MIT Digital Currency Initiative and the University of Brasilia presents

Cryptocurrency Design and Engineering

Lecture 10: Money Programmability
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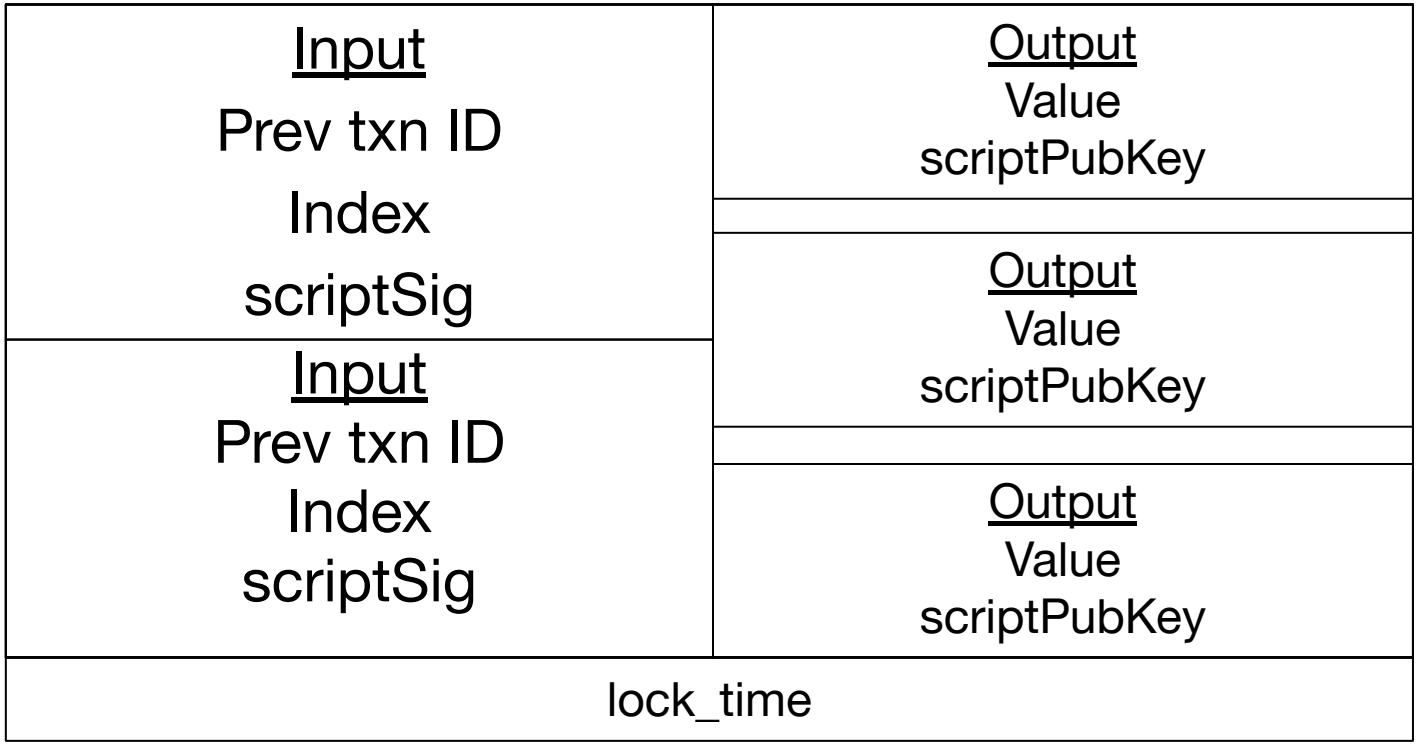
October 7, 2025
MAS.S62

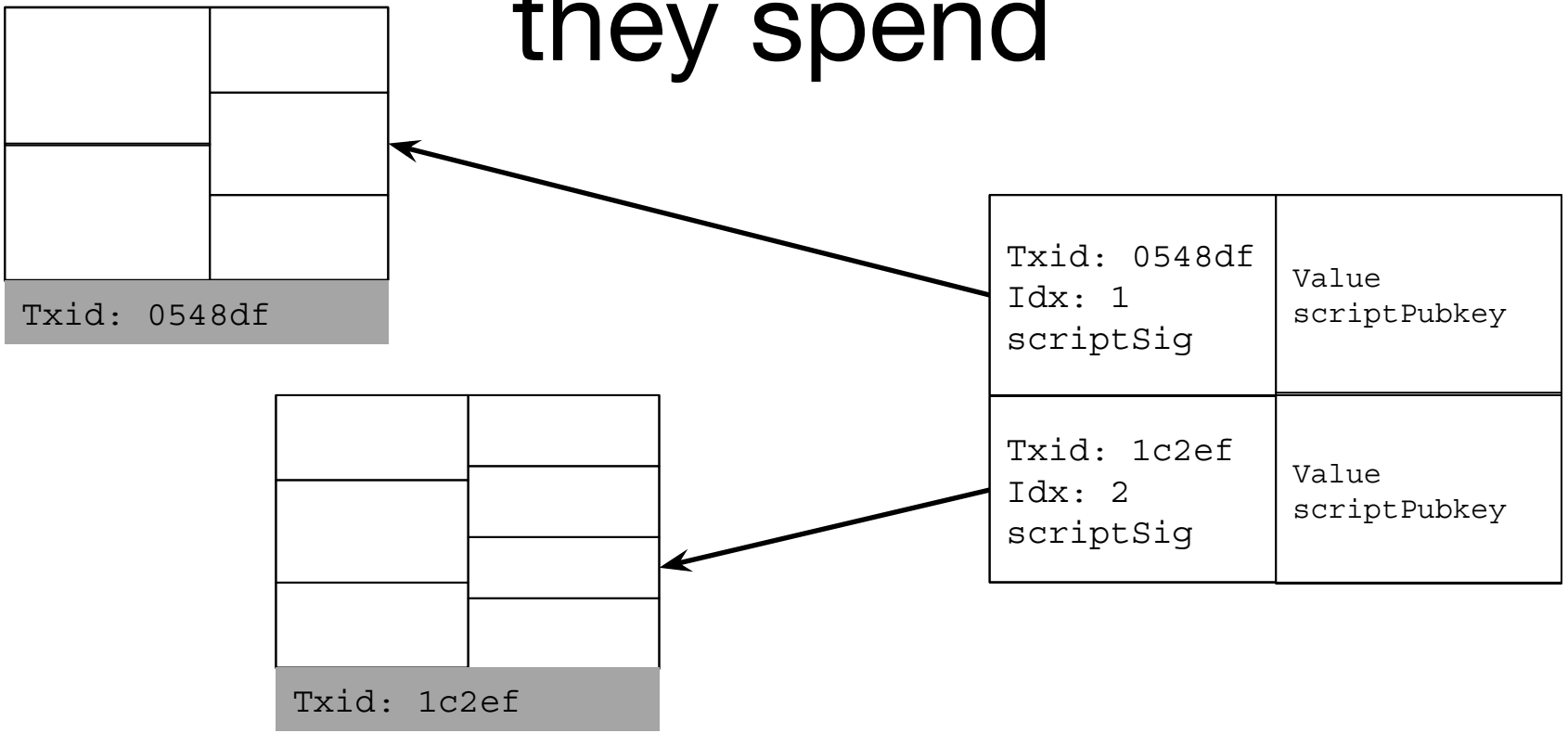
Why programmability?

- Conditional payments without intermediaries
- Better security (multisig, vaults)
- More complex applications with money

Transaction format



Inputs reference the outputs they spend



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

Transaction validity rules

- Sum(inputs) >= Sum(outputs)
- For every input:
  - Eval(scriptSig+scriptPubKey) == true
  - Output has not already been spent
- lock_time

Bitcoin Script

- Stack-based
- Limited expressivity
- Limited set of opcodes
- Scoped execution
- Predictable execution (somewhat)

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)

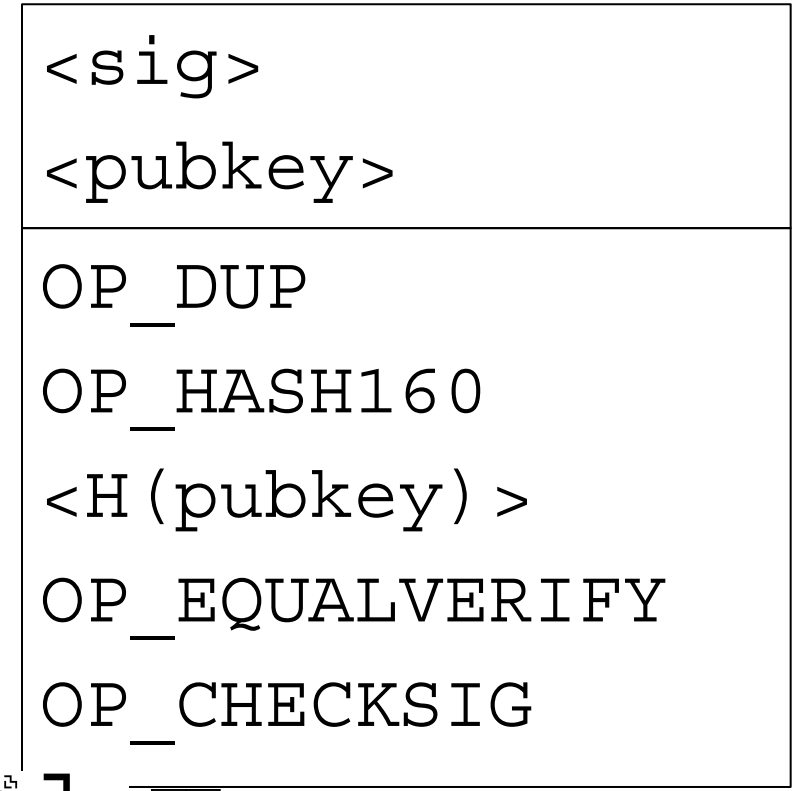
ScriptPubkey:

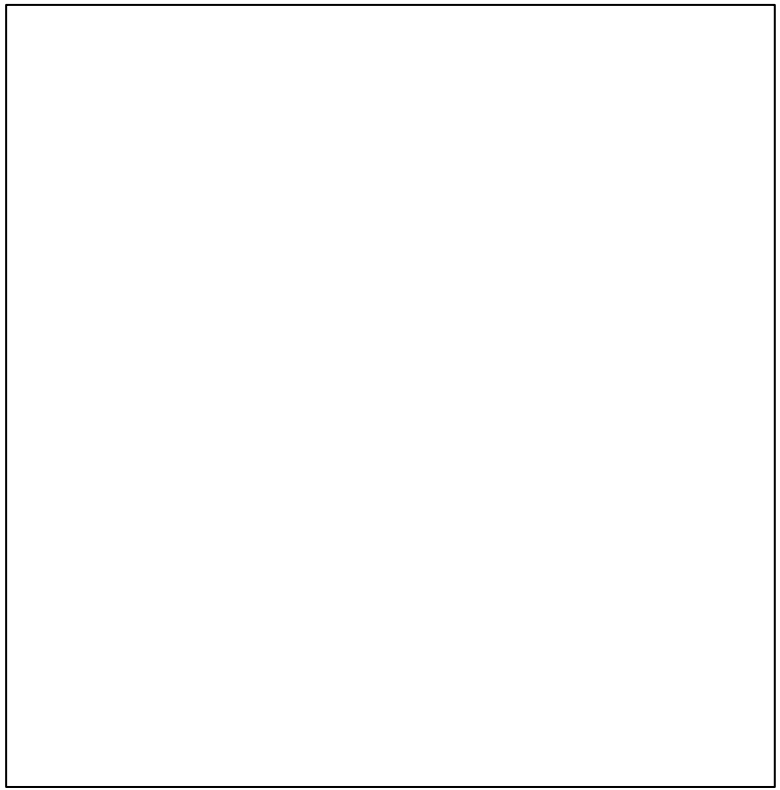
```
OP_DUP
OP_HASH160
<H(pubkey)>
OP_EQUALVERIFY
OP_CHECKSIG
```

ScriptSig:

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

Pay to Pubkey Hash (P2PKH)





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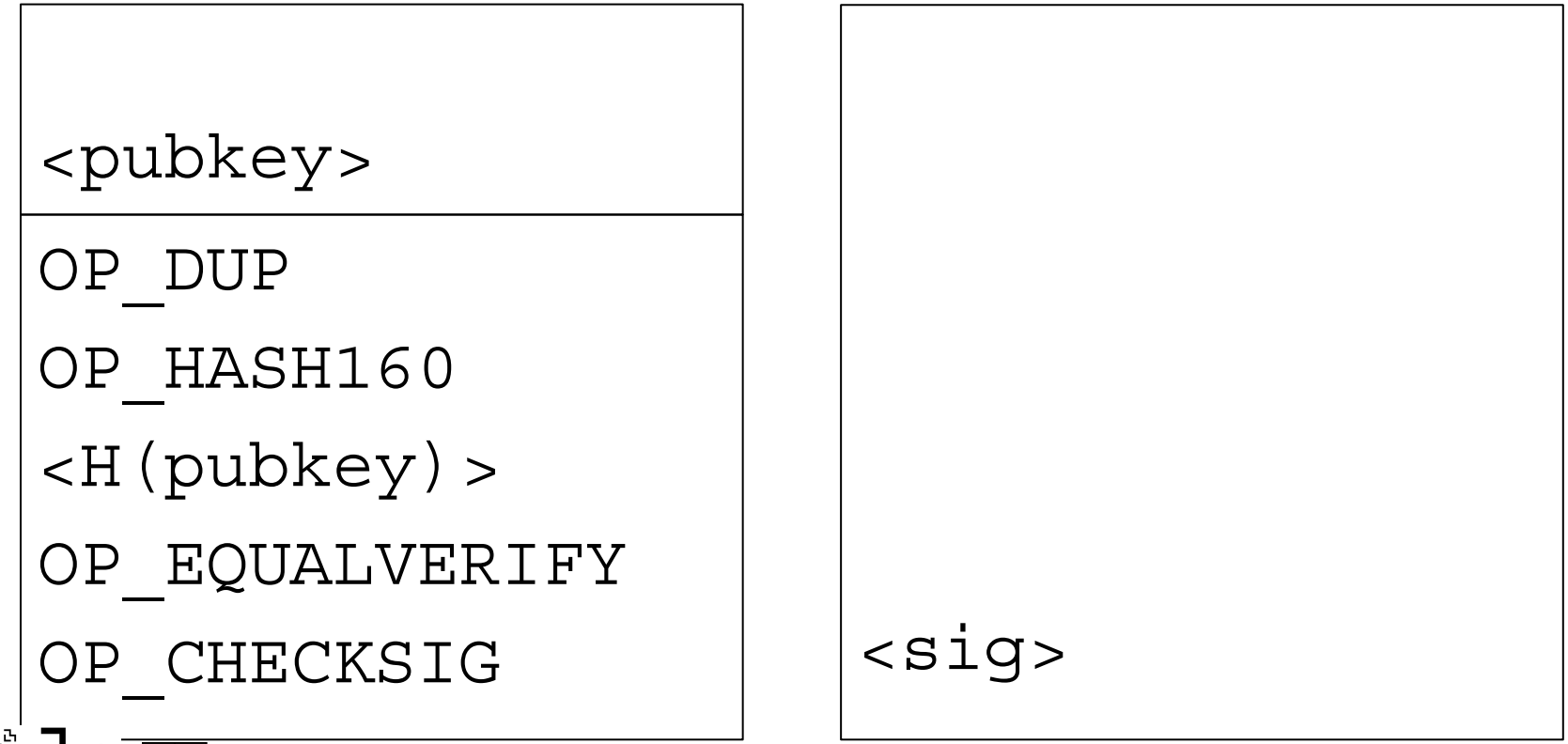

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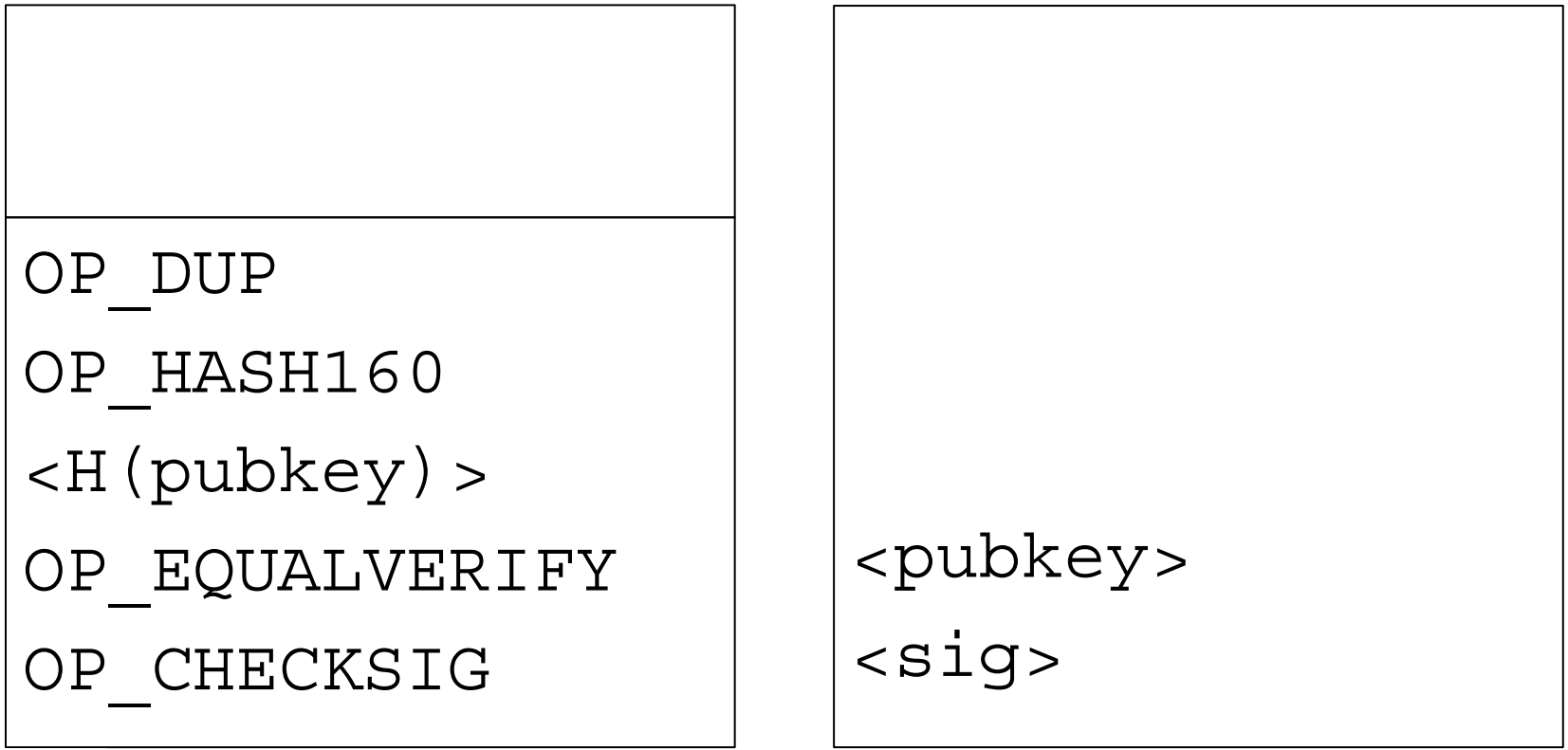

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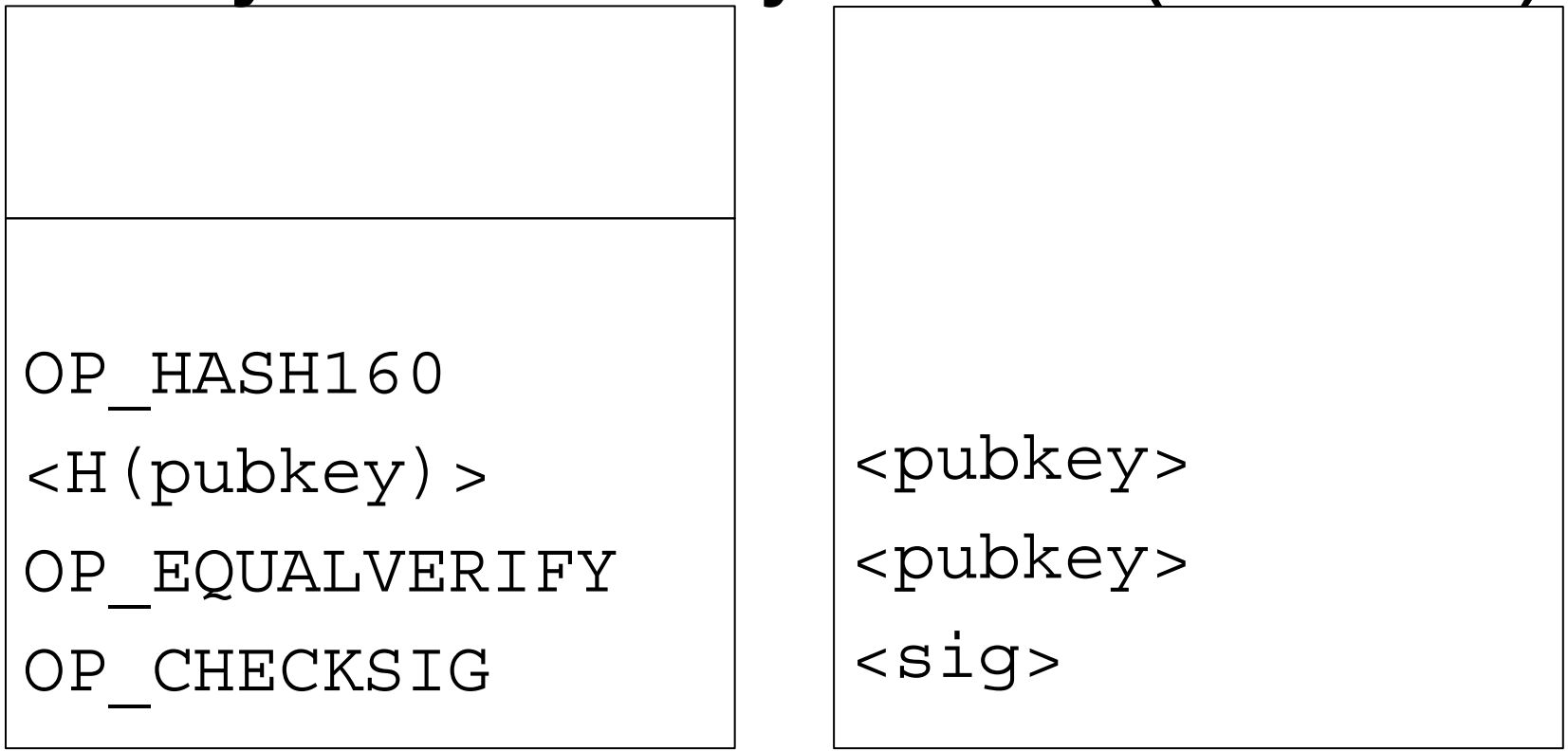

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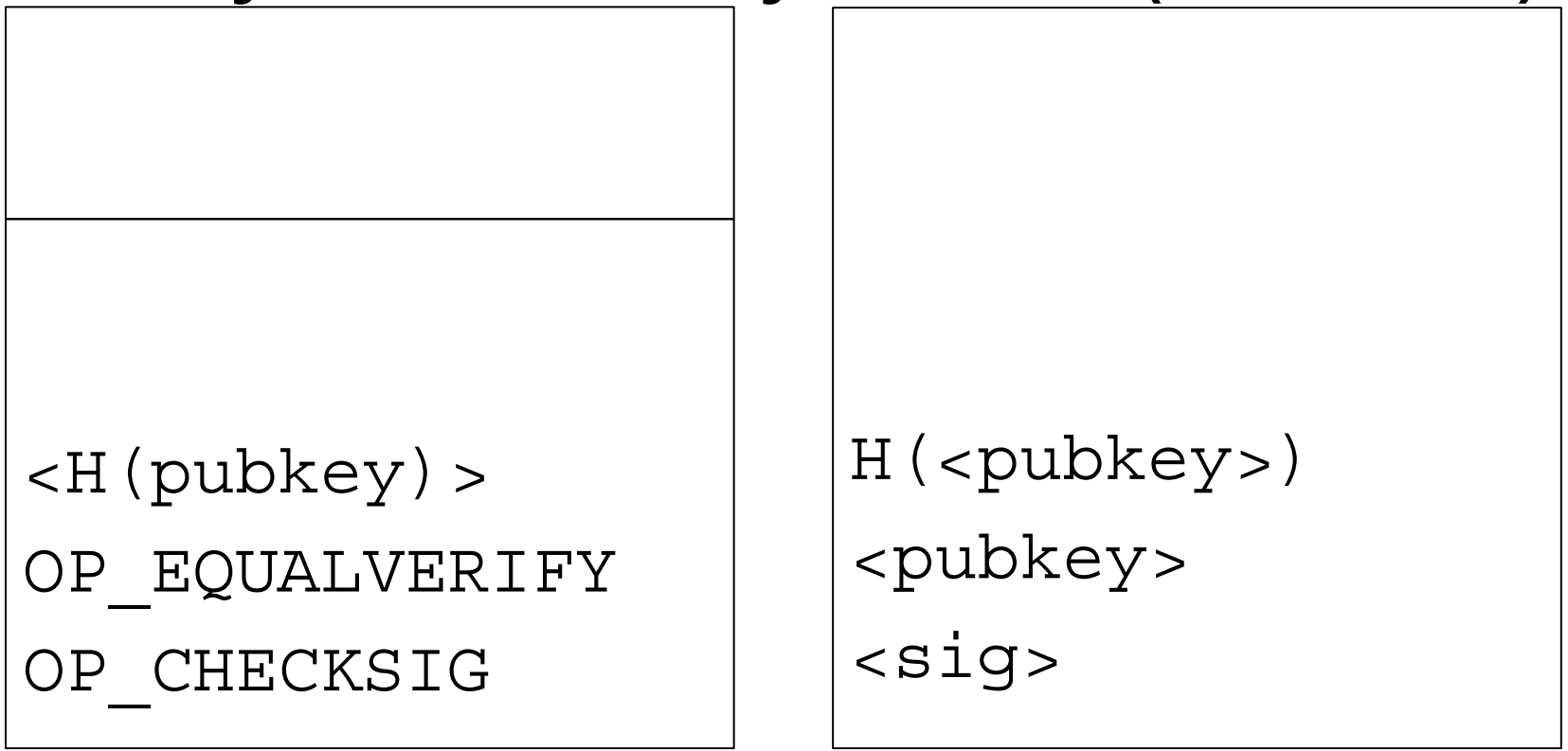

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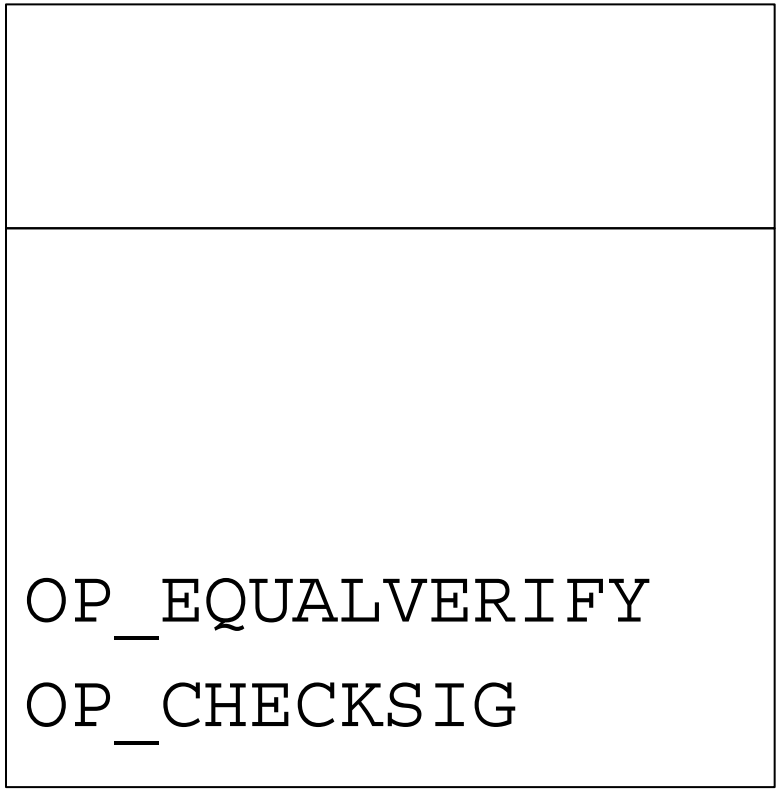

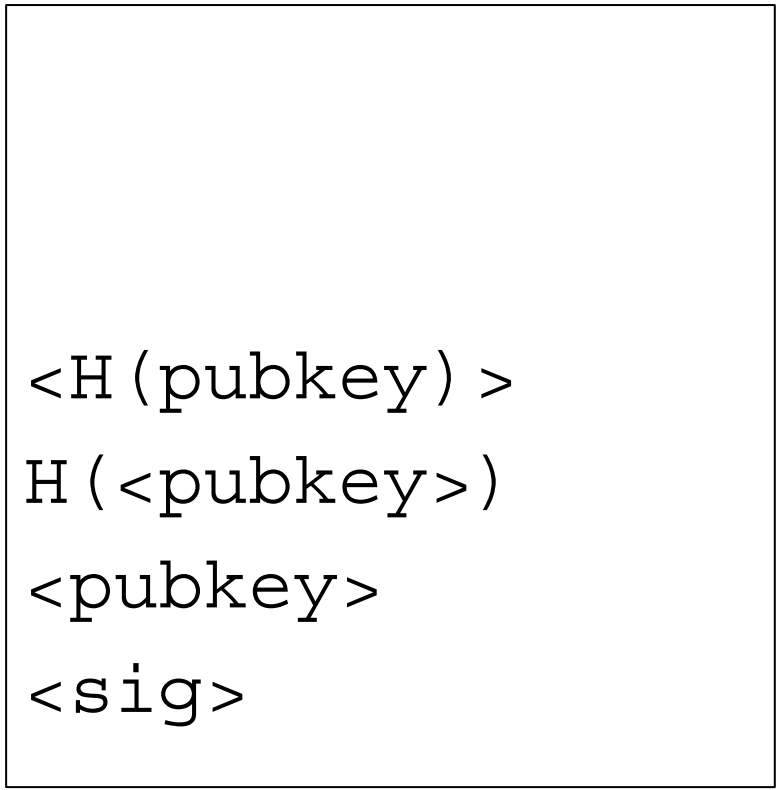

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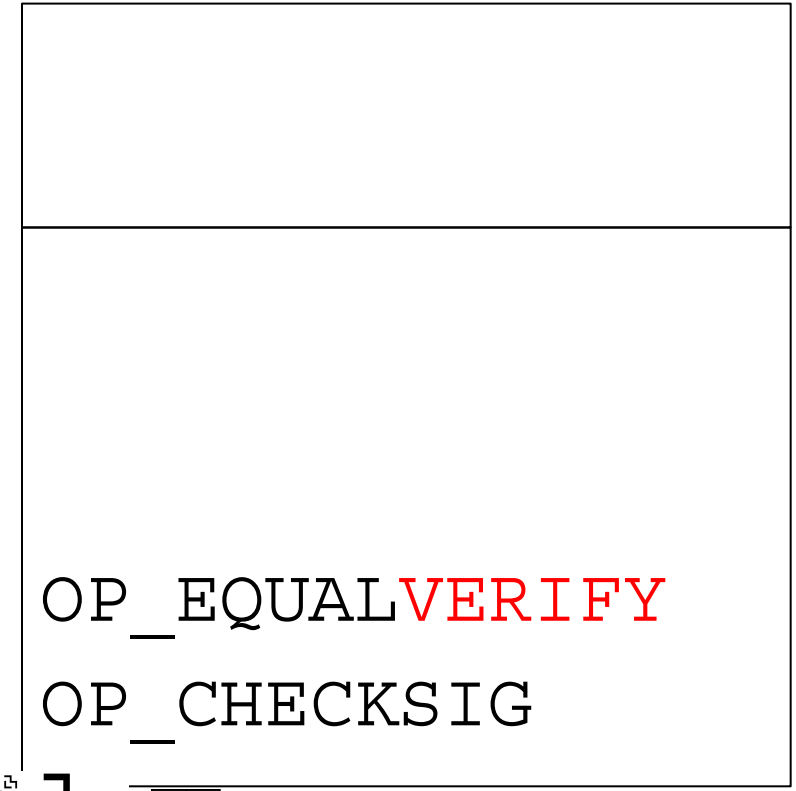

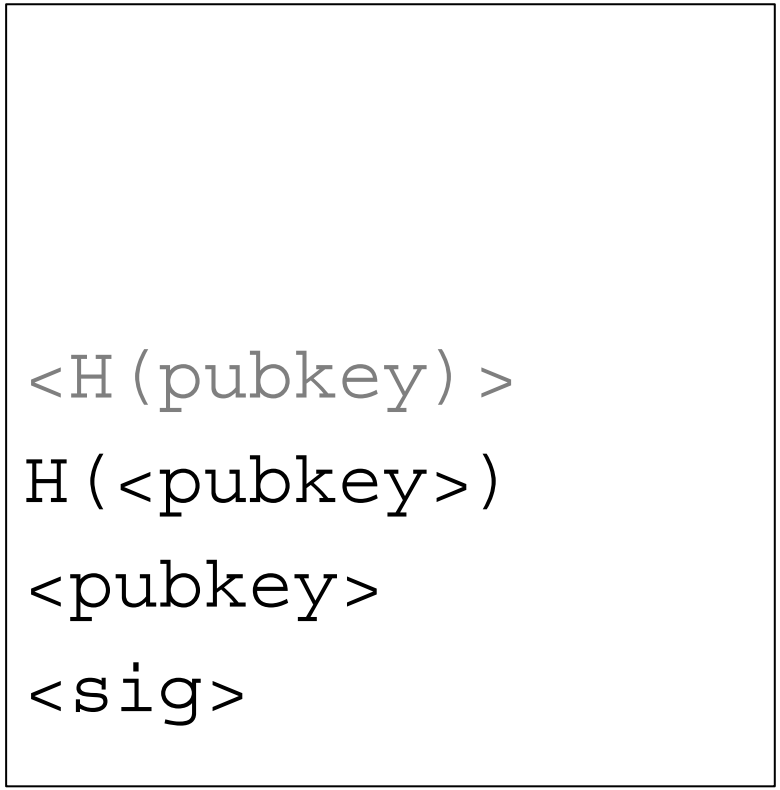

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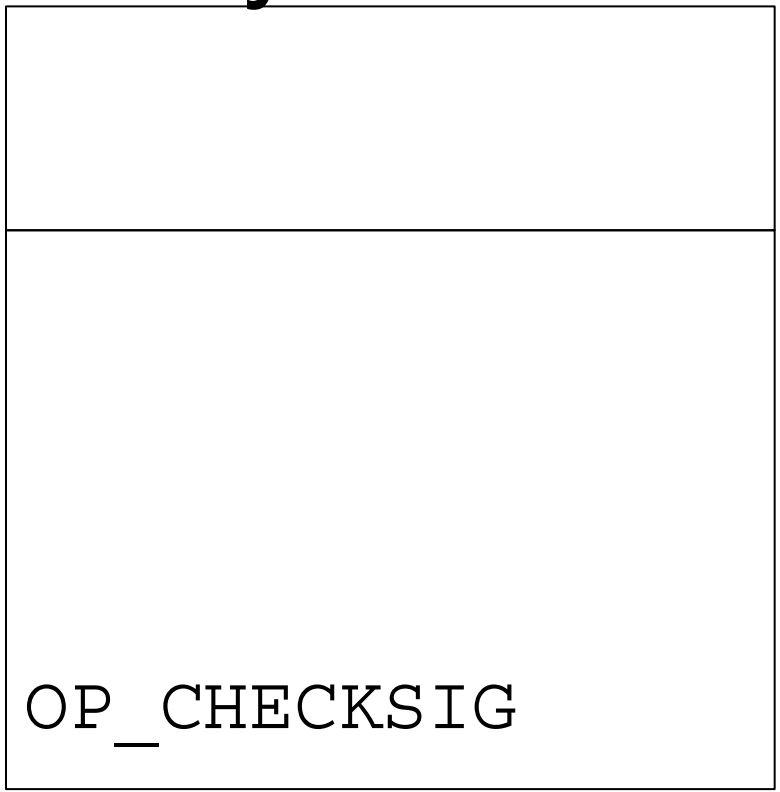

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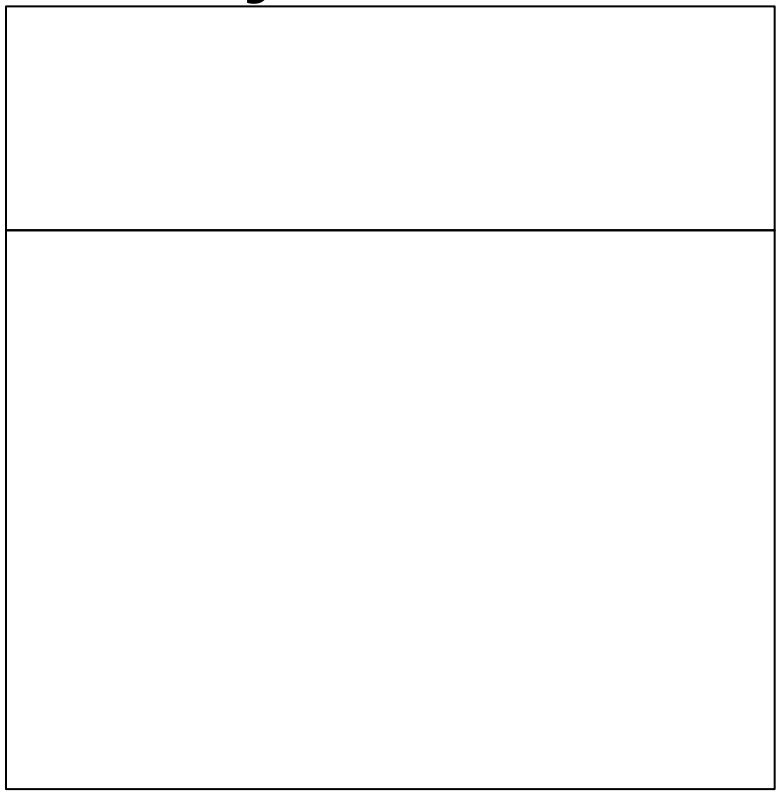
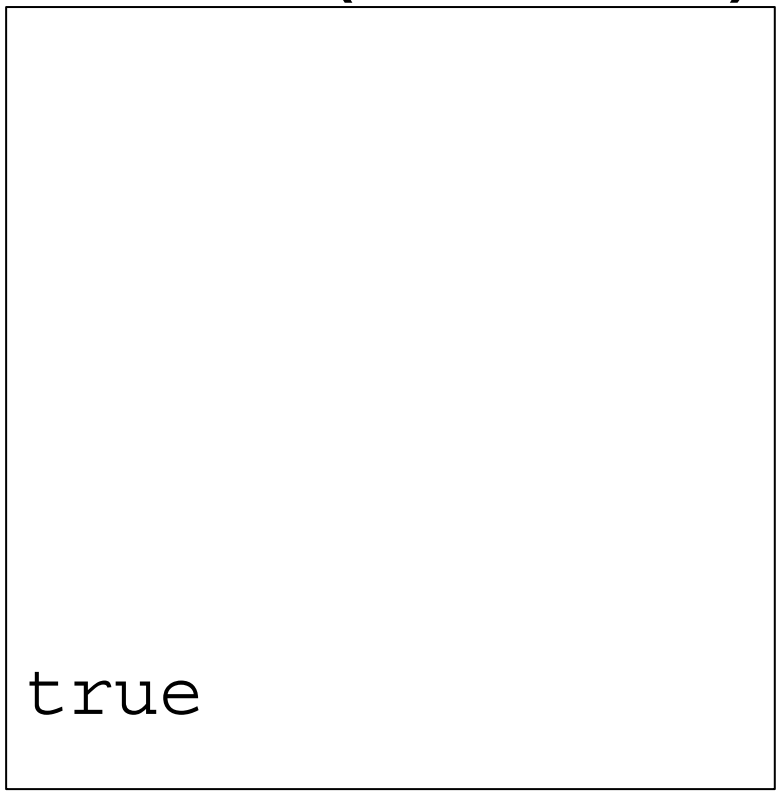
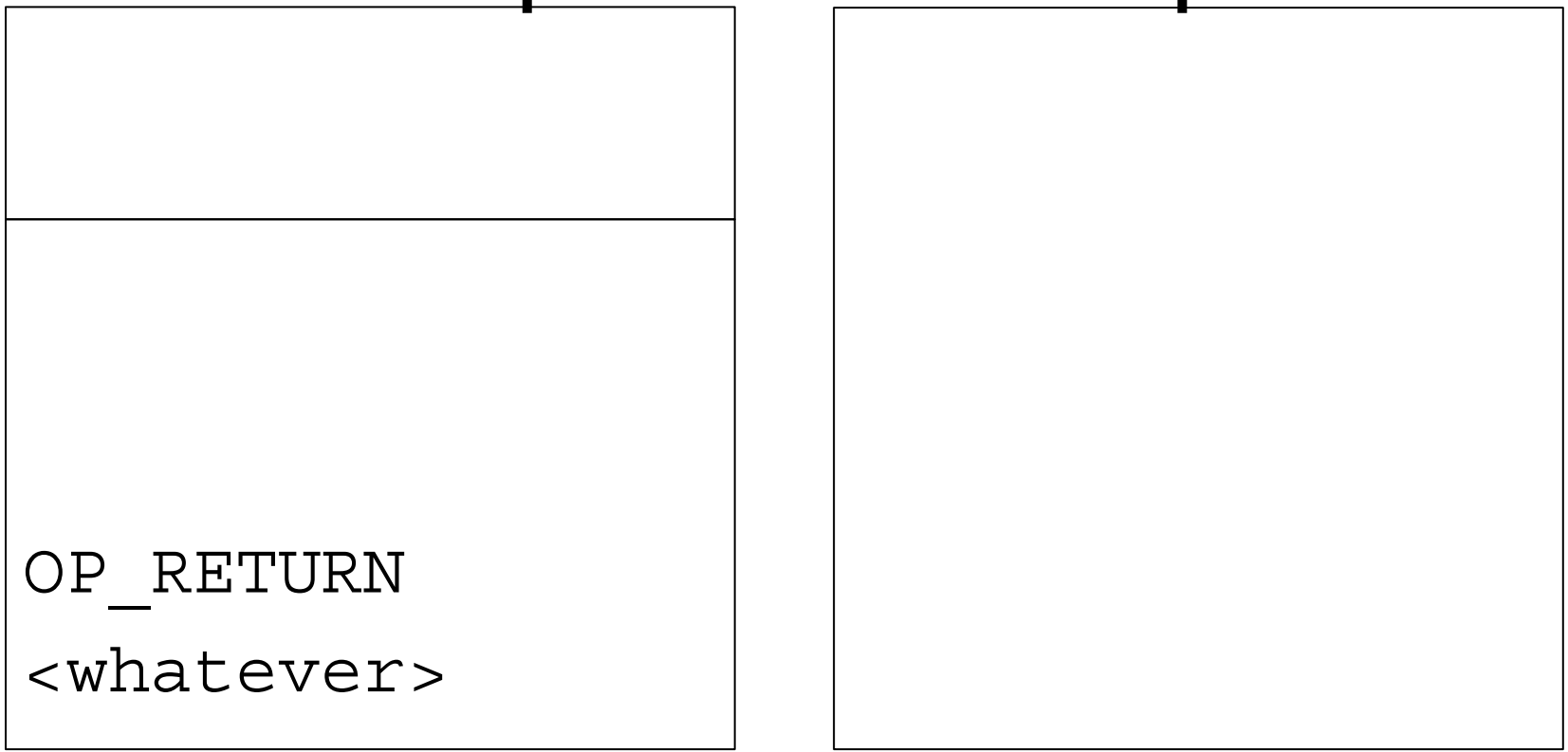
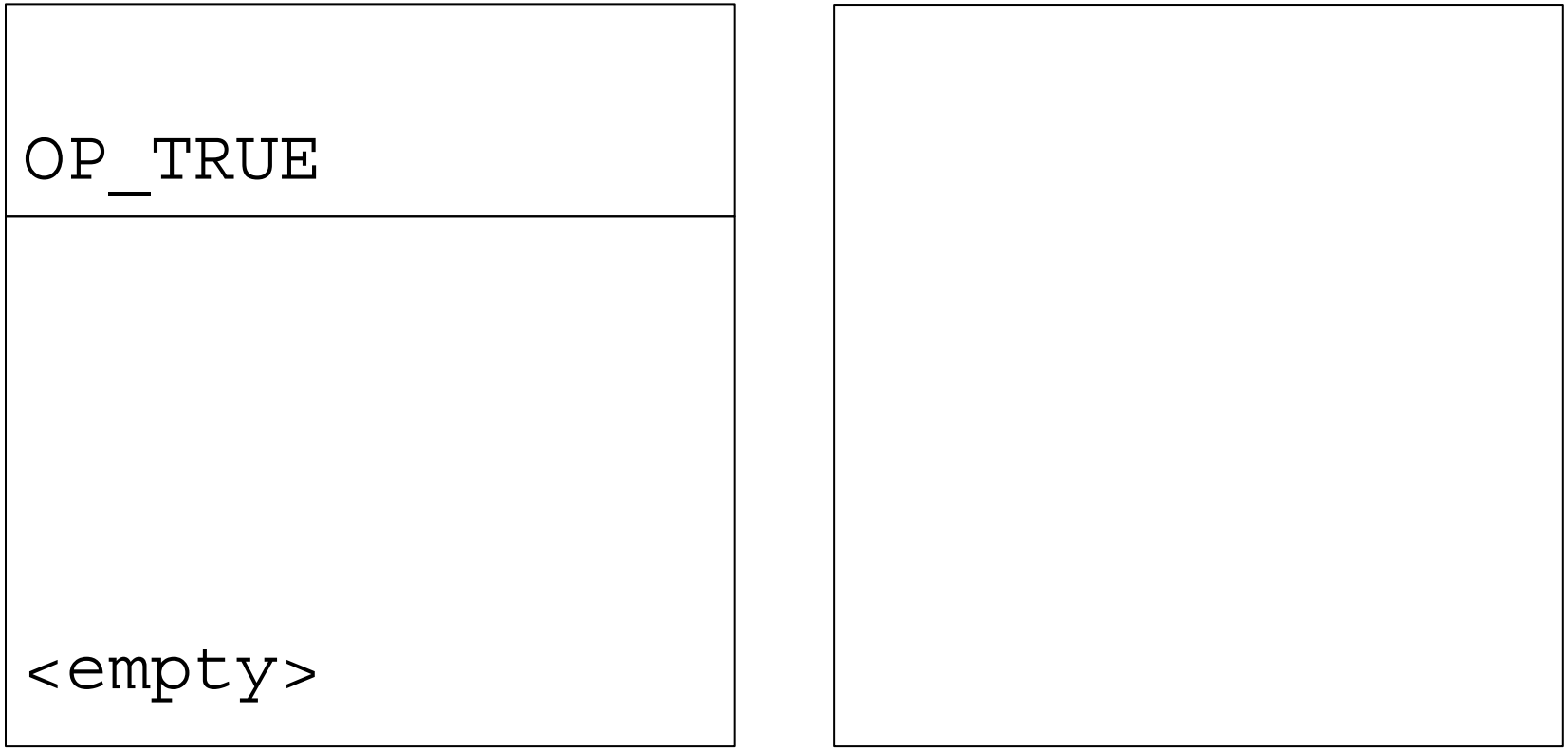




Unspendable output



Anyone can spend output



Other types of Bitcoin scripts

Type	ScriptPubKey
Pay to script hash (P2SH)	`OP_HASH160 <ScriptHash> OP_EQUAL`
Multisignature	`OP_n <PubKey1> <PubKey2> ... <PubKeyN> OP_m OP_CHECKMULTISIG`
Pay to taproot (P2TR)	`OP_1 <TaprootPubKey>`