Security

A-Level Computer Science ▪ Topic 17

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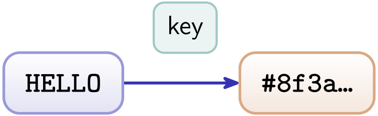


What we will cover

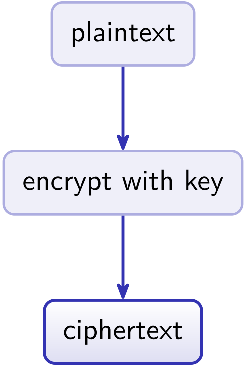
1. How encryption works
2. Symmetric, asymmetric, hybrid
3. Hashing
4. TLS, certificates, signatures
5. Recap

1 Encryption

Plaintext in, ciphertext out

Encryption 加密 turns readable **plaintext** 明文 into unreadable **ciphertext** 密文 using a maths operation that depends on a key. **Decryption** 解密 reverses it

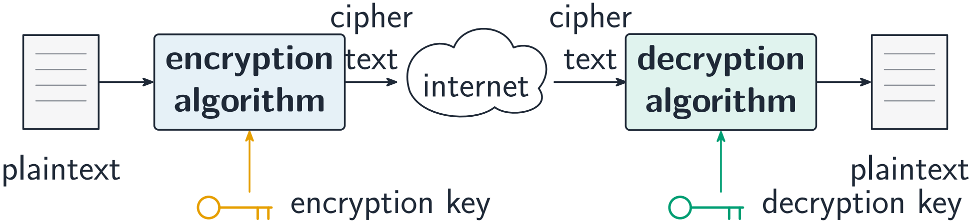
– but only with the right key.



An interceptor without the key sees meaningless data. Trying every key would take far too long.

The encryption process

Plaintext and a key go in; ciphertext comes out. Security rests on the key, not on hiding the algorithm.



Symmetric vs asymmetric

symmetric

对称加密

same key for encrypt and decrypt

fast – good for bulk data (a disk, a video)

problem: **key distribution** 密钥分发

how do you share the key safely in the first place?

asymm

非对称

a pair: **public k**
lished, **private ke**

encrypt with
crypt only wit

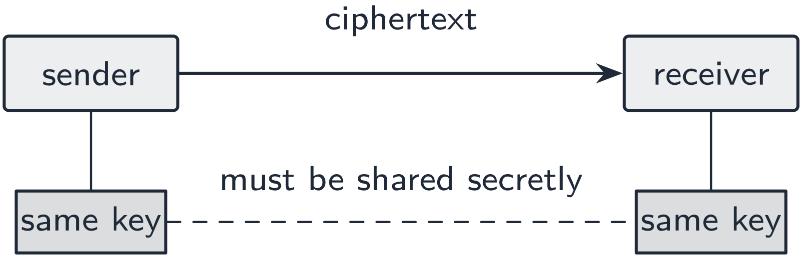
no prior key

much slower – no

A hardware security key stores a secret key to prove who you are

One shared key

> Symmetric encryption is fast, but both sides need the same secret – and getting it to them is the problem.



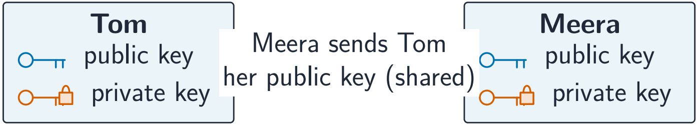
Sending a secret to Alice

get Alice's public key → encrypt the message → only Alice can open it

> One rule keeps the four keys straight: encrypt with the recipient's public key; sign with your own private key.

A public and a private key

> Encrypt with the recipient's public key; only their private key undoes it, so nothing secret is ever sent.



encrypt with the recipient's **public key** — only their matching **private key** can decrypt

The hybrid approach – how HTTPS actually works

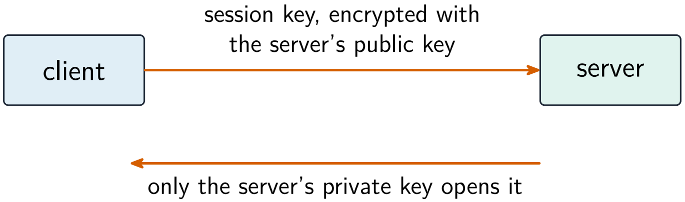
Use asymmetric crypto once to share a **session key** 会话密钥, then fast symmetric crypto for the data.

1. client makes a random session key
2. encrypts it with the server's public key
3. server opens it with its private key
4. both ends use fast symmetric encryption

The Enigma machine encrypted messages in the Second World War – an early, mechanical cipher devi

Hybrid: the best of both

> Asymmetric carries a fresh symmetric key; the bulk of the traffic is then encrypted fast.



both ends now share the session key → fast **symmetric** encryption for all the data

Where the private key lives, and what TLS gives you

asymmetric encryption 非对称加密	a public key encrypts, and only the matching private key decrypts
the private key	must stay secret – it is sometimes held on a hardware security key, so it never touches the disk
why hardware	a key that cannot be copied off the device cannot be stolen by malware
what TLS produces	an encrypted, authenticated, integrity-checked tunnel for higher-level protocols to run inside
each word matters	encrypted – unreadable; authenticated – you know who you reached; integrity-checked – unaltered in transit
quantum cryptography 量子密码学	threatens today's asymmetric algorithms, and offers key exchange that detects eavesdropping

> HTTPS is HTTP inside that tunnel. Naming all three properties – not just "it is encrypted" – is what the question is asking for.

Hashing is one-way – it is not encryption

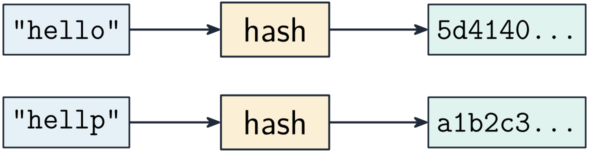
A **cryptographic hash** 密码散列 maps any input to a fixed-size **digest** 摘要.

hello	hellp
a94a8fe5...	7d793037...

- same input ⇒ same digest; a tiny change ⇒ a totally different digest
- infeasible to find two inputs with the same digest
- you cannot get the input back – used for passwords, **integrity** 完整性, signatures

A one-way function

> Easy to compute, infeasible to reverse, and any change to the input changes the digest completely.



one letter changed → a completely different digest; one-way (cannot reverse)

2 TLS and certificates

TLS – an encrypted, authenticated tunnel

TLS 传输层安全 (successor to SSL) encrypts data in transit, authenticates the server, and detects tampering.

1. client connects and proposes ciphers
2. server picks one and sends its **digital certificate** 数字证书
3. client checks the certificate
4. they exchange a fresh session key (asymmetric)
5. all later traffic uses fast symmetric encryption

What a digital certificate contains

A certificate binds an identity to a public key, and is signed by a trusted **Certificate Authority** 证书颁发机构 (CA).

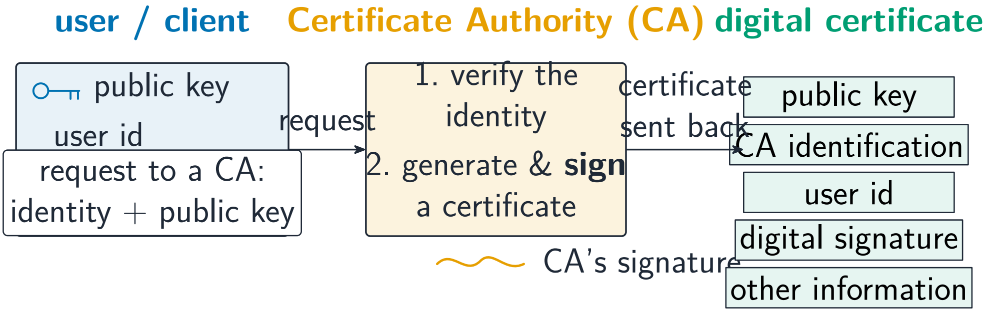
subject	**public key**	**issuer (CA)**	**validity**	**CA signature**

To verify:

check expiry, check the name matches the URL, check it is signed by a trusted CA, follow the chain to a trusted root. Fail any step ⇒ "Your connection is not private".

What a certificate carries

> A public key, an identity, and a CA's signature binding the two – which is what your browser checks.



Digital signatures – who sent it, and was it changed?

To sign

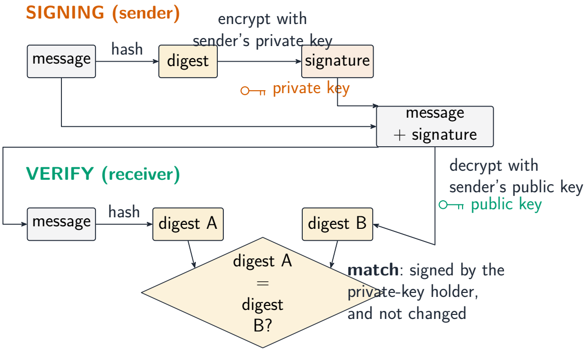
1. hash the message
2. encrypt the hash with the sender's private key
3. send the message and the signature

To verify

1. hash the received message
2. decrypt the signature with the sender's public key
3. compare the two digests

> A match proves **authentication** 身份验证 (only the private-key holder could have signed) *and* integrity (the message was not changed). A signature does not hide the message.

Digital signatures



Signing hashes the message and encrypts the digest with the private key; the receiver checks it with the public key

Putting it together

A secure request to `https://www.bank.com`: the server sends its certificate; the client verifies it against trusted CAs.

> Encryption stops eavesdroppers, the certificate proves the server's identity, and integrity checks stop a **man-in-the-middle 中间人攻击** altering the data.

Worked example – a contract for Bob

Alice sends Bob a contract. She wants him certain it came from her and was not altered, *and* she wants nobody else to read it. Which keys?

Signature (authentication + integrity): Alice hashes the contract and encrypts that hash with her private key. Bob checks with Alice's public key.

Confidentiality: Alice encrypts the contract with Bob's public key, so only Bob's private key can open it.

Sign with your own private key; encrypt with the recipient's public key.

Exam tips

- Distinguish **symmetric** encryption (one shared key, fast) from **asymmetric** (a public/private key pair).
- Explain the **TLS handshake** and why a **digital certificate** from a CA proves identity.
- Explain a **digital signature**: hash the message, then encrypt the hash with the private key – it proves integrity and origin.

3 Recap

Topic 17 – key takeaways

1 Keys

symmetric = one shared key; asymmetric = a pair

2 Hybrid

asymmetric shares a session key; then symmetric

3 TLS

certificate from a CA proves the server's identity

4 Sign

hash, encrypt with private key; does not hide

Check yourself

1. Why is symmetric encryption used for bulk data?
2. Is a hash reversible?
3. What does a CA's signature on a certificate prove?
4. Which key do you use to *sign*?

Answers **1.** it is fast **2.** no – it is one-way **3.** the public key belongs to that identity **4.** your own private key