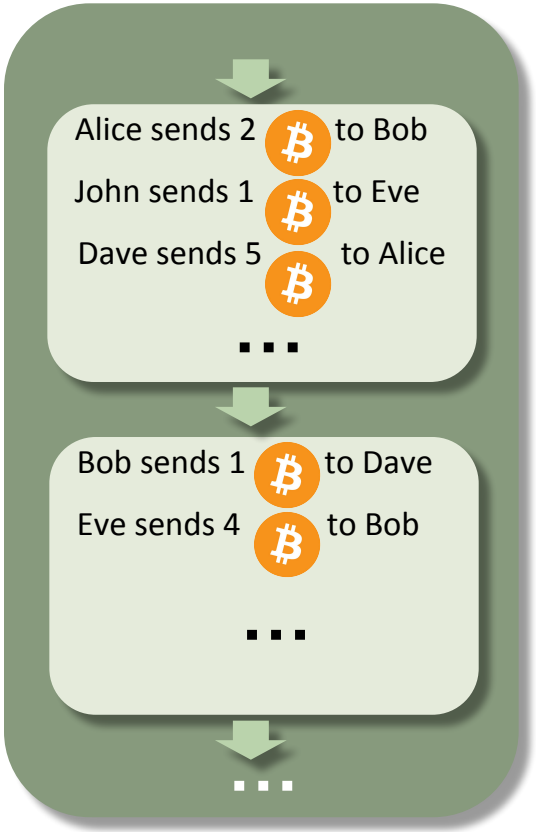
The power of Blockchain: Smart Contracts

Foteini Baldimtsi

The Blockchain at the heart of a cryptocurrency



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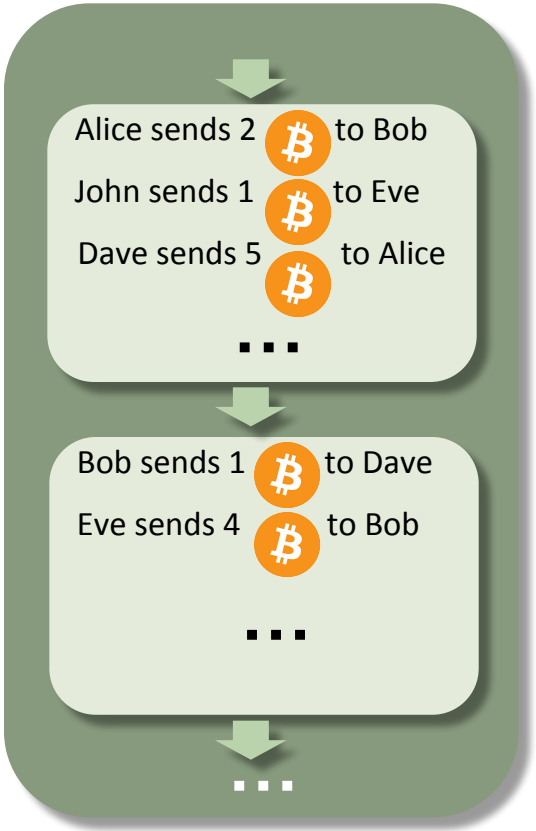
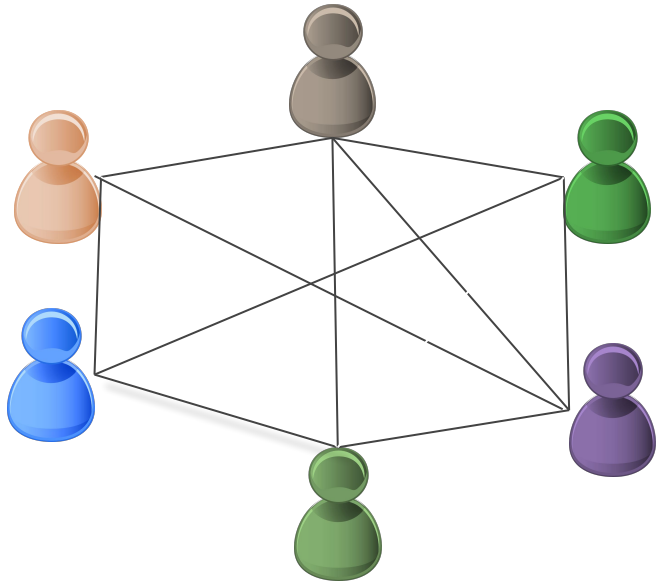
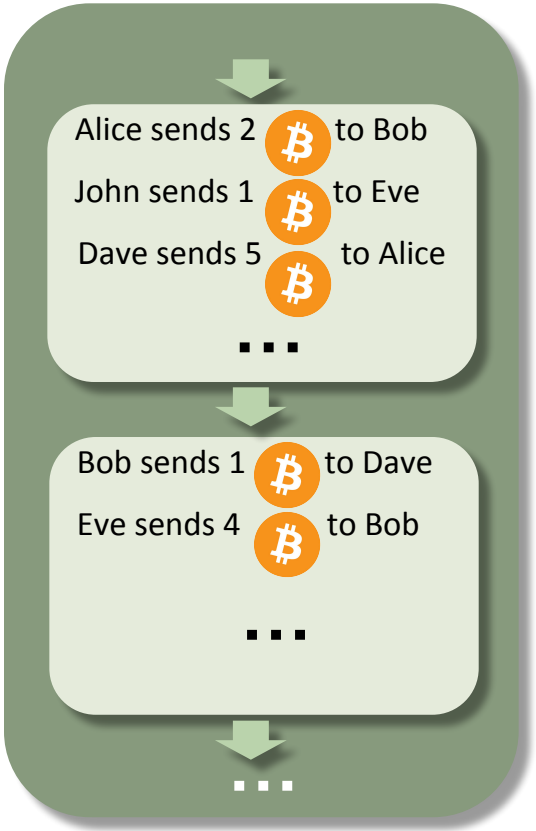




Abstracting the notion of Blockchain



- Immutable data collection
  - Data added in an “append-only” manner
  - Nobody can modify an old transaction
- Controlled in a decentralized manner by multiple parties running a consensus protocol
  - Byzantine agreement
  - Proof-of-work
  - Proof-of-space

Where is Blockchain used?

Cryptocurrencies

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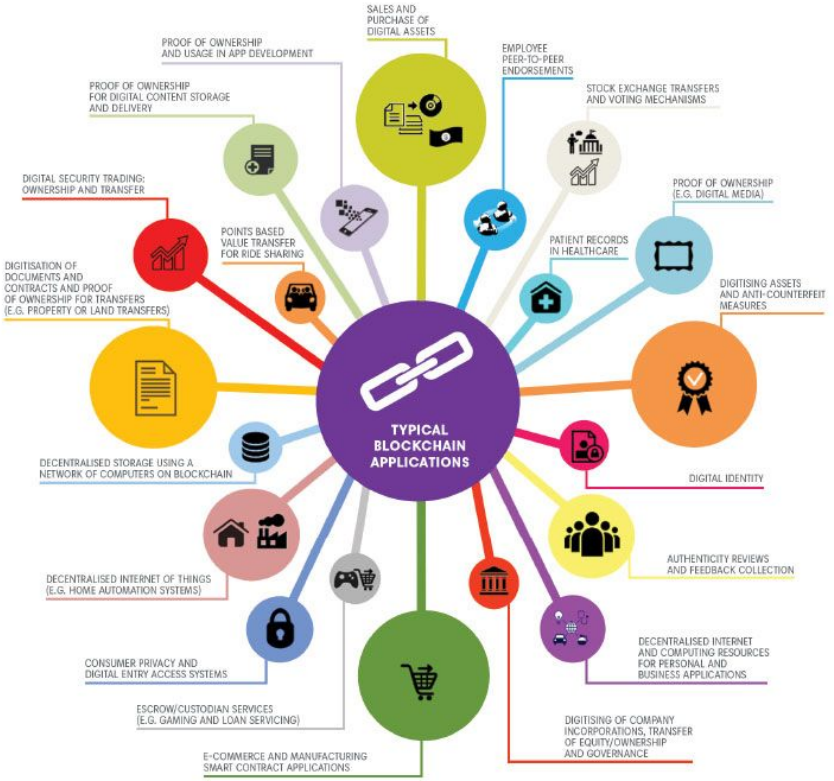


Why is Blockchain useful?

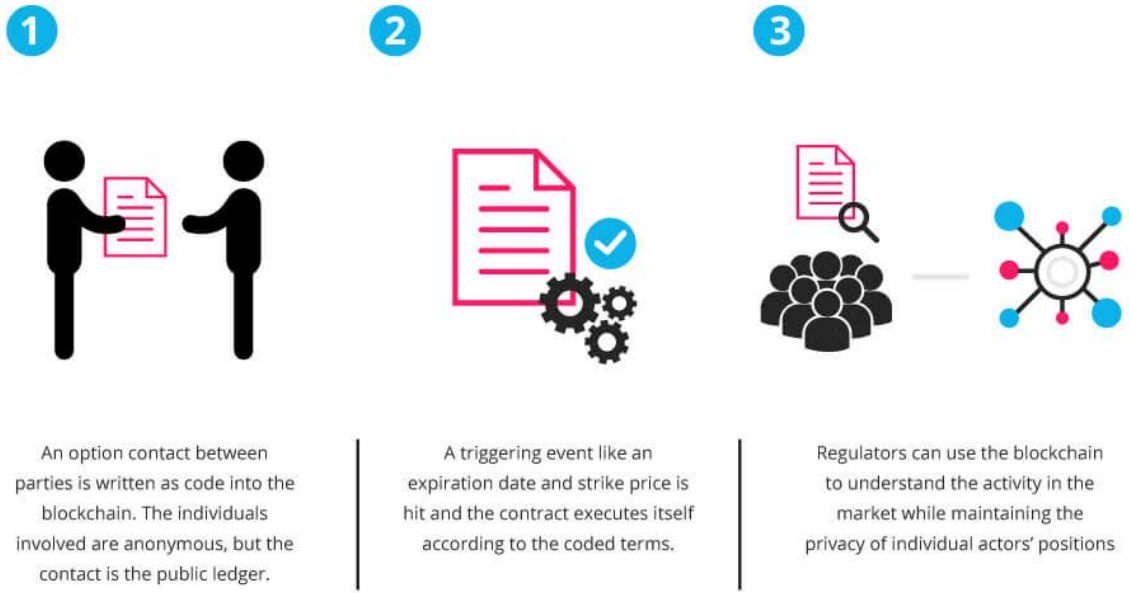
1. As a distributed, tamper-proof, **data structure**
   - No central trusted authority exists
   - Participating parties do not trust each other

2. As a mechanism for execution of **smart contracts**
   - Enforce the negotiation or performance of a contract
   - Allows for fair-exchange (blockchain is the mediator)
   - No direct interaction between parties

Smart Contracts

Introduced by Nick Szabo in 1994

Help you exchange money, property, shares, or anything of value in a transparent, conflict-free way while avoiding the services of a middleman



Smart Contract for Fair Exchange

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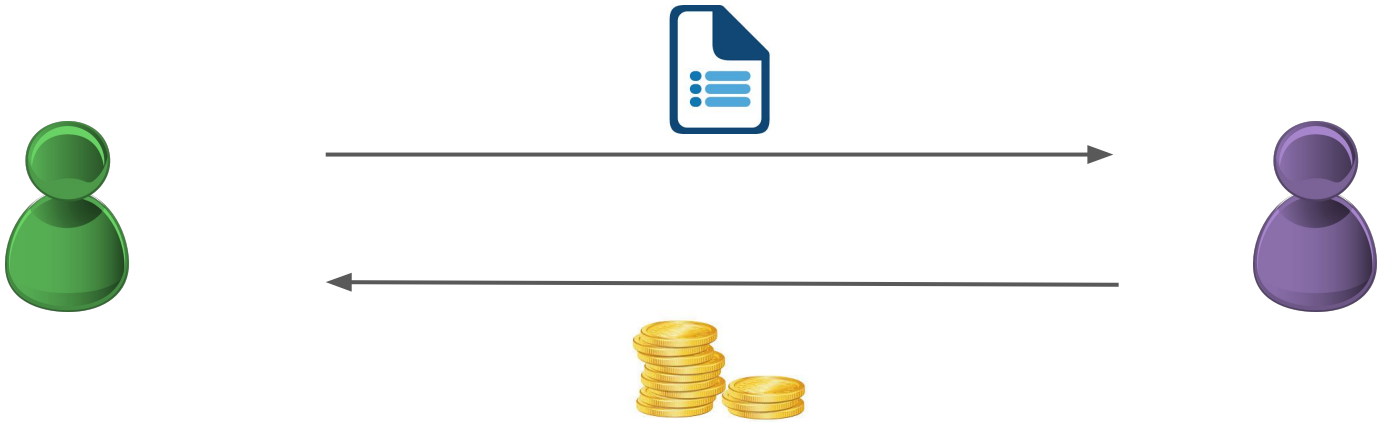

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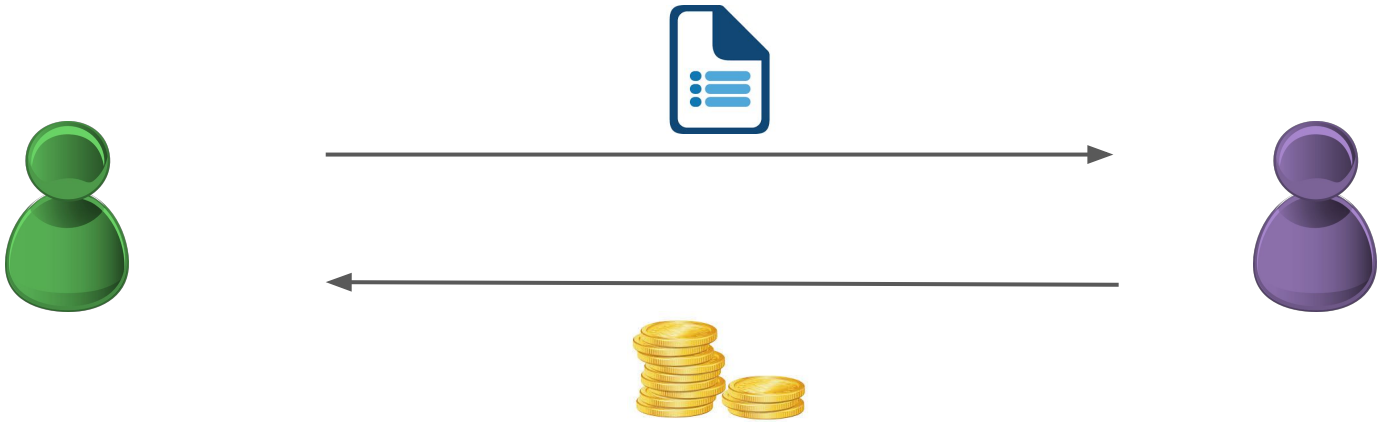

Impossible without the use of a trusted third party!

Needs to be an atomic operation!

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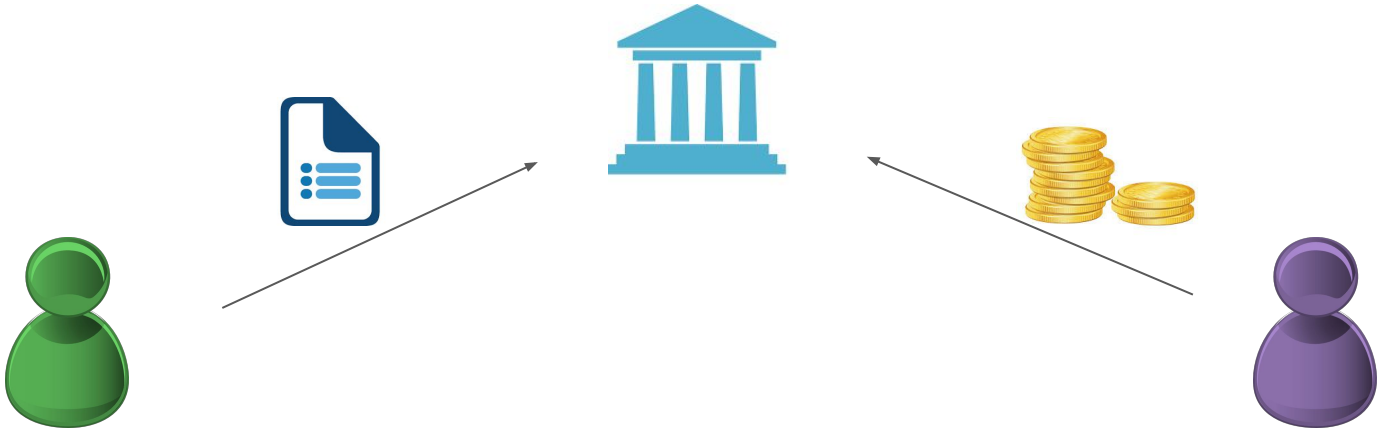

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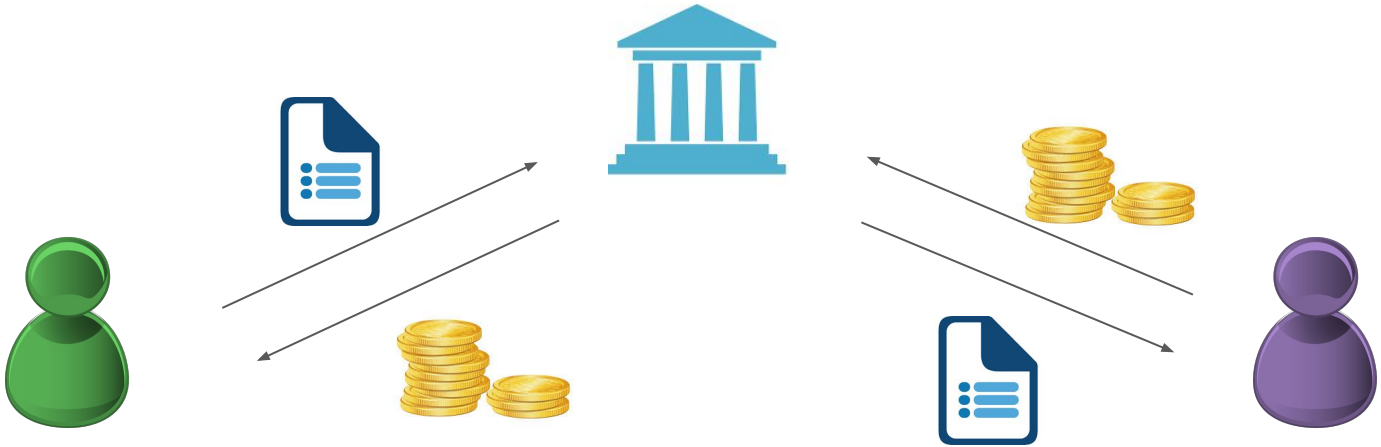

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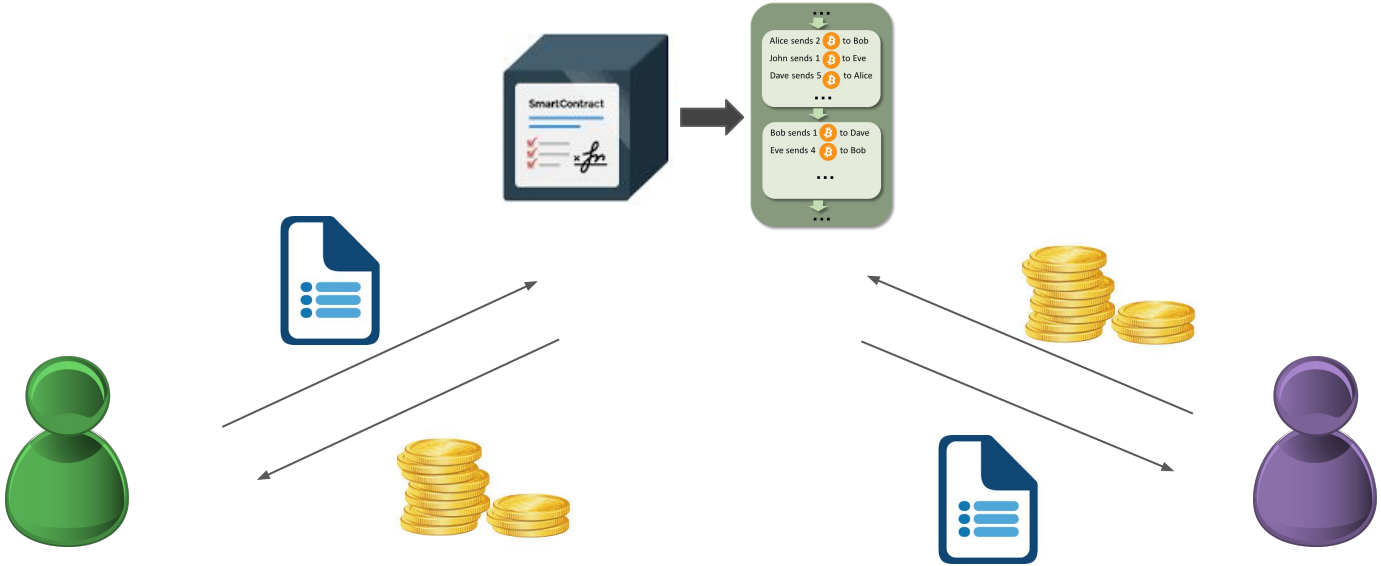

Smart Contract for Fair Exchange

1. Pick a secret key K
2. Encrypt document into $Enc_K(D)$

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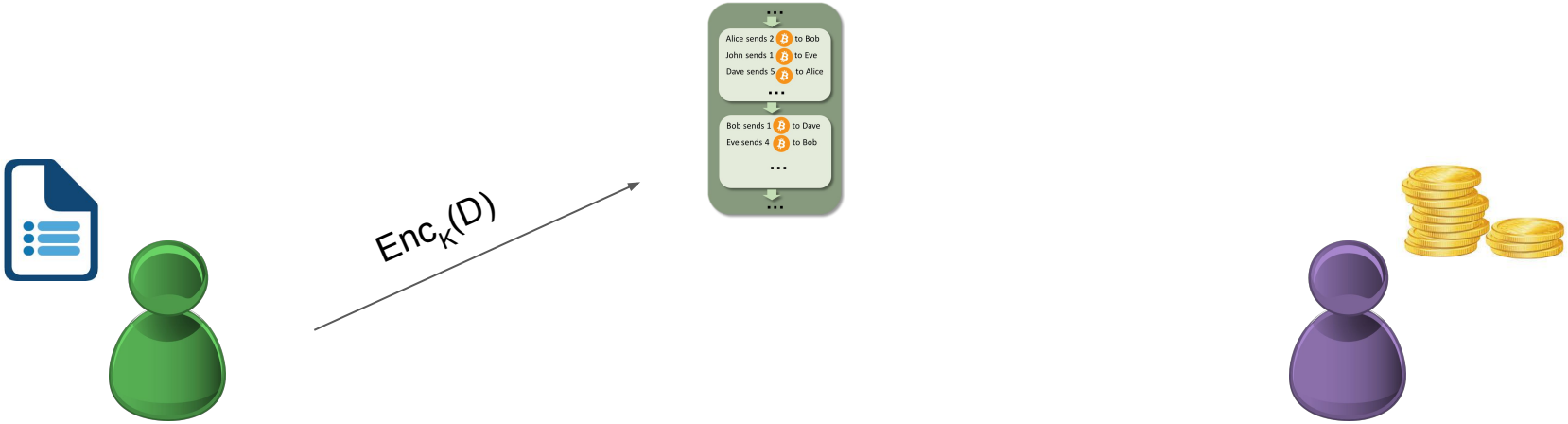

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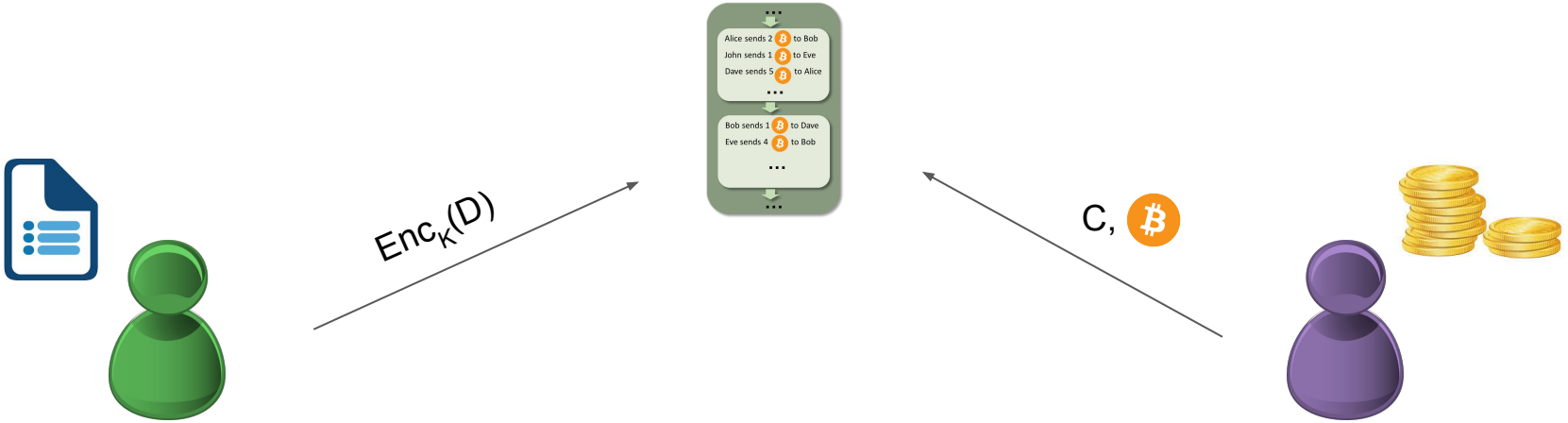

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   C = “ 1 ₿ for the secret key K”

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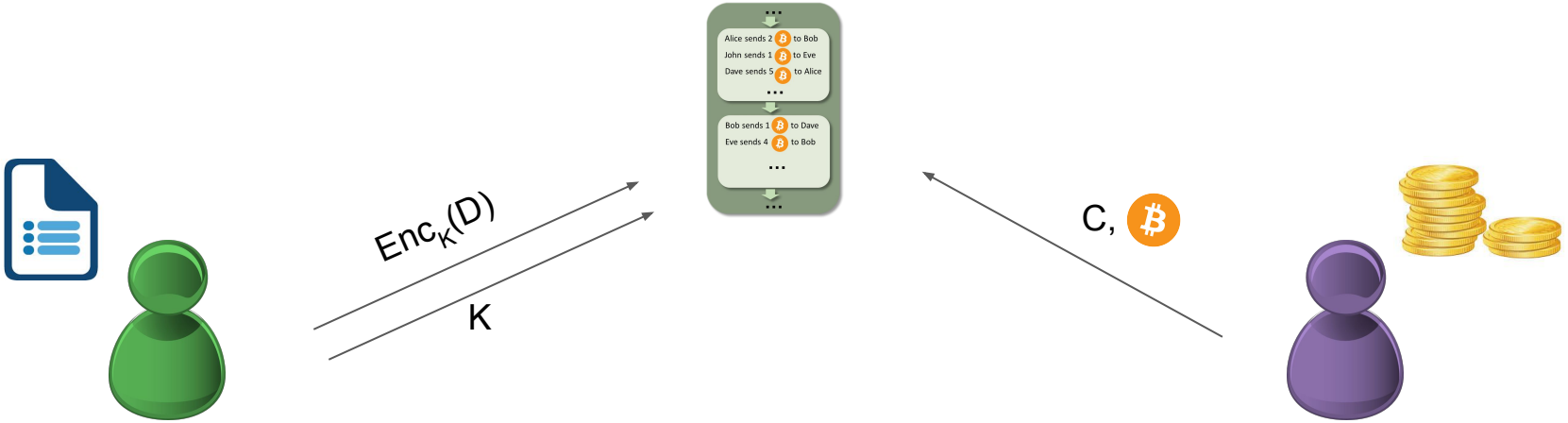

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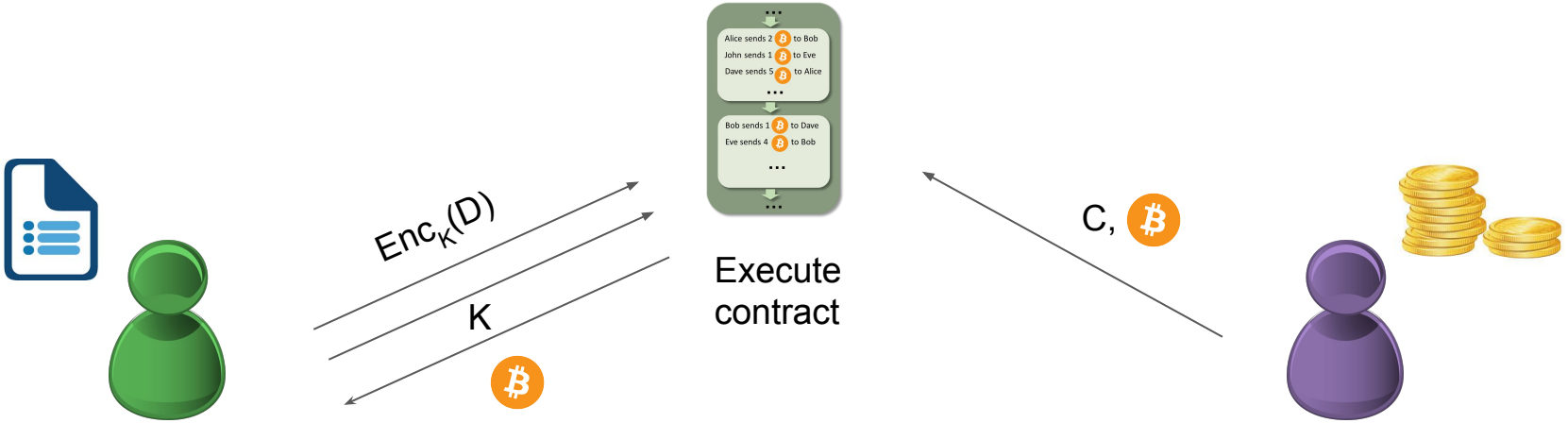

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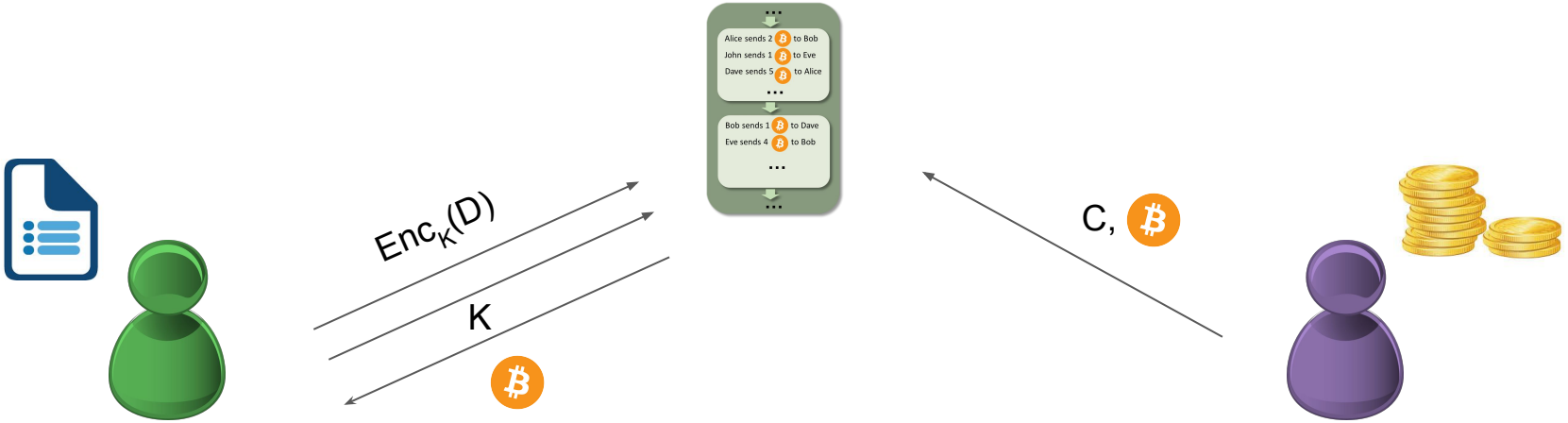

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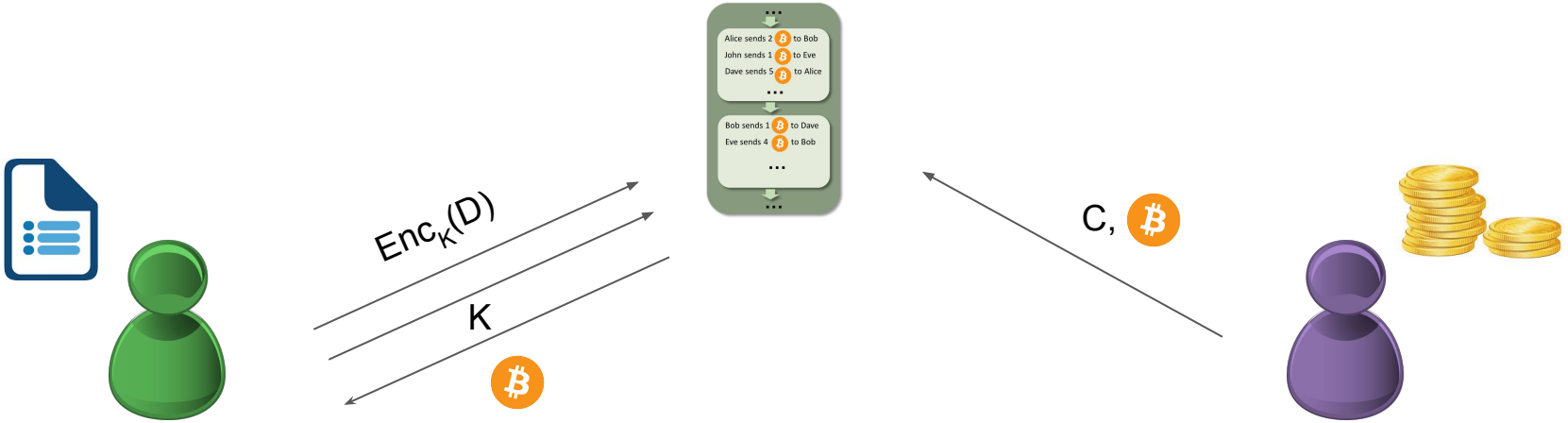
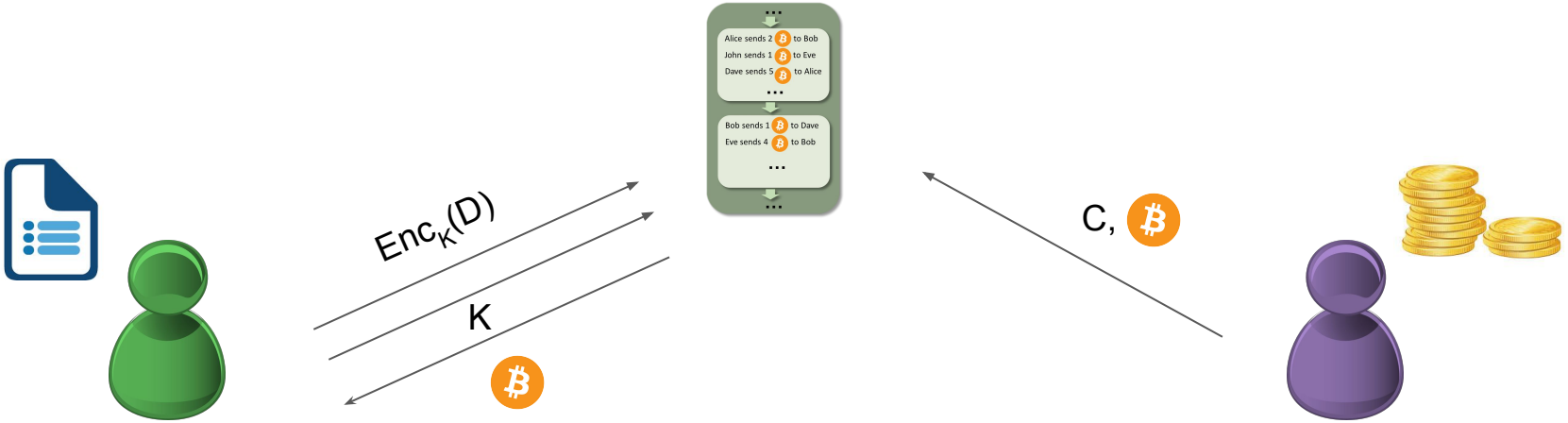


1. Pick a secret key K
2. Encrypt document into $Enc_K(D)$

1. Prepare contract
   C = " 1 ₿ for the secret key K"

Q: How can the buyer know that the seller has encrypted the correct document?
A: Break $D = D_1...D_n$, encrypt and post all shares and reveal some random ones before selling.

Smart Contract for Fair Exchange



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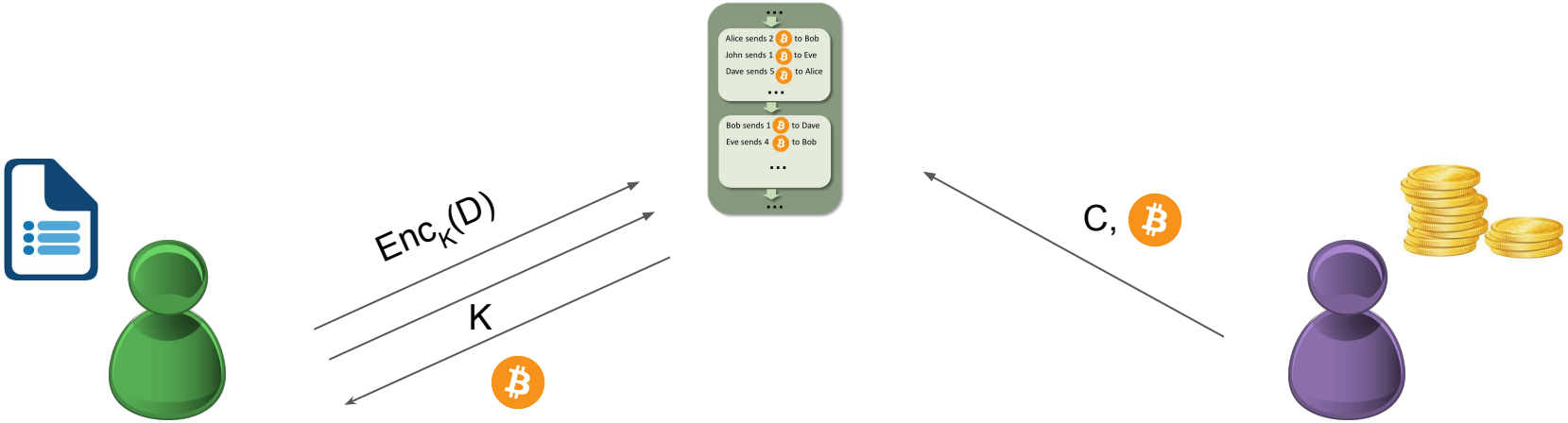
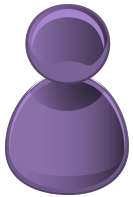


1. Pick a secret key K
2. Encrypt document into $Enc_K(D)$

1. Prepare contract
   C = " 1 ₿ for the secret key K for tw=10 hours"

Q: What if the seller never reveals K? What happens to the buyers coin?
A: Timelocked transactions: funds are returned after a specific time window.

Bitcoin Smart Contracts

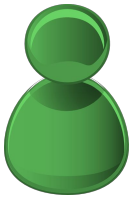


C = “ 1 ₿ for the secret key K for tw=10 hours”

Such a contract cannot be implemented in Bitcoin!

Bitcoin has been designed to only check two conditions:

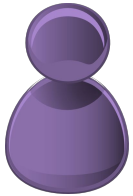
- Verification of an ECDSA signature (under specific parameters)
- Preimage of a hash function output



Post: $Enc_K(D)$, Hash(K) and ZK proof that the hashed key is the correct one

After verifying the proof, post

C = “ 1 ₿ for the preimage of Hash(K) for tw=10 hours”



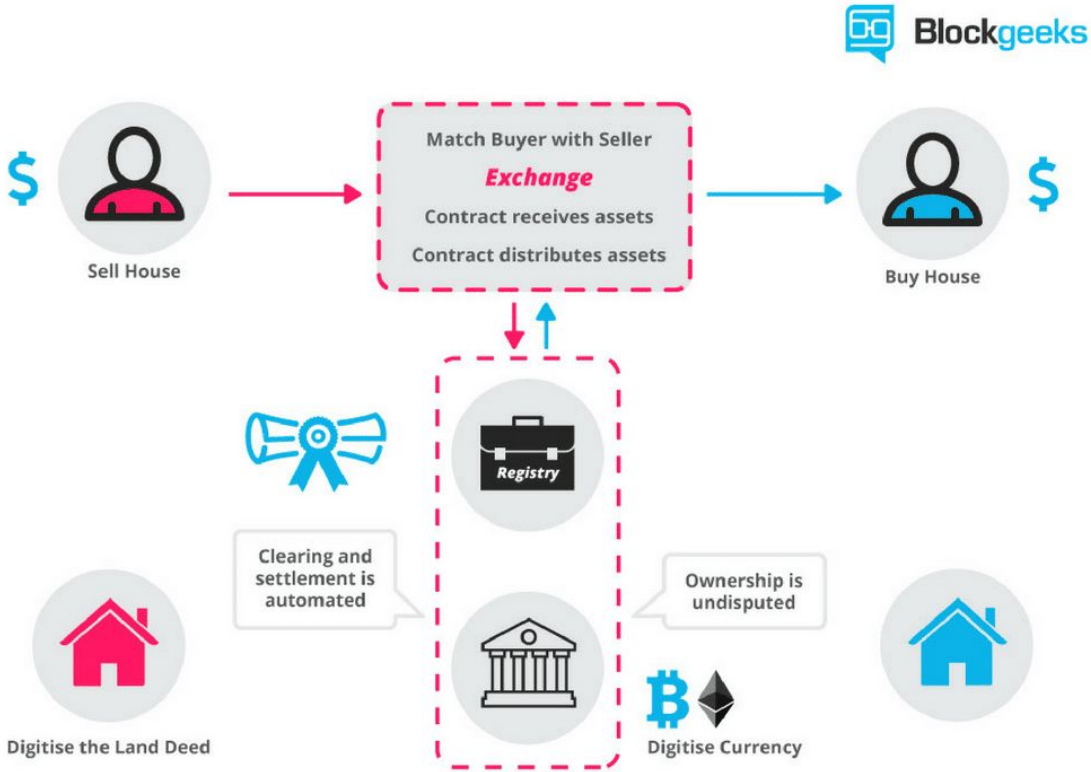
Ethereum smart contracts

Provides a “Turing-complete” scripting language: supports a broader set of computational instructions.

- Contracts can use data outside of the blockchain (i.e. weather, stock prices etc)
- We can build chains of contracts (the 2nd settles on information from the output of the 1st contract)

Smart contracts run on the **Ethereum Virtual Machine** (works at a level too low to be convenient to directly program).
Solidity is the most popular language for writing contracts (JavaScript-like)

Smart contracts interacting with each other



https://blockgeeks.com/guides/smart-contracts/

Ethereum smart contracts  need **gas** to run

Task	Gas Required	Cost (ETH)	Cost (USD)	Ops per ETH	Ops per USD	Ops per Block	Blocks to complete Op
Add or subtract two integers	3	0.00000009	0.00002655	11111111.11	37664.78343	1566666.667	0.0000006382978723
Add or subtract two integers 1 million times	3000000	0.09	26.55	11.11111111	0.03766478343	1.566666667	0.6382978723

Task	Gas Required	Cost (ETH)	Cost (USD)	Ops per ETH	Ops per USD	Ops per Block	Blocks to complete Op
Save a 256-bit word to storage	20000	0.0006	0.177	1666.666667	5.649717514	235	0.004255319149
Save 1 MB to storage (31250 256-bit words)	625000000	18.75	5531.25	0.05333333333	0.000180790960	0.00752	132.9787234
Save 1 GB to storage (1000 MB)	625000000000	18750	5531250	0.000053333333	0.000000180790	0.00000752	132978.7234

There is a need for efficient smart contract protocols!

https://hackernoon.com/ether-purchase-power-df40a38c5a2f

A note on privacy

The blockchain is **public** and all posted data:

- **Code** of the contract
- **PKs** of the participants
- **Data** send to the contract
- **Payments** (amounts and PKs)

- Generic smart contract anonymity compilers for ethereum [Hawk]
- Specialized tools for Bitcoin contracts anonymity [Tumblebit]

Advantages of smart contracts

Applications: Government: e-voting, e-IDs (decentralized PKIs), Auctions, Real estate, Healthcare, Supply chain

- Autonomy: no need for trusted third party
- Trust: data stored in a shared ledger (cannot be lost)
- Backup: data duplication
- Speed: automating various processes

thank you!

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