

Blockchains

Cryptocurrencies and Consortium Blockchains

Tero Keski-Valkama, Elisa Patronen



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- Blockchain is a collection of cryptotechnologies to achieve a distributed consensus about immutable, additive data in an untrusted environment.
 - ① Blockchain is a sequence of records, or blocks, so that each block contains a hash digest of the previous block (which recursively contains the hash digest of the previous block and so on).
 - ② A consensus mechanism with rules to determine which blocks are accepted to be the next block in the blockchain. Many solutions such as proof-of-work, proof-of-stake, proof-of-burn, Practical Byzantine Fault Tolerance, and hybrids.
 - ③ A discovery and broadcast infrastructure to relay transactions and blocks to peers and miners.
 - ④ Application-specific public key or other cryptography to prove identities of parties in transactions, wallets and so on.
 - ⑤ Microcode used to define the transaction semantics or smart contracts, such as [Bitcoin Script](#), [Solidity](#) or [Chaincode](#).
- In blockchain, a single valid block can be used to validate the whole chain of blocks to deep history so that anyone can make sure that nothing has been altered in the stored data, by checking that the hashes of the previous block always matches the content of the previous block.
- The consensus mechanism offers guarantees that all parties have a converging view in the blockchain regarding what is valid and what is not. It prevents changing the history and that the whole blockchain integrity is guaranteed.

There Shall Be No Blockchain But Bitcoin

click

Example of a Consortium Blockchain: Hyperledger Vision

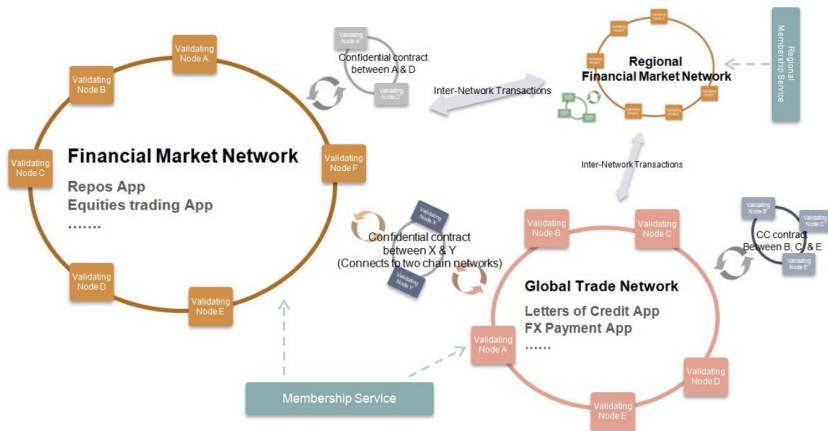


Figure: Hyperledger Vision¹

¹Hyperledger Whitepaper – academic fair use

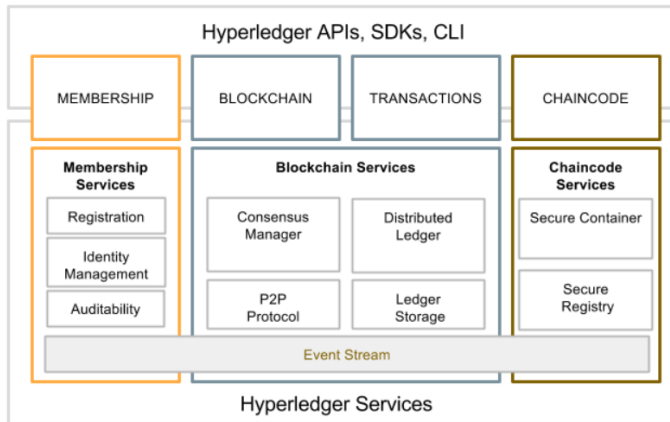


Figure: Hyperledger Architecture²

²Hyperledger Whitepaper – academic fair use

	Distributed Database	Consortium Blockchain	Cryptocurrency Blockchain
Consensus mechanism	Simple parallel consistency	Byzantine Fault Tolerance	Proof-of-Work, Proof-of-Stake, or a hybrid
Requires a cryptocurrency	no	no	yes
Access	Closed	Controlled	Open
Peers	None	Validated	Untrusted

3 kinds of consensus algorithms

Proof of
Work

Proof of
Stake

Byzantine Fault
Tolerance

3 kinds of consensus algorithms

Proof of Work

Bitcoin
2xSHA256

Ether
Ethash

Litecoin & Dogecoin
Script

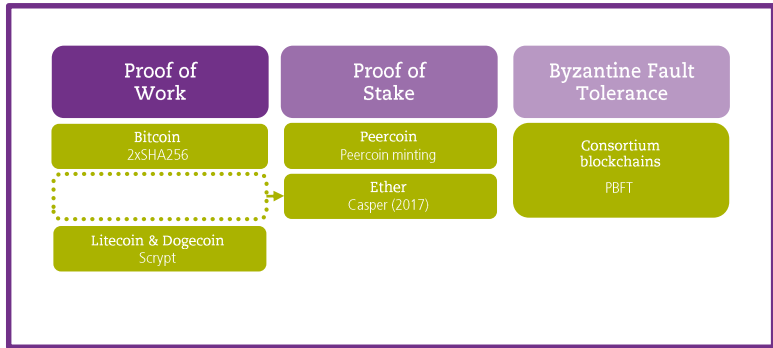
Proof of Stake

Peercoin
Peercoin minting

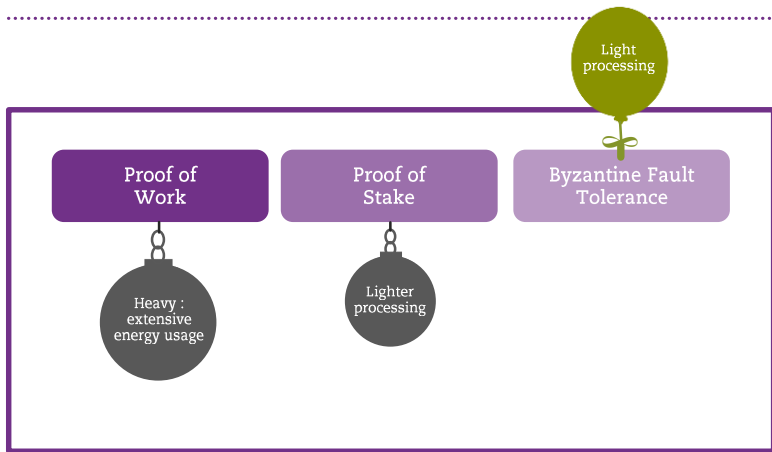
Byzantine Fault Tolerance

Consortium
blockchains
PBFT

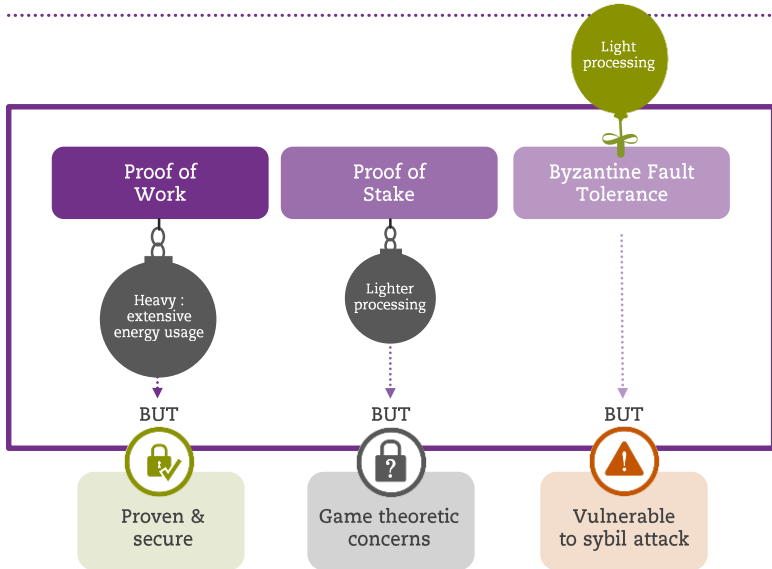
3 kinds of consensus algorithms



3 kinds of consensus algorithms



3 kinds of consensus algorithms



- Consensus is inherently a game theoretic concept in Byzantine systems, because the peers can try to cheat.
- In open ecosystems it must be made economically infeasible to break the rules or the goals of the system. This leads to the requirement of having a cryptocurrency built into the system. In practice, a validating peer gains cryptocurrency for processing transactions, and this cryptocurrency only has value if the whole system works.
- The Bitcoin network can process the maximum of 7 transactions per second with the current block size limit of 1 MB.
- Calculating Bitcoin mining hashes requires about 1 W of power for 1 GH/s of computation for the most energy efficient ASIC implementations.
- The current hashrate of the Bitcoin network of 3,051,683,778 GH/s translates to a power of about 3 GW.
- In standard reindeers of 200 kg, this amounts to burning 2.25 reindeers of equivalent coal every second.
- In closed consortiums, it is feasible to get rid of peers behaving incorrectly, so expensive proof-operations can be avoided.

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Bitcoin Network Burns

27 000 kg

coal in only

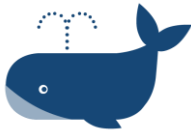
1 minute



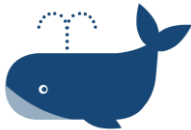
..Which means 1 620 000 kg per hour



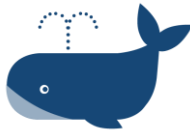
..Or approximately 12 blue whales!



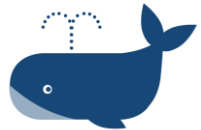
135 000 kg



135 000 kg



135 000 kg



135 000 kg



135 000 kg



135 000 kg



135 000 kg



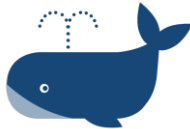
135 000 kg



135 000 kg



135 000 kg



135 000 kg



135 000 kg



- The point of Proof-of-Work is to prove that you have spent real resources in generating the block.
- Proof-of-work algorithms include for example Bitcoin double SHA256, or Dogecoin/Litecoin Scrypt.
- Bitcoin includes a double SHA-256 hash of the block in the blocks, and the block is only accepted if the hash value is lower than the difficulty limit. Hence, block hashes start with lots of zeros, for example:
0x0000000000000000012fdce7dd73fdbb087e66f4f6bb9672667b854282855669 for the block [#451676](#)
- Bitcoin Proof-of-Work does not require a lot of memory and can be easily implemented as an ASIC chip → all miners are based on cheap ASICs now, and the hashrate is basically limited by energy costs. These ASICs are special-purpose machines and cannot be used for any other purpose than mining Bitcoins.
- Litecoin and several other coins use Scrypt algorithm as Proof-of-Work. This algorithm requires more memory (128 kB to match a typical CPU L2 cache), and memory is difficult to implement on an ASIC. Litecoin and Dogecoin can be mined with general purpose GPUs and even CPUs, and even in browsers. This has an effect of moving the bottleneck towards more expensive, but ubiquitous general purpose hardware from simple energy use.

- Proof-of-Stake is a proposed alternative to energy wasting Proof-of-Work. Instead of proving you have done work, you prove you own a number of coins.
- Generally, for each block each coin gets a random chance of determining the next block.
- In 2017, Ethereum (Ether) moves to Proof-of-Stake algorithm, Casper. Some cryptocurrencies use a hybrid between Proof-of-Work and Proof-of-Stake.
- Game theoretic worries: If the miners have no stake, why would they play fair?



- Byzantine Fault Tolerance refers to a general game theoretic mathematical problem where distributed parties try to achieve consensus in spite of unreliable messaging and hostile actors.
- There are several algorithms and implementations with different characteristics.
- Practical Byzantine Fault Tolerance algorithm useful for consortium blockchains, but cannot be used for open blockchains.
- Byzantine Fault Tolerance algorithms do not generally consider an open system where new actors can join at will, and therefore they implicitly assume a kind of a Proof-of-Stake through association to the group.
- These algorithms generally need a centralized identity management to prevent a Sybil attack. Although it could be said that the centralized identity manager could freely perform a Sybil attack in these systems.



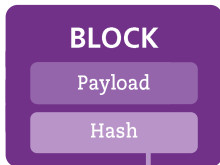
Inside of a blockchain

BLOCK

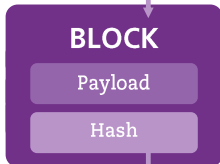
Payload

Hash

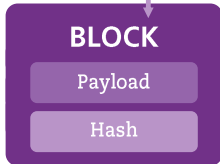
Inside of a blockchain



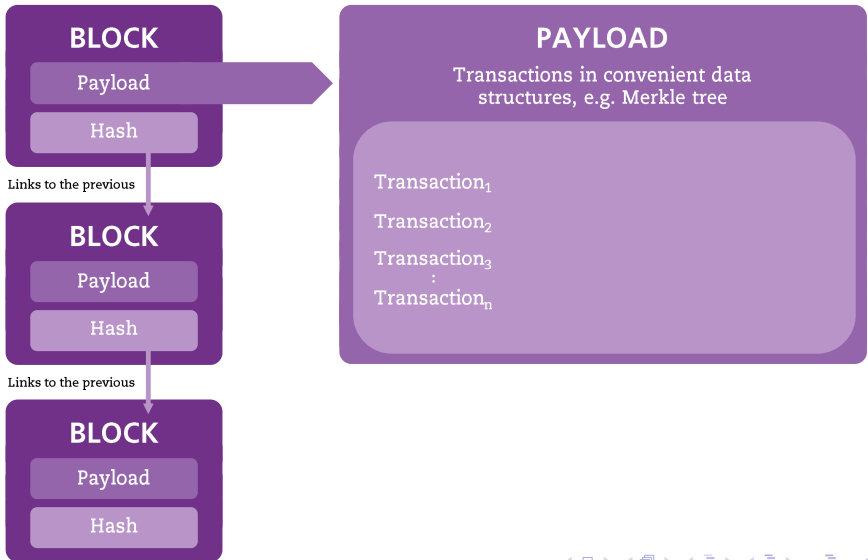
Links to the previous



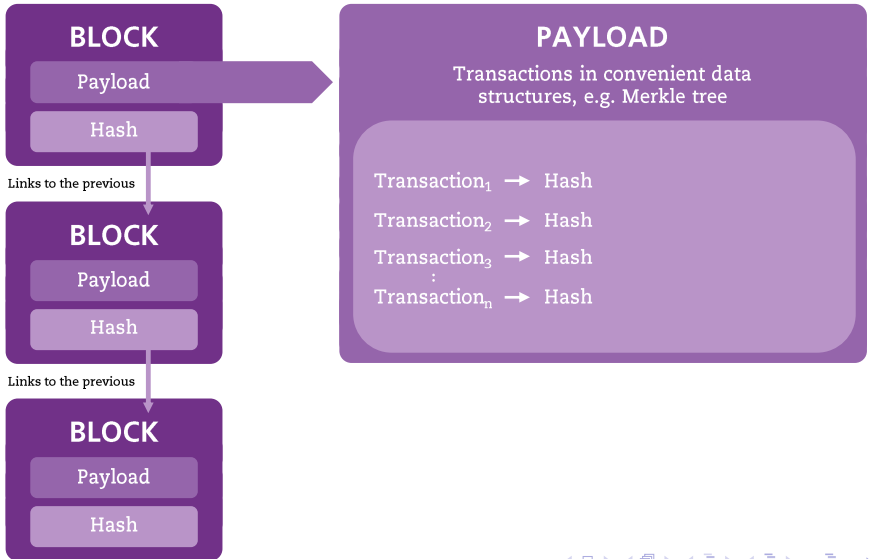
Links to the previous



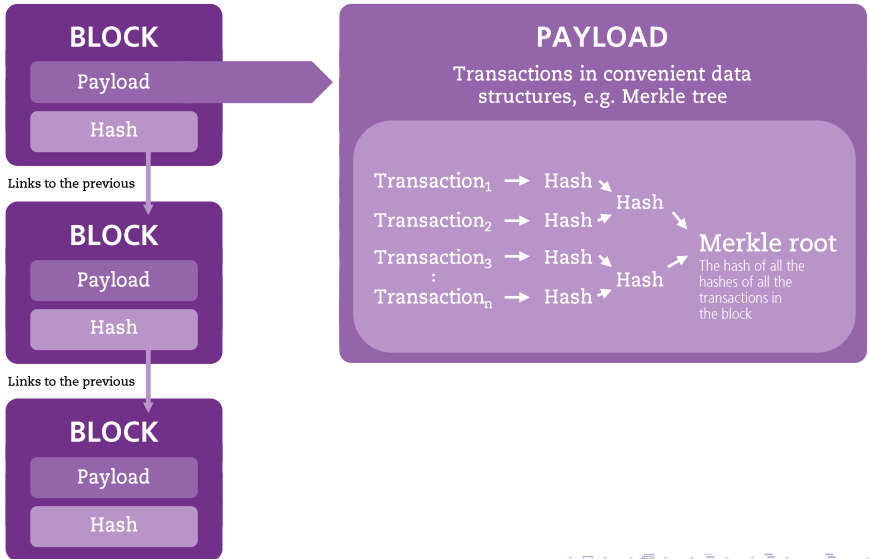
Inside of a blockchain



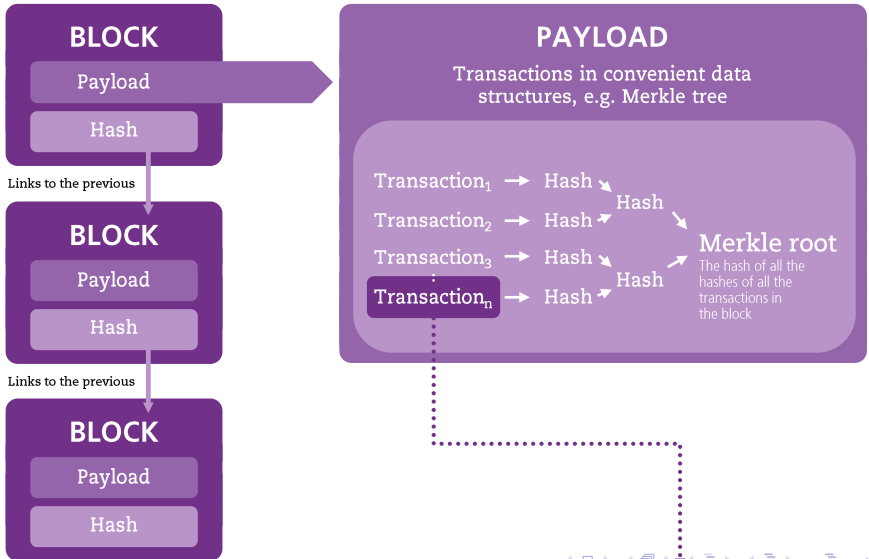
Inside of a blockchain



Inside of a blockchain



Inside of a blockchain





Transaction

Includes chaincode script that determines

- 1 Validation rules
- 2 How the global state is mutated

Transaction

Includes chaincode script that determines

- 1 Validation rules
- 2 How the global state is mutated

OLD TRANSACTION G

OLD
TRANSACTION X

Value
Output script = Output₁ (c)

OLD TRANSACTION Y

Value
Output script = Output₁ (c)

Value
Output script = Output₂ (c)

⋮

Value
Output script = Output_n (c)

Transaction

Includes chaincode script that determines

- 1 Validation rules
- 2 How the global state is mutated

NEW TRANSACTION

OLD TRANSACTION G

OLD
TRANSACTION X

Value
Output script = Output₁ (c)

OLD TRANSACTION Y

Value
Output script = Output₁ (c)

Value
Output script = Output₂ (c)

⋮

Value
Output script = Output_n (c)

New transaction is
done using
**any outputs
in any old
transactions**

Transaction

Includes chaincode script that determines

- 1 Validation rules
- 2 How the global state is mutated



NEW TRANSACTION

OLD TRANSACTION G

OLD TRANSACTION X

Value
Output script = Output₁ (C)

OLD TRANSACTION Y

Value
Output script = Output₁ (C)
Value
Output script = Output₂ (C)

Defines how that output can be spent (and by whom):
Money does not change the owner but the PERMISSION to use it.



Transaction

Includes chaincode script that determines

- 1 Validation rules
- 2 How the global state is mutated

OLD TRANSACTION G

OLD TRANSACTION X

Value
Output script = Output₁ (c)

OLD TRANSACTION Y

Value
Output script = Output₁ (c)
Value
Output script = Output₂ (c)

NEW TRANSACTION

(c) Input₁

(c) Input₂

(c) Input_n

Defines how that output can be spent (and by whom):
Money does not change the owner but the PERMISSION to use it.



Transaction

Includes chaincode script that determines

- 1 Validation rules
- 2 How the global state is mutated

OLD TRANSACTION G

OLD TRANSACTION X

Value
Output script = Output₁ (c)

OLD TRANSACTION Y

Value
Output script = Output₁ (c)
Value
Output script = Output₂ (c)

Defines how that output can be spent (and by whom): Money does not change the owner but the PERMISSION to use it.



NEW TRANSACTION

Output reference = (c) Input₁
Signature script
Output reference = (c) Input₂
Signature script
⋮
Output reference = (c) Input_n
Signature script


Transaction

Includes chaincode script that determines


- 1 Validation rules
- 2 How the global state is mutated


OLD TRANSACTION G

OLD TRANSACTION X

Value
Output script = Output₁ 


OLD TRANSACTION Y


Value
Output script = Output₁ 


Value
Output script = Output₂ 

Reference to
an output of
the old transaction

NEW TRANSACTION

Output reference
Signature script =  Input₁

Output reference
Signature script =  Input₂

Output reference
Signature script =  Input_n

Defines how that
output can be spent
(and by whom):
Money does not change
the owner but the
PERMISSION to use it.



Transaction

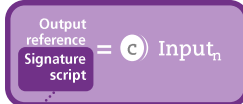
Includes chaincode script that determines

- 1 Validation rules
- 2 How the global state is mutated

OLD TRANSACTION X

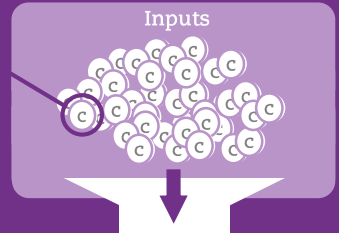


NEW TRANSACTION



Signature script + output script
= valid

NEW TRANSACTION



Transaction

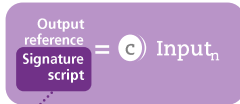
Includes chaincode script that determines

- 1 Validation rules
- 2 How the global state is mutated

OLD TRANSACTION X



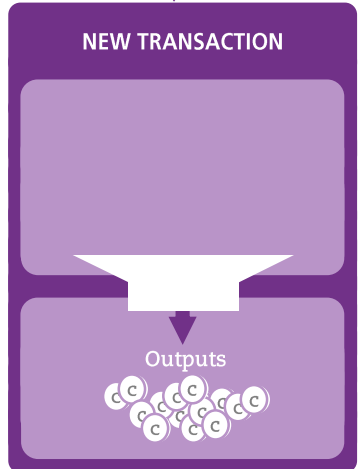
NEW TRANSACTION



Signature script + output script
= valid

Coins transferred

NEW TRANSACTION



Transaction

Includes chaincode script that determines

- 1 Validation rules
- 2 How the global state is mutated

OLD TRANSACTION X

Value
Output script = \textcircled{c} Output_n

NEW TRANSACTION

Output reference
Signature script = \textcircled{c} Input_n

Signature script + output script
= valid

Coins transferred

NEW TRANSACTION

Value
Output script = \textcircled{c} Output₁

Value
Output script = \textcircled{c} Output_x

Constrained

- Bitcoin Script
- Allow complex transactions (e.g. multisig), but no smart contracts or general purpose computing.
- The execution time is limited to a specific maximum per transaction.
- A special transaction set limits the utility of the blockchain to a specific application.

Turing Complete

- Hyperledger Chaincode, Ethereum Solidity
- Allow smart contracts and general purpose computing. Even “world computer”.
- Requires either transaction gas, a closed set of trusted peers, or whitelisted (non-Turing complete) transaction patterns.

Diamond blockchain

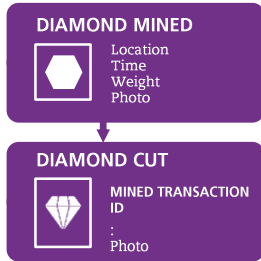
DIAMOND MINED



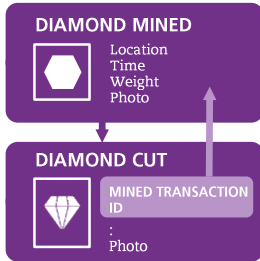
Location
Time
Weight
Photo



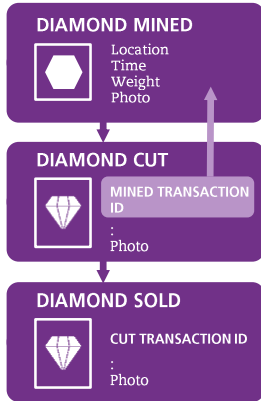
Diamond blockchain



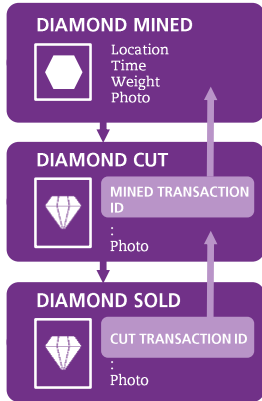
Diamond blockchain



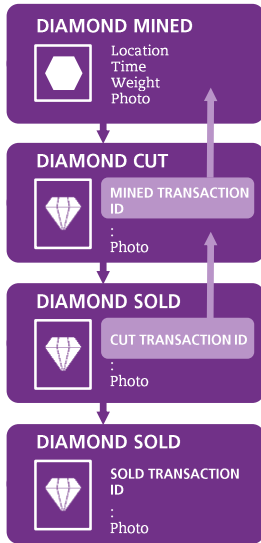
Diamond blockchain



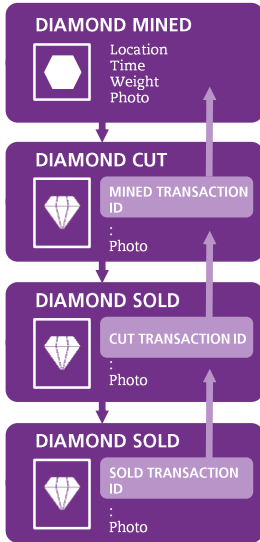
Diamond blockchain



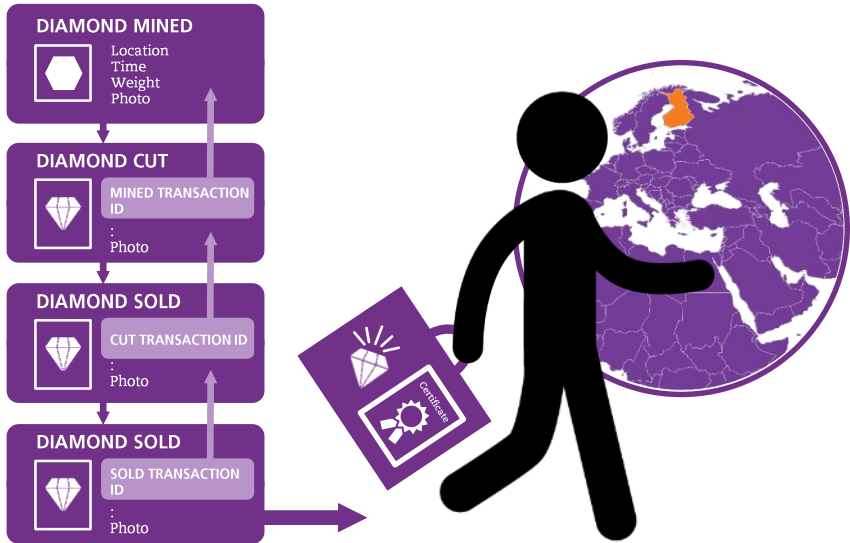
Diamond blockchain



Diamond blockchain



Diamond blockchain



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guardtime
an american company

UK: 0203 200 0000 0000
USA: 0203 200 0000 0000
AUSTRALIA: 0203 200 0000 0000
NEW ZEALAND: 0203 200 0000 0000
SINGAPORE: 0203 200 0000 0000
INDONESIA: 0203 200 0000 0000

MARK

Friday July 07 2006

GBP 200 index



UK equities
The FTSE 100 slipped for a second day as the pound strengthened against the dollar. The FTSE 100 closed at 2048.75, down 1.25 points from 2050.00.

FTSE 250 index



UK equities
The FTSE 250 slipped for a second day as the pound strengthened against the dollar. The FTSE 250 closed at 2048.75, down 1.25 points from 2050.00.

- [Princeton course book: Bitcoin and Cryptocurrency Technologies](#)
- [Guardtime KSI](#)
- [Hyperledger Whitepaper](#)