mas.s62
lecture 14
lightning network and cross chain swaps

2018-04-02

Tadge Dryja

schedule stuff

post spring break

general questions office hours tomorrow, 5-6

pset4 out Wednesday

next class: discreet log contracts

today

payment channels

- recap
- optimizations: key addition,
- hash trees
- cross chain swaps

revokable tx

Commit Tx (held by Alice)	
input	output
fund txid Bob's signature	Alice key & 100 blocks or AliceR & Bob key 2 coins
	Bob address 8 coins

revokable tx

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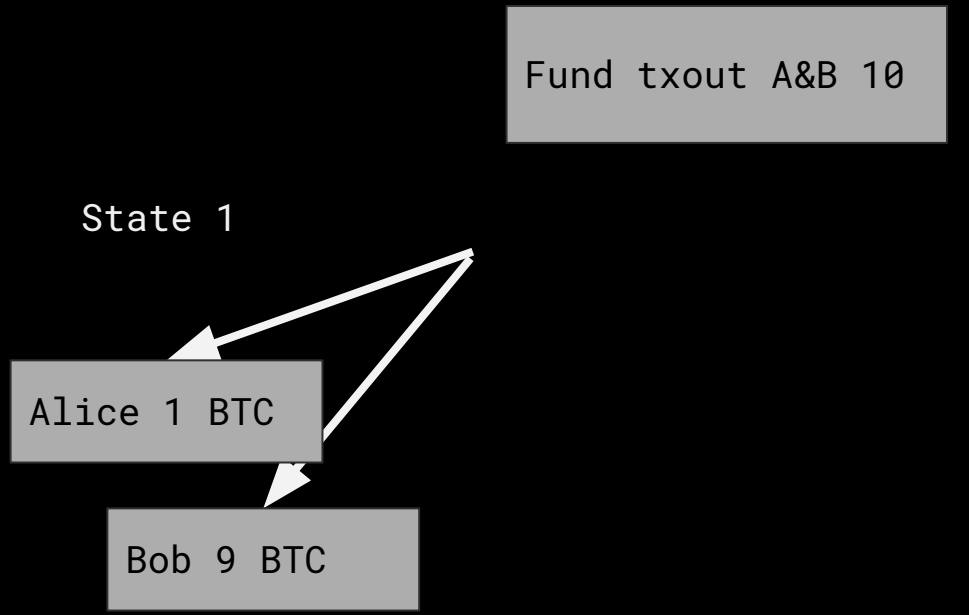
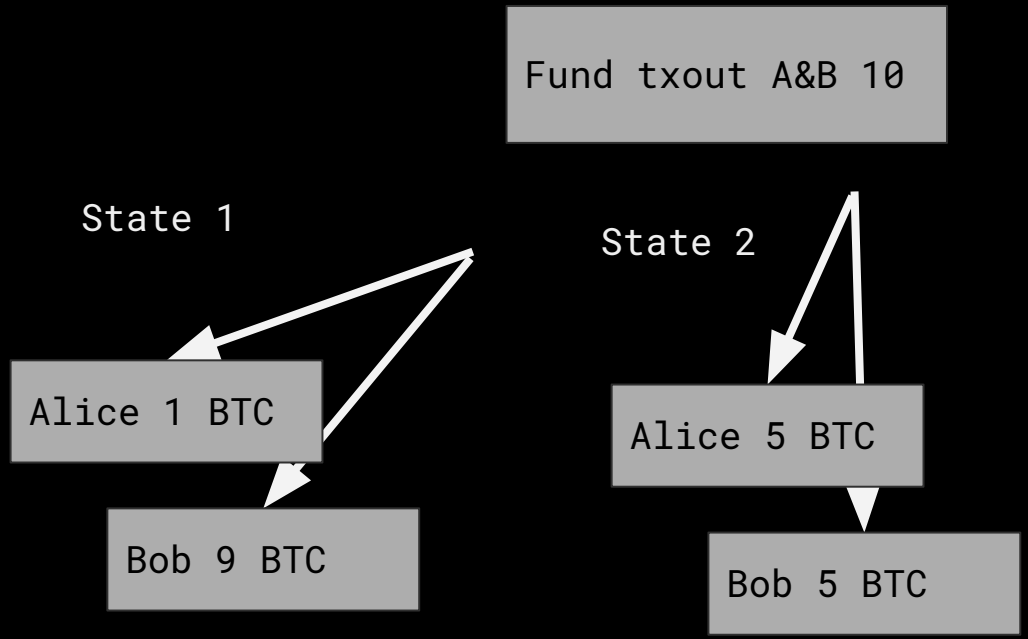
add and delete states



In Lightning, states are added sequentially, and validity is enforced by revealing private keys to previous states

add and delete states



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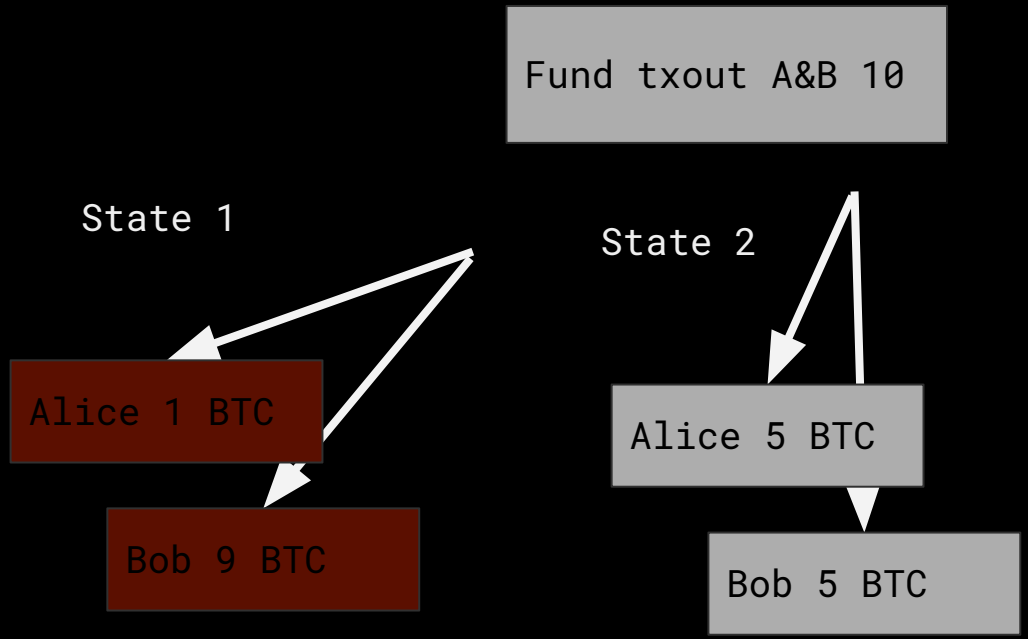

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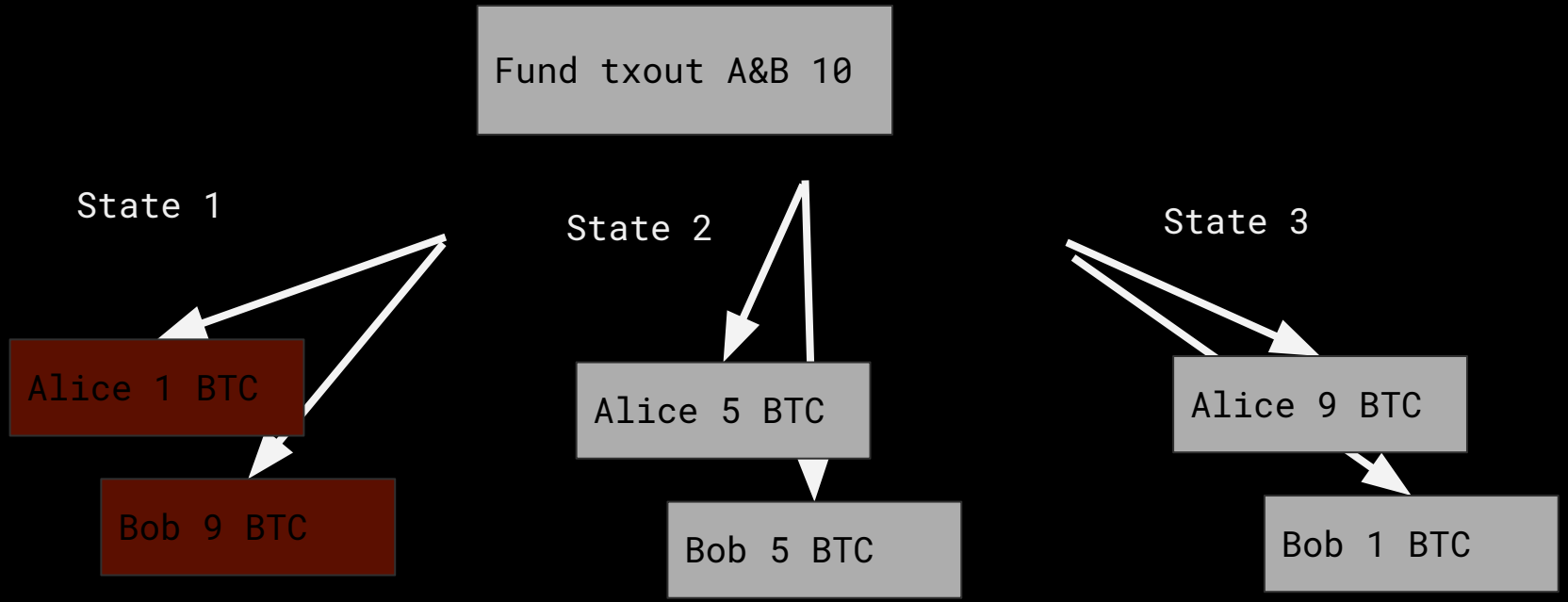

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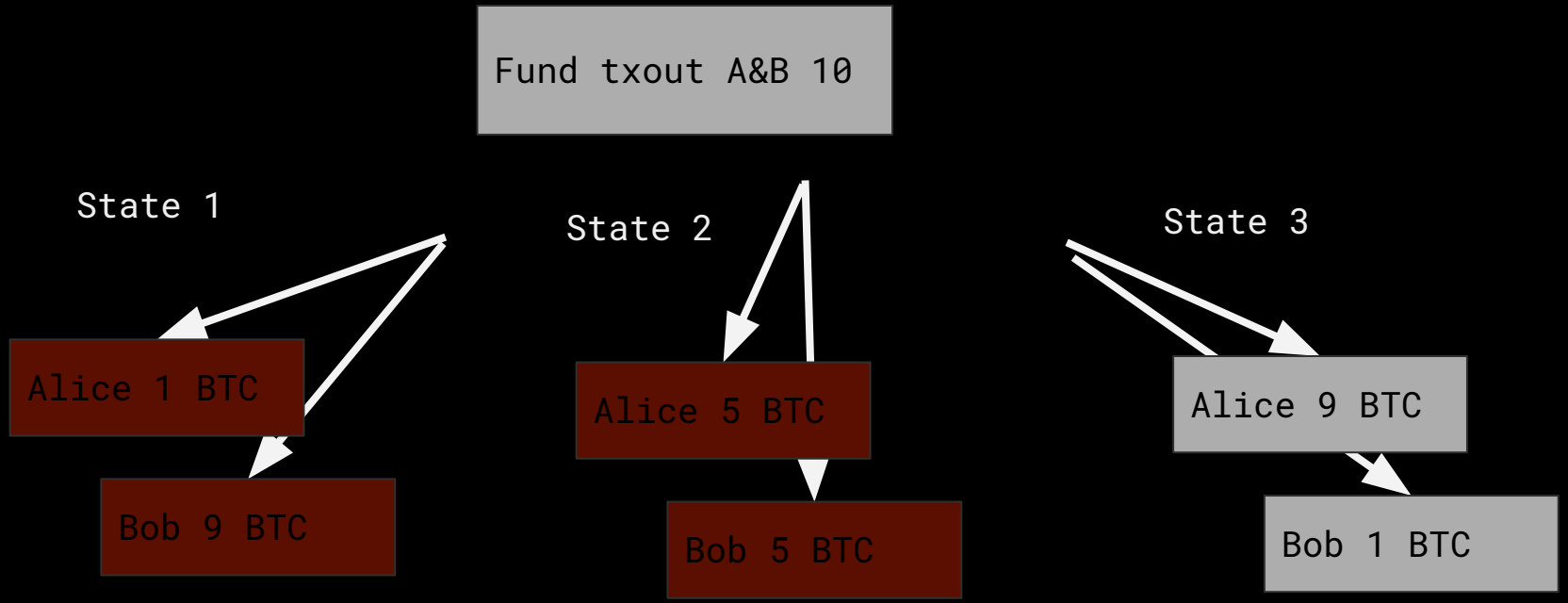

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reveal to revoke

Either party broadcasts & has to wait

Alice gives Bob the AliceR privKey

Bob gives Alice the BobR privKey

Now if they broadcast the counterparty can take all funds while they wait!

preimage or private key

KeyA && time

|| (KeyB && KeyC)

optimizations here?

preimage or private key

KeyA && time

|| (KeyB && KeyC)

KeyC could be a hash/preimage pair, 20 bytes instead of ~70

Even smaller?

Adding keys

Add KeyB and KeyC

B + C = R

what's the private key for R?

Adding keys

Add KeyB and KeyC

B + C = R

what's the private key for D?

bG + cG = rG

(b + c)G = rG

sum of private keys works

reduced script

KeyD || KeyA && time

opcodes:

OP_IF KeyR OP_ELSE

<delay> OP_CHECKSEQUENCEVERIFY

OP_DROP KeyA OP_ENDIF OP_CHECKSIG

reduced script

stack: 1 SigR

```
OP_IF    KeyR    OP_ELSE
<delay> OP_CHECKSEQUENCEVERIFY
OP_DROP    KeyA   OP_ENDIF   OP_CHECKSIG
```

reduced script

stack: 0 SigA

```
OP_IF    KeyR    OP_ELSE
<delay> OP_CHECKSEQUENCEVERIFY
OP_DROP    KeyA   OP_ENDIF   OP_CHECKSIG
```

reveal key, revoke state

need to keep track of old secrets

one for each state

32 bytes each... not great for scaling

hash tree

reveal secrets 1 at a time

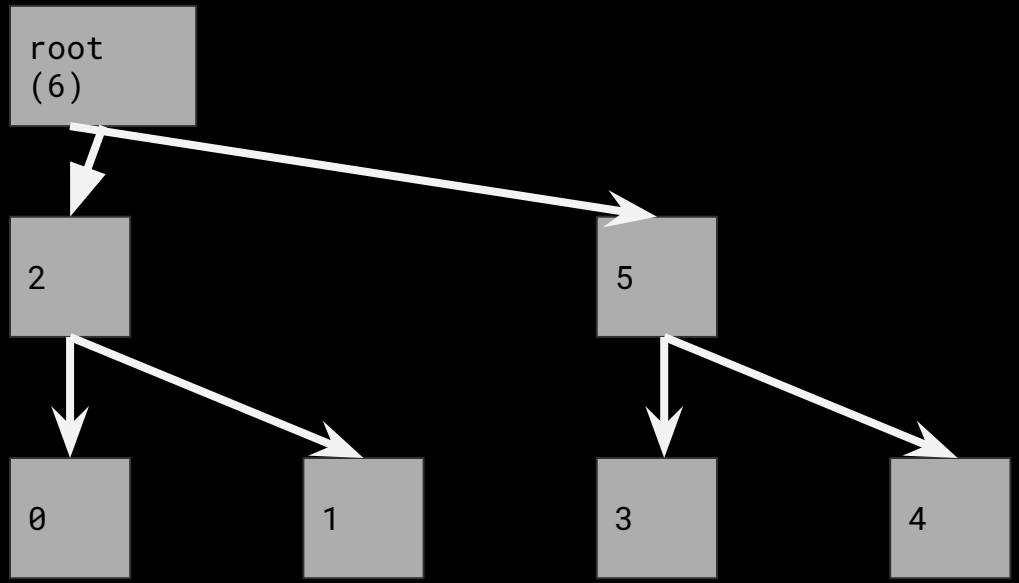
store only log(n) secrets

recompute any received secret

Elkrem

left child: append 0, hash

right child: append 1, hash



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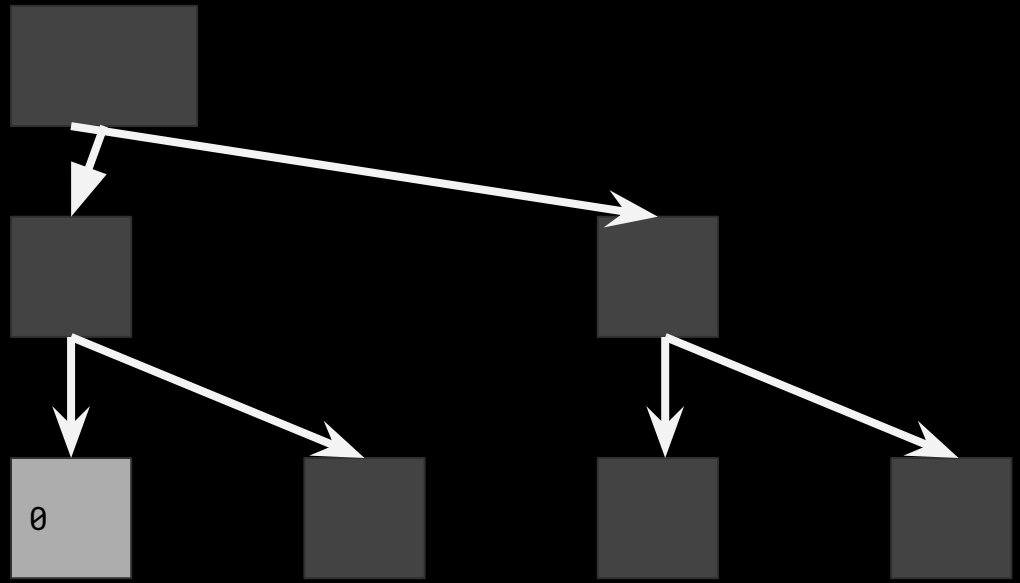

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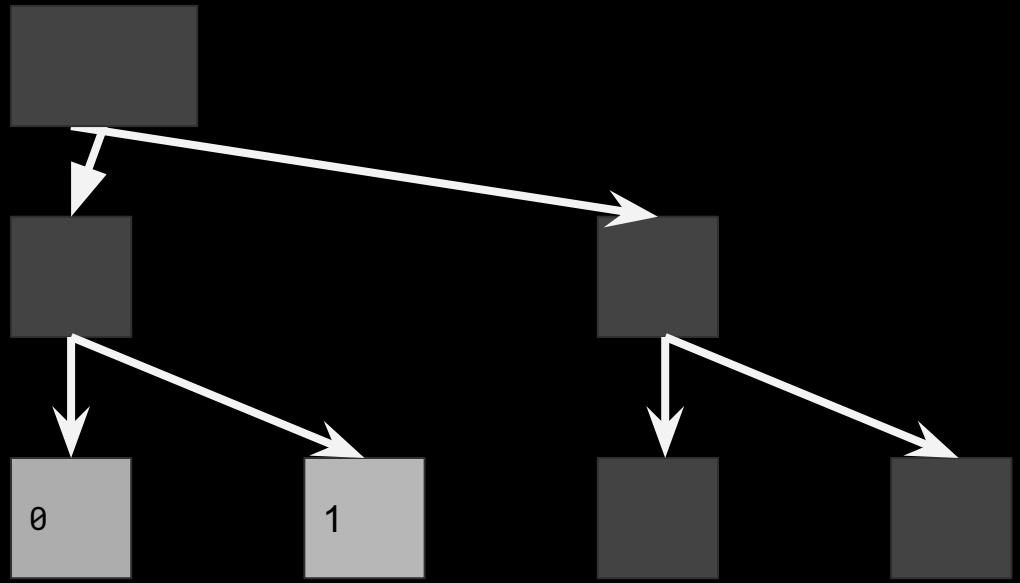

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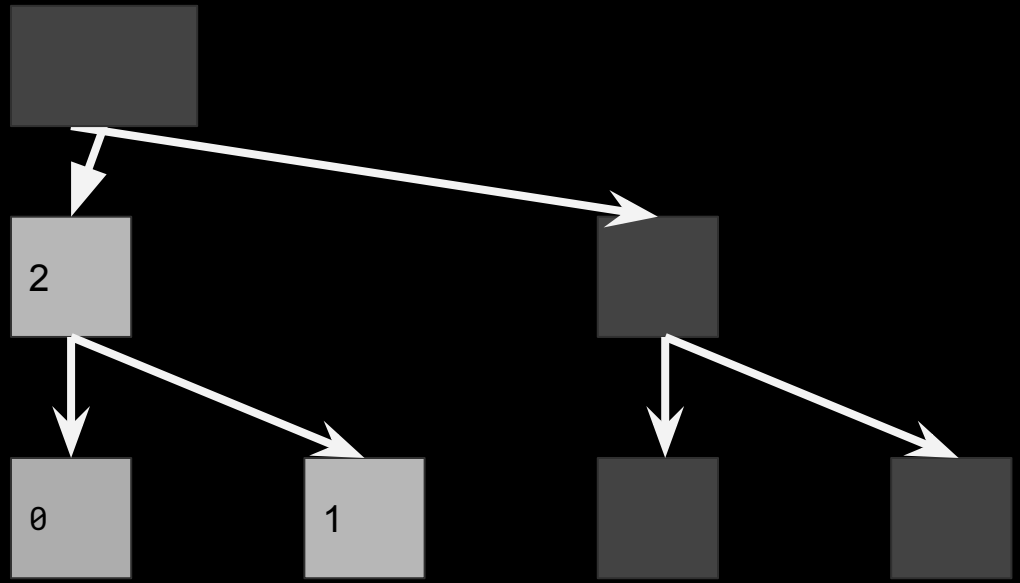

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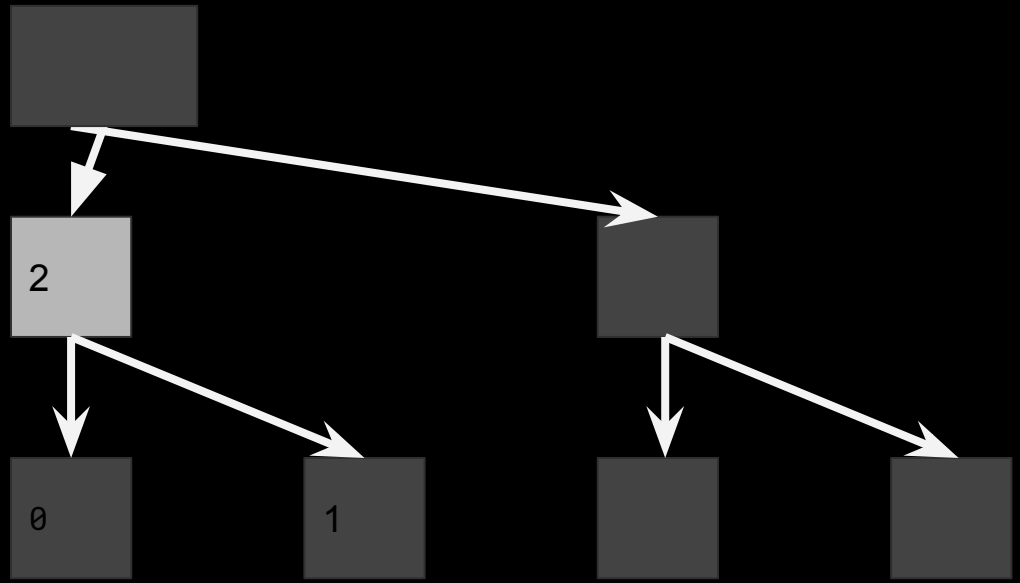

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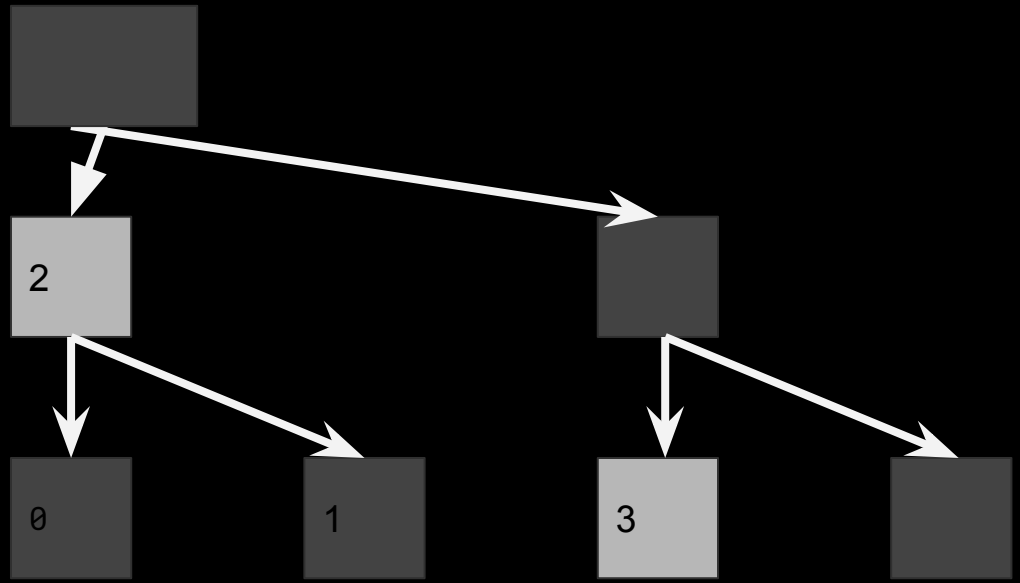

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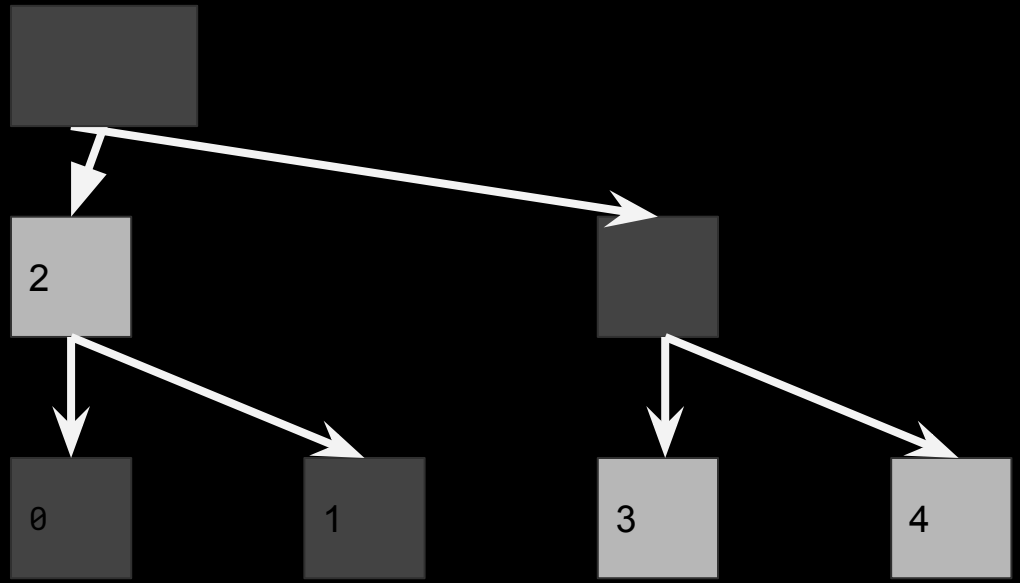

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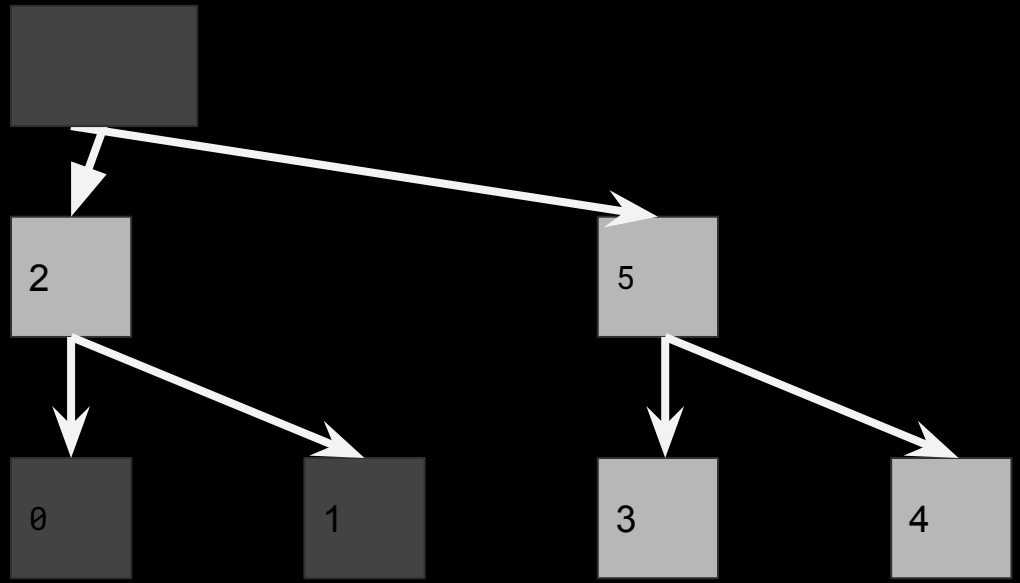

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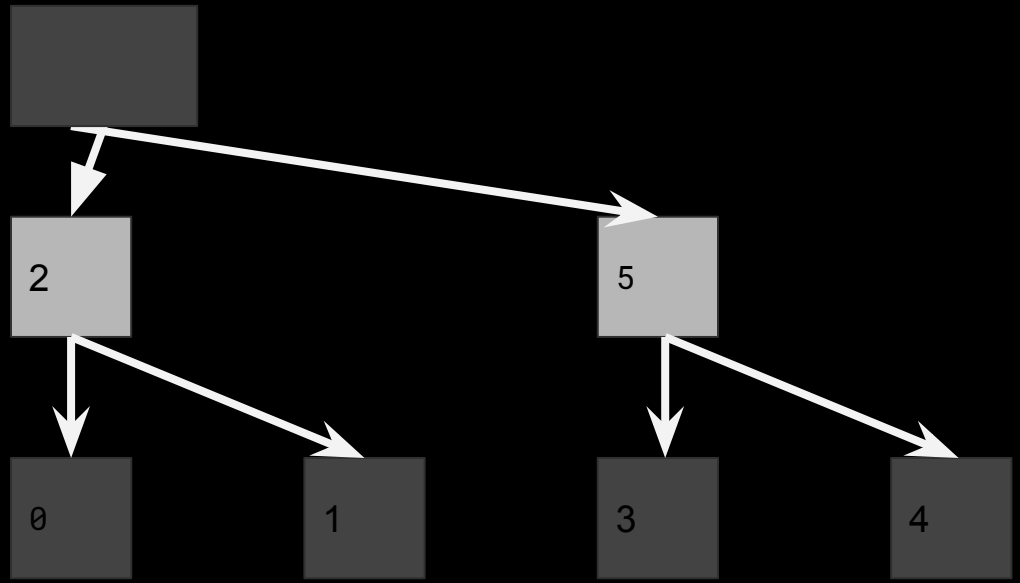

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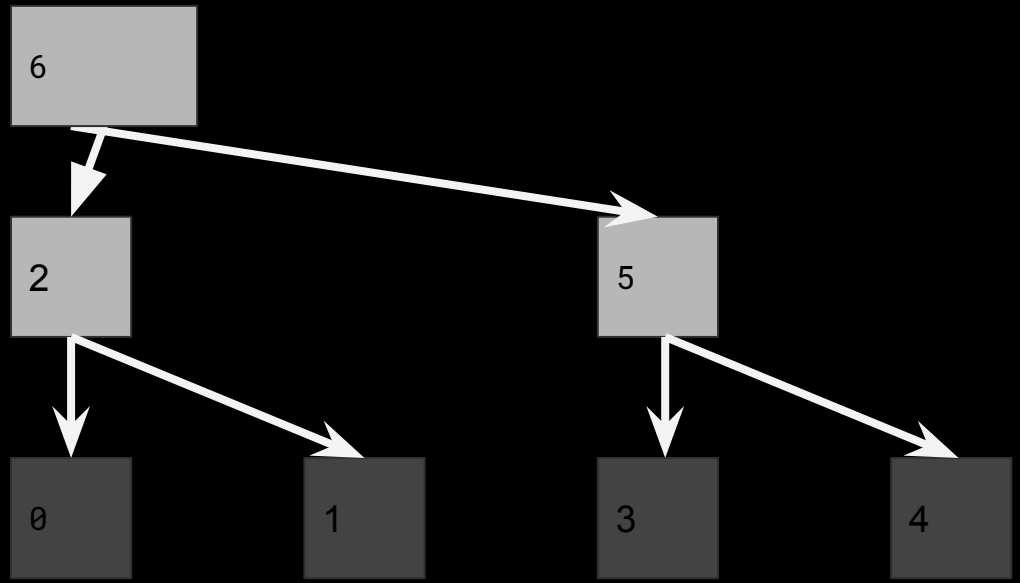

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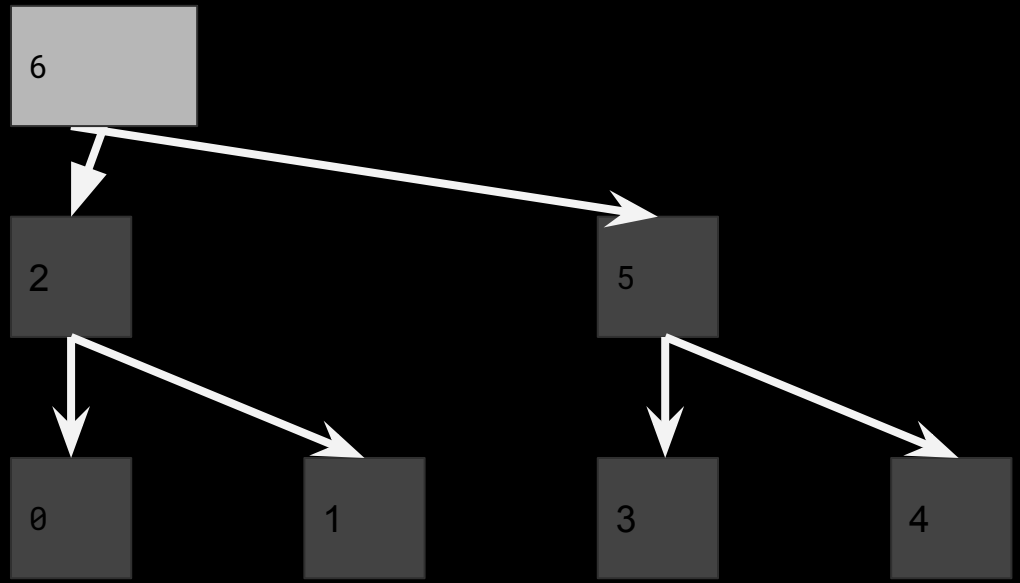


intermission

0x7f sec to stretch

cross chain

there are altcoins

most of them (used to) work like Bitcoin, as they just copied the whole codebase on github

(see e.g. coingen.io)

some recent coins very different

cross chain

people trade altcoins for bitcoins

they even trade altcoins for altcoins

how to trade? use "exchanges"

coin exchanges

exchange model:

give us all your coins

post orders on our site to swap

ask for your coins back

coin exchanges

exchange model:

give us all your coins

(this part works fine)

post orders on our site to swap

ask for your coins back

coin exchanges

exchange model:

give us all your coins

post orders on our site to swap

ask for your coins back

(here's where the model tends to fail)

cross-chain swaps

no custody

you get coinA iff I get coinB

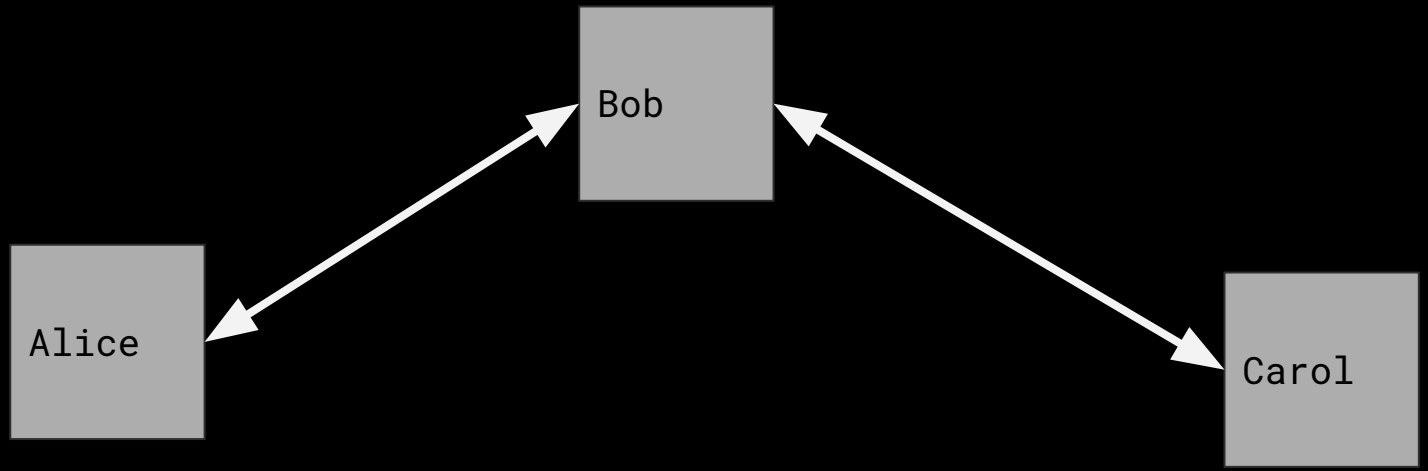
use HTLCs just like in lightning network

channels are on different networks

Preimage determines who spends

Commit Tx (held by Bob)	
input	output
fund txid Alice's signature	Alice address: 2 coins
	Bob key && 100 blocks || Alice && BobR key 7 coins
	HTLC Alice && R || Bob && height 500000 1 coin

cross chain



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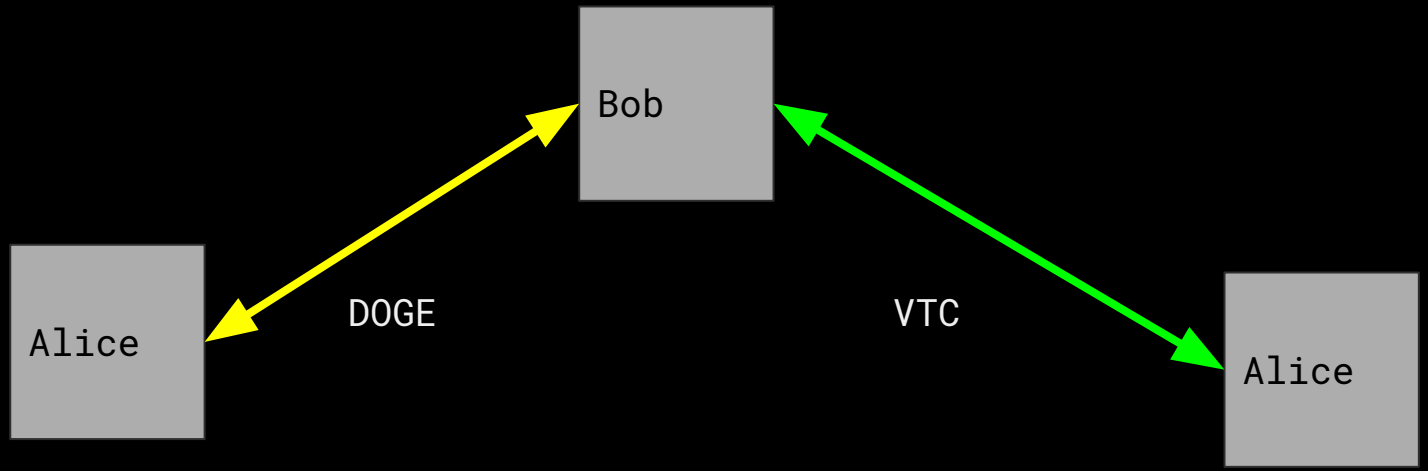
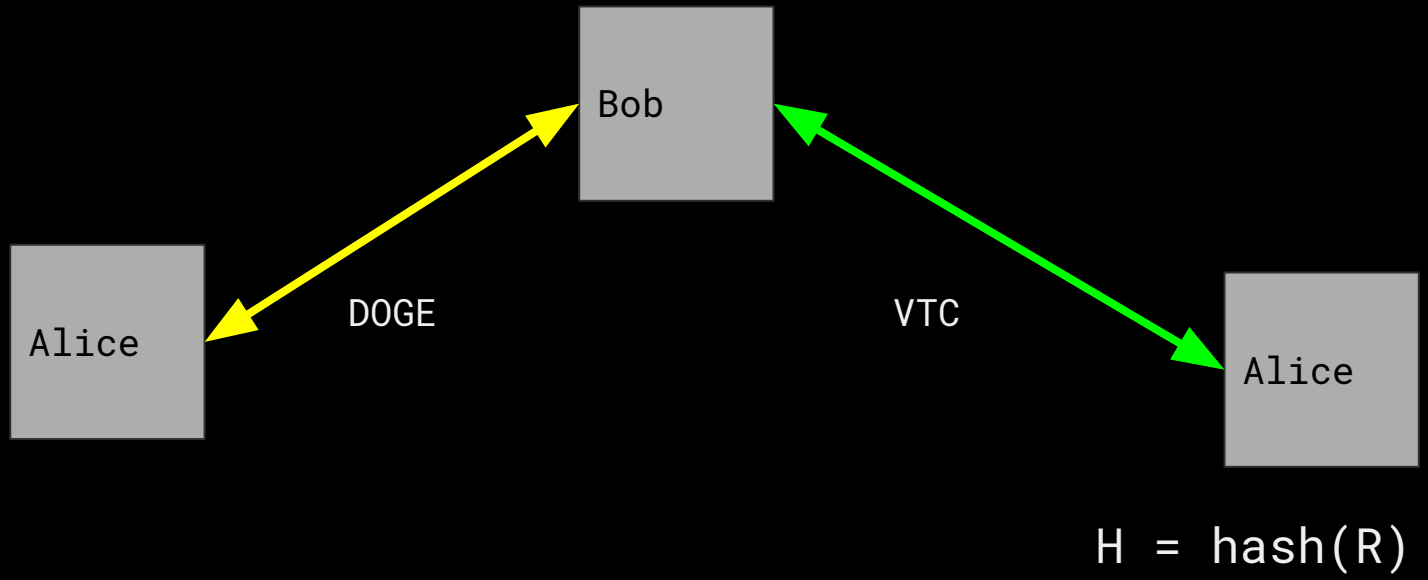
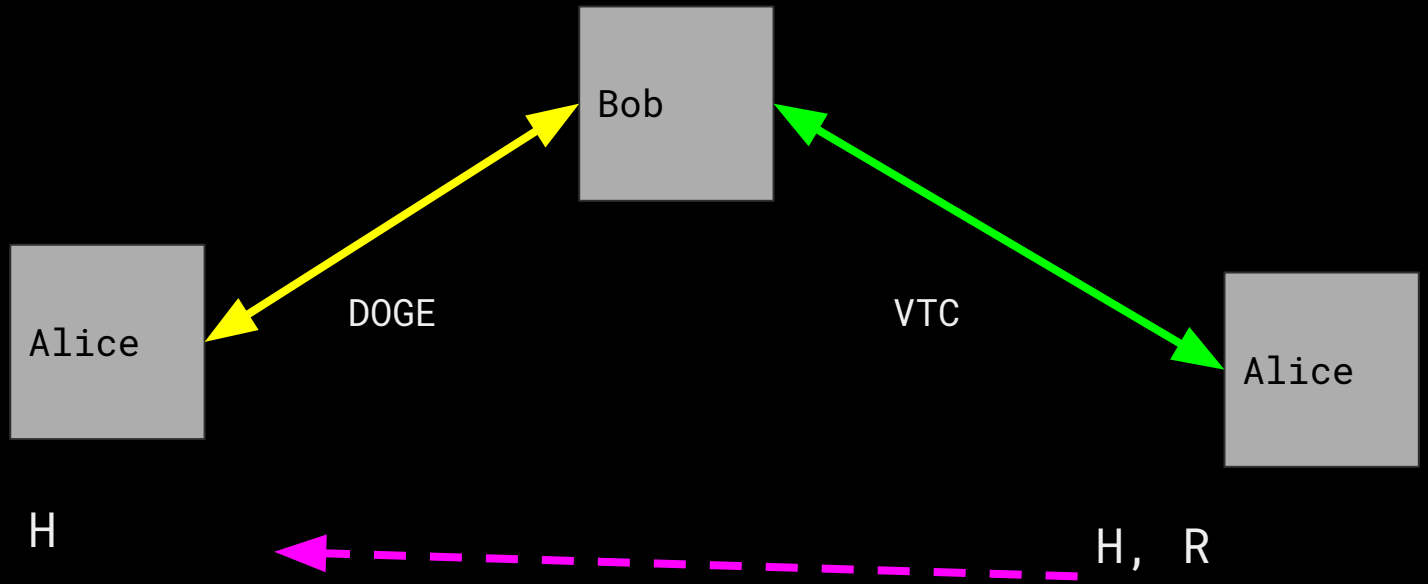


HTLC construction



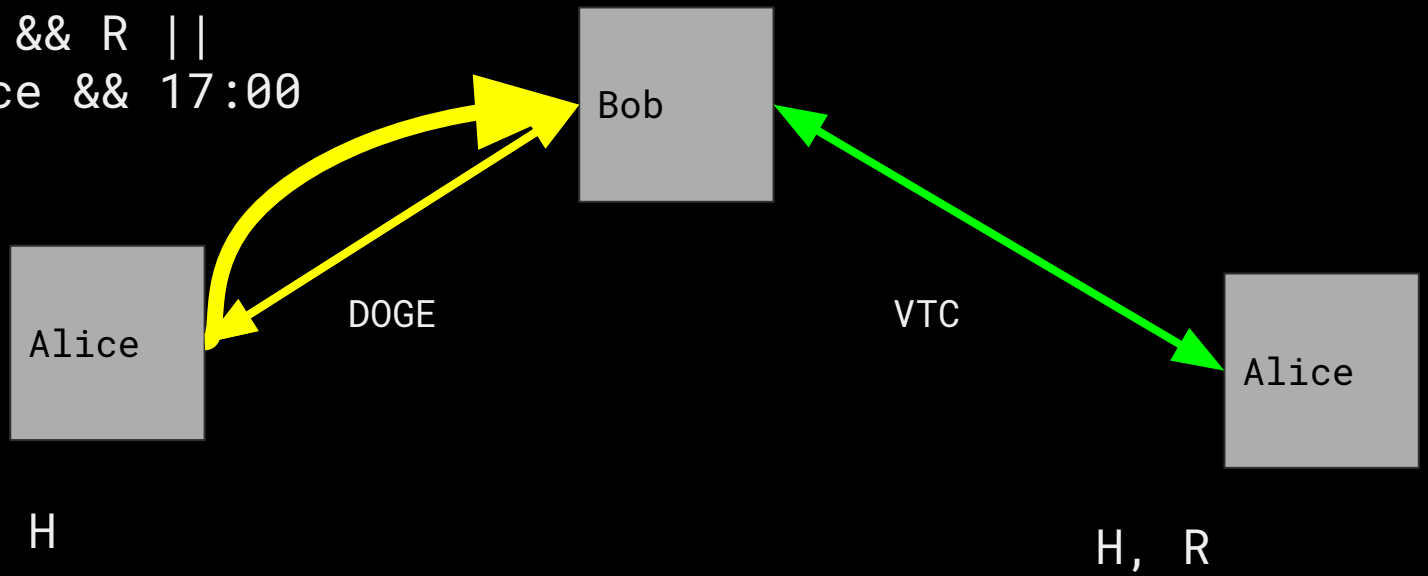
H = hash(R)

HTLC construction



HTLC forwarding

HTLC:
Bob && R ||
Alice && 17:00



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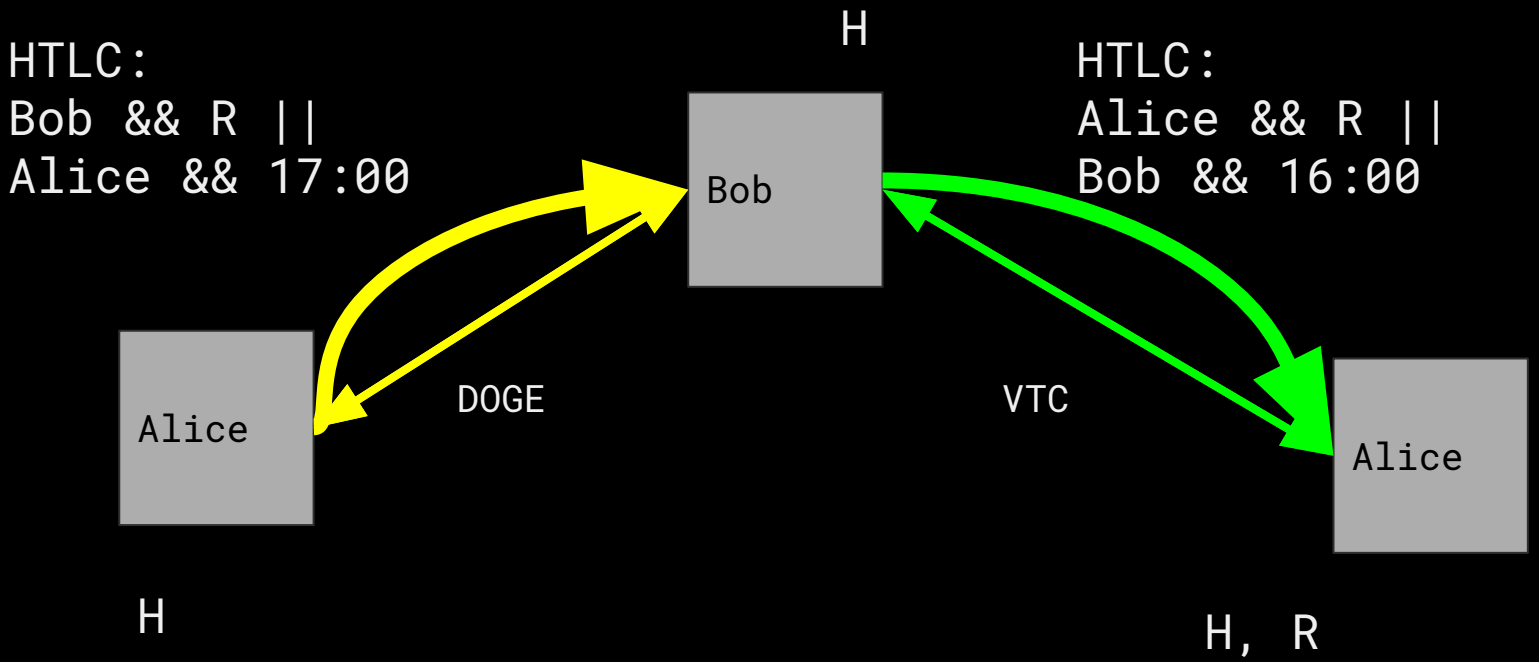
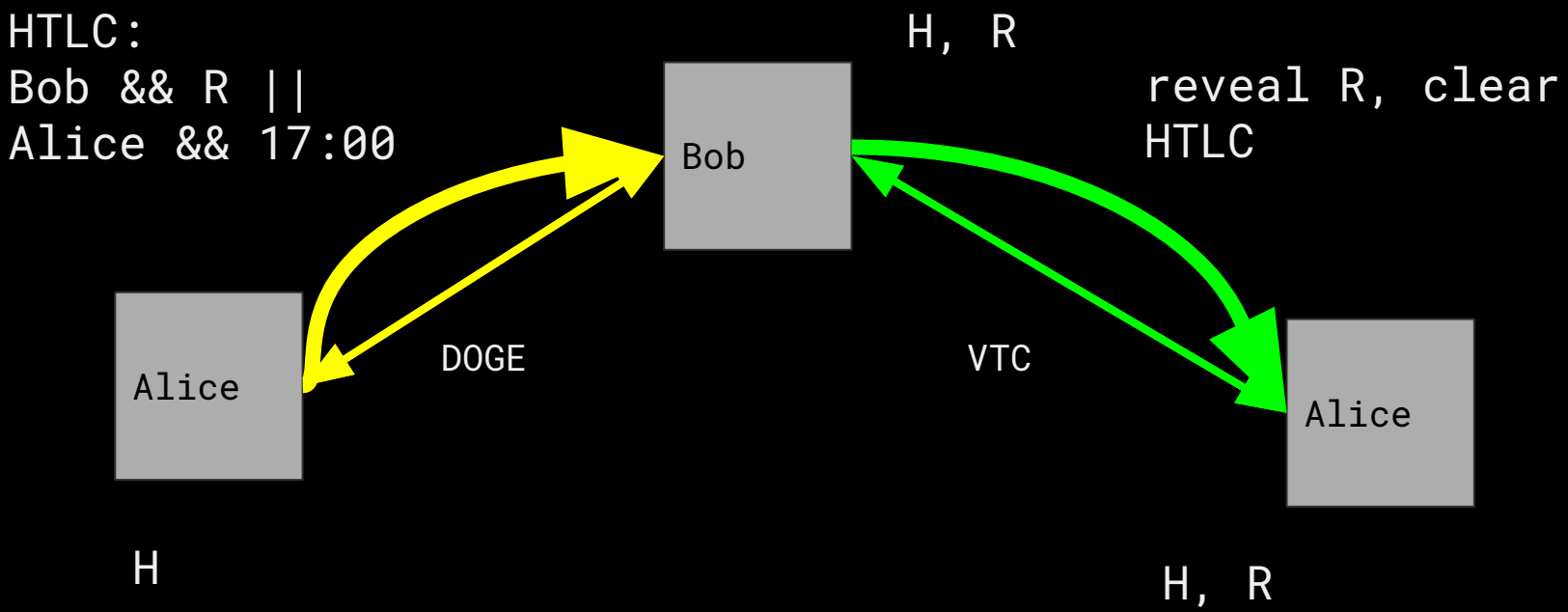


HTLC clearing



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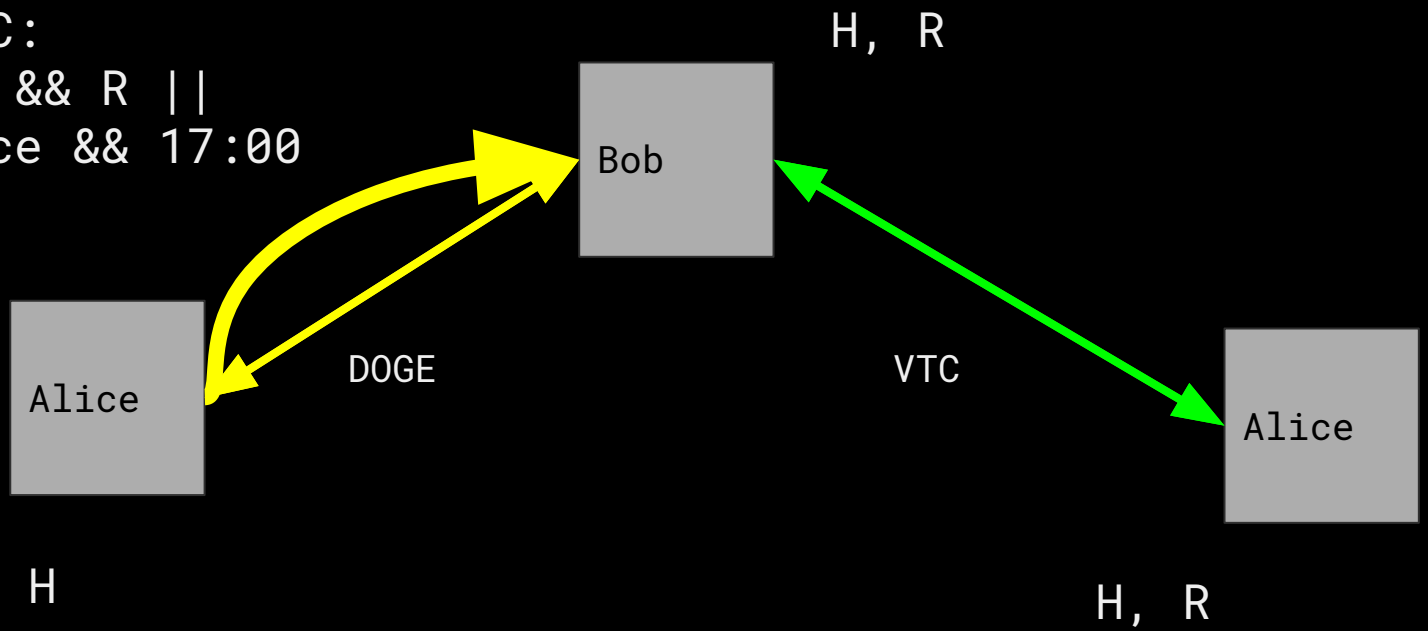

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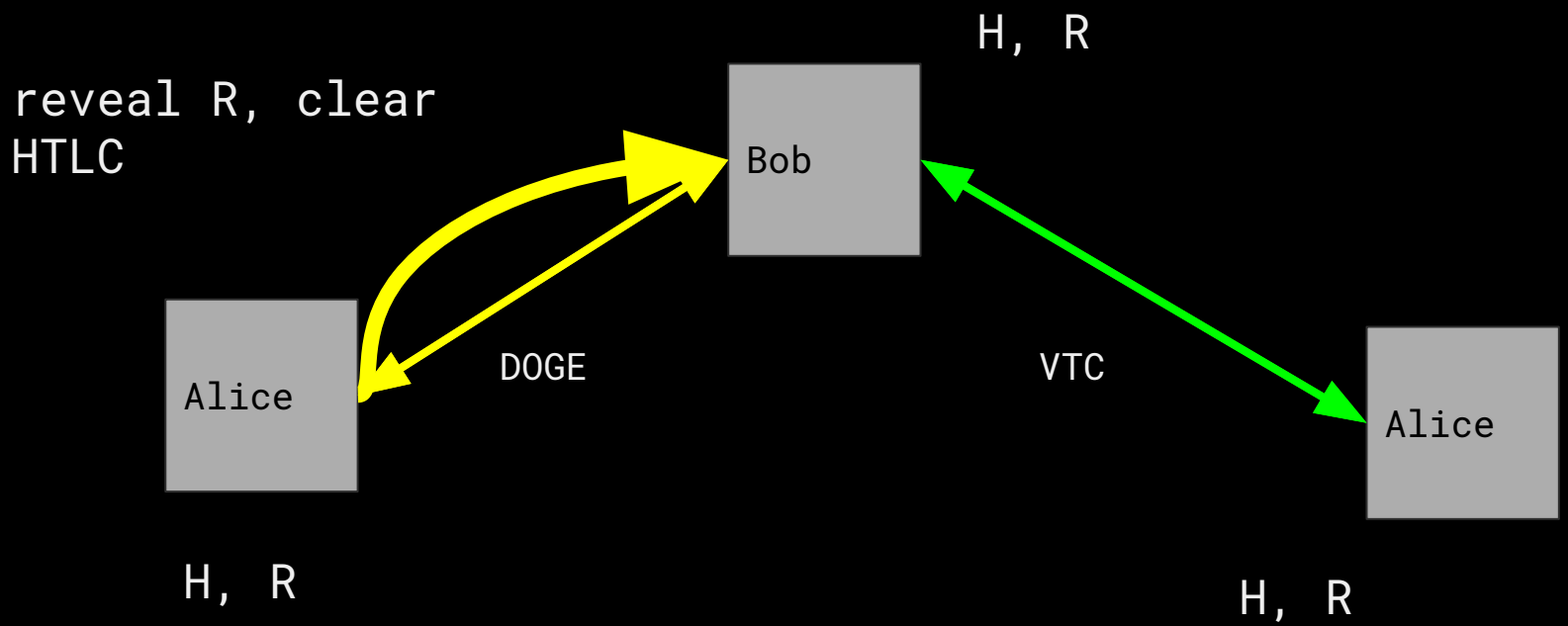

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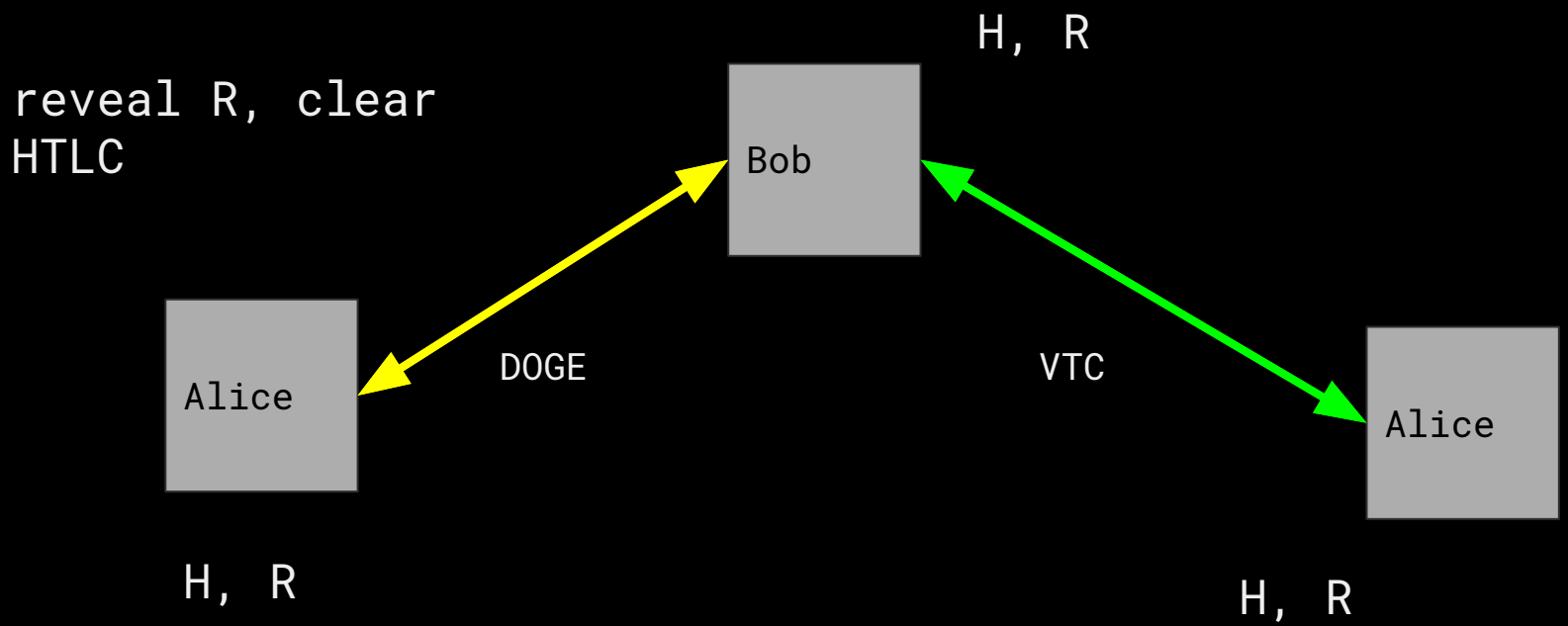

cross chain swaps

H can be revealed on either chain, so both parties need to watch both blockchains

They have channels on each chain so that makes sense

Receiver doesn't need to be initiator, but probably will be

how to trade

good for trade execution, but what about discovery?

how to trade

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post orders on blockchain?

how to trade

good for trade execution, but what about discovery?

post orders on blockchain?

non-binding, frontrunning, non-scalable

how to trade

multiple models:

central orderbook & counterparty

- exchange is one side of every trade and keeps the spread
- similar centralization to current custodial model, but less risk

how to trade

multiple models:

central orderbook, multiple counterparties

- connecting to many counterparties is costly
- how to enforce trade execution?

how to trade

multiple models:

distributed orderbook

- how to ensure fairness?
- how to enforce trade execution?
- scalability of orders?

cross-chain swaps

basic idea works, but still many unsolved questions

further research required

people working on this here! (ask)