CSE446: Blockchain & Cryptocurrencies

Lecture – 14: Ethereum - 2

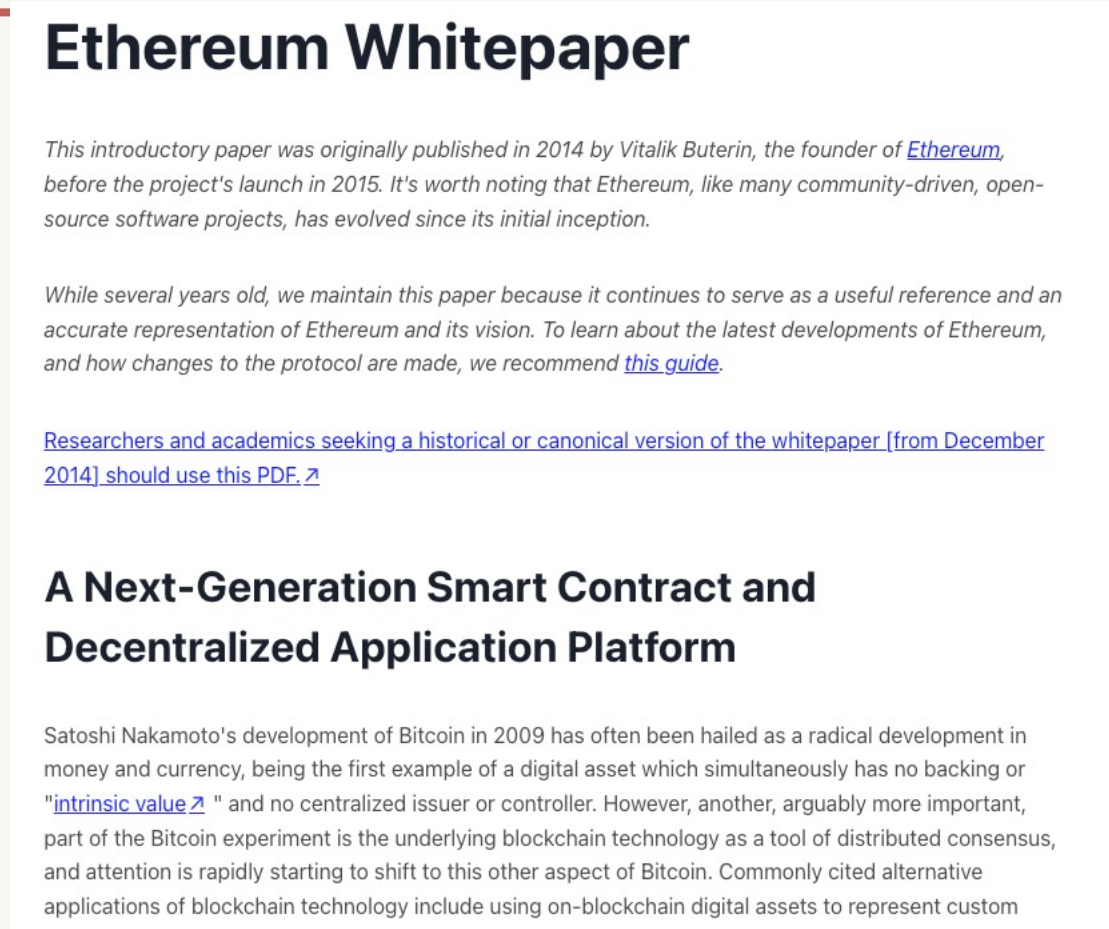
Inspiring Excellence

Agenda

- Ethereum History
- Ethereum components
- Ethereum accounts

Ethereum whitepapr

- First draft was written by Vitalik Buterin himself (2013)
- Contains high level descriptions of Ethereum's core functionalities
- Living document and regularly updated by Ethereum core developers (not only Buterin!)
- Extensive summary of the Ethereum platform and technology



Ethereum Whitepaper

This introductory paper was originally published in 2014 by Vitalik Buterin, the founder of Ethereum, before the project's launch in 2015. It's worth noting that Ethereum, like many community-driven, open-source software projects, has evolved since its initial inception.

While several years old, we maintain this paper because it continues to serve as a useful reference and an accurate representation of Ethereum and its vision. To learn about the latest developments of Ethereum, and how changes to the protocol are made, we recommend this guide.

Researchers and academics seeking a historical or canonical version of the whitepaper [from December 2014] should use this PDF. ↗

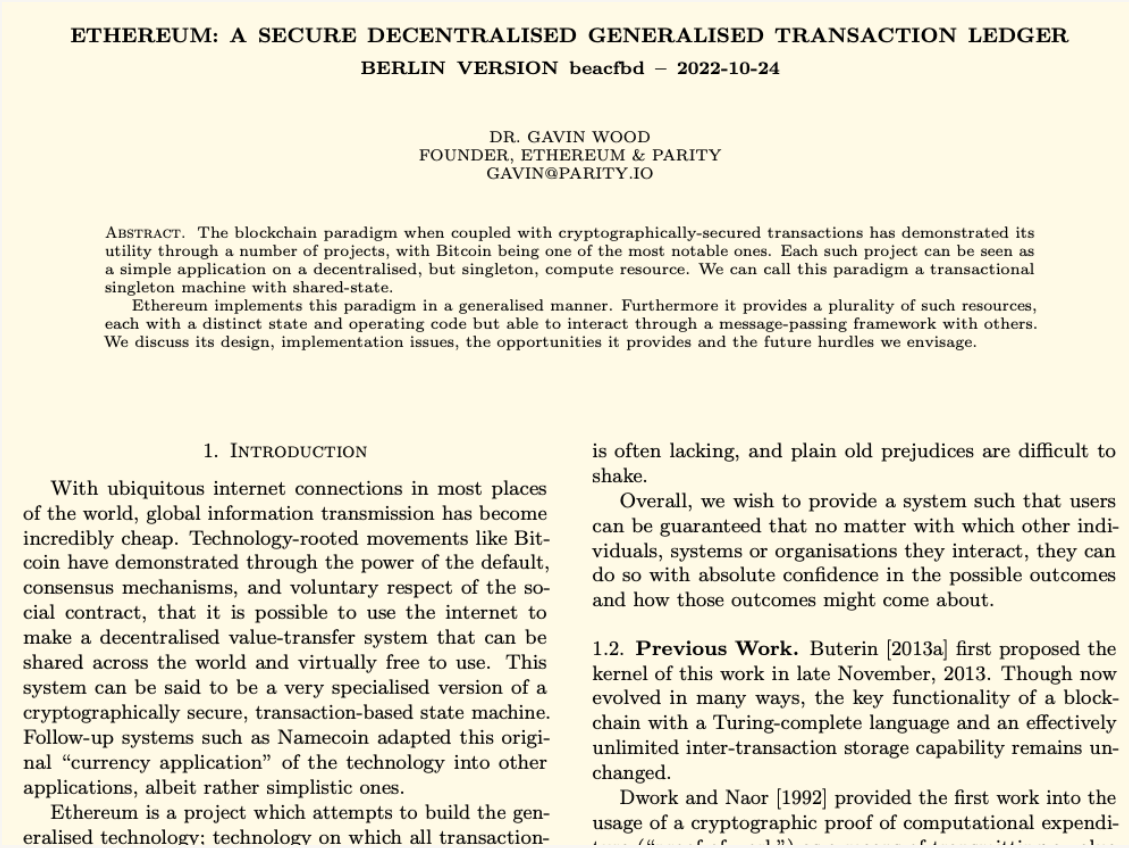
A Next-Generation Smart Contract and Decentralized Application Platform

Satoshi Nakamoto's development of Bitcoin in 2009 has often been hailed as a radical development in money and currency, being the first example of a digital asset which simultaneously has no backing or "intrinsic value ↗ " and no centralized issuer or controller. However, another, arguably more important, part of the Bitcoin experiment is the underlying blockchain technology as a tool of distributed consensus, and attention is rapidly starting to shift to this other aspect of Bitcoin. Commonly cited alternative applications of blockchain technology include using on-blockchain digital assets to represent custom

https://ethereum.org/en/whitepaper/

Ethereum yellowpaper

- Published in April 2014 by Dr. Gavin Wood
- Dr. Gavin Wood is still listed as the only author
- Defines the technical specification of Ethereum
- Very detailed, contains mathematical function definitions and byte code mappings
- Required to implement a full node
- Only updated when errors are found or the specification changes



ETHEREUM: A SECURE DECENTRALISED GENERALISED TRANSACTION LEDGER

BERLIN VERSION beacfbd – 2022-10-24

DR. GAVIN WOOD
FOUNDER, ETHEREUM & PARITY
GAVIN@PARITY.IO

ABSTRACT. The blockchain paradigm when coupled with cryptographically-secured transactions has demonstrated its utility through a number of projects, with Bitcoin being one of the most notable ones. Each such project can be seen as a simple application on a decentralised, but singleton, compute resource. We can call this paradigm a transactional singleton machine with shared-state.

Ethereum implements this paradigm in a generalised manner. Furthermore it provides a plurality of such resources, each with a distinct state and operating code but able to interact through a message-passing framework with others. We discuss its design, implementation issues, the opportunities it provides and the future hurdles we envisage.

1. INTRODUCTION

With ubiquitous internet connections in most places of the world, global information transmission has become incredibly cheap. Technology-rooted movements like Bitcoin have demonstrated through the power of the default, consensus mechanisms, and voluntary respect of the social contract, that it is possible to use the internet to make a decentralised value-transfer system that can be shared across the world and virtually free to use. This system can be said to be a very specialised version of a cryptographically secure, transaction-based state machine. Follow-up systems such as Namecoin adapted this original "currency application" of the technology into other applications, albeit rather simplistic ones.

Ethereum is a project which attempts to build the generalised technology; technology on which all transaction-

is often lacking, and plain old prejudices are difficult to shake.

Overall, we wish to provide a system such that users can be guaranteed that no matter with which other individuals, systems or organisations they interact, they can do so with absolute confidence in the possible outcomes and how those outcomes might come about.

1.2. **Previous Work.** Buterin [2013a] first proposed the kernel of this work in late November, 2013. Though now evolved in many ways, the key functionality of a blockchain with a Turing-complete language and an effectively unlimited inter-transaction storage capability remains unchanged.

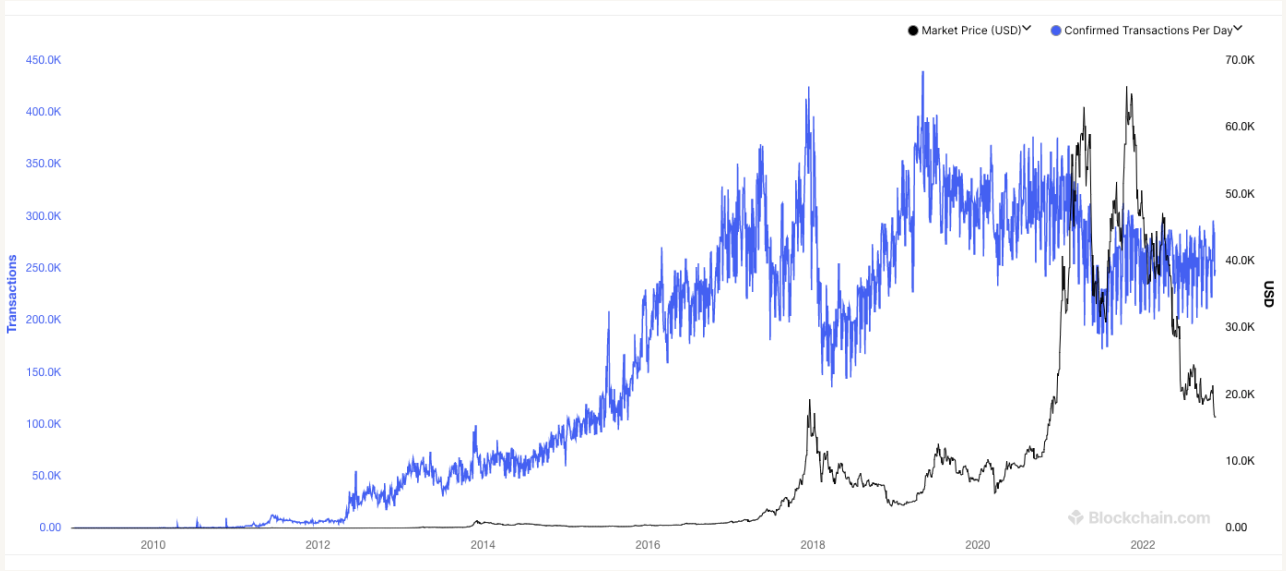
Dwork and Naor [1992] provided the first work into the usage of a cryptographic proof of computational expendi-

https://ethereum.github.io/yellowpaper/paper.pdf

Ethereum foundation

- “The Ethereum Foundation’s mission is to promote and support Ethereum platform and base layer research, development and education to bring decentralized protocols and tools to the world that empower developers to produce next generation decentralized applications (dapps), and together build a more globally accessible, more free and more trustworthy Internet.”
- Founded in June 2014 in Zug, Switzerland
- Non-profit organization. Web: https://ethereum.foundation/
- Foundation council consists of Vitalik Buterin and Patrick Storchenegger who is responsible for all legal affairs
- Owns (or had owned) at least 31,591 Bitcoins funding capital due to the crowdsale

Ethereum vs Bitcoin: network metrics

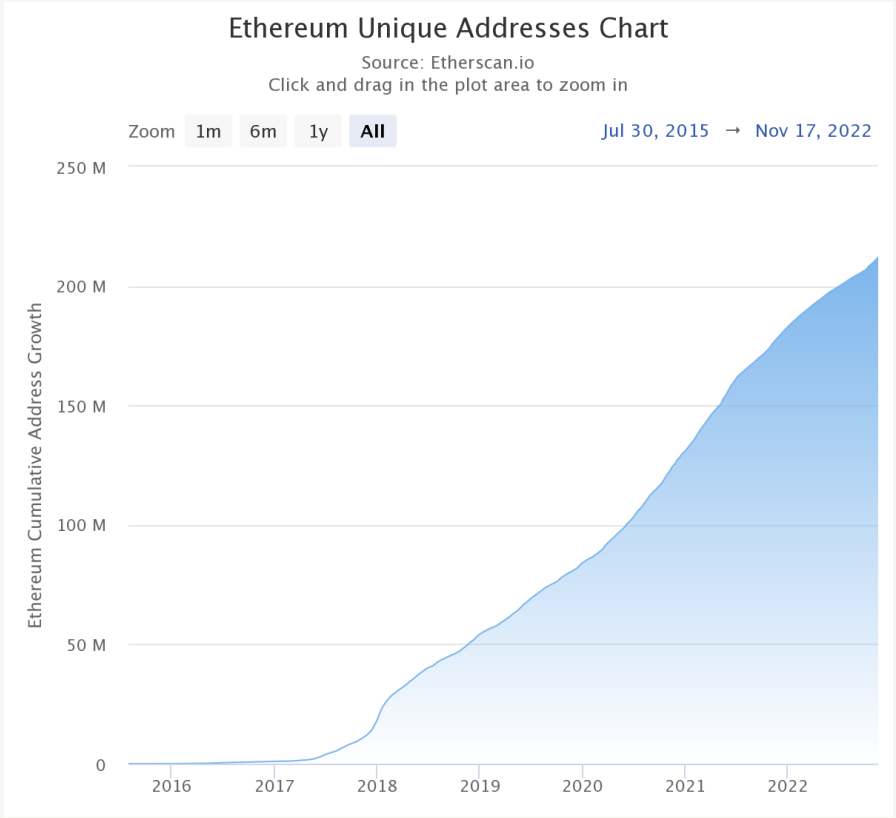


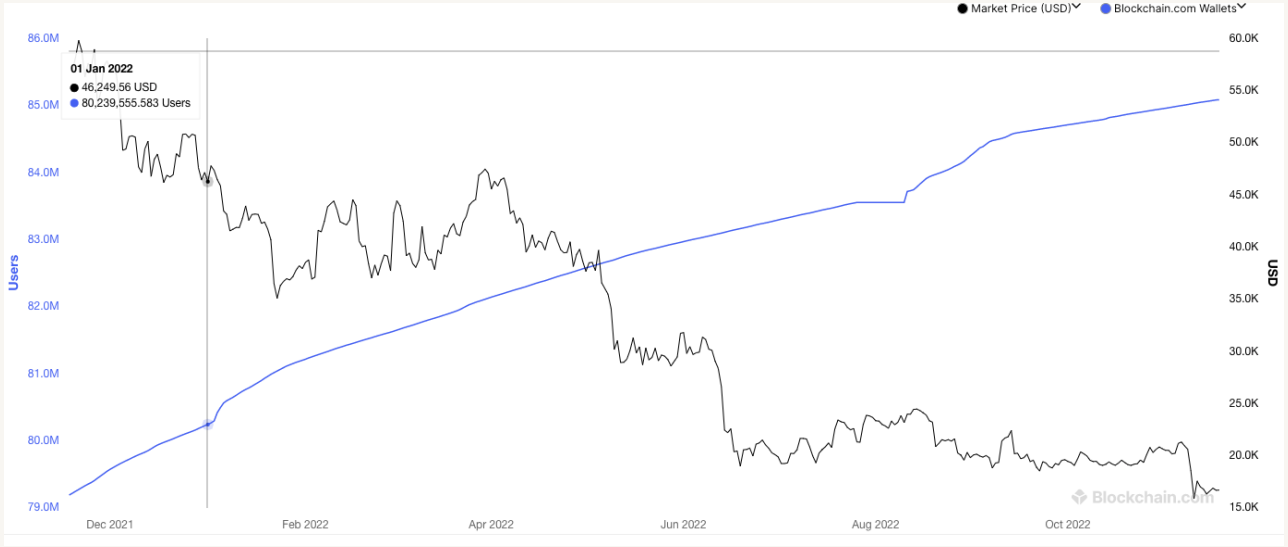
- Currently around 1250K transactions/day for Ethereum
- Bitcoin has around 250K transactions/day
- Ethereum is around 5x faster than Bitcoin with respect to tx/day

https://etherscan.io/chart/tx

https://www.blockchain.com/explorer/charts/n-transactions

Ethereum vs Bitcoin: number of wallets





- Around 212M addresses in Ethereum
- Around 85M addresses in Bitcoin

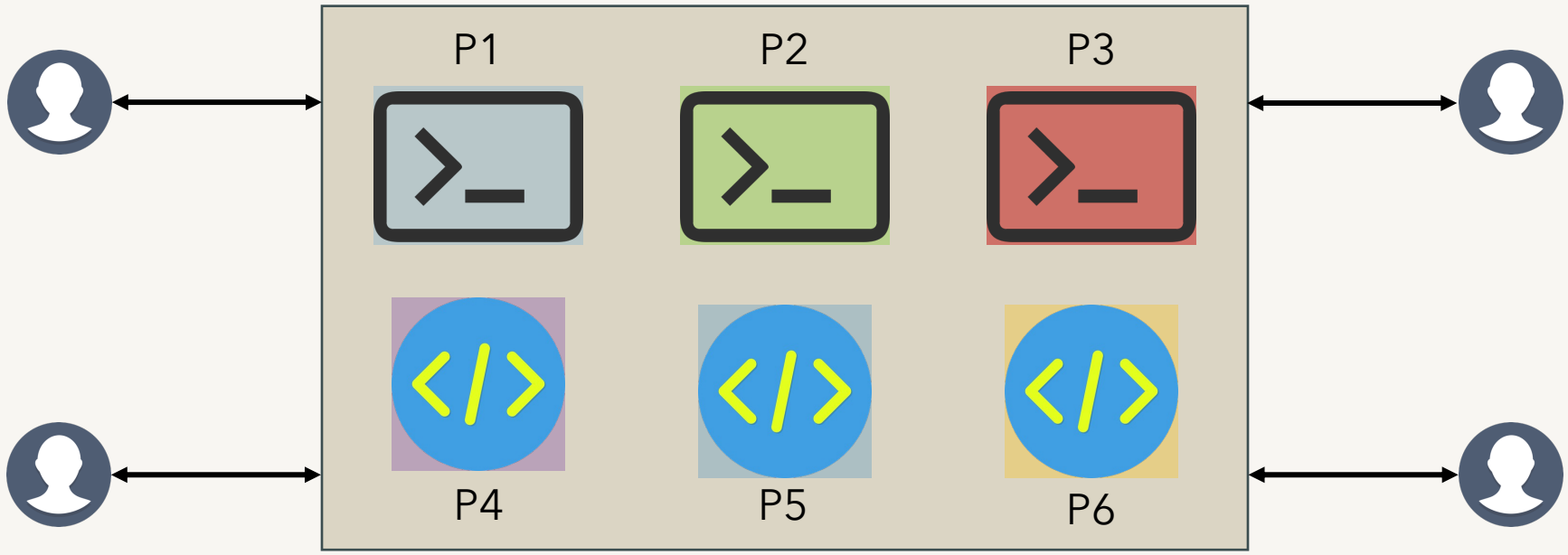
https://etherscan.io/chart/address

https://www.blockchain.com/explorer/charts/my-wallet-n-users

Ethereum world computer

- What Ethereum is trying to do is to develop a world computer
- A world computer is something that anyone can
  - access
  - install programs (known as smart-contracts)
  - run (execute) those smart-contracts
  - store data into the world computer
  - retrieve data from the world computer

World computer



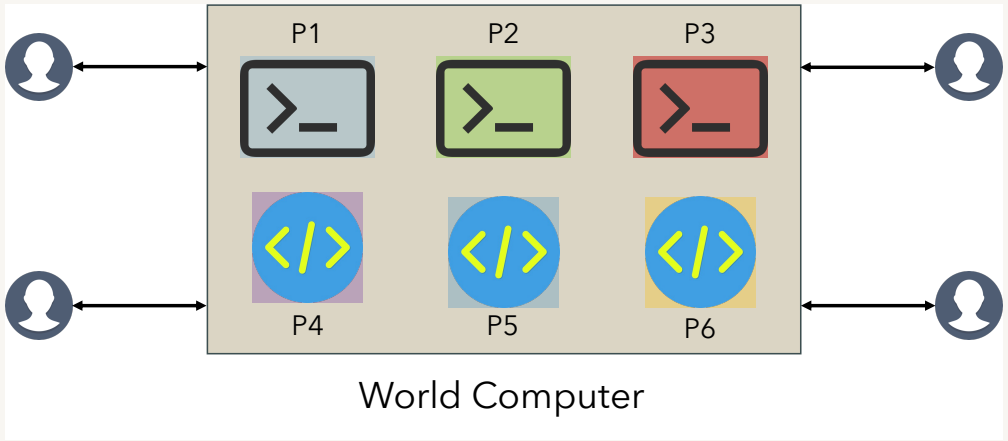
World Computer

Ethereum

- Drawing parallel to the existing centralised system:
  - A client usually connects to a central server (it can be a web server, database server or even a storage server)
  - This creates a bottleneck: a single point of failure in case when the server crashes

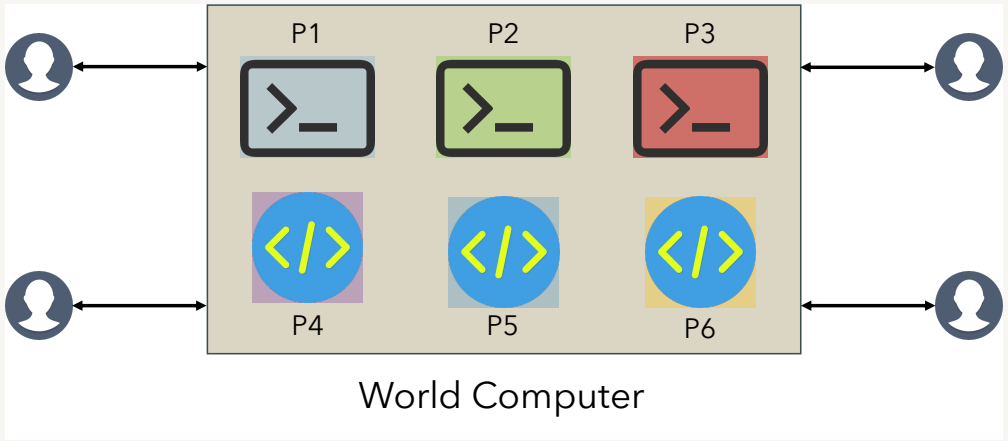
World computer

- Is a single world computer possible?
- Where will it be hosted?
- Who will control it?
- Who will provide the huge computation and storage capacity?

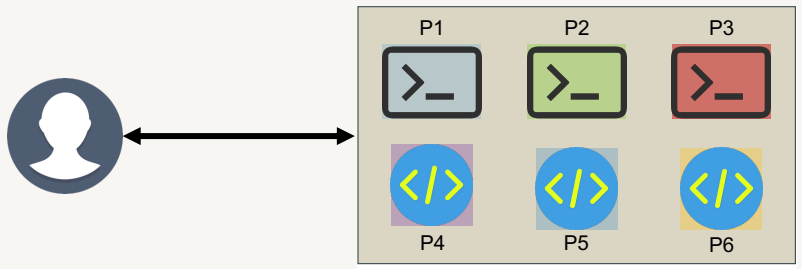


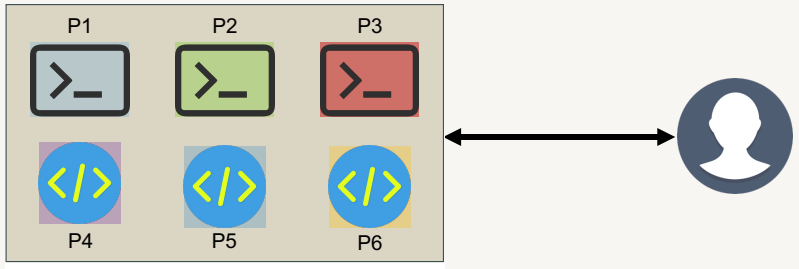
World computer

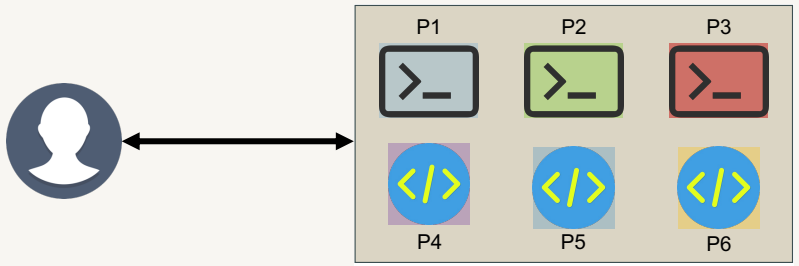
- How to avoid a single point of failure?
- What to do when attacks happen?
- How to mitigate attacks?
- Solution: Decentralise the world computer

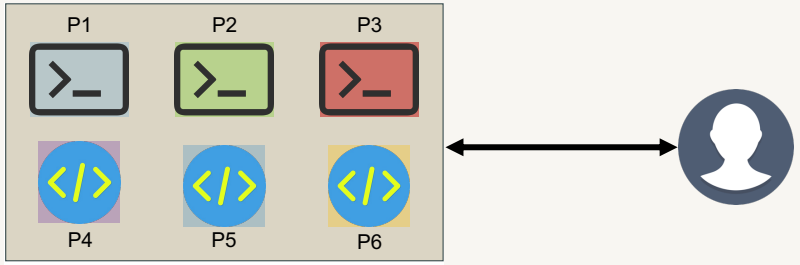


World computer

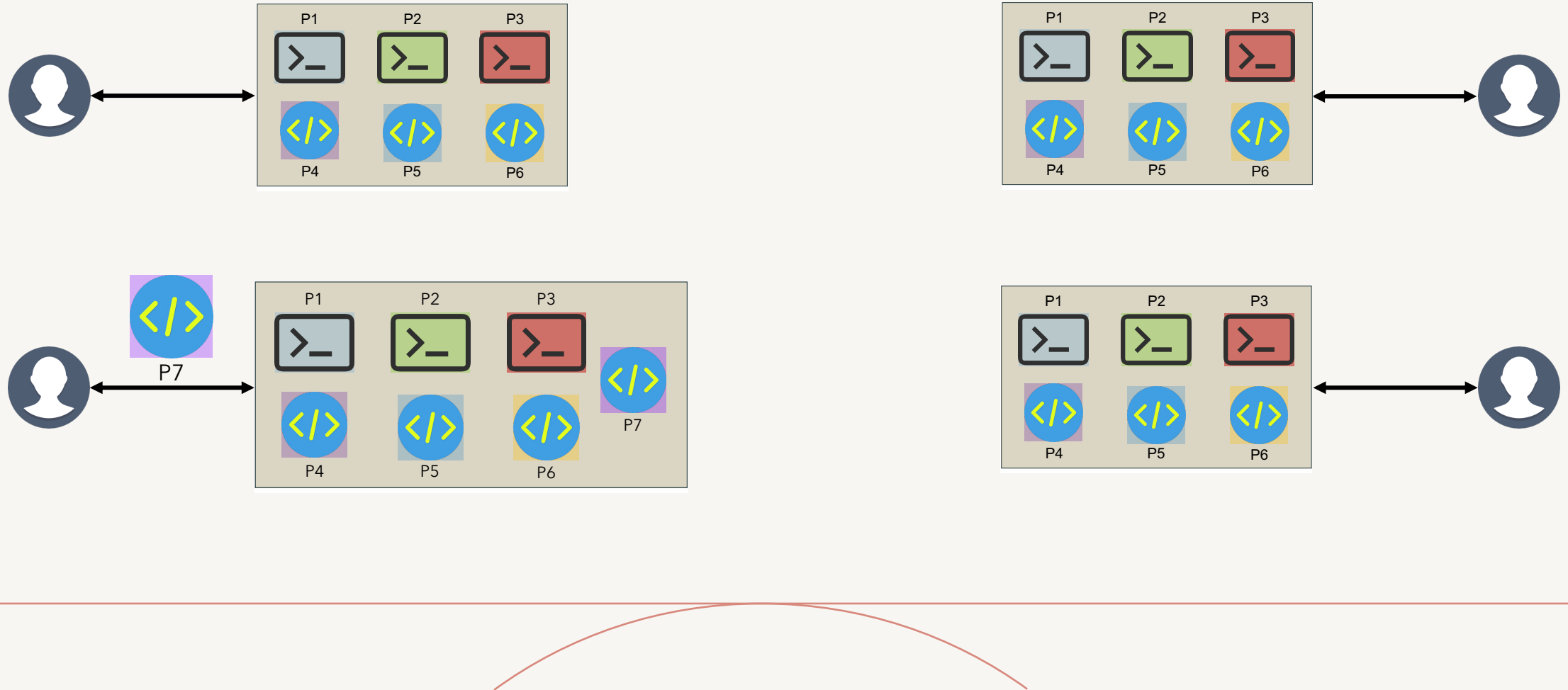




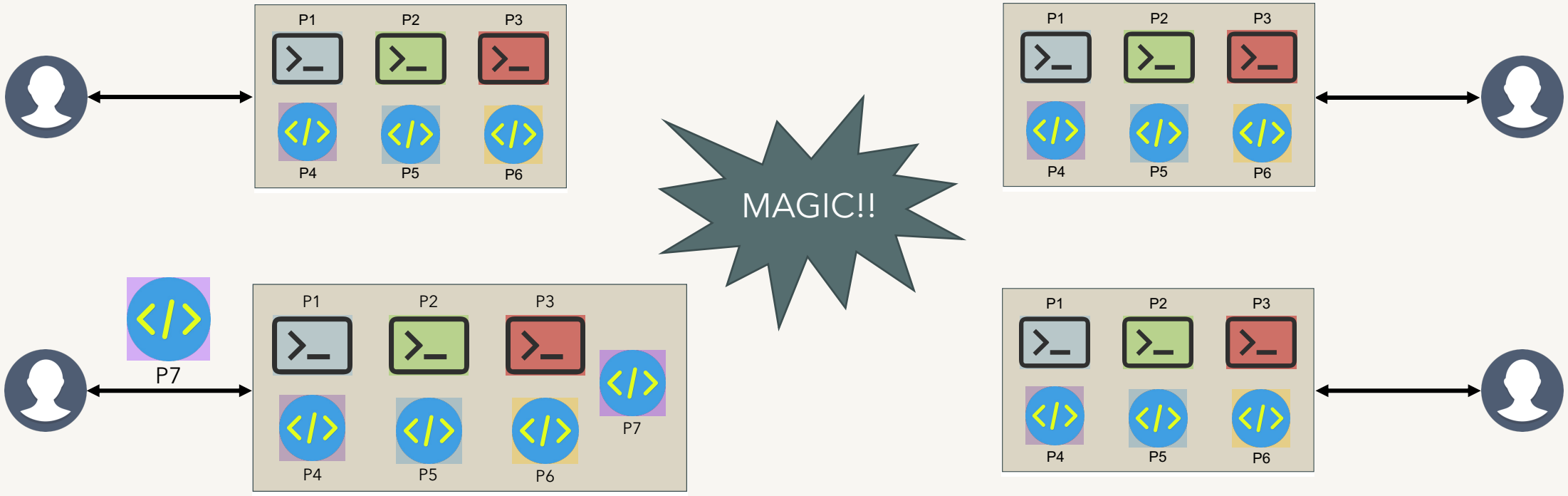




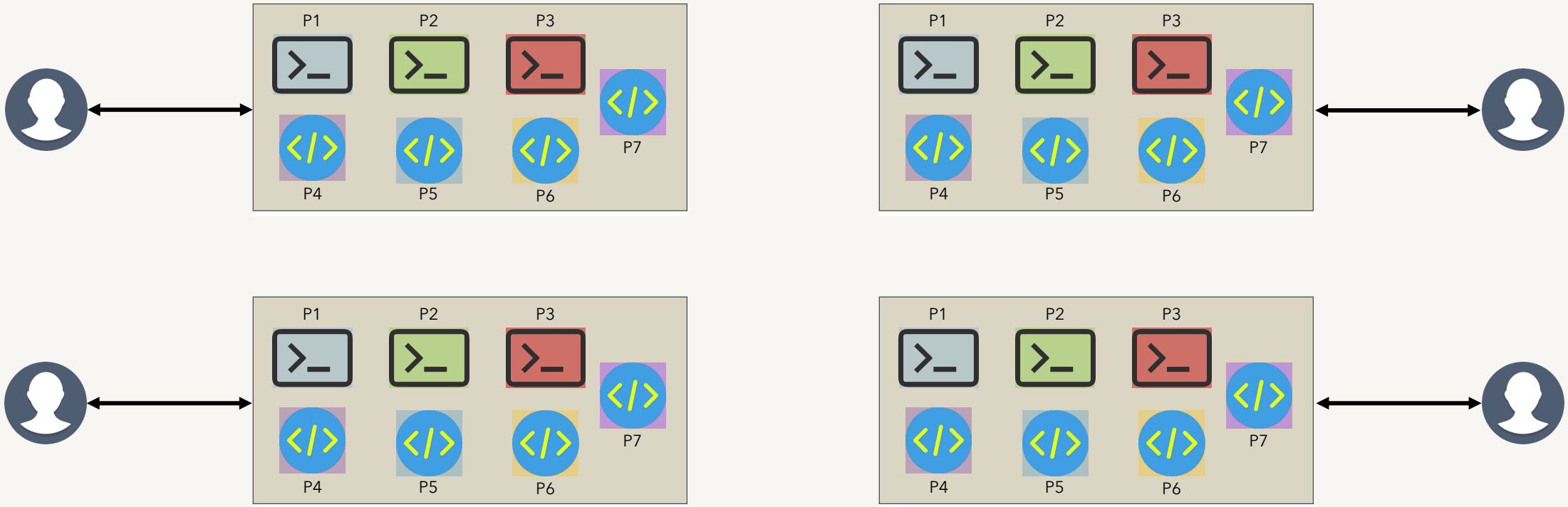
World computer



World computer

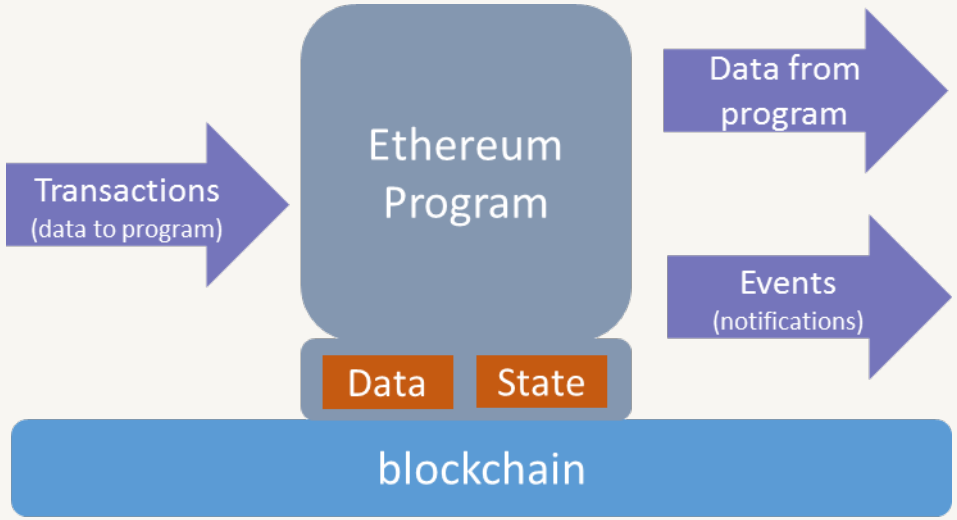


World computer



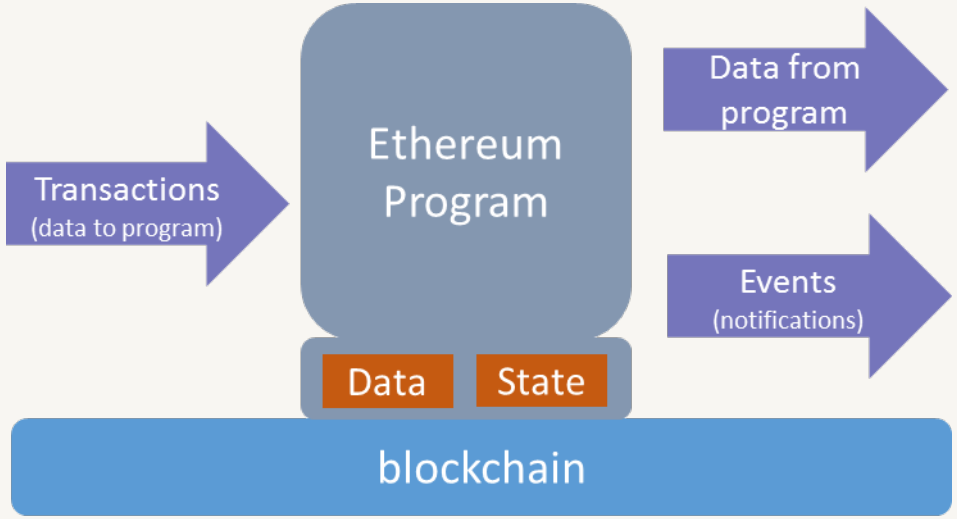
Ethereum

- Ethereum provides a VM (Virtual Machine) along with its blockchain
- An Ethereum program is like any computer program
  - You can install it within the VM
  - Installing a program is known as deploying the code
- Upon receiving data/command via transactions
  - It executes the code based on its logic
  - This changes its state(s)



Ethereum

- States of the EVM and the data it contains are stored in the blockchain
- A consensus protocol ensures a universal synchronisation of state and data for each program in the blockchain
- Data can be retrieved from the program



Ethereum

- This blockchain based VM (called EVM or Ethereum Virtual Machine) distribution allows Ethereum to act as a decentralised World Computer!
- The decentralised nature of the platform guarantees that the application will always run without any downtime, modification, censorship, fraud or other interference!
- Being based on blockchain means: Once a code is deployed in the EVM, it is replicated to all nodes running the EVM
- This is an extremely powerful capability, sought after in many application domains!
- Apart from running applications, Ethereum blockchain can also transfer money between 2 parties without a central authority, just like bitcoin

Ethereum

- Unlike any traditional server based setting, here, you interact with the EVM inside your own computer!
- You can deploy (install) your code within a single EVM and then
  - it gets installed in every single EVM in each node within the network by means of consensus!
- Then, you interact with your code to
  - store data in the blockchain
  - call a function to perform some computations
- These change states of the EVM which are also get propagated using its consensus mechanism

Ethereum

- An Ethereum program is called a smart-contract
  - Deployed in the blockchain via transactions
  - Costs a crypto-currency called *Ether*
- Almost works like a function in a programming language
  - Can be invoked with data to perform specified operations on the supplied data which can be retrieved

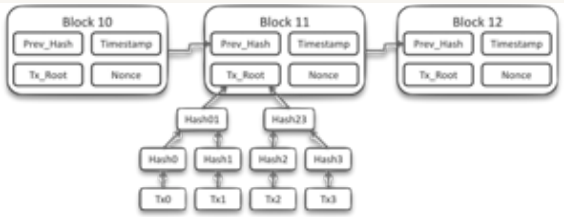
Ethereum

- Since smart-contracts stored in a blockchain
  - Irreversible once part of a blockchain
  - Provides strong security guarantee against the compromisation of the infrastructure
- A DApp (Decentralised application) is a web-service
  - Provides an interface for interaction between the Ethereum blockchain and other web-services
  - Utilises JavaScript

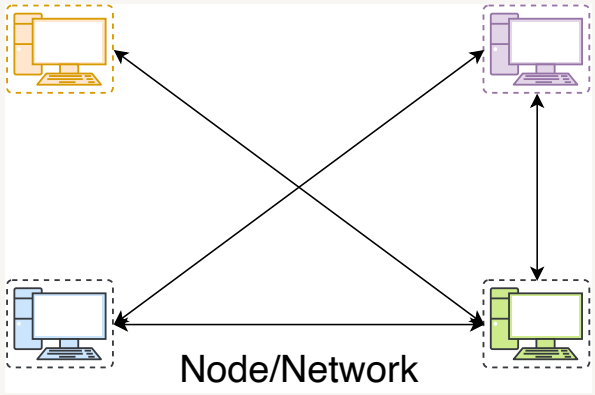
Ethereum components

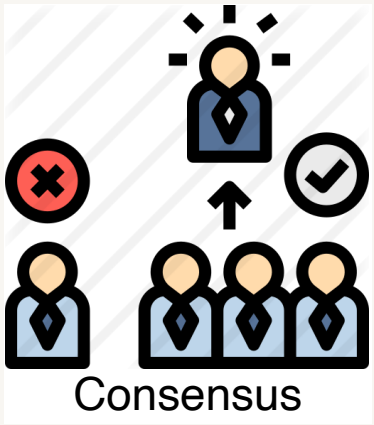
Users & code representation

EVM



Blockchain

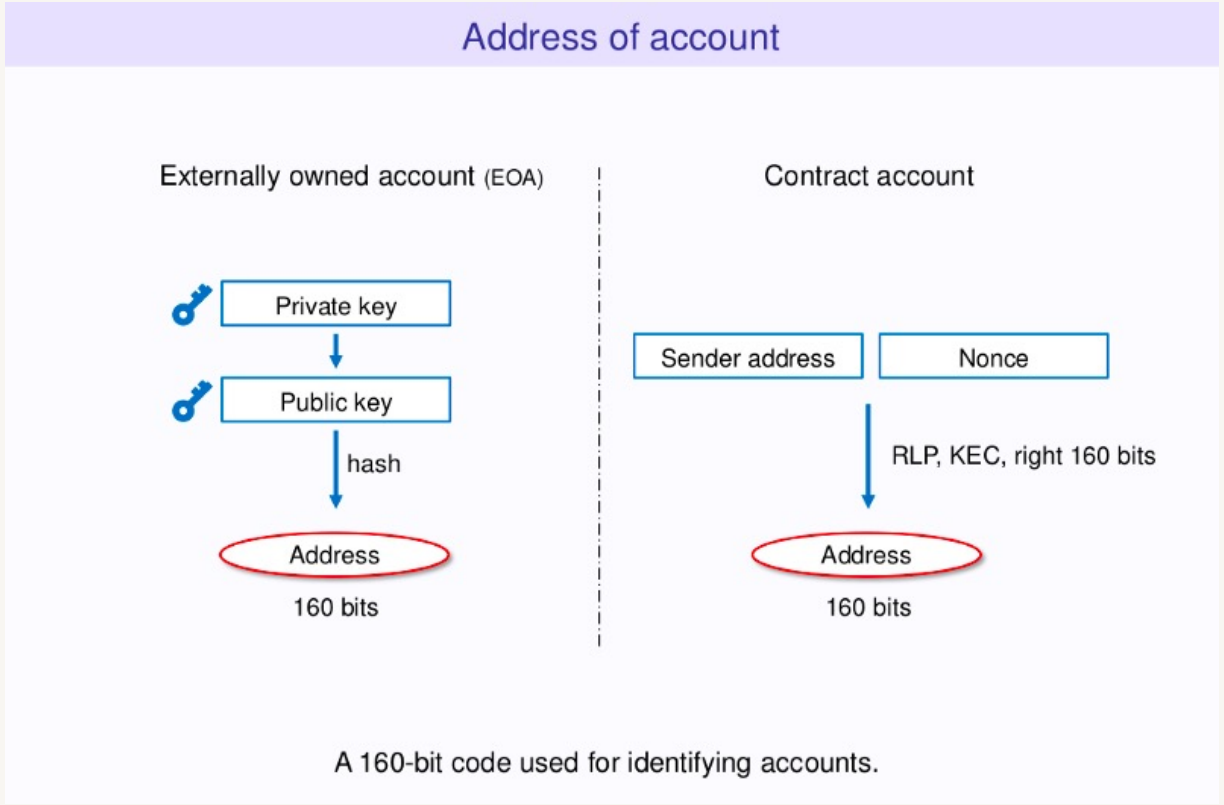




Ethereum address

- Ethereum address is different to Bitcoin's address
  - It is generated in a similar way but using different mechanisms
- It utilises the similar concept of public and private key where the address is generated from the public key
  - Private key -> Public key -> keccak256(public key) -> last twenty bytes of the hash = Ethereum address
- Unlike Bitcoin, Ethereum has two types of accounts:
  - Externally owned accounts (EOA): represented by an address of a user generated by public/private key
  - Contract accounts: generated when a smart-contract is deployed in the EVM

Ethereum address



https://cdn-images-1.medium.com/max/800/1*zEEt3J7gnUiyOhzXVl1jHw.png

RLP - > Recursive Length Prefix (a data serialization process)
KEC -> Keccak 256 Hashing

Ethereum address

- Contract accounts don’t have any private key associated with it
- They can receive and send Ether just like an EOA
- They contain code unlike any EOA
- They can be invoked only by a transaction (similar to calling a function of a programming language program)
  - Either by an EOA or by another contract

Ethereum accounts

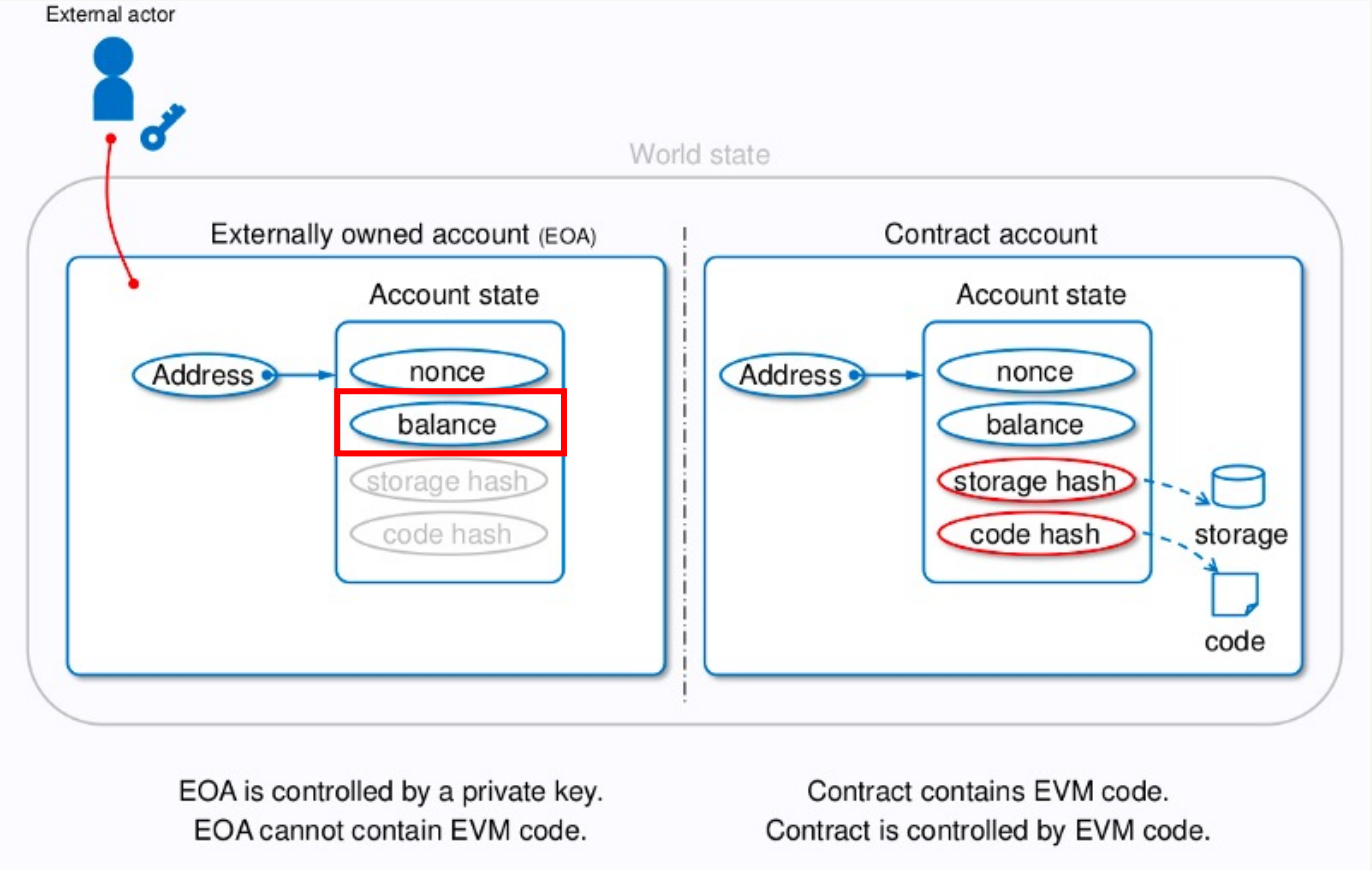
- Compared to Bitcoin, Ethereum uses an account-based ledger
  - Remember Bitcoin uses a transaction based ledger
- Each distinct address represents a separate, unique account
- There are two accounts: EOA and contract account
- Accounts that are controlled by private keys and owned externally are EOA accounts
- EOA accounts do not have any code stored on the blockchain
  - This type can be seen as the default wallet of a user
- It can sign transactions, issue smart contract functions calls and send Ether from one account to another
- The origin of any transaction is always an account controlled by a private key

Ethereum accounts

- Smart Contract accounts are controlled by their code
- Smart Contracts are treated as account entities with their own, unique address
- Contracts can send messages to other accounts, both externally controlled accounts and smart contract accounts
- They have a persistent internal storage to write and read data from

Ethereum accounts

- Every EOA has its balance stored in the blockchain
- This is unlike Bitcoin where no separate balance database is maintained

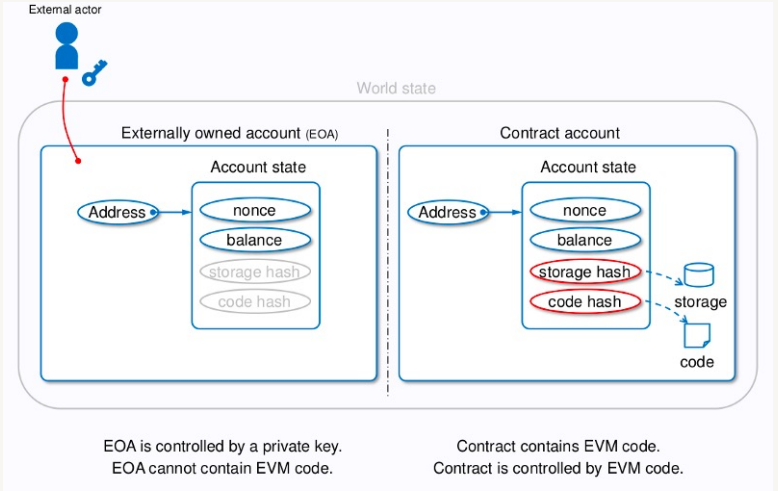


Here, world state represents the blockchain

https://cdn-images-1.medium.com/max/800/1*YC5PFXSJlZPw6zQWOuE7WQ.png

Ethereum accounts

- nonce: # of transactions sent / # of contracts created
- balance: # Wei owned (1 ether = 10^{18} Wei)
- storageRoot: Hash of the root node of a *Merkle Patricia* tree (MPT) of storage contents of the account
  - MPT will be discussed later
  - The tree is empty by default
- codeHash: Hash of the EVM (Ethereum Virtual Machine) code of this account



https://cdn-images-1.medium.com/max/800/1*YC5PFXSJlZPw6zQWOuE7WQ.png

Ether denomination

Babbage, Lovelace and others represent influential CS/blockchain people

Unit	Wei Value	Wei
wei	1 wei	1
Kwei (babbage)	1e3 wei	1,000
Mwei (lovelace)	1e6 wei	1,000,000
Gwei (shannon)	1e9 wei	1,000,000,000
microether (szabo)	1e12 wei	1,000,000,000,000
milliether (finney)	1e15 wei	1,000,000,000,000,000
ether	1e18 wei	1,000,000,000,000,000,000

http://ethdocs.org/en/latest/ether.html

Question?