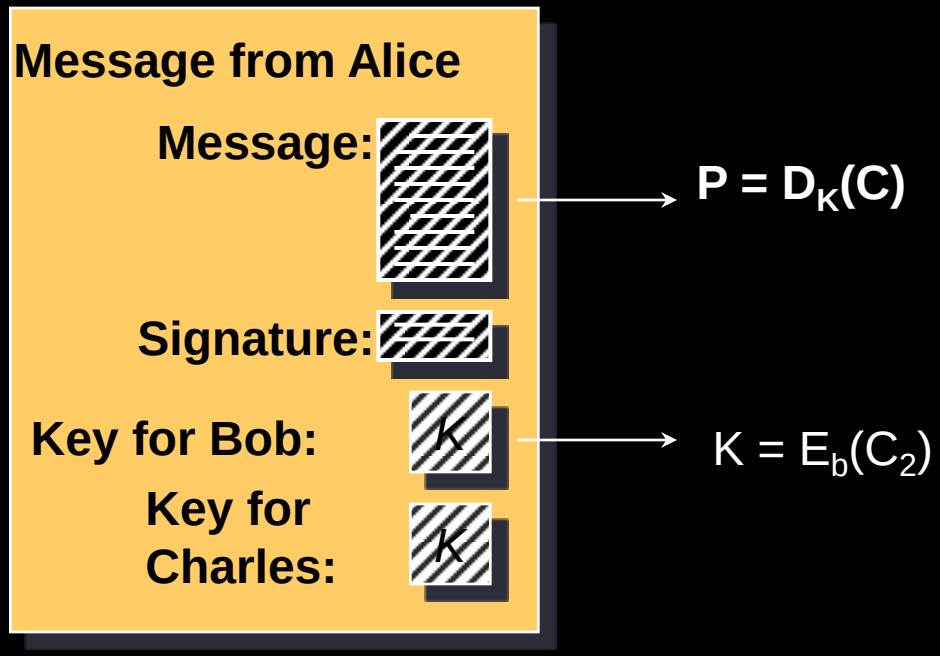
Secure and authenticated messaging



Bob receives the message:

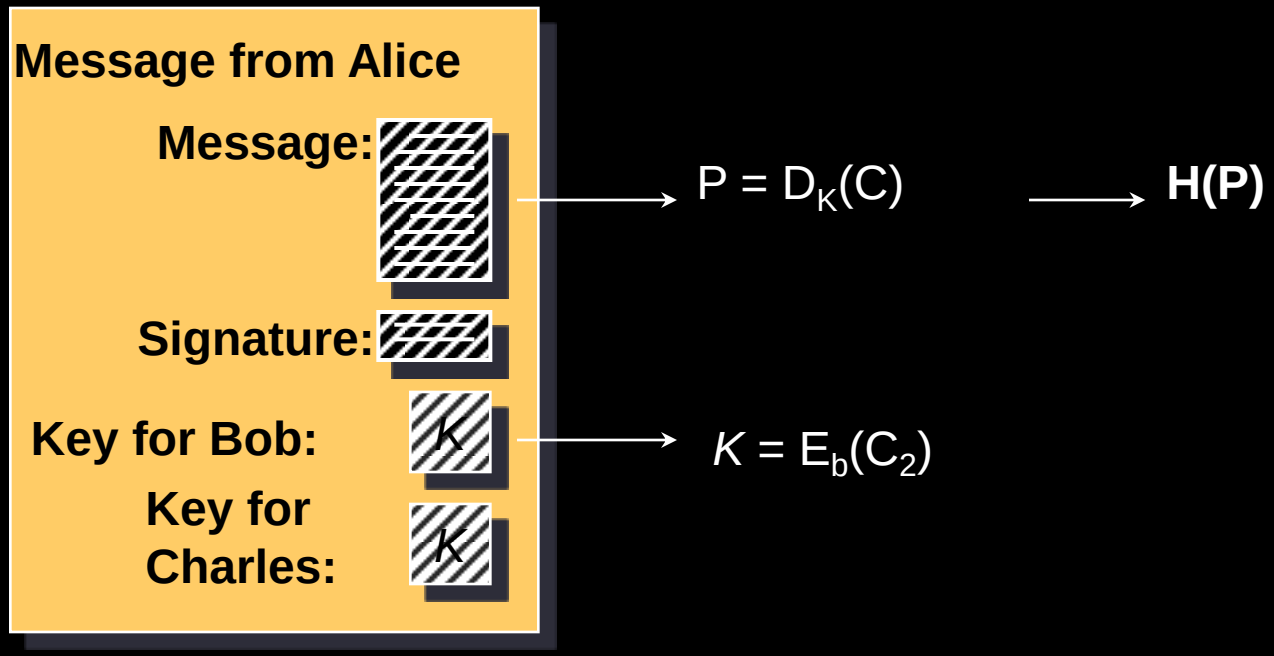
- extracts key by decrypting it with his private key

Secure and authenticated messaging



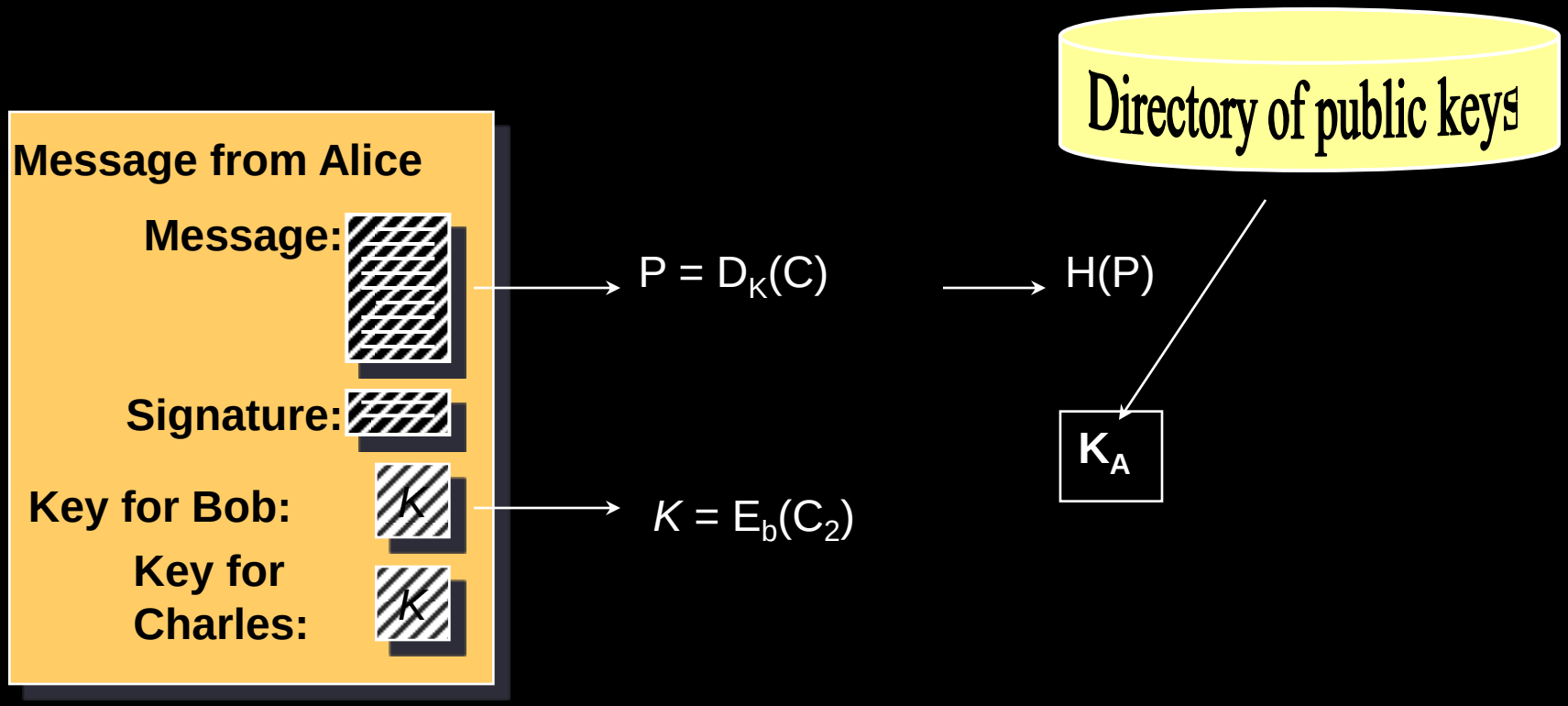
Bob decrypts the message using *K*

Secure and authenticated messaging



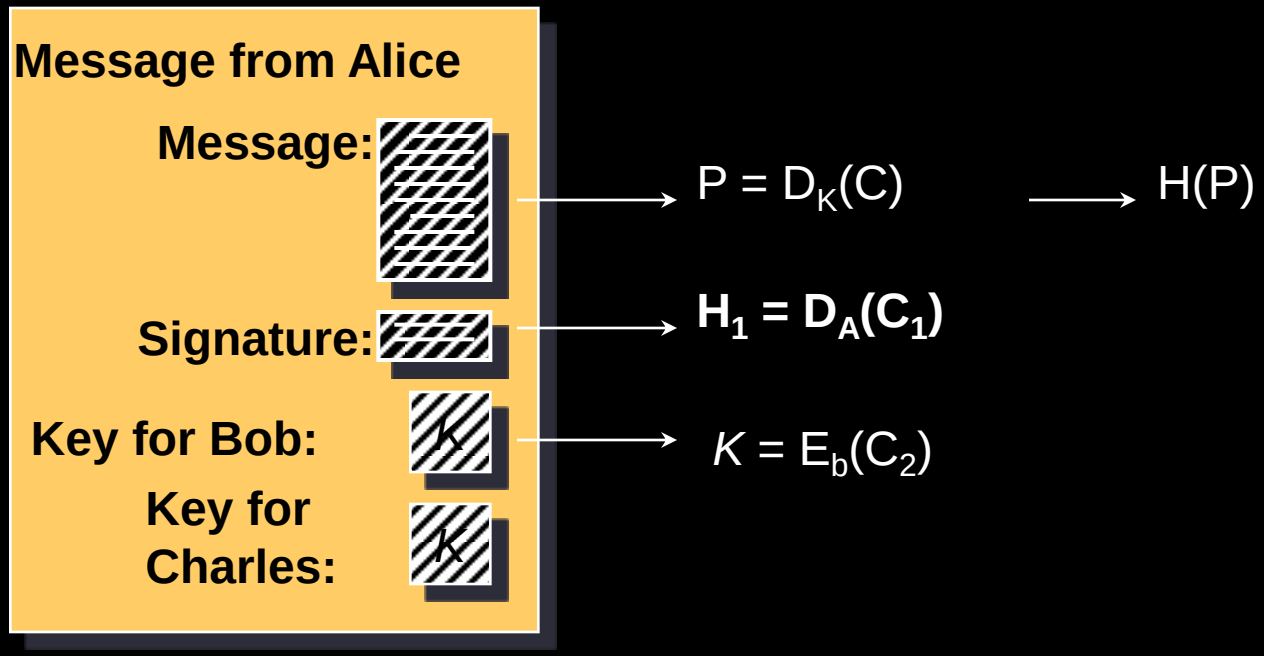
Bob computes the hash of the message

Secure and authenticated messaging



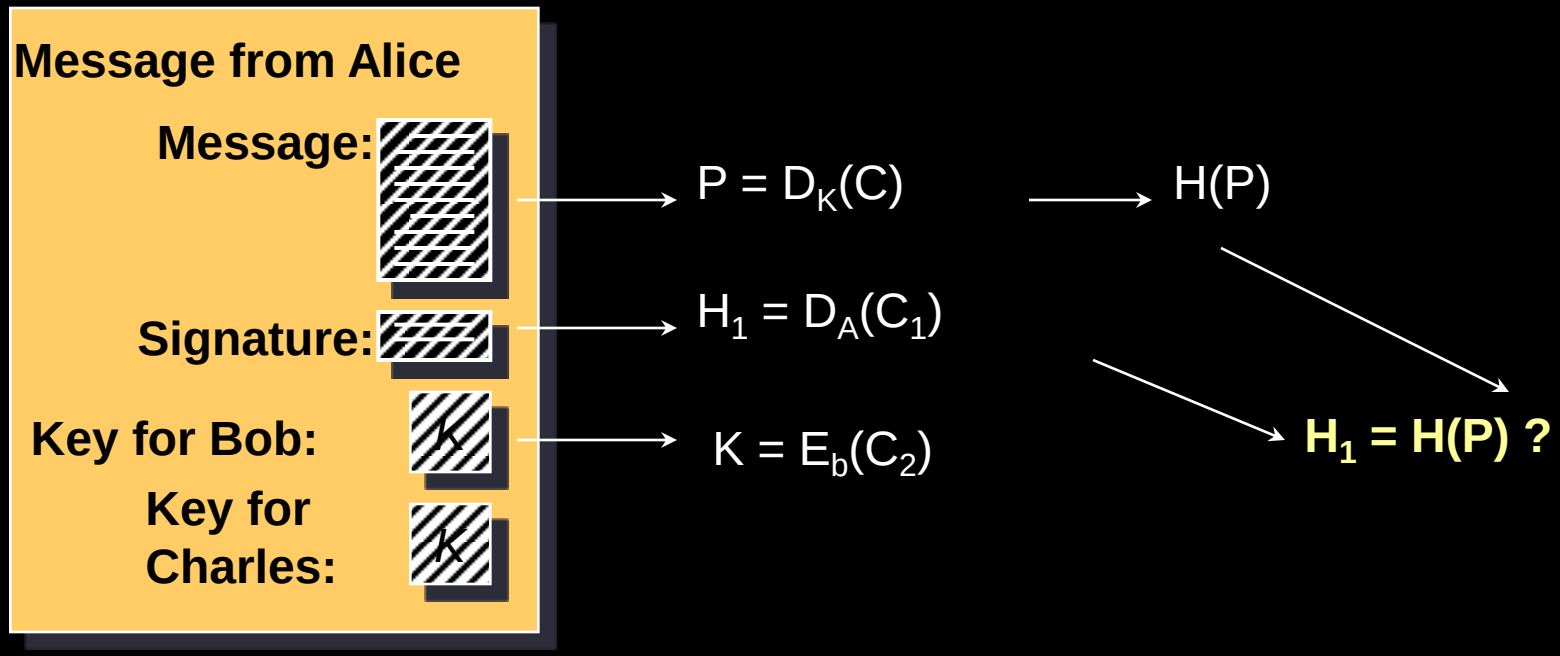
Bob looks up Alice's public key

Secure and authenticated messaging



Bob decrypts Alice's signature using Alice's public key

Secure and authenticated messaging



Bob validates Alice's signature

Cryptographic toolbox

- Symmetric encryption
- Public key encryption
- One-way hash functions
- Random number generators
  - Nonces, session keys

Examples

- Key exchange
  - Public key cryptography
- Key exchange + secure communication
  - Public key + symmetric cryptography
- Authentication
  - Nonce + encryption
- Message authentication codes
  - Hashes
- Digital signature
  - Hash + encryption

The end