Bitcoin Mechanics

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Summary

- The use of UTXO (Unspent Transaction Output) instead of accounts
- A chain of blocks of transactions instead of a chain of transactions
- Bitcoin script

UTXO

Unspent Transaction Output

INPUT	OUTPUT
(coinbase)	pk_M 100

INPUT	OUTPUT
TX[0][0]	pk_M 20
	pk_A 80

INPUT	OUTPUT
TX[1][0]	pk_M 10
	pk_B 10

20 BTC

10 BTC

Motivation

The network nodes

- do not need to keep track of accounts balance
- keep only the UTXO in memory

A chain of blocks of transactions

What a P2P network looks like

Transaction propagation

Flooding routing algorithm

When receiving a transaction, forward it to all connected peers id

1. the transaction has not been seen before (stop the process)
2. the transaction is valid:
    - The signatures are valid
    - All inputs are UTXOs
    - The sum of the input amounts is greater or equal than the sum of the output amounts

Propagation Time

According to the paper "*Information propagation in the bitcoin network*" by Decker and Wattenhofer (2013):

> *The **median time** until a node receives a block is **6.5 seconds** whereas **the mean** is at **12.6 seconds**.*
>
> *The long tail of the distribution means that even **after 40 seconds there still are 5% of nodes that have not yet received the block***

- It is hard to maintain data consistency and avoid double spending attack (rf lecture 1)

The Bitcoin solution : Mining

Confirming transaction into blocks

- Miners validate every transaction broadcasted on the network and add them to a mempool (unconfirmed transactions)
- Every 10 minutes, one node is selected (see consensus later) to create a block containing all unconfirmed transactions and broadcast that block to the network to be added to the blockchain
- All blocks validate the new node before adding it to their own copy of the blockchain

How is this solving the problems

➡ New transactions cannot use input UTXO of transactions that have not been confirmed yet

✓ Data is always consistent and not double spending attack unless two different blocks are mined at the same time (see consensus problem)

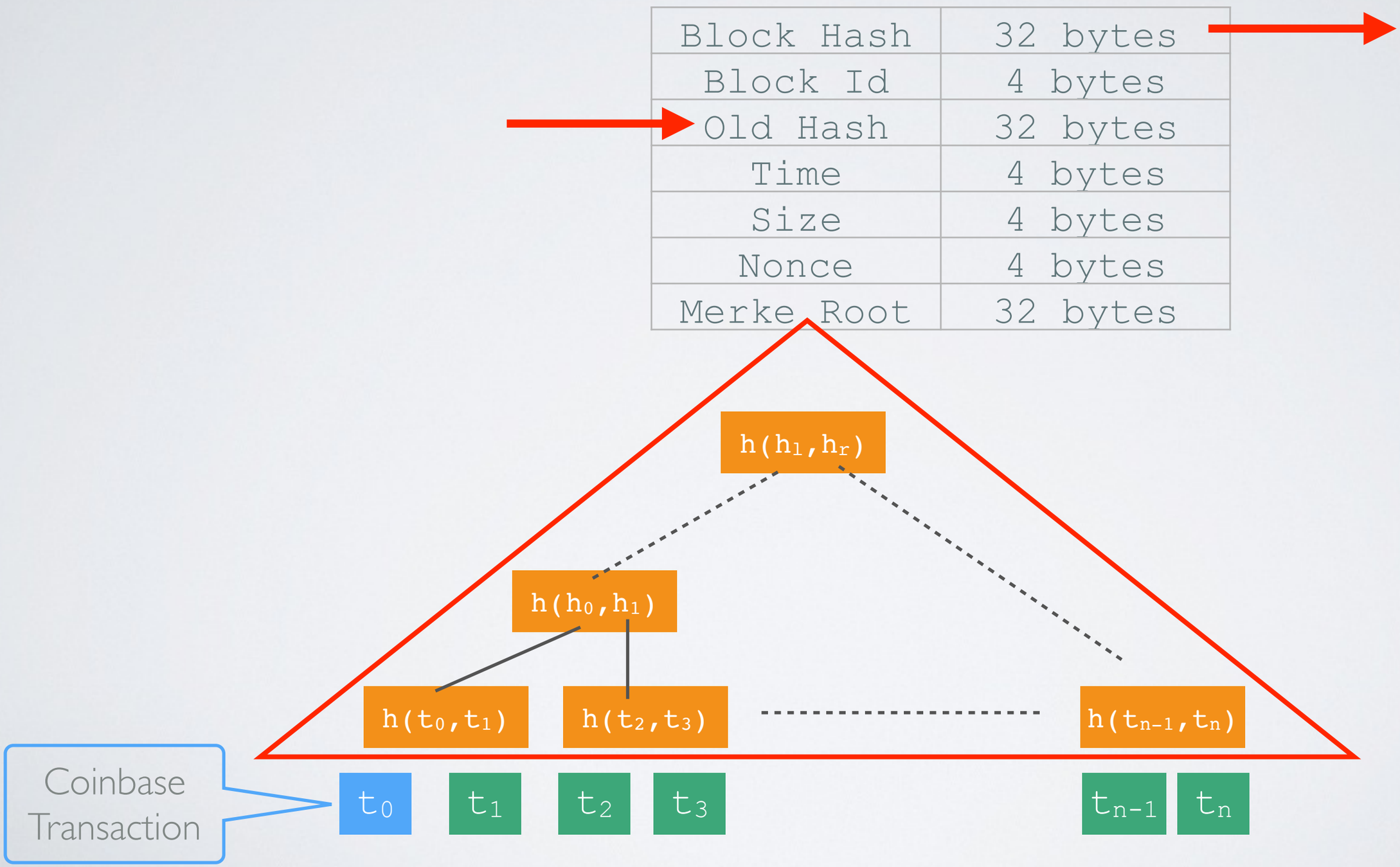
Mining awards

➡ Miners verify/broadcast blocks transactions and broadcast and are rewarded for that work

- **Coinbase transaction** (first transaction in the block)
  Currently 6.25 BTC - Block reward halves every four years
  The only way BTC is created (max 21M BTC in total)
- and/or **Transaction Fees** (chosen by the issuer)

Anatomy of the Bitcoin blockchain

Block Hash	32 bytes
Block Id	4 bytes
Old Hash	32 bytes
Time	4 bytes
Size	4 bytes
Nonce	4 bytes
Merke Root	32 bytes



Let's look at some blocks

Bitcoin Script

The language

Input and Output addresses are actually scripts

- Stack based language (simplistic)
- Cryptography primitives
- No loop (no halting problem)

See all instructions
https://wiki.bitcoinsv.io/index.php/Opcodes_used_in_Bitcoin_Script

Pay to Public Key Hash (P2PKH)

```
scriptPubKey: OP_DUP OP_HASH160 <pubKeyHash?> OP_EQUALVERIFY OP_CHECKSIG
scriptSig:    <signature> <publicKey>
```

Pay to Script Hash (P2SH)

The payer can specify a redeeming script

```
scriptPubKey: OP_HASH160 <redemptionScriptHash> OP_EQUAL
```

Multi Signature

Spending a UTXO requires t-out-of-n signatures

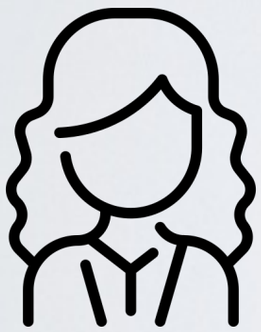
Escrow Transactions

Pay 50 to 2-of-3 Alice Bob Judy

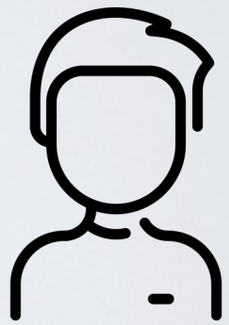
[Pay 50 to Bob]$_{\text{Alice}}$

Escrow dispute

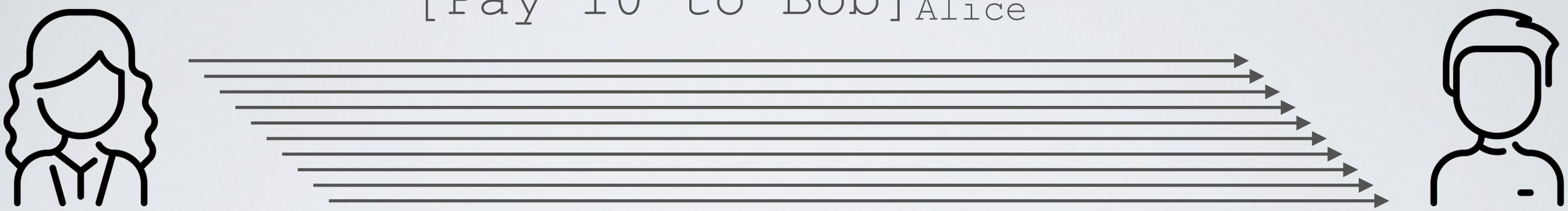
[Pay 50 to Alice]Judy



Pay 50 to 2-of-3 Alice Bob Judy



Micro Payments



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