Intro to Blockchain

What is Blockchain

This fancy term blockchain actually means a block of data that has been recorded over a certain amount of time and is grouped and cryptographically linked to a previous set of data forming a chain of events.

Why Blockchain

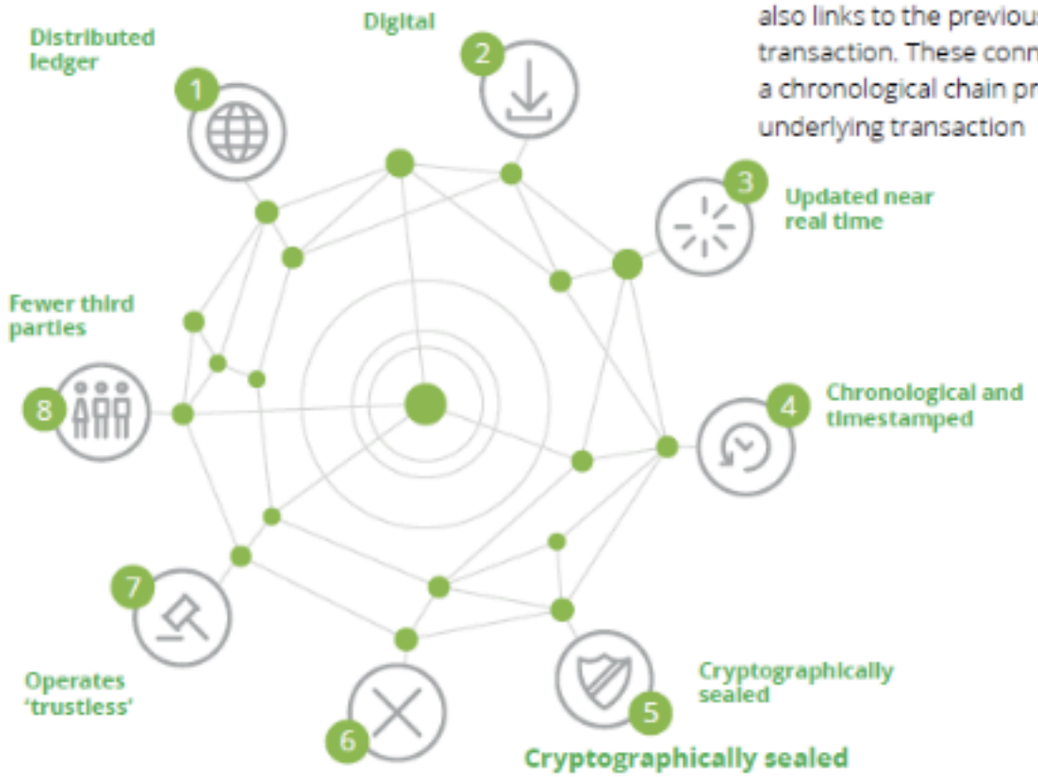
1. Trust — Blockchain helps in creating applications that are decentralized and collectively owned by multiple people. No body within this group has the power to change or delete previous transactions. Even if someone tries to do so, it will not be accepted by other stakeholders.
2. Autonomy — There is no single owner for Blockchain based applications. No one controls the blockchain, but everyone participates into its activities. This helps in creating solutions that cannot be manipulated or induce corruption.
3. Integrity — The state and transactions are secured cryptographically and cannot be modified easily.
4. Intermediaries — Blockchain based application can help remove the intermediaries from existing processes. Generally, there is a central body like Vehicle registration, licence issuing etc who acts as registrar for registering vehicles as well as issuing driver licences. Without Blockchain based systems, there is no central body and if a licence is issues or vehicle is registration after Blockchain mining process, that will remain a fact for epoch time-period without the need of any central authority vouching for it.

KEY CHARACTERISTICS OF THE BLOCKCHAIN

Digital
All the information on Blockchain is digitized, eliminating the need for manual documentation

Chronological and time-stamped
Blockchain, as the name suggests is a chain of blocks – each being a repository that stores information pertaining to a transaction and also links to the previous block in the same transaction. These connected blocks form a chronological chain providing a trail of the underlying transaction

Distributed ledger
Indistinguishable copies of all information are shared on the Blockchain. Participants independently validate information without a centralized authority. Even if one node fails, the remaining nodes continue to operate, ensuring no disruption



Consensus-based
A transaction on Blockchain can be executed only if all the parties on the network unanimously approve it. However, consensus based rules can be altered to suit various circumstances

Cryptographically sealed
Blocks created are cryptographically sealed in the chain. This means that it become impossible to delete, edit or copy already created blocks and put it on network, thereby creating true digital assets and ensuring a high level of robustness and trust. Furthermore, the decentralized storage in a Blockchain is known to be very failure-resistant. Even in the event of the failure of a large number of network participants, the Blockchain remains available, eliminating the single point of failure. Data stored in a Blockchain is immutable.

Explore more about this at : www.deloitte.com/convergence

101 Blockchains | KEY FEATURES OF BLOCKCHAIN TECHNOLOGY

01 CANNOT BE CORRUPTED

Every node on the network has a copy of the digital ledger. To add a transaction every node needs to check its validity. If the majority thinks it's valid, then it's added to the ledger. This promotes transparency and makes it corruption-proof.

02 DECENTRALIZED TECHNOLOGY

The network is decentralized meaning it doesn't have any governing authority or a single person looking after the framework. Instead, a group of nodes maintain the network making it decentralized.

03 ENHANCED SECURITY

As it eliminates the need for central authority, no one can just simply change any characteristics of the network for their benefit. Also using encryption ensures another layer of security for the system.

04 DISTRIBUTED LEDGERS

The ledger on the network is maintained by all other users on the system. This distributes the computational power across the computers to ensure a better outcome.

05 CONSENSUS

Every blockchain thrives because of the consensus algorithms. The architecture is cleverly designed, and consensus algorithms are at the core of this architecture. Every blockchain has a consensus to help the network make decisions.

06 FASTER SETTLEMENT

Blockchain offers a faster settlement compared to traditional banking systems. This way a user can transfer money relatively faster, which saves a lot of time in the long run.

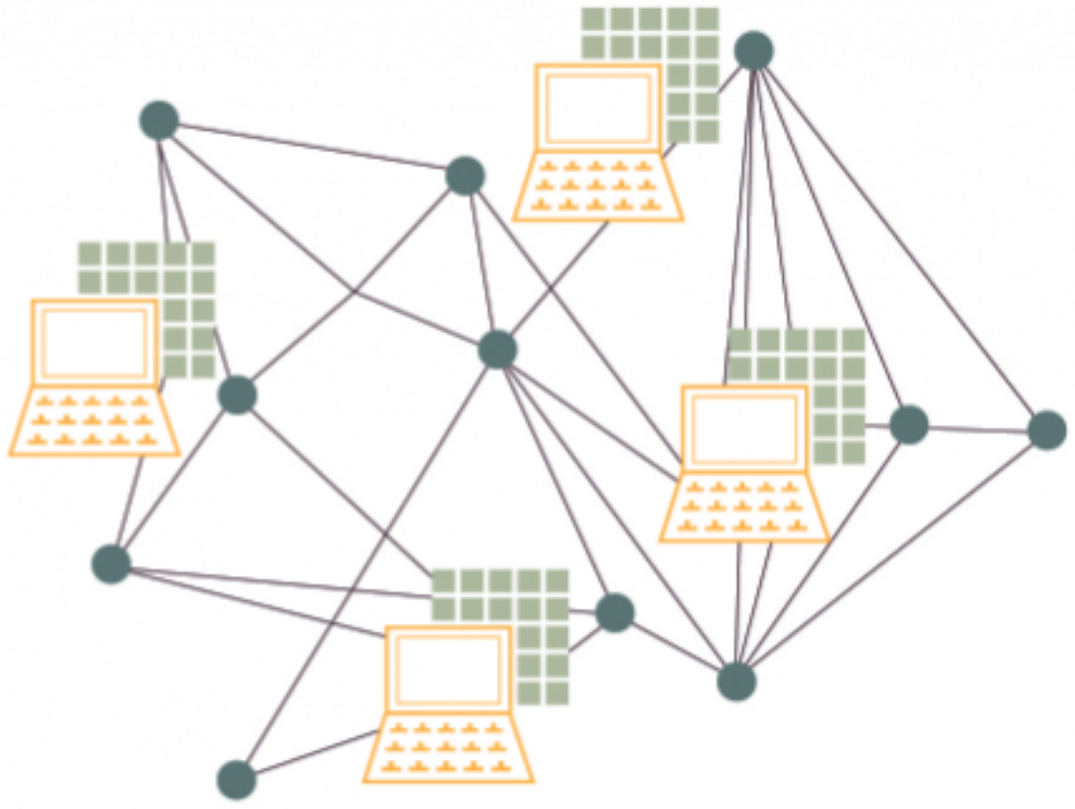
BLOCKCHAIN FEATURES

Created by 101blockchains.com

*https://101blockchains.com/introduction-to-blockchain-features/

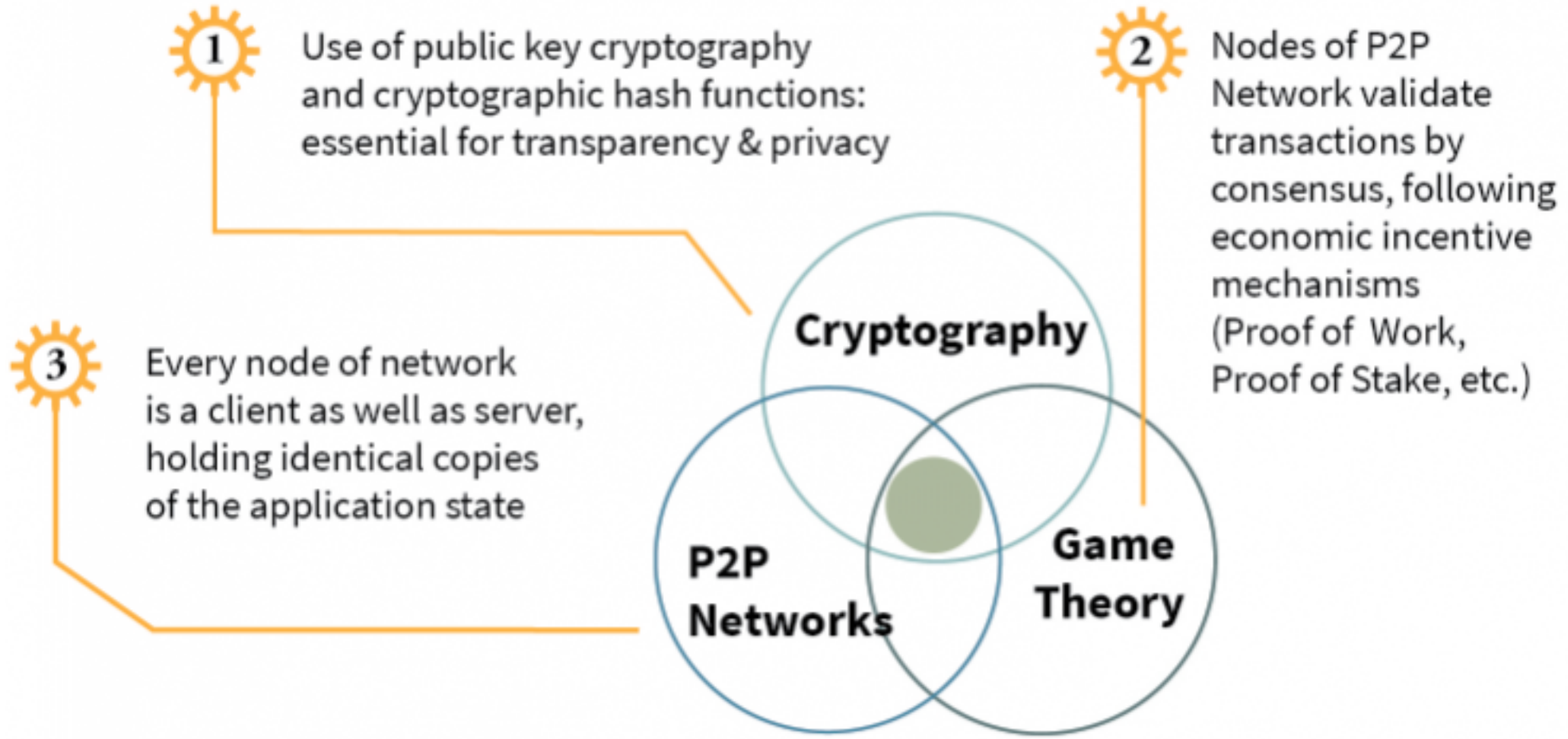
Like a spreadsheet in the sky

- Shared
- Public
- Ledger of transactions
- Anyone can inspect the transactions
- No single entity controls



From the Book "**Token Economy**" by Shermin Voshmgir, 2019
Excerpts available on **https://blockchainhub.net**

Behind the Blockchain Protocol



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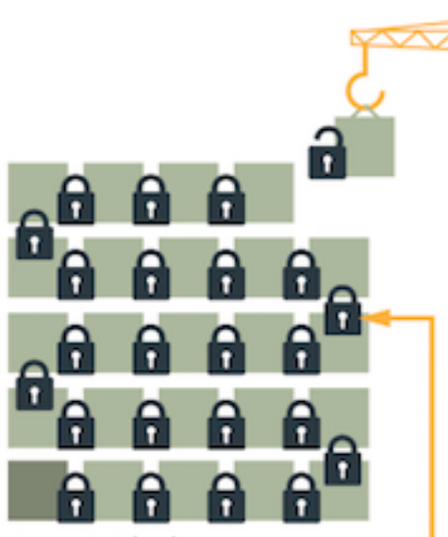
Why is it called Blockchain?



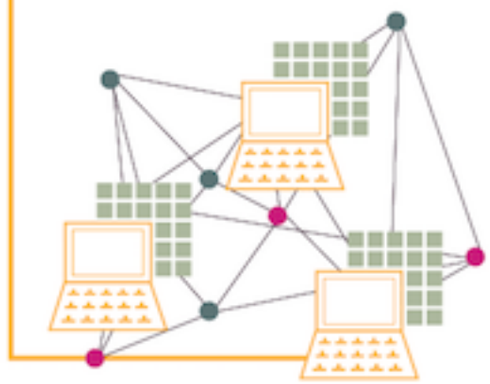
Genesis Block

The network stores all the information in cryptographically secured data pieces called blocks. The first block in a blockchain is called the Genesis Block. Each block has limited storage size. Blocks store a fingerprint (the hash) of the previous block, thus they are 'chained' together with cryptography.

3 Cryptography

2 Game Theory

Each new block of transaction get added to the blockchain by consensus of network validators at even time intervals. Validators are rewarded with a native token for validating transactions according to the rules through fault tolerant and attack resistant economic incentivisation mechanism.



1 P2P Network

Each full node on the network stores a copy of the entire blockchain (transaction history).

From the Book "**Token Economy**" by Shermin Voshmgir, 2019
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Why is a Blockchain tamper resistant?

Each network participant keeps a copy of the entire blockchain - the file where all past transactions are recorded. Consensus of network validators verifies new transactions. In the Bitcoin network transactions are validated by network miners who are ircentivised to verify transactions through PoW (Proof of Work).

If a malicious party makes unauthorized changes to his copy of the blockchain on one computer, other members of the network will refuse the transaction since that malicious version of the blockchain data will differ from the rest of network.

From the Book "**Token Economy**" by Shermin Voshmgir, 2019
Excerpts available on **https://blockchainhub.net**

Blockchain Technology Stack

Ethereum and similar Blockchain

Smart Contracts

Relationship

Define behavioural rulesets for all participants of the smart contracts

Application

Record of Transaction (Ledger)

Assets

File (ledger) containing all information, tracking all assets since genesis block, which is stored on every (full) node of the network.

Consensus Rules

Governance

Encoded rulesets of all rights and obligations of all actors in the network: conditions under which transactions are created, sent and verified by the network, including economic incentive (token) & the creation/referencing of identities & addresses.

Nodes in the Network

Network

A network of all devices running the blockchain protocol and keeping records of transactions (ledger).

Blockchain

From the Book "**Token Economy**" by Shermin Voshmgir, 2019
Excerpts available on **https://blockchainhub.net**

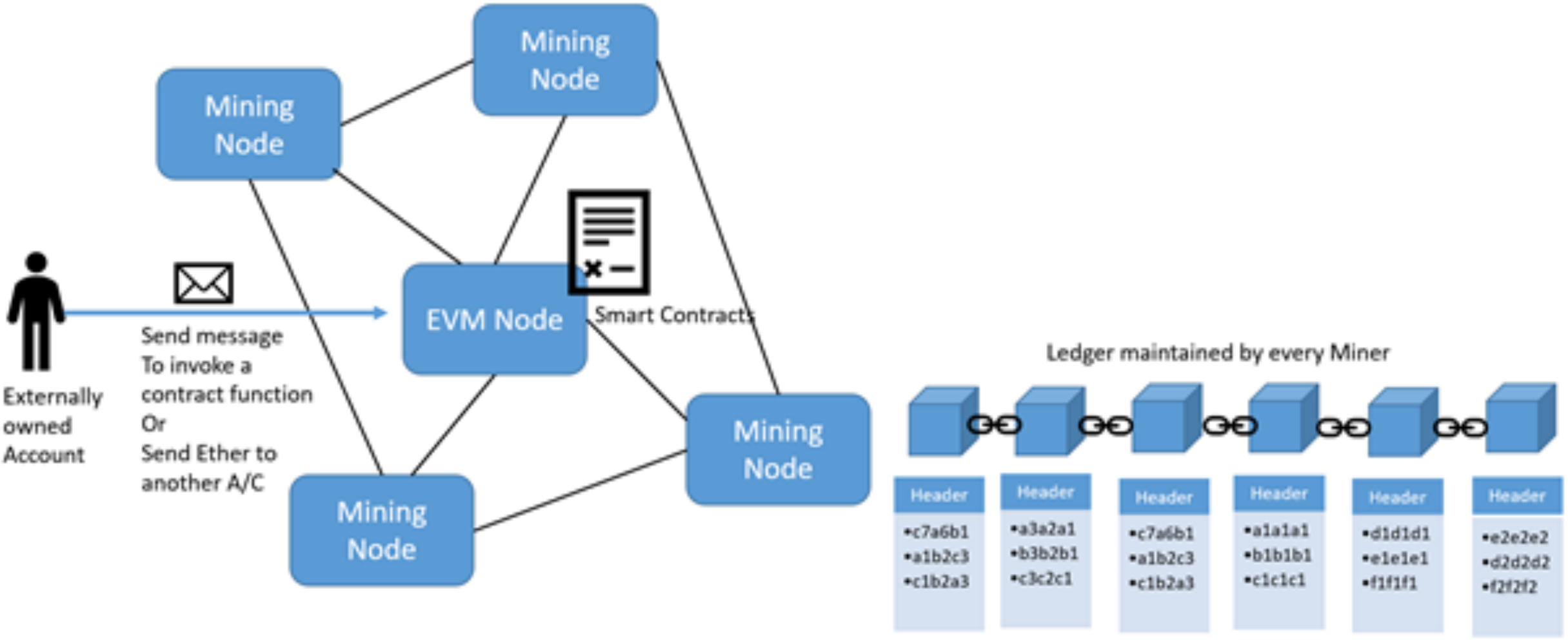
Ether

Ether is the currency of Ethereum. Every activity on Ethereum that modifies its state costs Ether as fee and miners who are successful in generating and writing a block in chain are also rewards Ether. Ether can easily be converted to dollars or other traditional currencies through Crypto-exchanges.

Gas

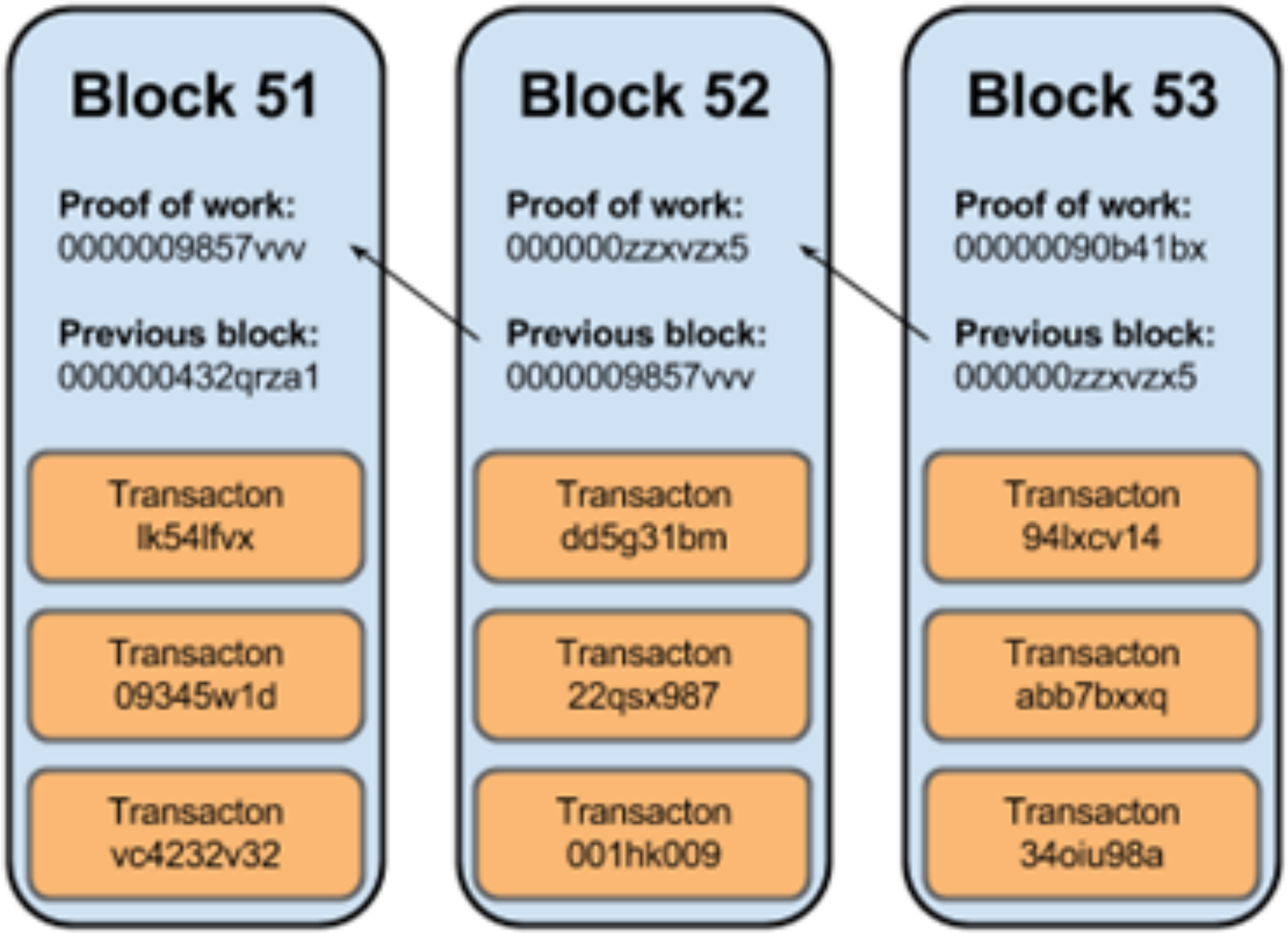
Ether is paid as fees for any execution that changes state in Ethereum. Ether is traded on public exchanges and its price fluctuate daily. If Ether is used for paying fees, then the cost of using the same service could be very high on certain days and low on other days. People will wait for price of Ether to fall to execute their transactions. This is not ideal for a platform like Ethereum. Gas helps in alleviating this problem. Gas is the internal currency of Ethereum. The execution and resource utilization cost is predetermined in Ethereum in terms of Gas units. This is also known as Gas Cost. There is also Gas price that can be adjusted to lower price when price of Ether increases and higher price when price of Ether decreases. For example, to invoke a function in a contract that modifies a string will cost Gas which is pre-determined, and Users should pay in terms of Gas to ensure smooth execution of this transaction.

Blockchain and Ethereum Architecture

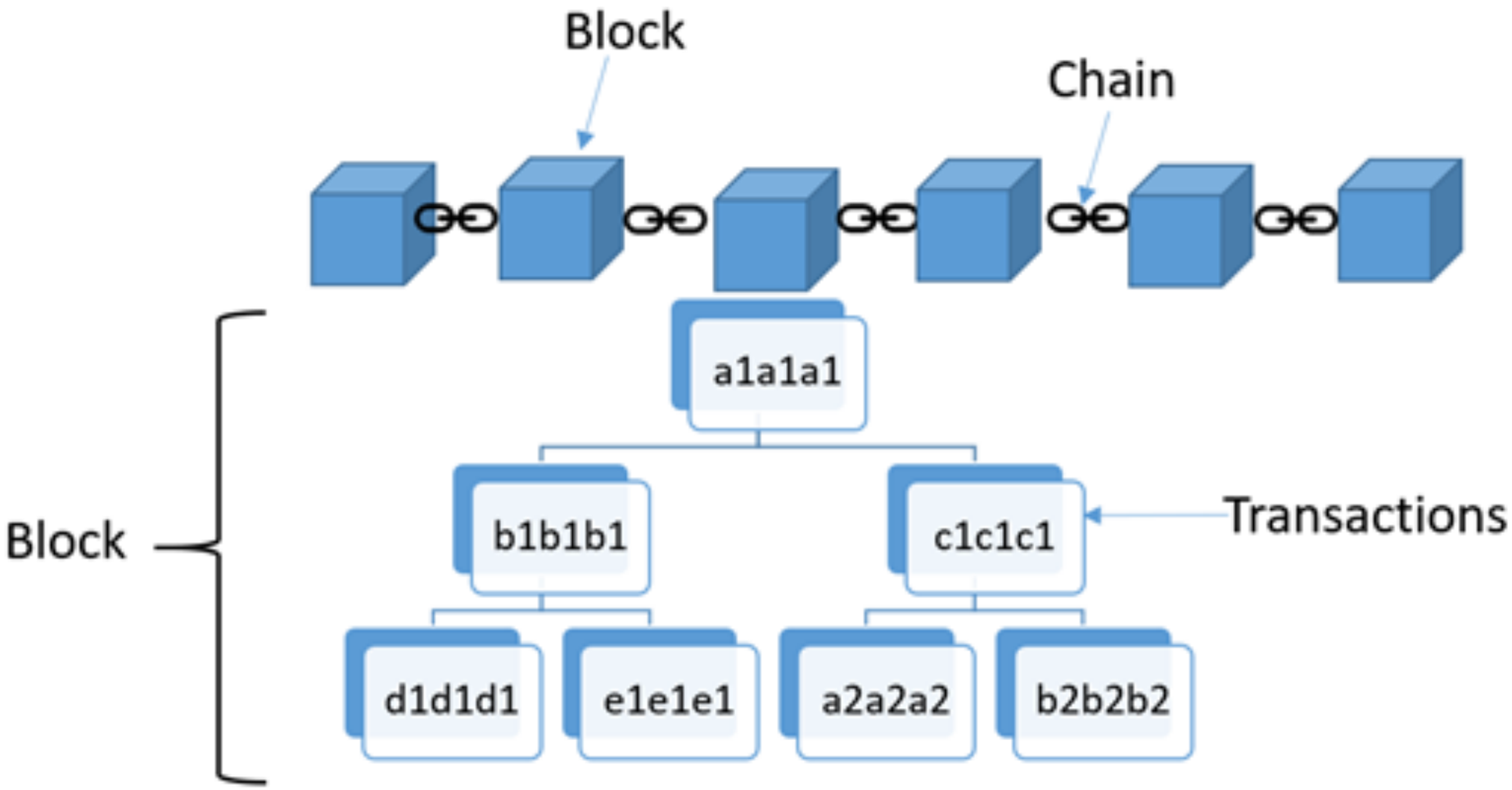


*https://medium.com/coinmonks/https-medium-com-ritesh-modi-solidity-chapter1-63dfaff08a11

How are blocks related to each other



How are transactions and blocks related to each other



Nodes

There are two types of nodes in Ethereum.

· Ethereum virtual machines and

· Mining Nodes

It is to be noted that this distinction is made to clarify concepts of Ethereum. In most scenarios' there is no dedicated EVM machines instead all nodes acts as miner as well as EVM node.

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Ethereum Virtual Machines (EVM)

Think of EVM as the execution runtime for Ethereum network. EVM's are primarily responsible to provide a runtime that can execute code written in smart contracts. It can access accounts — contract and externally owned, its own storage data. It does not have access to ledger but has limited information about current transaction.
EVM are the execution component in Ethereum. The purpose of EVM is to execute the code in smart contract line by line. However, when a transaction is submitted, the transaction is not executed immediately instead is it pooled in a transaction pool. These transactions are not yet executed and not yet written to the Ethereum ledger. EVM nodes are similar to Mining nodes however they do not do mining.

Mining Nodes

A miner is responsible for writing transactions to the Ethereum chain. A miner job is very similar to that of an accountant. As an accountant is responsible for writing and maintain the ledger similarly, a Miner is solely responsible for writing transaction to Ethereum ledger. A miner is interested in writing transactions to ledger because of the reward associated with it. Miners get two types of reward — reward for writing a block to the chain and cumulative gas fees from all transactions in the block. There are generally many miners available within a blockchain network each trying and competing to write transactions. However only one miner can write the block to the ledger and rest will not able to write the current block and determination of a miner who will write the block happens using a challenge. The challange is given to every node and every miner tries to solve the puzzle using its compute power. The miner who solves the puzzle first write block containing transactions to ledger and also receiver 5 ether as reward. Every Mining node maintains its own instance of Ethereum ledger and the ledger is same ultimately across all miners. It is job of miners to ensure that their ledger is updated with latest blocks. There are three important functions performed by Miners or Mining Nodes.

· Mine or create a new block with transaction and write the same to Ethereum Ledger
· Advertise and send a newly mined block to other miners.
· To accept new blocks mined by other miners and keep its own ledger instance up-to-date

Mining Nodes refers the nodes that belong to Miners. These nodes are part of the same network where EVM is hosted. At some point of time, the miners would create a new Block, collect all transaction from transaction pool and adds them to the newly created block. Finally, this Block is added to the chain. There are additional concepts like consensus, solving of target puzzle before writing the block and will be explained in section “How mining works”.

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How Does Mining Work

· The miner hashes all the transactions in the block, these hashes are further combined in pairs to generate a new hash. The process continues until there is just one hash for all transactions in the block. The hash is referred as Root transaction hash or Merkel Root transaction hash. This hash is added to the block header.
· The miner also identifies the hash of the previous block. The previous block will become parent to the current block and its hash will also be added to the block header.
· The miner in similar way calculates the State and Receipts transaction root hashes and add them to the block header.
· A nonce and timestamp is also added to the block header. The mining process starts where the miner keeps changing the nonce value and try to find a hash that will satisfy as an answer to the given puzzle. It is to be kept in mind that everything mentioned here is executed by every miner in the network.
Eventually, one of the miner would be able to solve the puzzle and advertise the same to other miners in the network. The other miners would verify the answer and if found correct would further verify every transaction while accept the block and append the same to their ledger instance.
This entire process is also known as Proof of Work wherein a miner provides proof that is has worked on computing the final answer that could satisfy as solution to the puzzle.

Accounts

Accounts are main building block for Ethereum ecosystem. It is the interaction between accounts that Ethereum wants to store as transaction in its ledger. Ethereum supports two types of accounts. Each account has a balance property that returns the current value stored in it.

Transaction

A transaction is an agreement between a buyer and seller, a supplier and a consumer or a provider and a consumer that there would be exchange of assets, products or services in lieu of currency, crypto-currency or some other asset either in present or in future. Ethereum helps in executing transaction. There are four types of transaction that can be executed in Ethereum.

1. Transfer of Ether from one account to another. The accounts can be externally owned accounts or contract account. Following are the possible cases

a. An externally owned account sending ether to another externally owned account in a transaction.

b. An externally owned account sending ether to a contract account in a transaction.

c. A contract account sending ether to another contract account in a transaction.

d. A contract account sending ether to an externally owned account in a transaction

2. Deployment of Smart contract — An externally owned account can deploy a contract using a transaction in Ethereum virtual machine.

3. Using or invoking a function within a contract — Executing a function in a contract that changes state are considered as transactions in Ethereum. If executing a function does not change state, it does not require a transaction

A transaction has some important properties related to it.

From Account property denotes the account that is originating the transaction and represents an account who is ready to send some gas or ether. We will consider concepts related to Gas and Ether later section in this chapter. From account can be externally owned or a contract account.

To account property refers to an account that is receiving ethers or benefits in lieu of an exchange. In case of transaction related to deployment of contract, the To field is empty. It can be externally owned or a contract account.

Value refers to the amount of ether that is transferred from one account to another.

Input refers to the compiled contract bytecode and is used during contract deployment in EVM. It is also used for storing data related to smart contract function calls along with its parameters.

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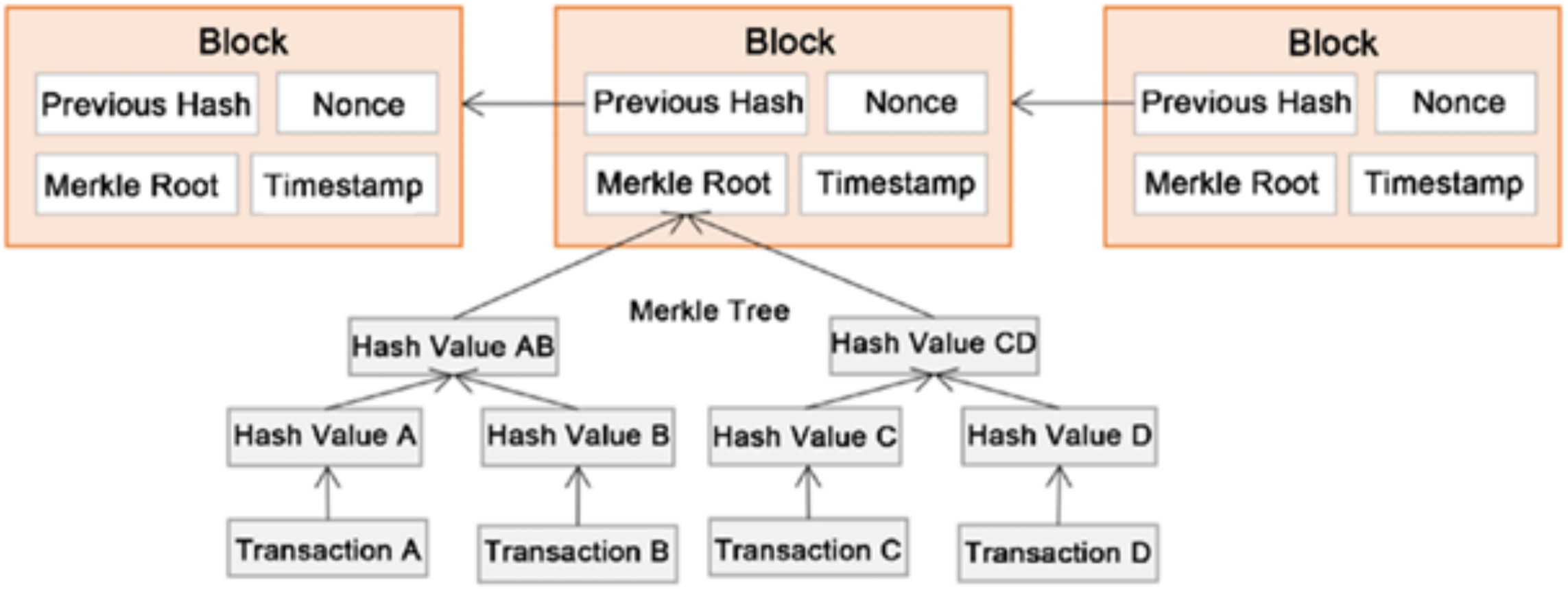
Transaction

Blockhash refers to the hash of Block to which this transaction belongs to.
BlockNumber is the block in which this transaction belongs to.
Gas refers to amount of gas supplied by sender which executing this transaction
GasPrice refers to the price per gas the sender was willing to pay in Wei (Wei is explained in section related to Ether). Total Gas is computed at Gas units * Gas price
Hash refers to the hash of transaction
Nonce refers to number of transactions made by the sender prior to current transaction.
TransactionIndex refers to the serial number of current transaction in block
Value refers to amount of ether transferred in Wei
V, R and S relates to digital signature and signing of transaction.

How Does Mining Work



Block

Block is an important concept in Ethereum. Block are containers for transaction. A block contains multiple transactions. Each block has different number of transactions based on Gas limit. Gas limit will be explained in detail in later sections. The blocks are chained together to form blockchain. Each Block has a parent and it stored the hash of parent block in its header. Only the first Block known as Genesis block does not have a parent.

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```
{ difficulty: BigNumber { s: 1, e: 5, c: [ 135070 ] },
  extraData: '0xd783010702846765746885676f312e398777696e646f7773',
  gasLimit: 4011042861,
  gasUsed: 43406,
  hash: '0xba93a91df520c7565e80347346e47b83a41d473a33352d1cf7e689c30b305ba5',
  logsBloom: '0x0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
000000000000000000000000000000000000000000000000000000',
  miner: '0xa57de277ede9c1521f51f6989ed2497a5b9c1926',
  mixHash: '0x4e80de770c329aebbc2e9e861190784f57b7f9910bbb0495348280522284f32e4',
  nonce: '0x655dee191333922c',
  number: 70,
  parentHash: '0x27d3dbc34614f88583f29ea1b7546e83563e55638b1d0a258de04f4912f42aaf',
  receiptsRoot: '0x5dff465dd85c4ad02c71ec4099284ecaf91ed9bb600f7903978386059c16fb8d',
  sha3Uncles: '0x1dcc4de8dec75d7aab85b567b6ccd41ad312451b948a7413f0a142fd40d49347',
  size: 742,
  stateRoot: '0xb15363a8958d218eff295b5e877517ee4243f1b681d987793c5ec30a04bc4592',
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  totalDifficulty: BigNumber { s: 1, e: 6, c: [ 9302609 ] },
  transactions:
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  uncles: [] }
```

Block

The **Difficulty** property determines the complexity of the puzzle/challenge given to miners for this block.
GasLimit determines the maximum gas allowed. This helps in determining how many transaction can be part of the block.
GasUsed refers to the actual gas used for this block for executing all transactions in it.
Hash refers to the hash of the block.
Nonce refers to the number that helping in solving the challenge.
Miner property is the account identifier of miner also known as coinbase or Etherbase
Number is the sequential number of this block on the chain
ParentHash refers to parents blocks hash.
ReceiptsRoot, StateRoot and transactionRoot refers to Merkel trees discussed during mining process.
Transactions refers to array of transactions that are part of this block.
TotalDifficulty refers to total difficulty of the chain until this block

End to End Transaction

Sam wants to send $$ to Mark

Transaction reaches the network

The nodes compete and validates the transaction

A new block with transaction is generated

Both Accounts are updated

The Block is replicated and stored on all nodes

Smart Contract

A smart contract is a contract implemented, deployed and executed within Ethereum environment. Smart contracts are digitization of the legal contracts. Smart contracts are deployed, stored and executed within the Ethereum Virtual machine. Smart contracts can store data. The data stored can be used to record information, fact, associations, balances and any other information needed to implement logic for real world contracts. Smart contracts are very similar to Object oriented classes. A smart contract can call another smart contract just like an Object-oriented object to create and use objects of another class. Think of smart contract as a small program consisting of functions. You can create an instance of the contract and invoke functions to view and update contract data along with execution of some logic