Khatam Blockchain Lab

Basic Cryptography for Blockchain

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- **Steganography**

  concealing a msg in another msg without attracting attention

- **Cryptography**

  Secure communication in presence of third party

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Kirchhoff's principle

1) The system must be practically, if not mathematically, indecipherable.
2) It must not be required to be secret, and it must be able to fall into the hands of the enemy without inconvenience.
3) Its key must be communicable and retainable without the help of written notes, and changeable or modifiable at the will of the correspondents.
4) It must be applicable to telegraphic correspondence.
5) Apparatus and documents must be portable, and its usage and function must not require the concourse of several people.
6) Finally, it is necessary, given the circumstances that command its application, that the system be easy to use, requiring neither mental strain nor the knowledge of a long series of rules to observe.

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Cryptography

- **Unkeyed**

  Cryptographic Hash function

- **Keyed**

  Symmetric-key algorithms

  Asymmetric-key algorithms

Cryptographic hash functions

- Any input string → Fix length string
- Always the same for the same input
- Small change in input →Large change in output
- Fast computation

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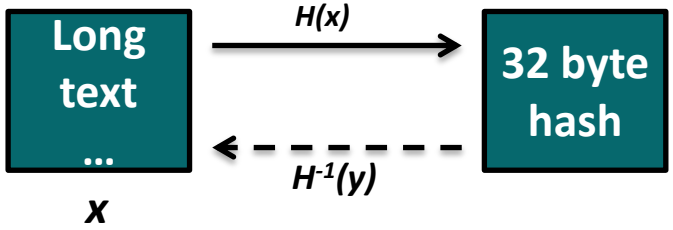
Cryptographic hash functions

- Assume ***H(x)*** is a cryptographic hash function
- Fast computable
- ***H(x)*** is a **one-way** mathematical functions
- Finding the $H^{-1}(y)$ is computationally hard



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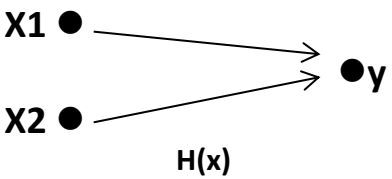
Cryptographic hash functions

Collision resistance



Given the **X1** it is computationally hard to find **X2**

Random looking

Small perturbation in **x** leads to big and random looking changes in **H(x)**

Fixed size output

It means that collision do exists.

- Bitcoin uses **SHA256** as its cryptographic hash function.

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Cryptographic hash functions
Collision resistance

- **Weak collision resistance**

  given an input, it is computationally infeasible to find another input with the same hash

- **Strong collision resistance**

  It is computationally infeasible to find two input that result in the same hash

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Hash finger print

- Using **collision resistance** and **random looking** property one can use hash as **finger print.**
- No one have found two different files with same **SHA256.**
- We can assume hash of a file is a **unique property** of it.

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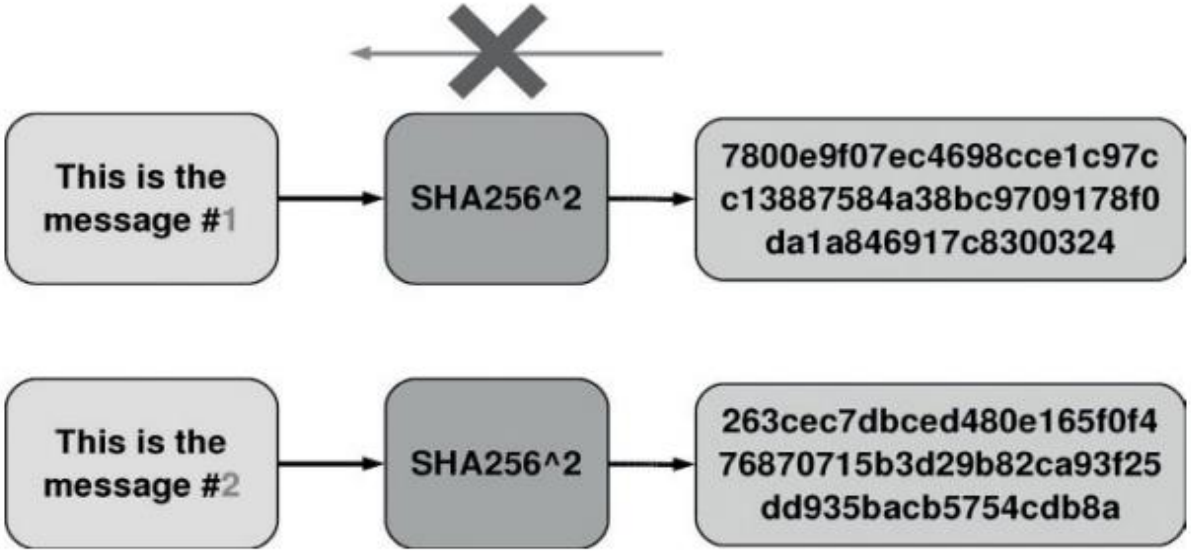
Bitcoin hash functions



Bitcoin uses SHA256^2 for proof of work

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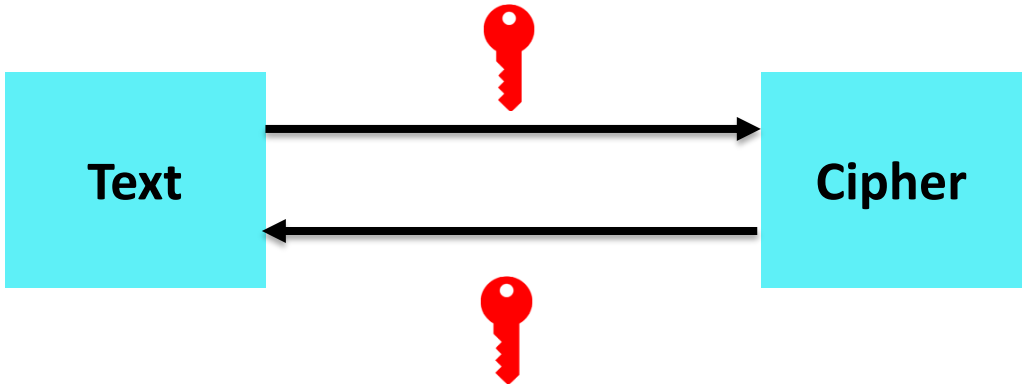
Symmetric-key cryptography



Bitcoin uses AES-256 for storing private keys in wallet

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Asymmetric-key Cryptography (Public-key)

- Key distribution problem

  when two people use symmetric, they must share the same key.

- Public-private key pair

  private: to unlock the safe

  Public : to lock the safe

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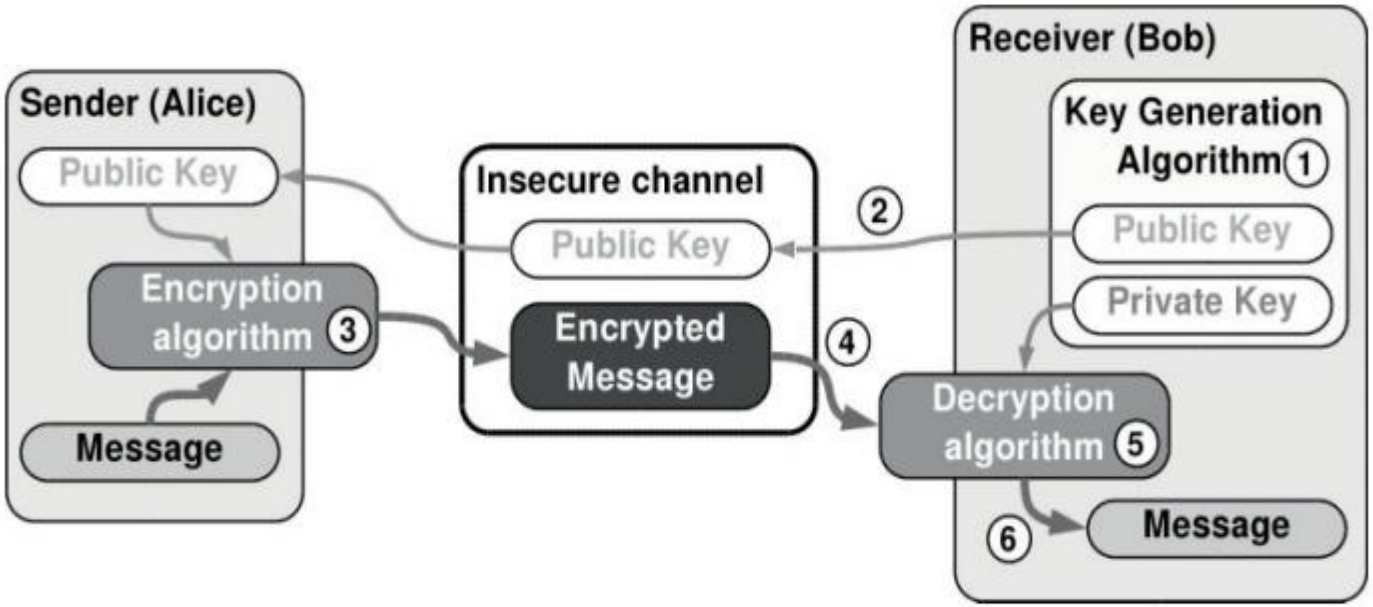
Asymmetric-key Cryptography (Public-key)



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Digital Signature

- Everyone have a singing key (aka. Secret key) and a verifier key (aka. Public key).
- Generation a pair of key is easy.
- Finding singing key from verifier key is computationally hard. **As hard as impossible!**

Signing key

Verifier key

Digital Signature

- Everyone announce her/his verifier key to public, similar to **card number.**
- Bitcoin addresses obtained from verifier key.
- Signing key is secret, similar to **password.**

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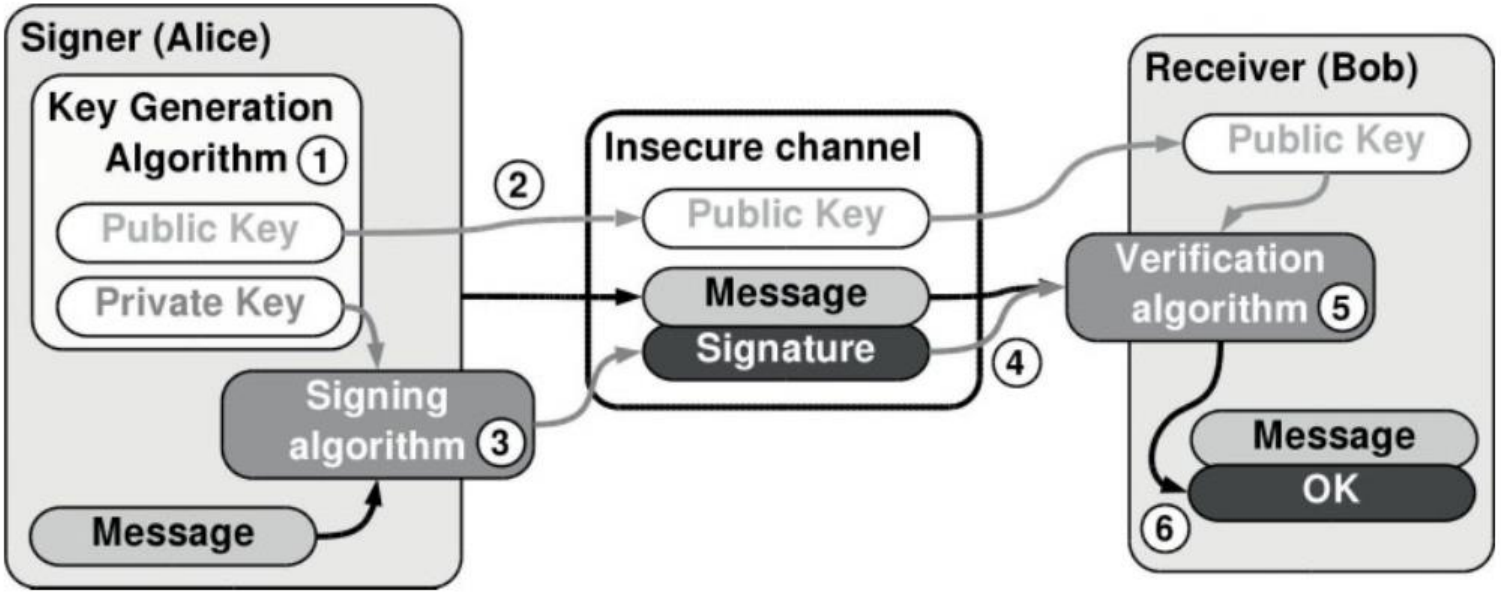
Digital Signature



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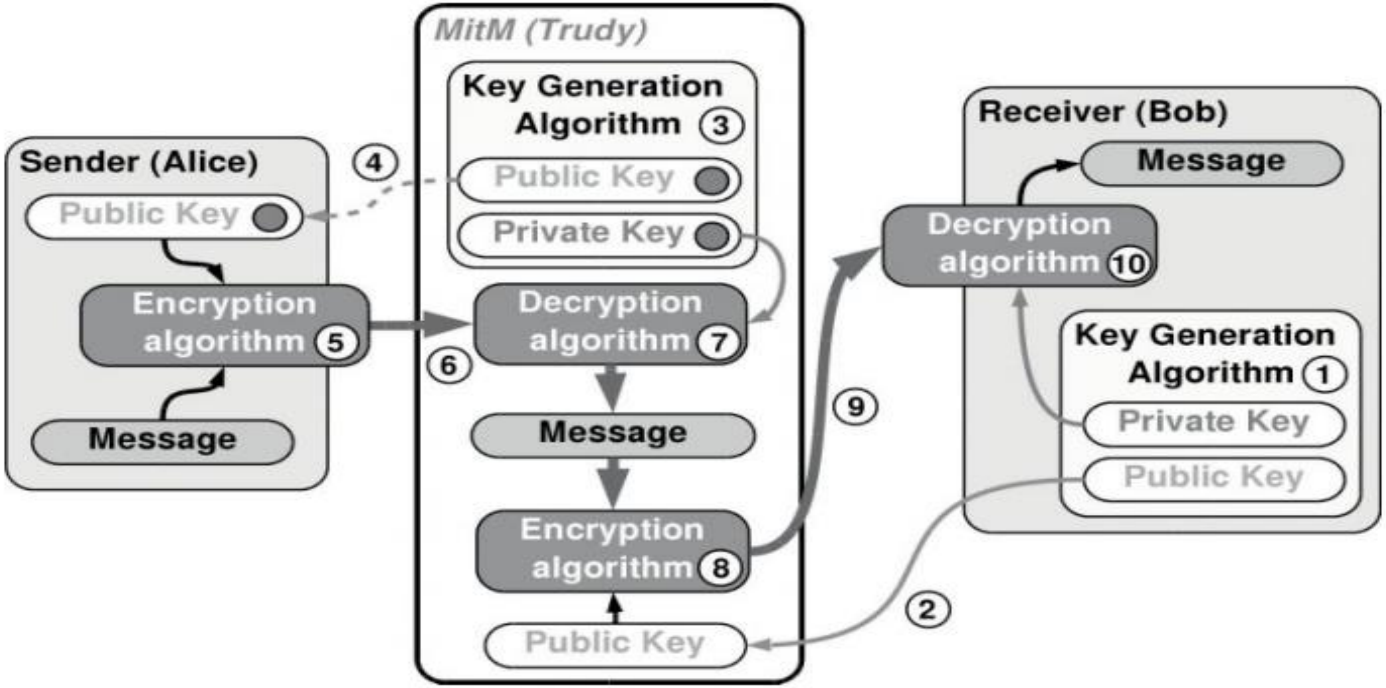
Man-in-the-middle attack



To avoid man-in-the-middle

- Interchange keys using a **different channel**
- **Web of trust**: user sign the public keys of other user they know
- **Public key Infrastructure** (PKI) & Certificate Authority(CA)

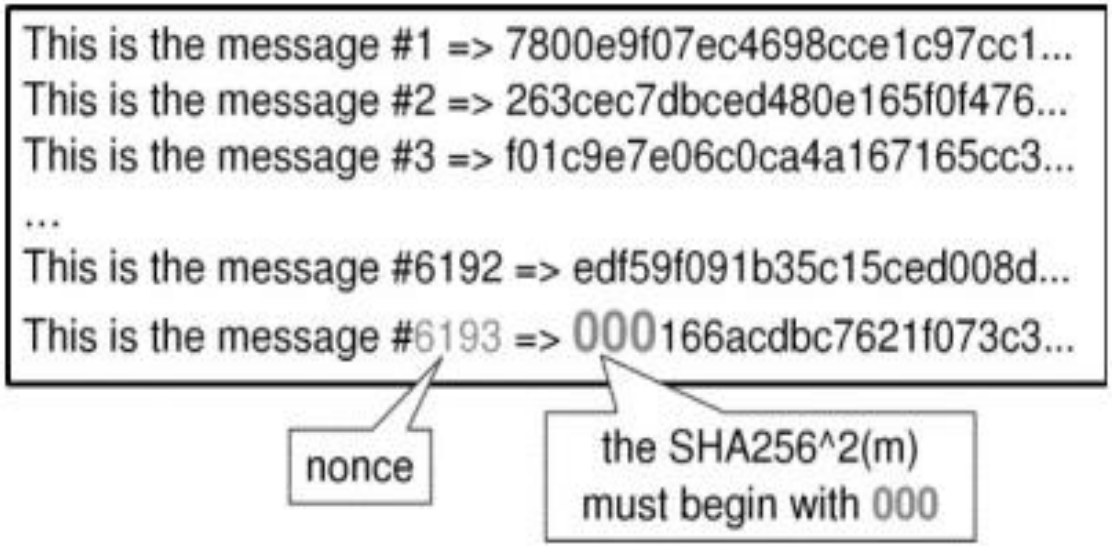
DoS attack

How to avoid DoS attack?

- Sync: challenge-response (CAPTCHA)
- Async: solution-verification (partial hash inversion)

To avoid DoS attack

- Partial hash inversion proof of work



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Bitcoin Address generation