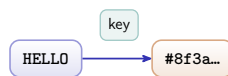


Security

A-Level Computer Science • Topic 17

A-Level Computer Science



Security

What we will cover

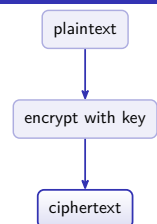
- 1 How encryption works
- 2 Symmetric, asymmetric, hybrid
- 3 Hashing
- 4 TLS, certificates, signatures
- 5 Recap

1 Encryption

Security
└ 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.

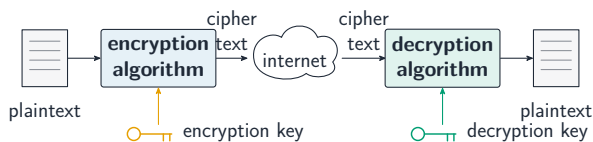


An interceptor without the key sees meaningless data. Trying every key would take far too long.

Security
└ Encryption

The encryption process

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



Security
└ Encryption

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?

asymmetric

非对称

a pair: **public key** published, **private key** encrypt with, decrypt only with
no prior key
much slower – no



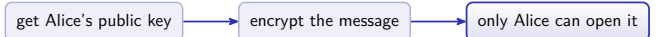
A hardware security key stores a secret key to prove who you are

One shared key

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



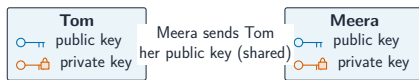
Sending a secret to Alice



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.

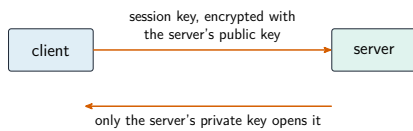
- 1 client makes a random session key
- 2 encrypts it with the server's public key
- 3 server opens it with its private key
- 4 both ends use fast symmetric encryption



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

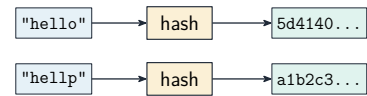
A **cryptographic hash** 密码散列 maps any input to a fixed-size **digest** 摘要.



- 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

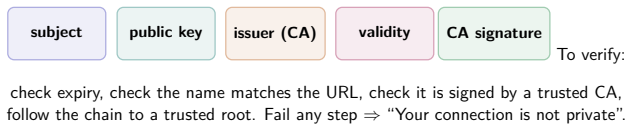
TLS – an encrypted, authenticated tunnel

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

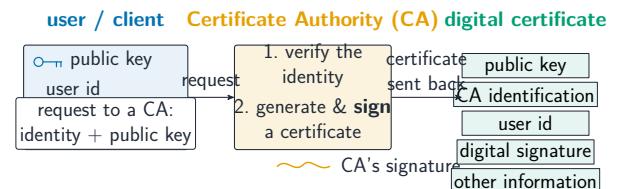
What a digital certificate contains

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



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

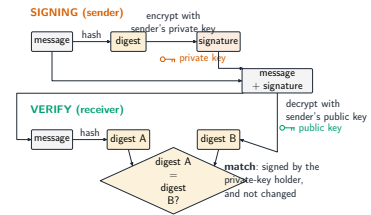
- 1 hash the message
- 2 encrypt the hash with the sender's private key
- 3 send the message and the signature

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

3 TLS

certificate from a CA proves the
server's identity

2 Hybrid

asymmetric shares a session key;
then symmetric

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