ECAM
BRUSSELS ENGINEERING SCHOOL

DB701μ Introduction to
Blockchain with Python

Session 1

Block, Miner, Blockchain and Applications

Sébastien Combéfis

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Objectives

- Understand what is blockchain and its components

  Distributed database with transactions stored in blocks

- Global overview of how blockchain are secured

  Fingerprinting with hash algorithm and cryptographic challenges

- Lookup at several common applications of blockchain

  Cryptocurrency, smart contract, identity management, etc.

Blockchain

Distributed Database

- Blockchain is basically a technology to store data
  - Making it possible for reliable data exchange between users
  - Providing guarantees on data immutability
  - Without any central supervision entity
- Many applications have been developed on a blockchain

  Cryptocurrency, smart contracts, identity management, etc.

Blockchain

- A blockchain is a data structure holding transactions

  Completely open to any and everyone on the network

- Blockchain technologies characterised by three main properties
  - **Security**: since theoretically not alterable
  - **Transparency**: since content visible by everyone
  - **Decentralisation**: since stored in a P2P fashion

- A chain of records controlled by no single authority

  Extremely difficult to change a stored information

Blockchain Type

- Two broad categories of blockchain depending on privacy level

  A blockchain can be a public or a private one

- Public blockchain is a permissionless ledger
  - Anyone can download it, browse the history and modify it
  - Can be compromised if the rules are not executed strictly
- Only trusted participants can access a private blockchain
  - Overall control of the network in the hands of the owners
  - Possibility to define rules with levels of permissions

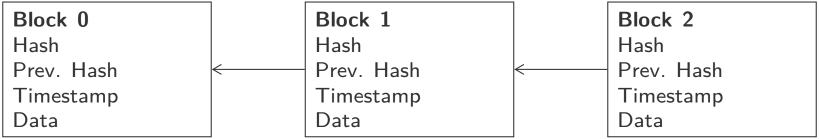
Block

- Information is stored in a chain of secure blocks

  Each block can be seen as an instance of a data structure

- A blockchain is an array of blocks referring each other linearly

  The size of the array can dynamically change with time



Block 0
Hash
Prev. Hash
Timestamp
Data

Block 1
Hash
Prev. Hash
Timestamp
Data

Block 2
Hash
Prev. Hash
Timestamp
Data

Mining

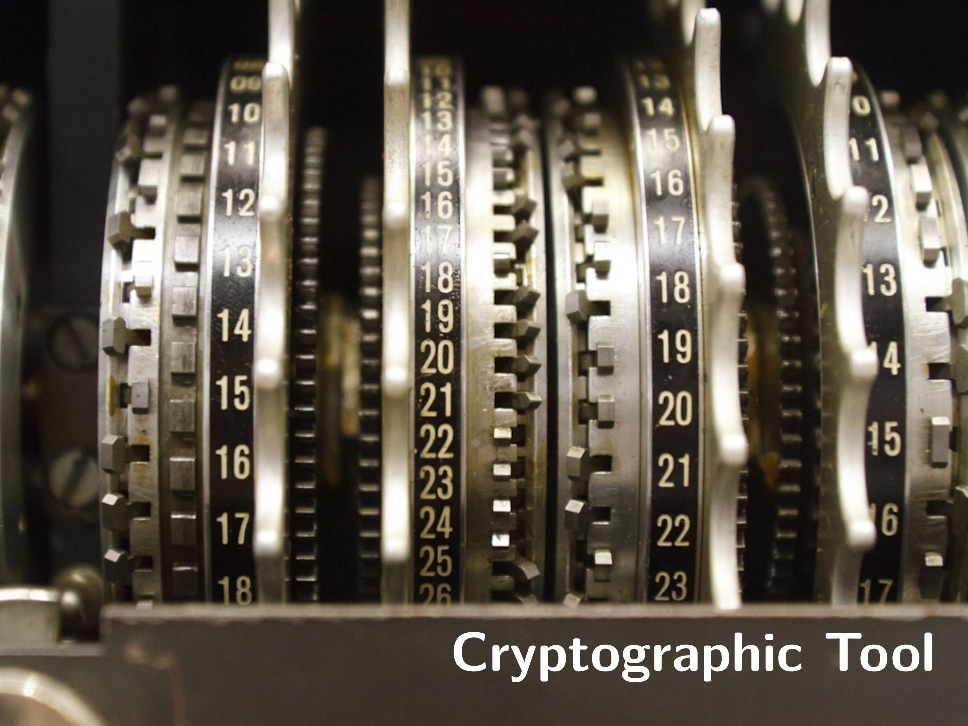
- New blocks can be added into a given blockchain

  This operation is done by the mining process

- New blockchain is shared amongst all the users with P2P

  New blocks checked and propagated if correct, rejected otherwise

- Checking that a block is valid is done with a specific algorithm
  - Typically the “proof of work” algorithm
  - Solving a “mathematical puzzle” with a given level of difficulty



Cryptographic Tool

Alice and Bob (1)

- Alice and Bob exchange messages on communication channel

  Insecure channel, with Eve trying to intercept the exchanges

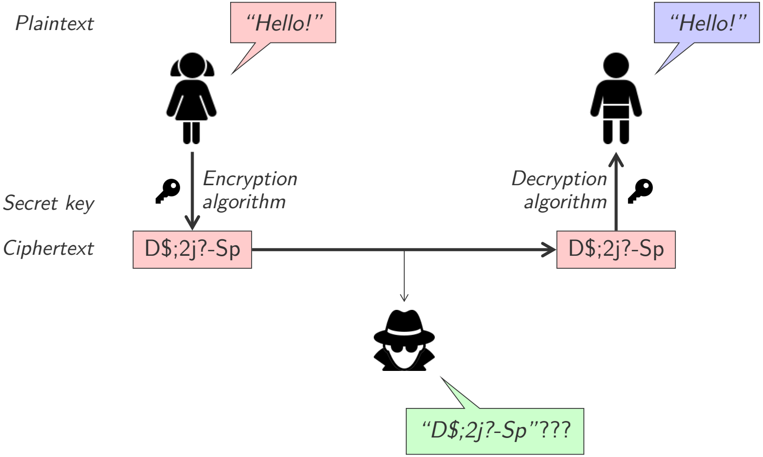
- Cryptography turns a clear text into a ciphered text

  Transmission of the ciphered text, Eve cannot understand it

- Only Alice and Bob can read the message thanks to a key

  This key needs to be shared between both stakeholders

Alice and Bob (2)



Symmetric Encryption

- Using the same secret key K with symmetric encryption

  The key defines the encryption e_K and decryption d_K functions

- Exposure of either e_K or d_K renders the system insecure

  Also, e_K and d_K are typically very close

- Require secure channel between Alice and Bob to exchange K

  Very difficult if they live far away or do not know each other

Asymmetric Encryption

- d_K impossible to find from e_K with asymmetric encryption
  - Public key e_K to encrypt a plaintext
  - Private key d_K to decrypt a ciphertext
- No need for a key exchange on a secure channel

  Only Bob can decrypt a plaintext encrypted with e_K
- Several public-key cryptosystem do exist

  Diffie-Hellman, RSA and ElGamal (and their variants)

Hash Function

- Technique used to check for data integrity

  Computing a digital fingerprint for a given data

- Using a hash function h to get a fingerprint $y = h(x)$

  For any x, a binary sequence of arbitrary length

- A fingerprint is a binary sequence (typically 160 bits)
  - Storing the data x and its fingerprint $h(x)$ separately
  - The fingerprint $h(x)$ should be stored in a secure place

Collision

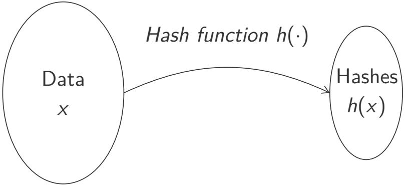
- Hash function does some compression of the data

  The domain of the function is larger than its image

- Two different data x and x' can result in the same fingerprint

  This is known as collision and is expected from hash functions

- Ideally collisions must be minimised



Signature Scheme

- Digitally sign a document with a signature scheme

  Adding the signature to the message, not “writing on top of it”

- Problem with the verification of a signature

  How is it possible to compare a signature with the “original” one

- Signed document can be used several times

  For example, authorisation for an action (withdraw 100 *euros)*

Certificate

- Mechanism to authenticate public keys with certificate

  Require some kind of Public Key Infrastructure (PKI)

- Relies on a trusted certification authority (CA)
  - Signs the public keys of all people in the network
  - Verification key ver_{CA} known “by magic” by everyone

- Signed certificate contains several information

  Name, email, address, list of public keys

BITCOIN·DIGITAL·DECENTRALIZED·PEER TO PEER
1 TROY OZ 999 GOLD PLATED
MUB MONETARY METALS

Application

Cryptocurrency

- Bitcoin and cryptocurrencies are the first application

  Electronic decentralised medium of exchange without control

- Opposed to currency managed by central banking systems

  Confidence towards the bank institutions are necessary

- Blockchain used to host and publish a distributed ledger

  Public financial transaction database allowing control by peers

Smart Contract

- Adding code to be executed inside a blockchain

  Makes it possible to establish a contract between entities

- Smart contract holds executable content

  Triggered and executed when some conditions are met

Identity Management

- Blockchain used to build trusted database with public access
  - Used to manage identities of people
  - Store degrees delivered by schools and checked by companies
- Can also be used to protect intellectual property

  Storing copyrights information as smart contracts

References

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