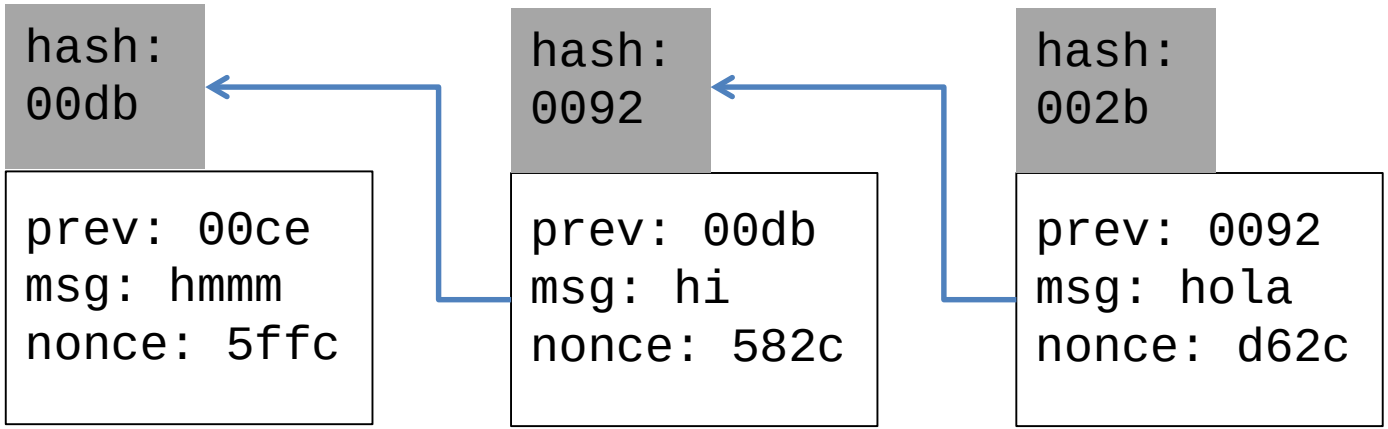
Cryptocurrency Engineering and Design

MAS.S62
2/19/2018 Lecture 4
Neha Narula

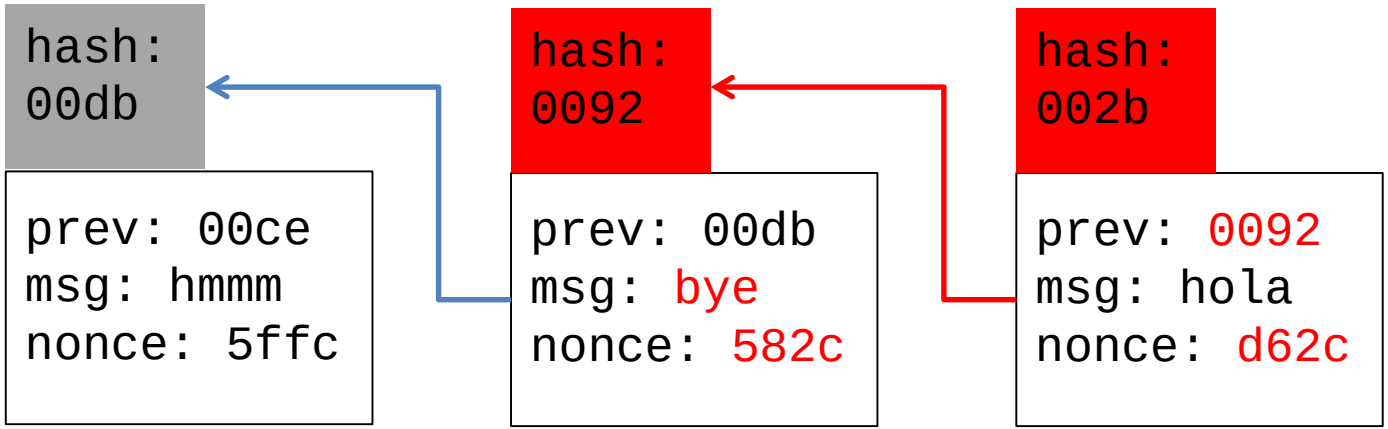
Recap

- Signatures
- Merkle trees
- RSA, ECDSA

Blockchain


hash:
00db
prev: 00ce
msg: hmmm
nonce: 5ffc
hash:
0092
prev: 00db
msg: hi
nonce: 582c
hash:
002b
prev: 0092
msg: hola
nonce: d62c

Blockchain


hash:
00db
prev: 00ce
msg: hmmm
nonce: 5ffc
hash:
0092
prev: 00db
msg: bye
nonce: 582c
hash:
002b
prev: 0092
msg: hola
nonce: d62c

What do we need in a transaction?

What do we need in a transaction?

- Amount
- User, authorization
- Who you’re paying

```
Who: Alice
Amount: $5
Payee: Bob
Auth: Sig_Alice(??)
```

What do we need in a transaction?

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```
Who: Alice
Amount: $5
Payee: Bob
Auth: Sig_Alice(TXN)
```

What do we need in a transaction?

- Amount
- User, authorization
- Who you're paying

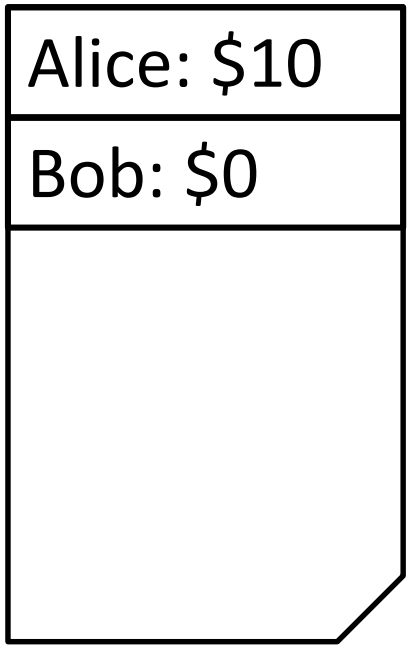
```
Who: Alice
Amount: $5
Payee: Bob
Auth: Sig_Alice(TXN-sig)
```

What do we need in a transaction?

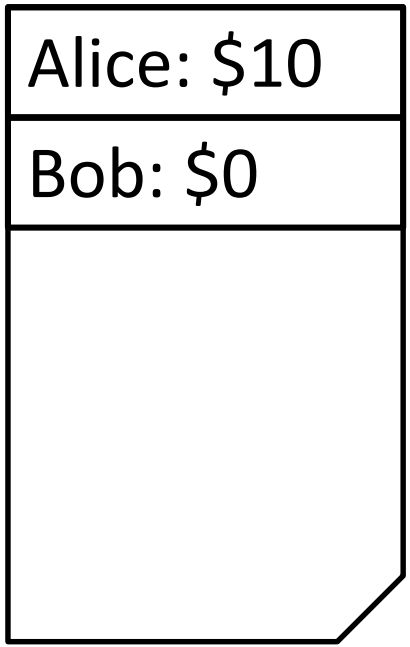
- Amount
- User, authorization
- Who you're paying

```
Who: Alice
Amount: $5
Payee: Bob
Auth: Sig_Alice(H(TXN-sig))
```

Account based model

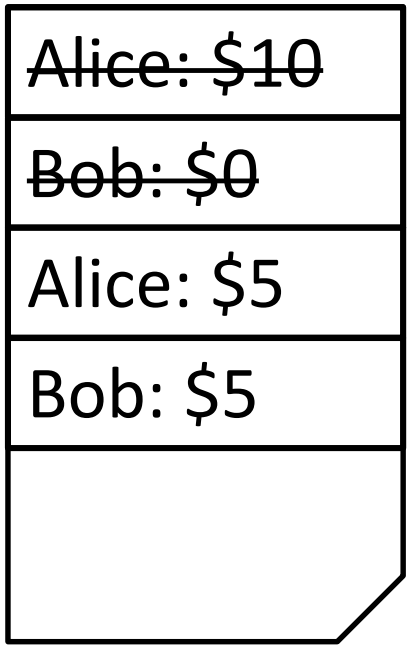


Account based model




```
Who: Alice
Amount: $5
Payee: Bob
Auth: Sig_Alice(TXN-sig)
```

Account based model

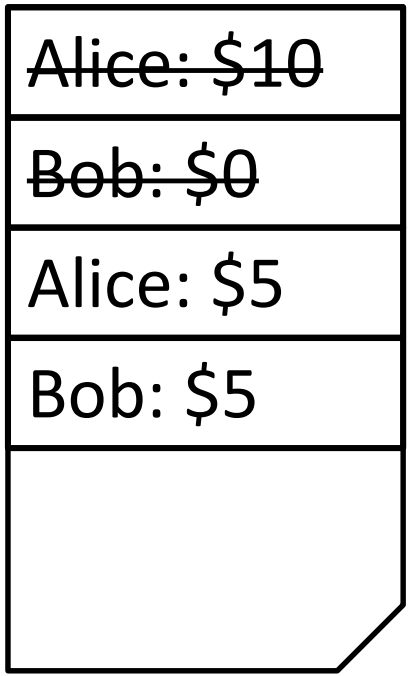


Who: Alice
Amount: $5
Payee: Bob
Auth: Sig_{Alice}(TXN-sig)

Account based model

- Store list of accounts and balances
- A transaction is valid if there is enough balance in the account
- Sender debited, receiver credited

Replay attacks




```
Who: Alice
Amount: $5
Payee: Bob
Auth: Sig_Alice(TXN-sig)
```

Replay attacks

~~Alice: $10~~

~~Bob: $0~~

Alice: $5

Bob: $5

Who: Alice
Amount: $5
Payee: Bob
Auth: Sig_{Alice}(TXN-sig)

Replay attacks

~~Alice: $10~~

~~Bob: $0~~

~~Alice: $5~~

~~Bob: $5~~

Alice: $0

Bob: $10

Who: Alice
Amount: $5
Payee: Bob
Auth: Sig_{Alice}(TXN-sig)

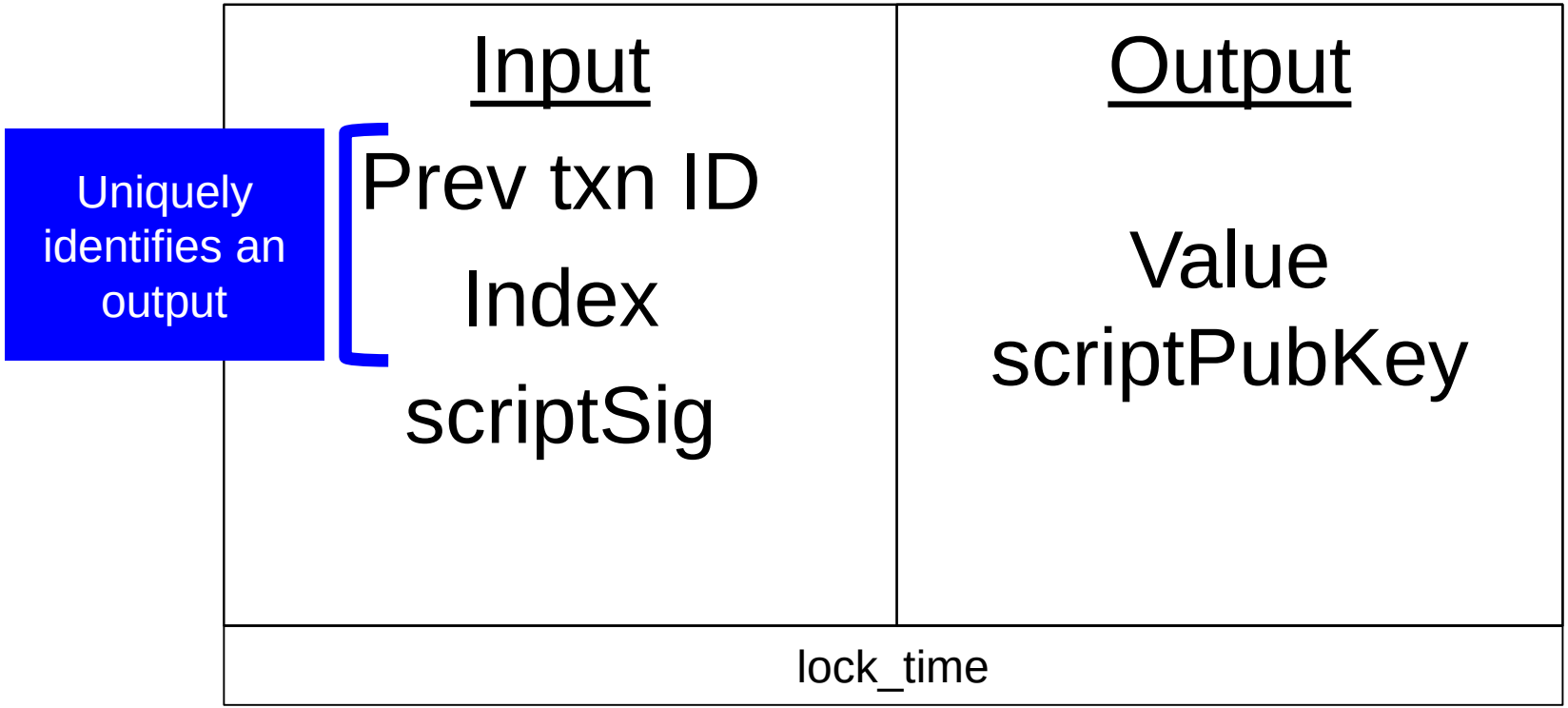
Unspent Transaction Outputs

- All coins are not the same
- Refer to specific coins when spending
- Coins are consumed; create new ones
- A coin can only be spent once

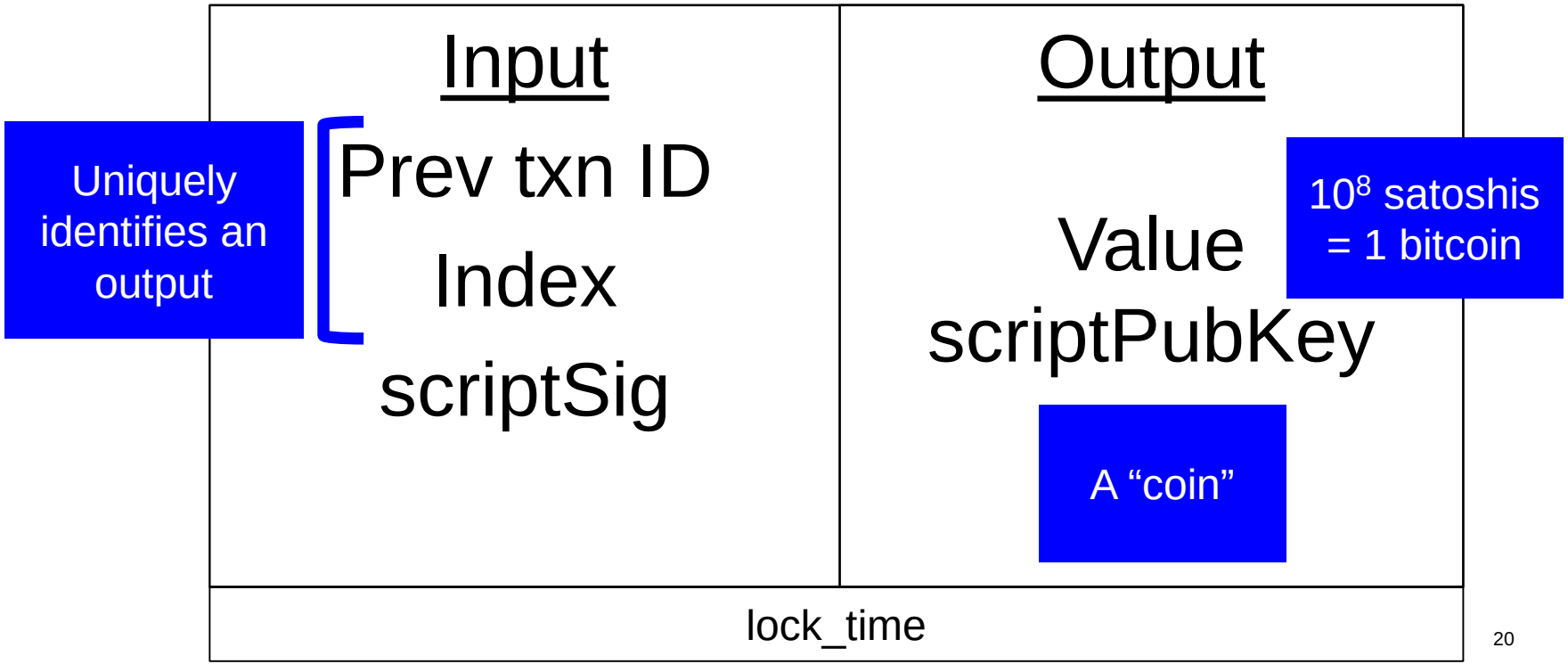
Transaction format

Input	Output
Prev txn ID Index scriptSig	Value scriptPubKey
lock_time	

Transaction format



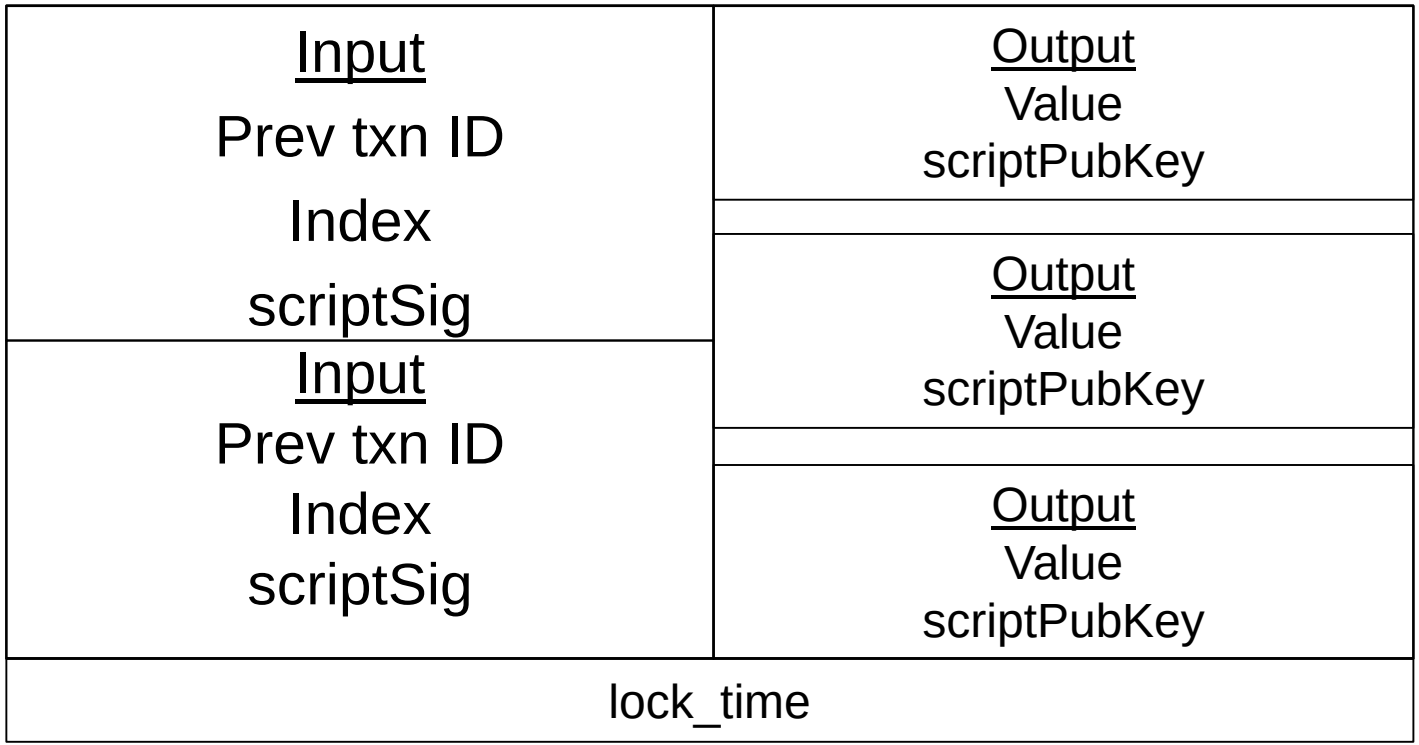
Transaction format



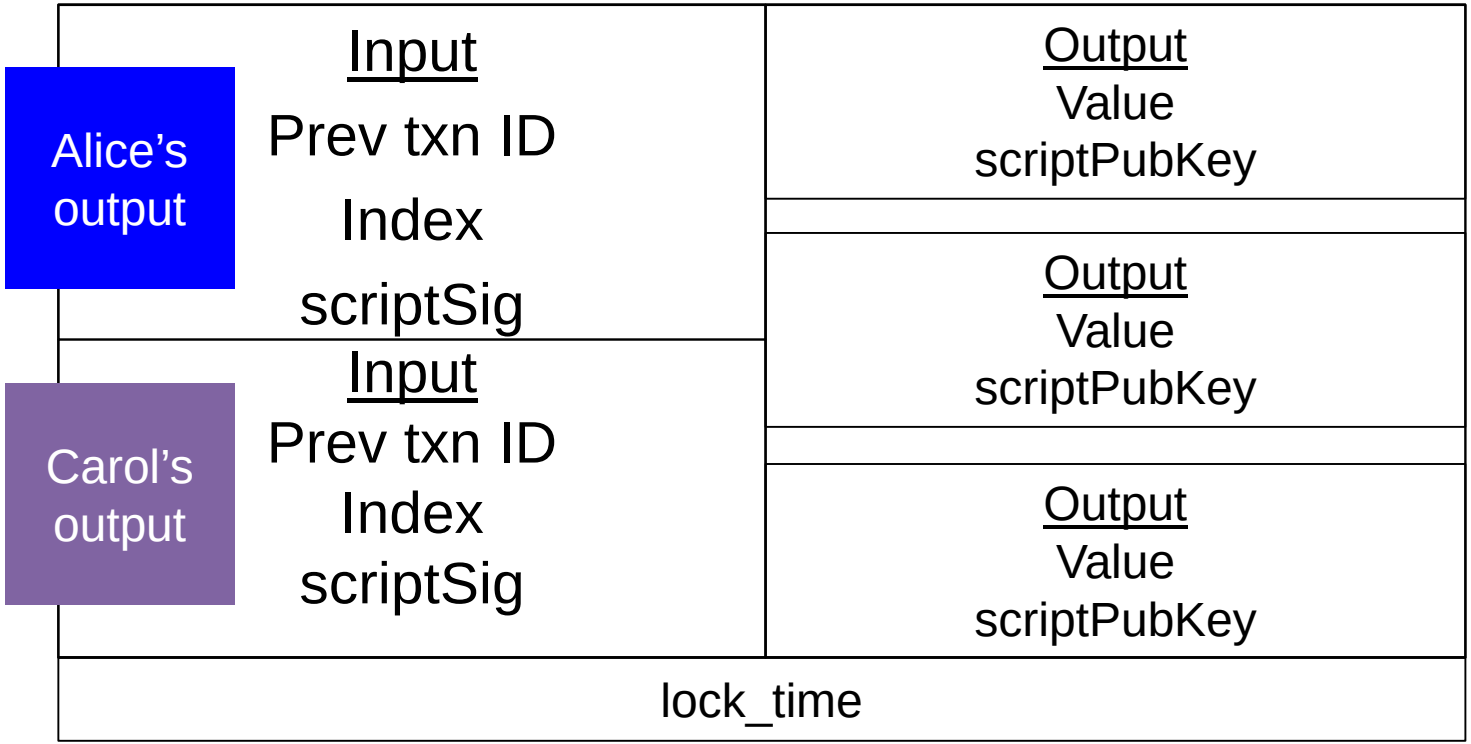
ScriptSigs and scriptPubkeys

- ScriptPubkeys are predicates
- ScriptSigs help satisfy the predicates
- When can you spend a coin? You know how to produce a satisfying scriptSig

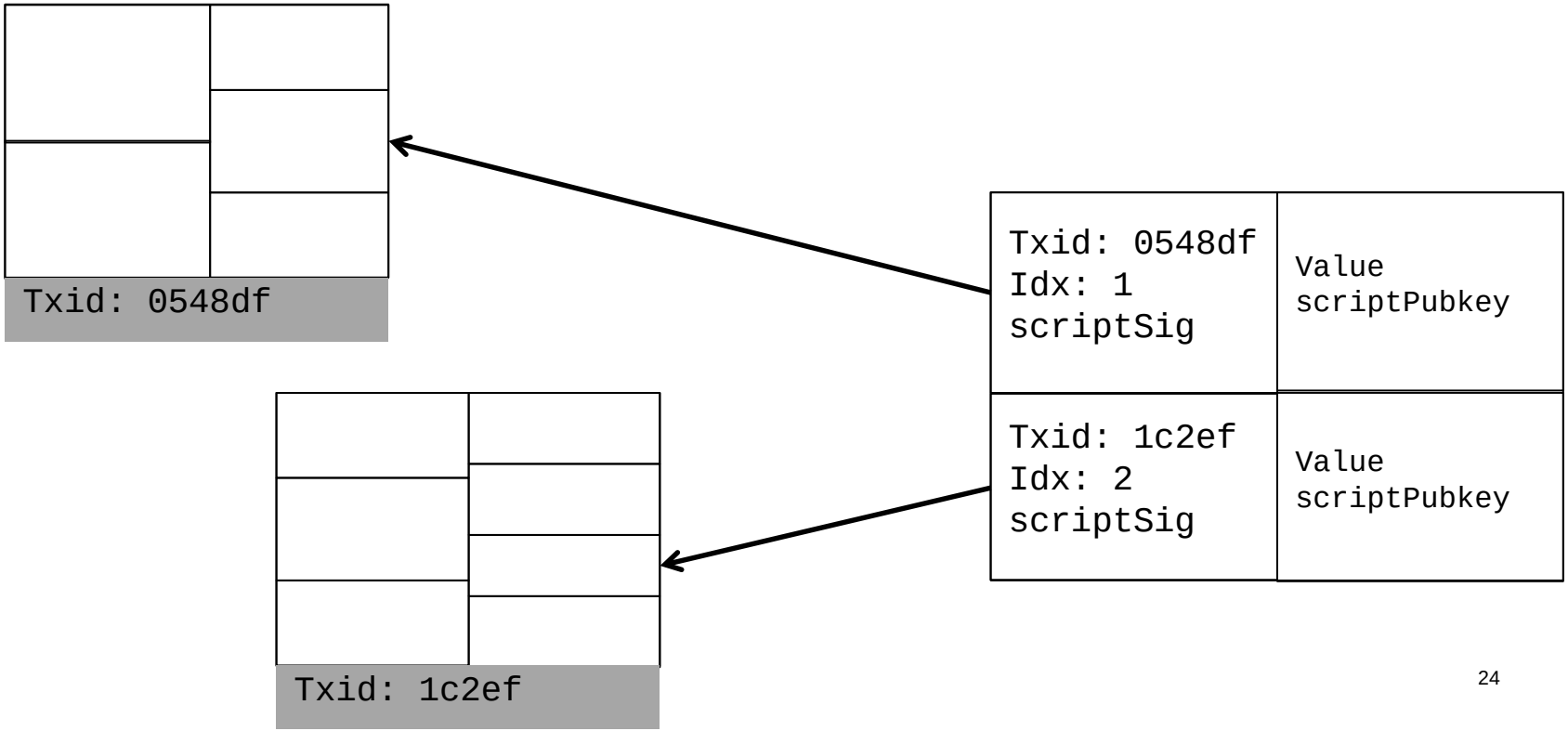
Multiple inputs and outputs



Inputs and outputs are independent



Transactions



```
"txid" : "c80b343d2ce2b5d829c2de9854c7c8d423c0e33bda264c40138d834aab4c0638",
"hash" : "c80b343d2ce2b5d829c2de9854c7c8d423c0e33bda264c40138d834aab4c0638",
"size" : 85,
"vsize" : 85,
"version" : 1,
"locktime" : 0,
"vin" : [
    {
        "txid" : "3f4fa19803dec4d6a84fae3821da7ac7577080ef75451294e71f9b20e0ab1e7b",
        "vout" : 0,
        "scriptSig" : {
            "asm" : "",
            "hex" : ""
        },
        "sequence" : 4294967295
    }
],
"vout" : [
    {
        "value" : 49.99990000,
        "n" : 0,
        "scriptPubKey" : {
            "asm" : "OP_DUP OP_HASH160 cbc20a7664f2f69e5355aa427045bc15e7c6c772 OP_EQUALVERIFY OP_CHECKSIG",
            "hex" : "76a914cbc20a7664f2f69e5355aa427045bc15e7c6c77288ac",
            "reqSigs" : 1,
            "type" : "pubkeyhash",
            "addresses" : [ "mz6KvC4aoUeo6wSxtiVQTo7FDwPnkp6URG” ]
        }
    }
]
```

Consensus rules

- Sum(inputs) <= Sum(outputs)
  - One exception: coinbase transactions
  - Why not equal? Fees!
- For every input, Eval(scriptSig+scriptPubKey) == true
- Output has not already been spent
- lock_time

Pay to Pubkey Hash (P2PKH)

- Idea: Send money to a pubkey
- Pubkeys are big, a hash of a pubkey is only 32 bytes (+1 byte for prefix)
- scriptPubkey: instructions on how to verify a signature of a pubkey that is hashed
- scriptSig: signature, pubkey

Pay to Pubkey Hash (P2PKH)

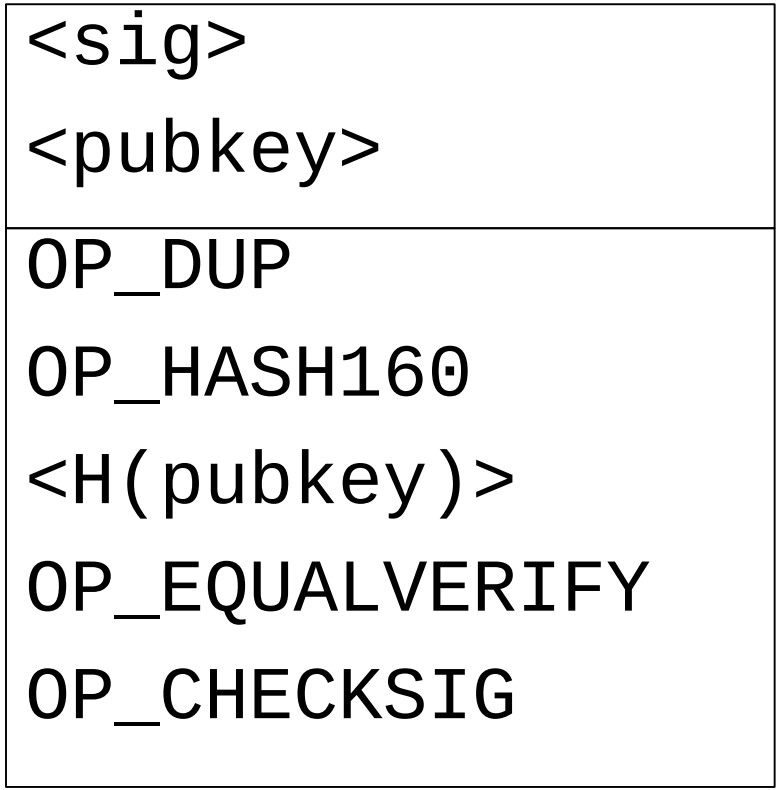
ScriptPubkey:

```
OP_DUP
OP_HASH160
<H(pubkey)>
OP_EQUALVERIFY
OP_CHECKSIG
```

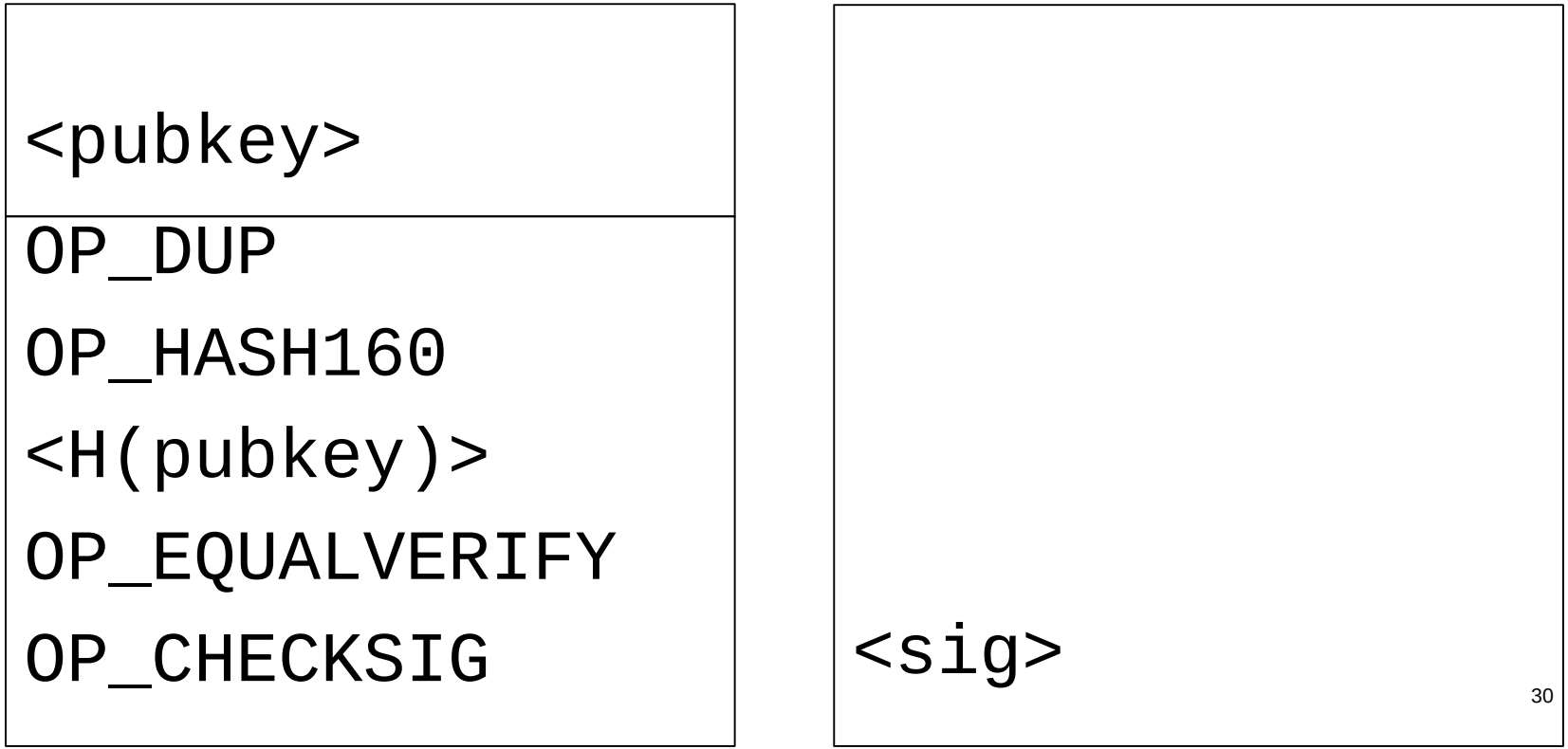
ScriptSig:

```
<sig>
<pubkey>
```

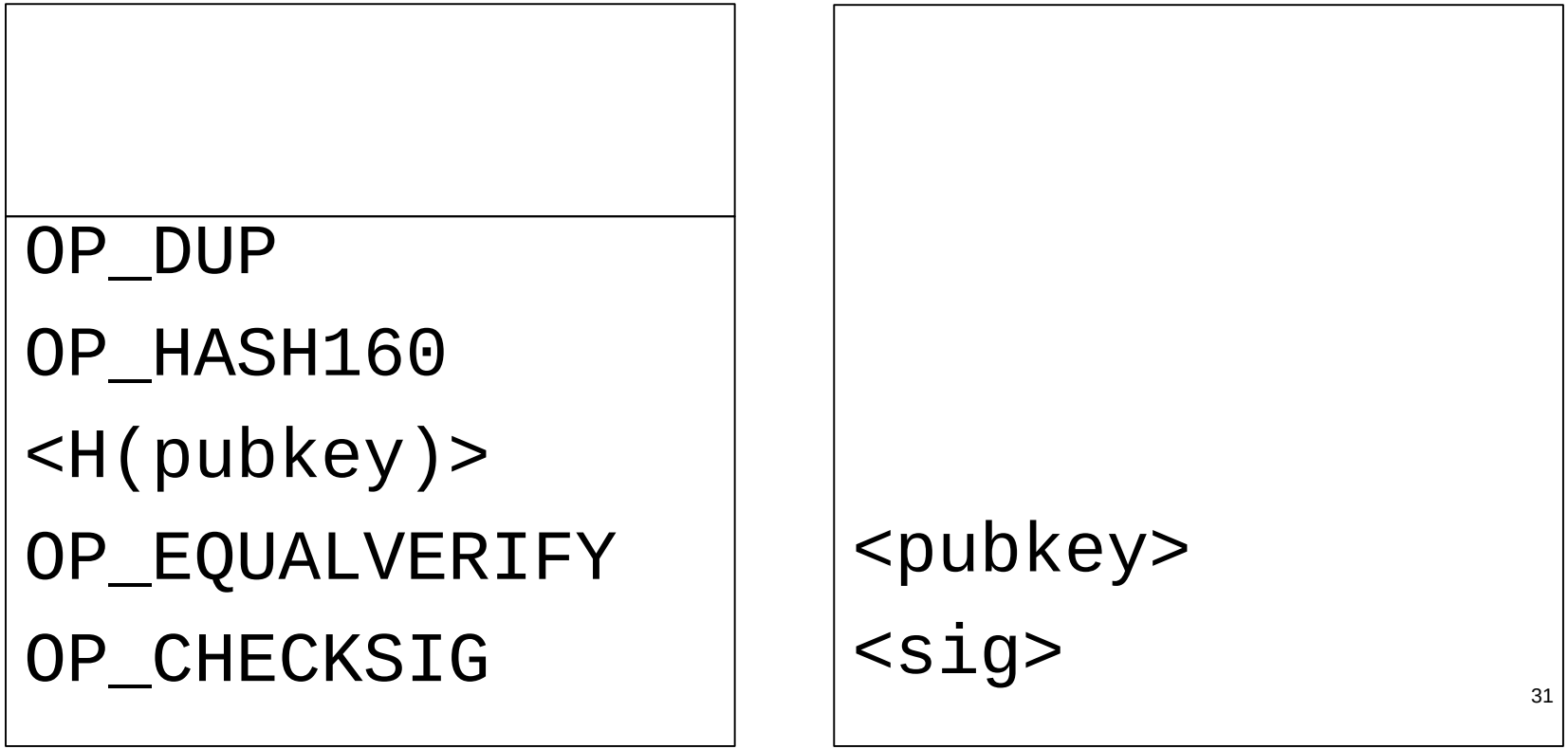
Pay to Pubkey Hash (P2PKH)



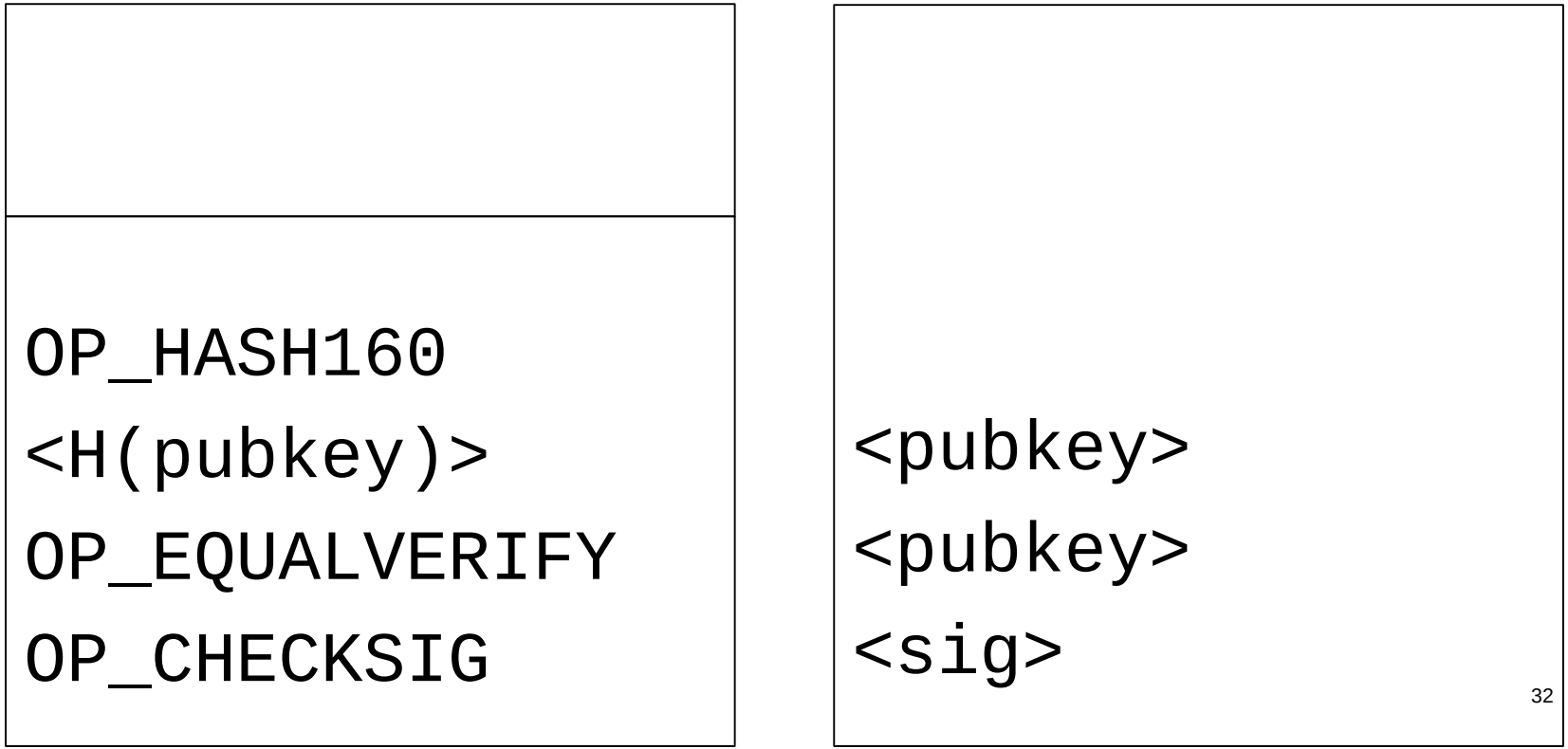
Pay to Pubkey Hash (P2PKH)



Pay to Pubkey Hash (P2PKH)



Pay to Pubkey Hash (P2PKH)



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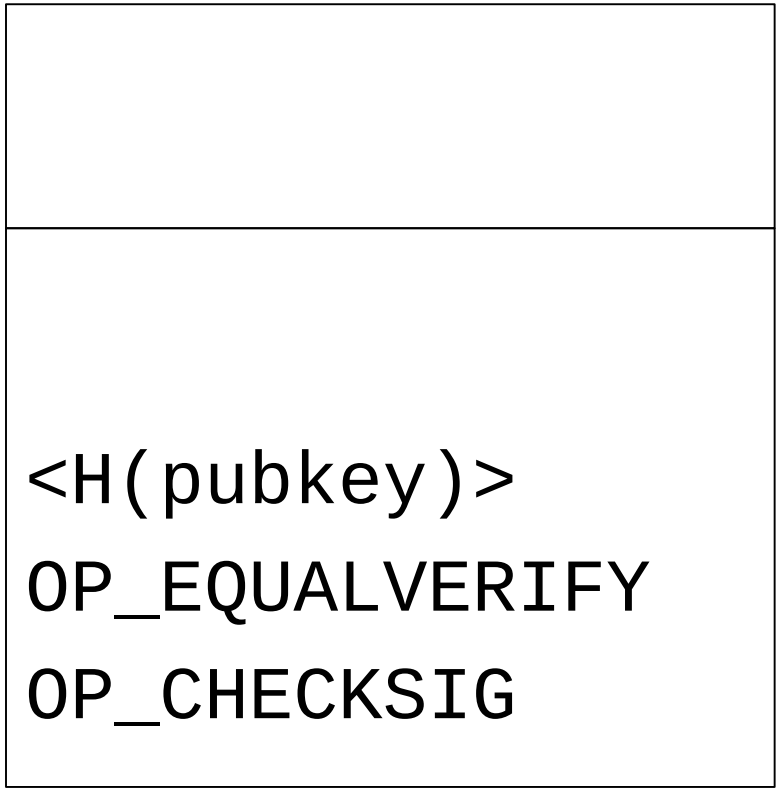
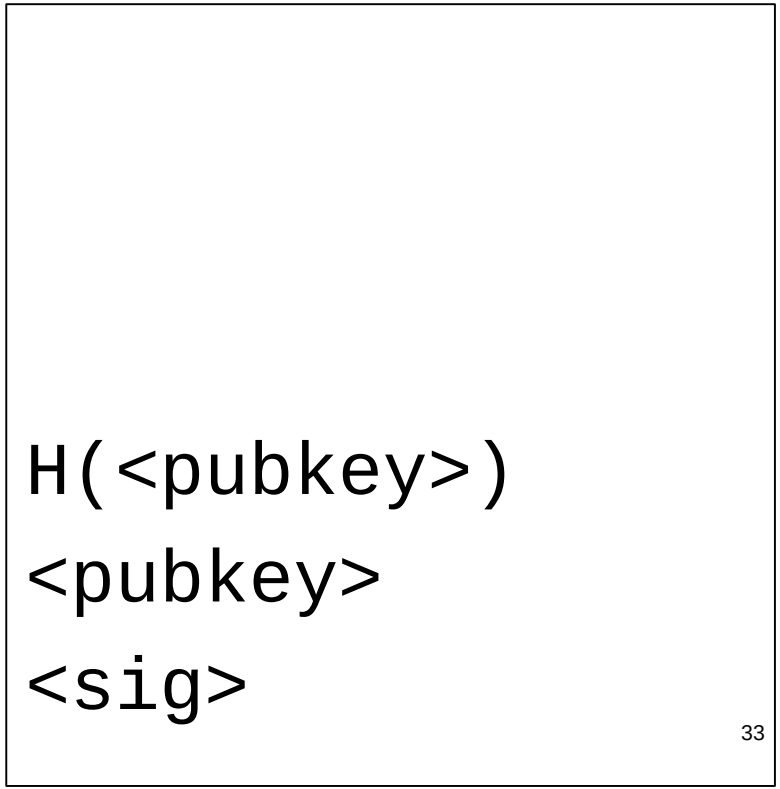
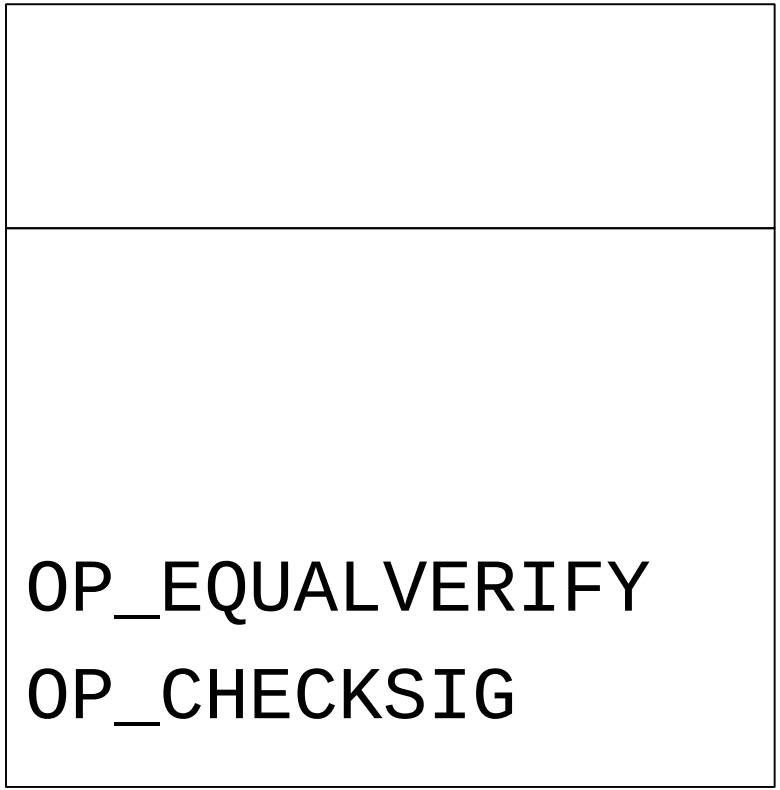
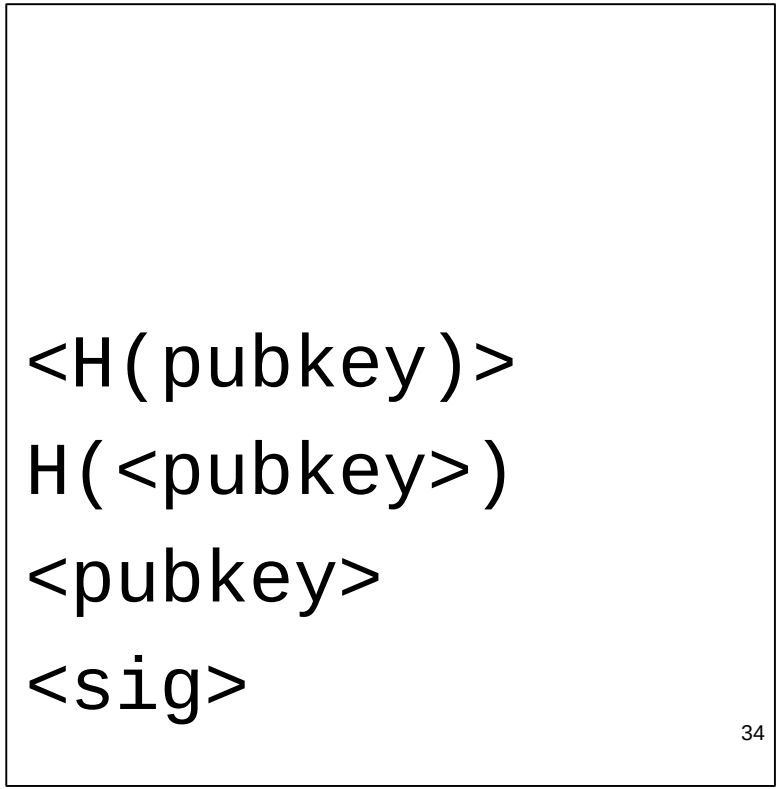




Pay to Pubkey Hash (P2PKH)





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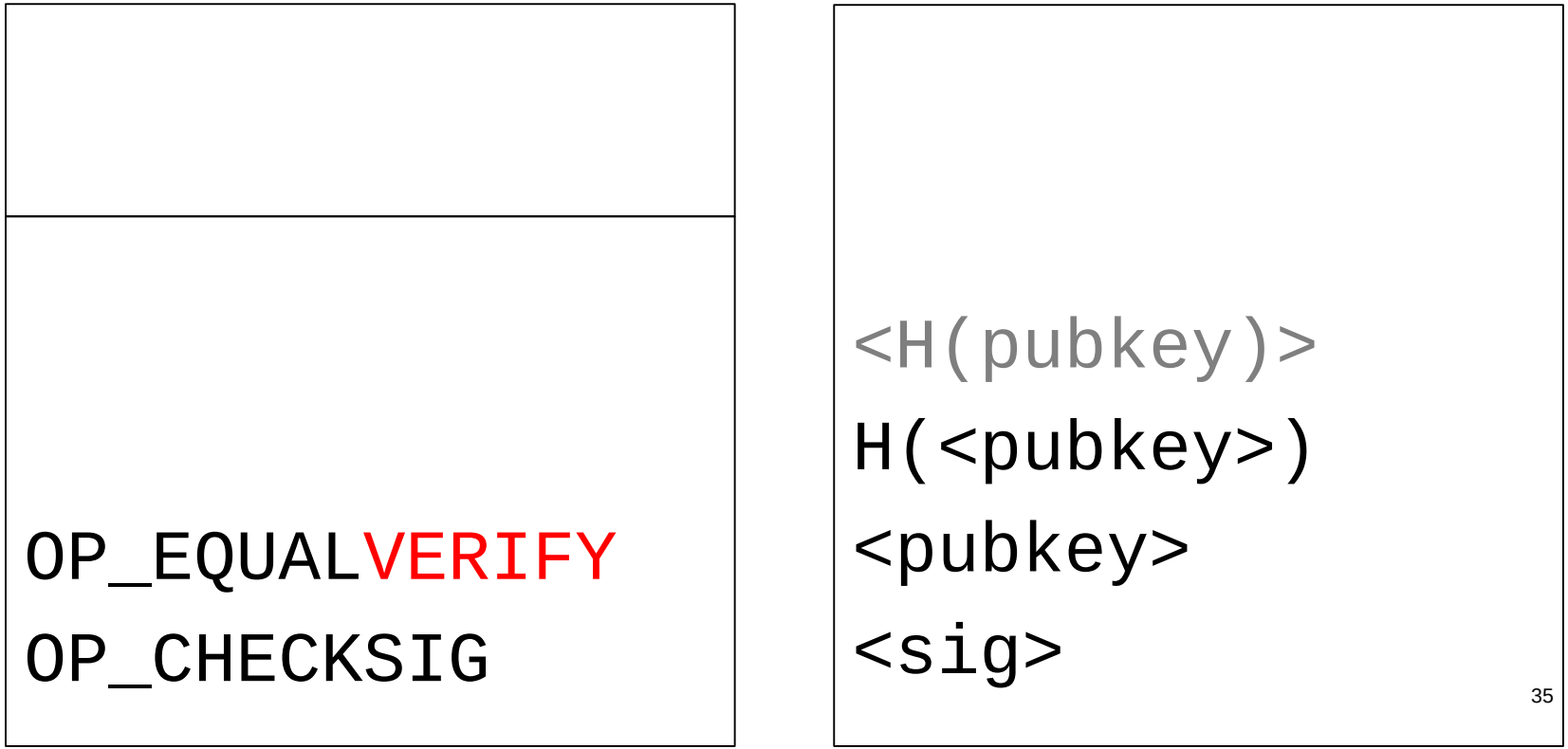

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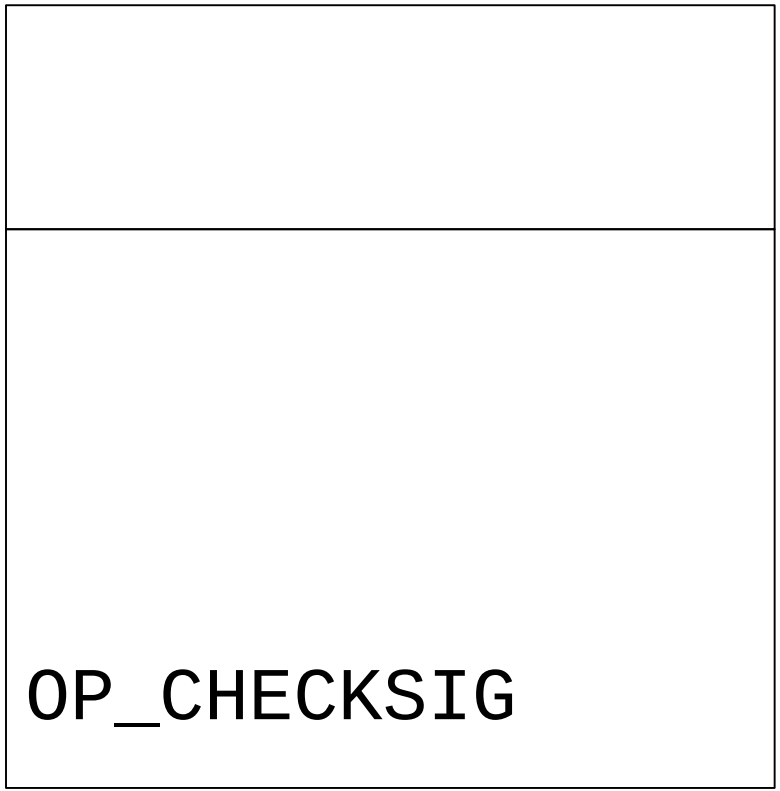

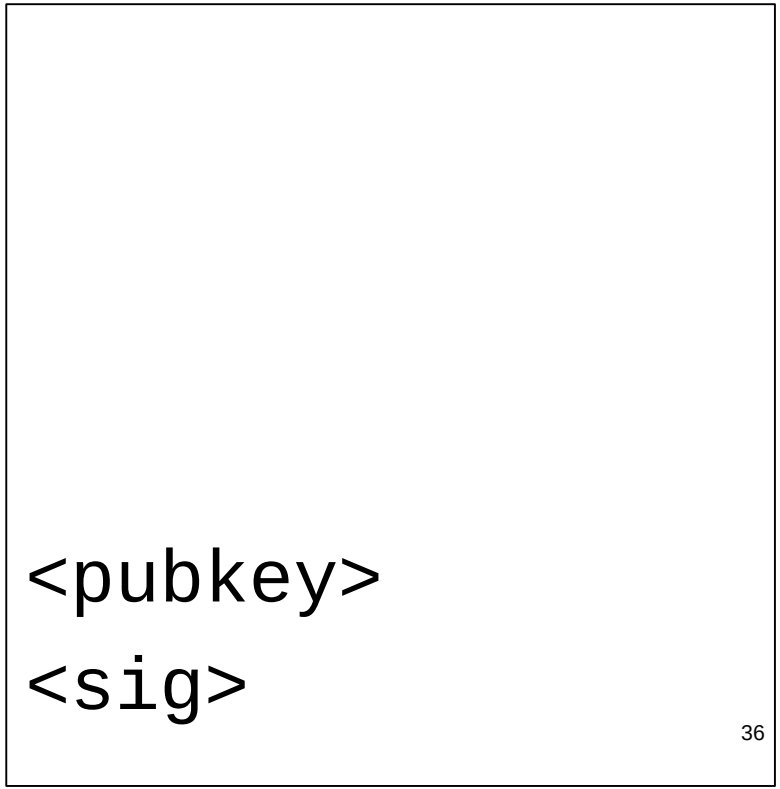

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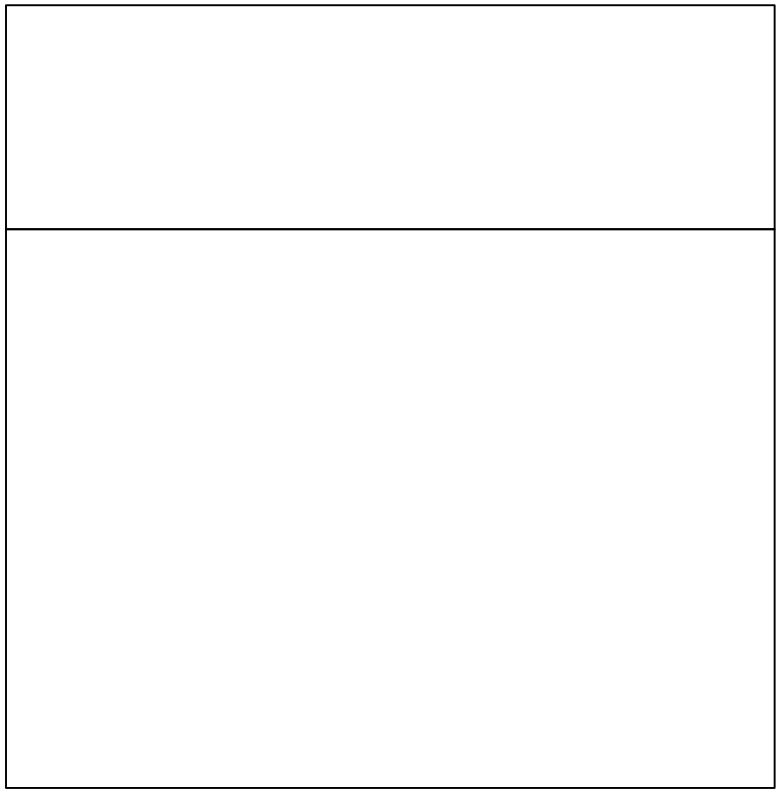
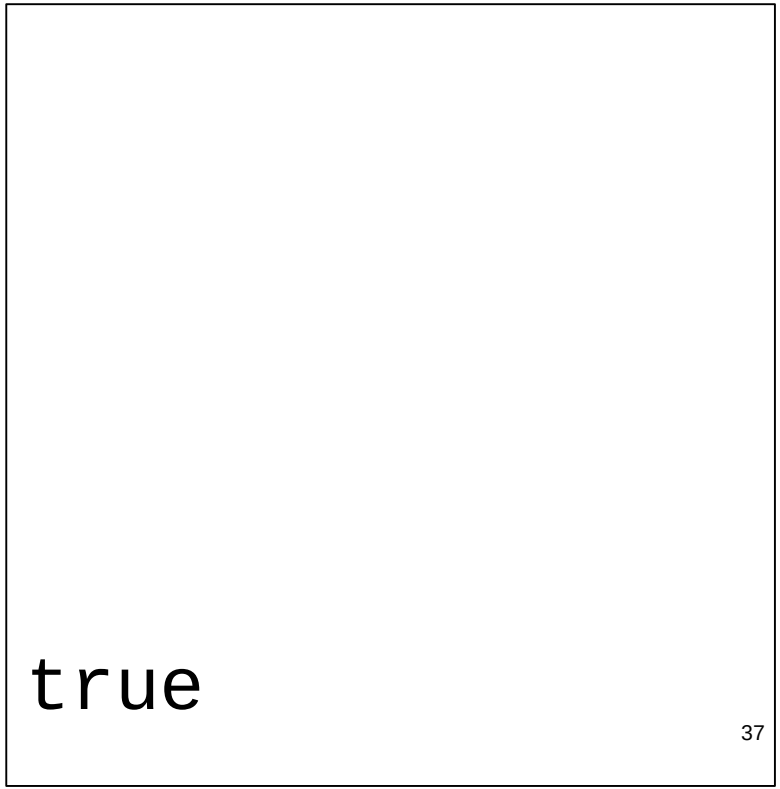


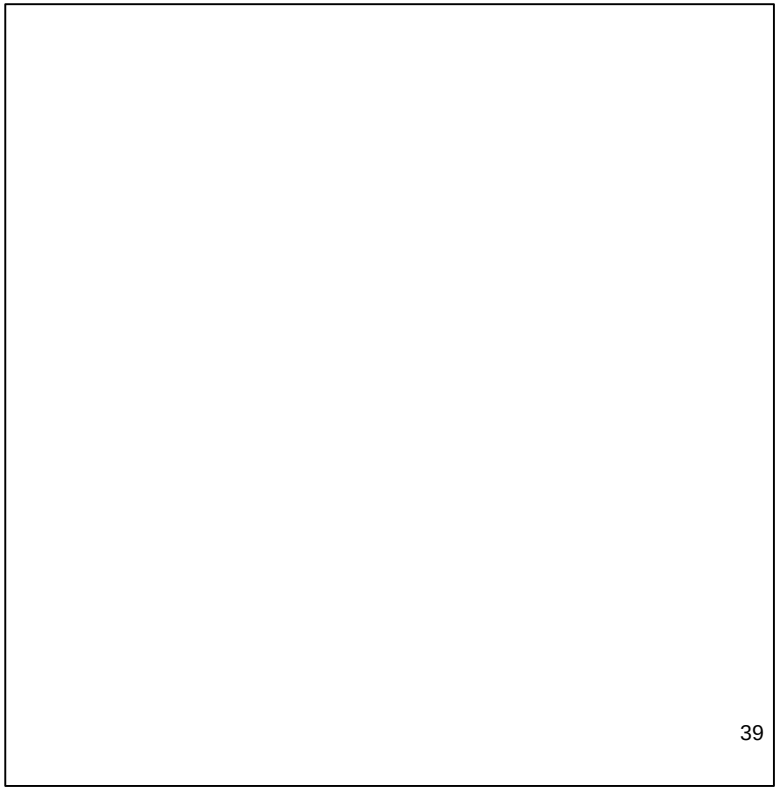


Unspendable output

OP_RETURN
<whatever>

Anyone can spend output

OP_TRUE
<empty>



Benefits of UTXOs

- Help with replay attacks:
  - State order the number of unspent coins, not all accounts
- Privacy (can generate new pubkeys)

Downsides of UTXOs

- Complex
- Fungibility: blacklisting coins

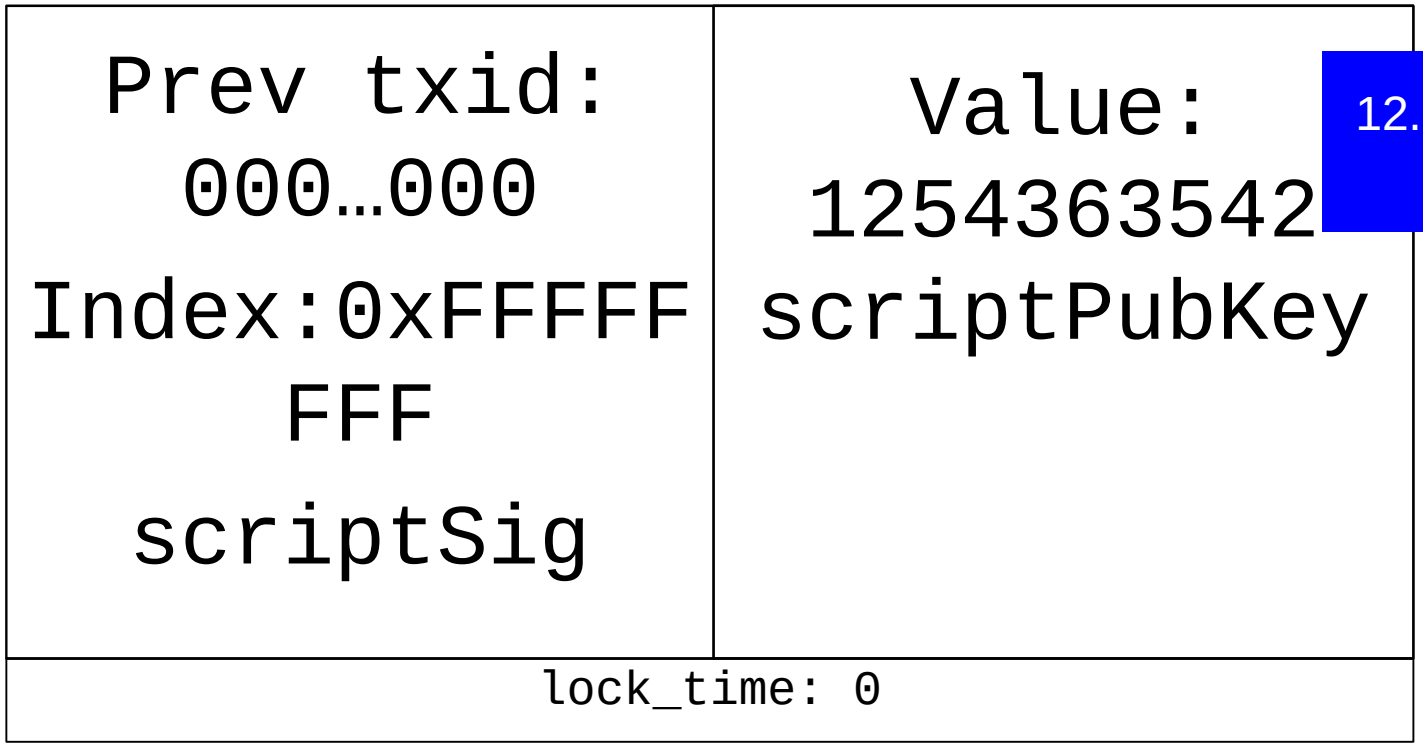
UTXO set

- Every Bitcoin node computes this from the blockchain
- Represents valid set of coins
- ~60M UTXOs
- ~3GB

Coinbase transaction

Prev txid: 000…000 Index:0xFFFFFFFF scriptSig	Value: 1254363542 scriptPubKey
lock_time: 0	

Coinbase transaction



12.5 BTC + fees

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Spring 2018