how to build a private dex

henry de valence // penumbra @ devcon vi, bogota // 12 october 2022

penumbra is {

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- private proof-of-stake L1

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interchain shielded pool

penumbra is

- private proof-of-stake L1
- interchain shielded pool
- private dex

why build a private dex?

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why build a private dex?

because every market is a market in information

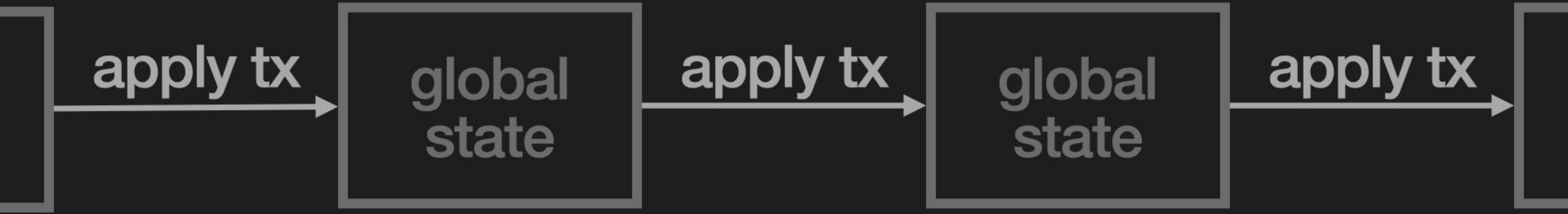
…so information leaks are value leaks

…so privacy unlocks capital efficiency

first challenge: state model

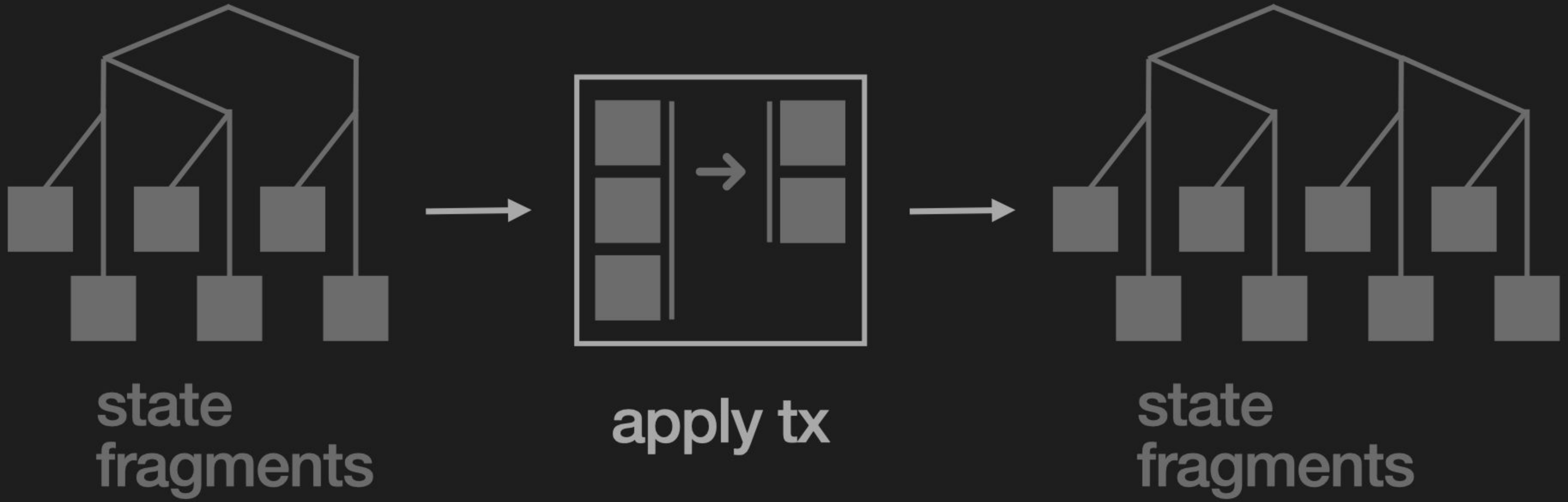
transparent blockchains use

mutable state



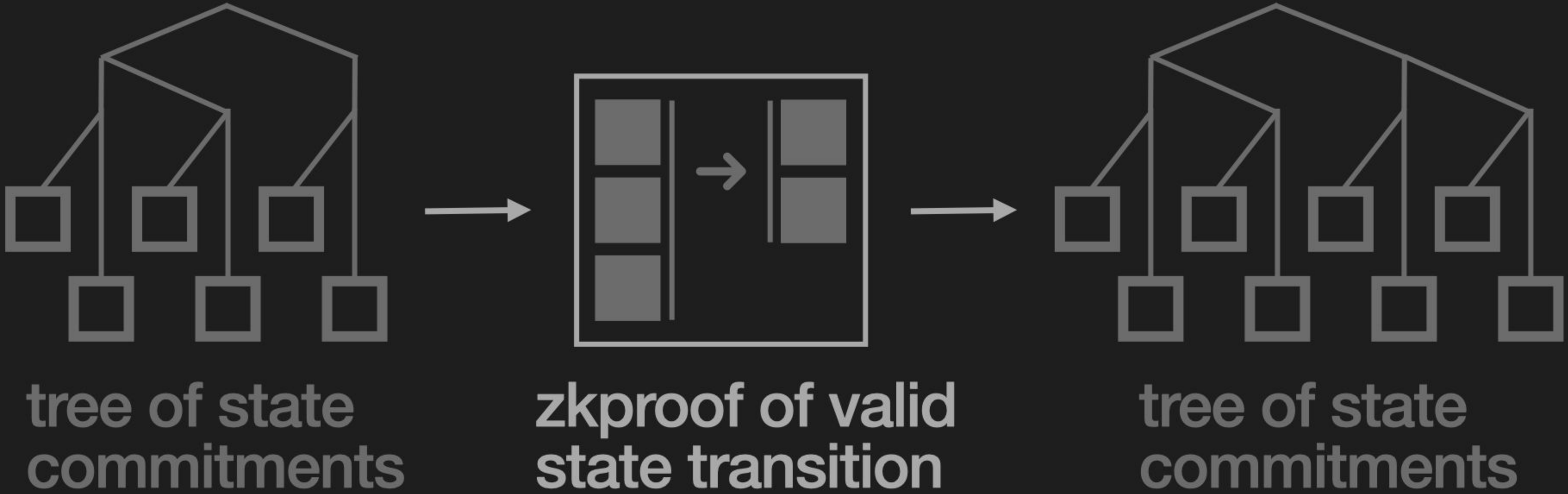
shielded blockchains need

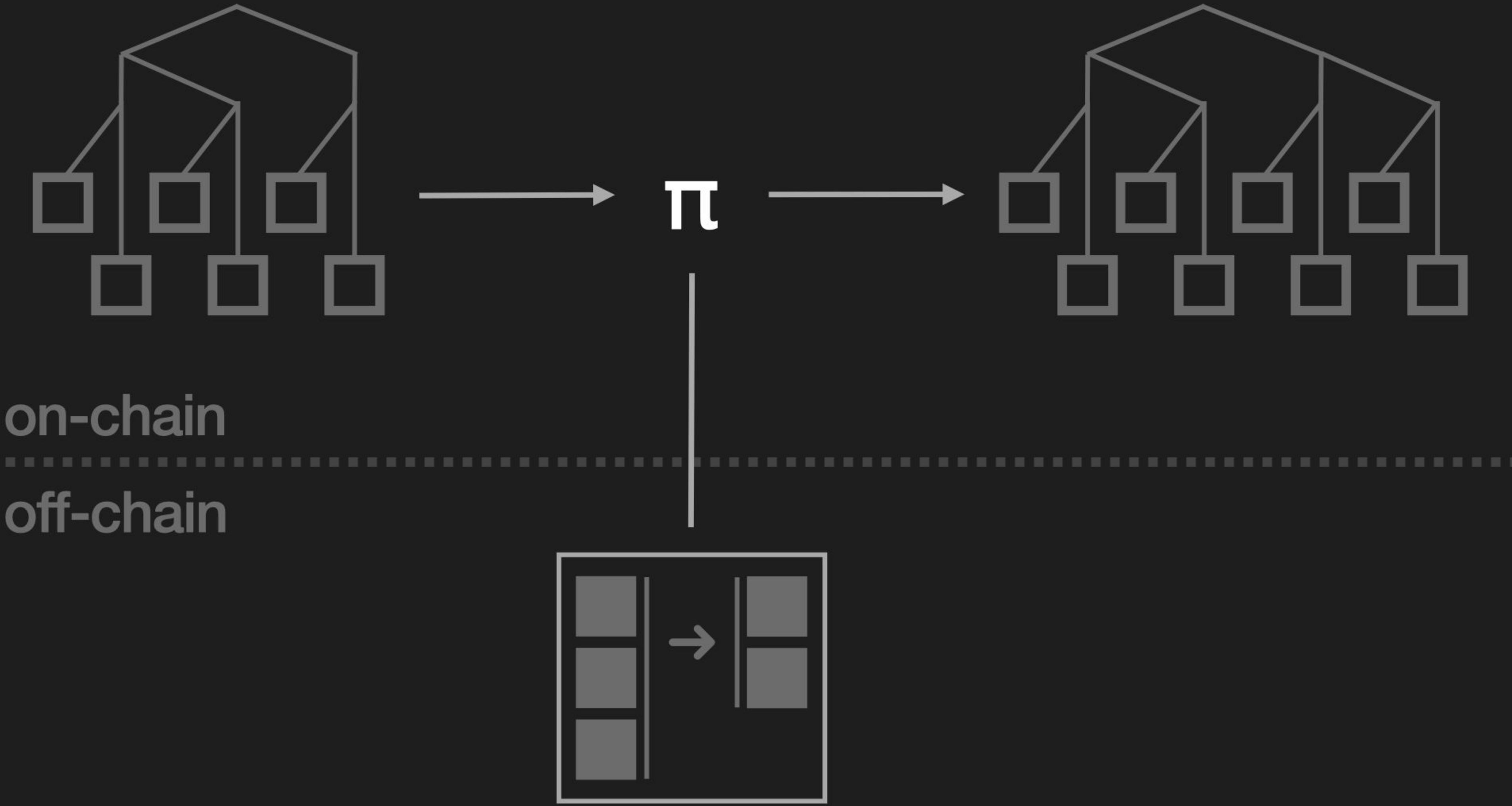
composable state



...so that **state transitions**

can be **private**

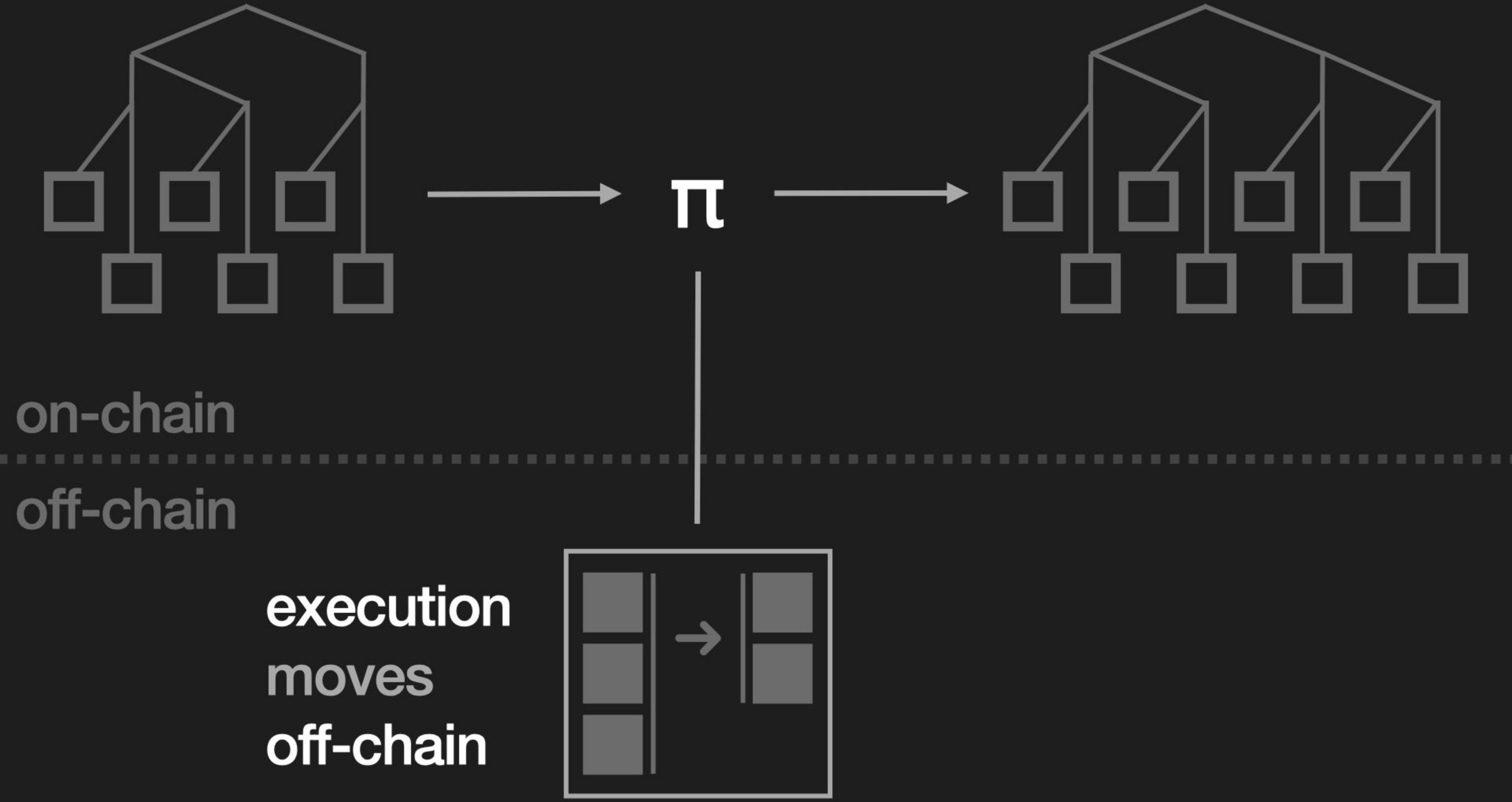

tree of state commitments
zkproof of valid state transition
tree of state commitments



π

on-chain

off-chain



execution
moves
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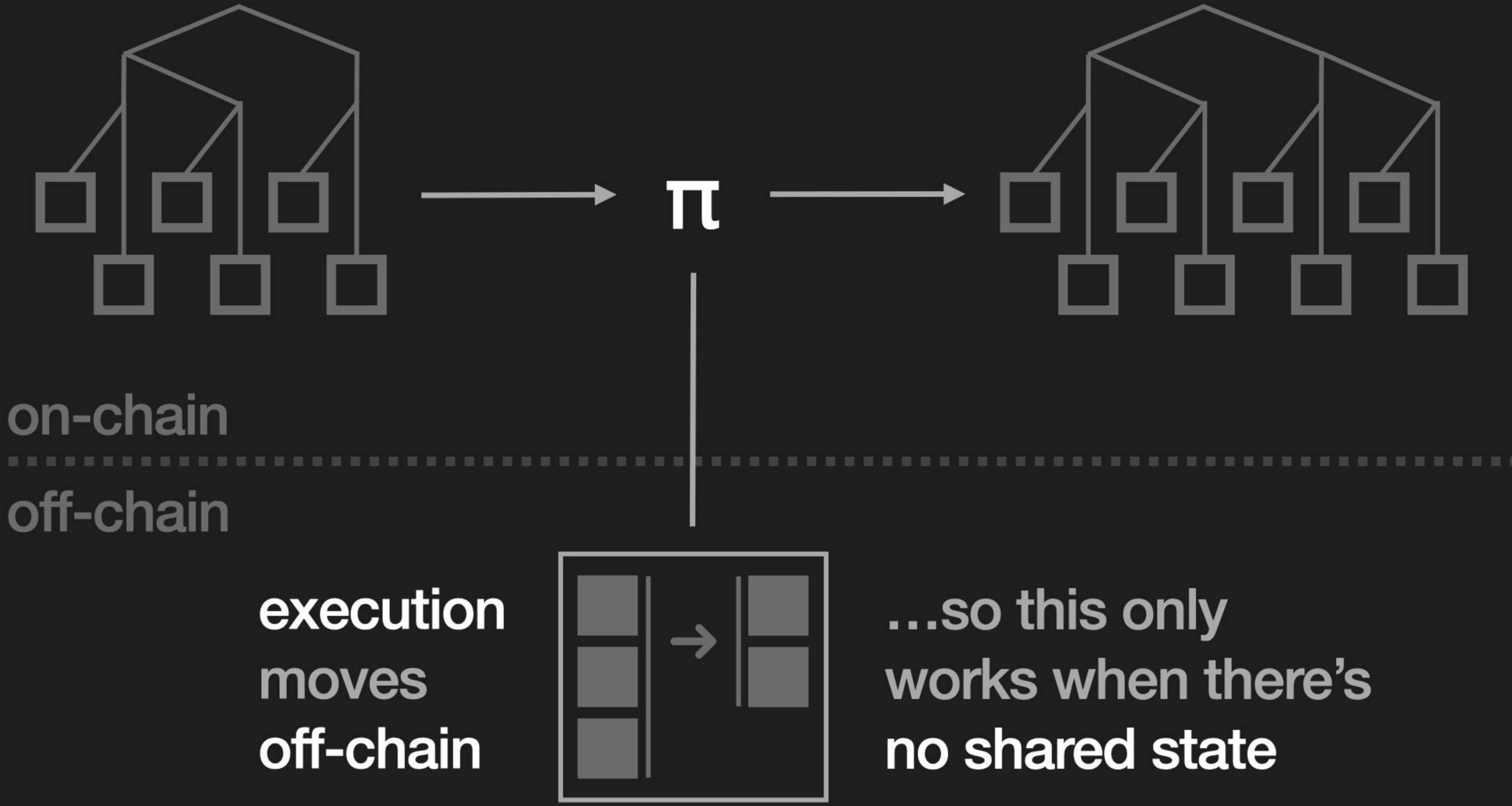

on-chain

off-chain

execution moves **off-chain**

…so this only works when there’s **no shared state**

how do we recover late binding?

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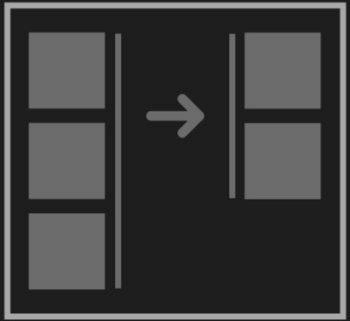
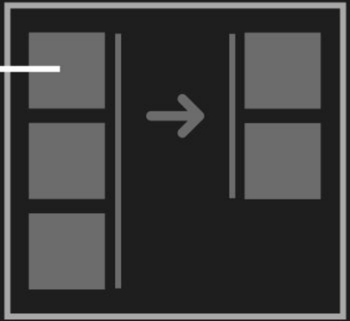


what we have:
early binding

how do we recover late binding?



entire tx is "sealed"

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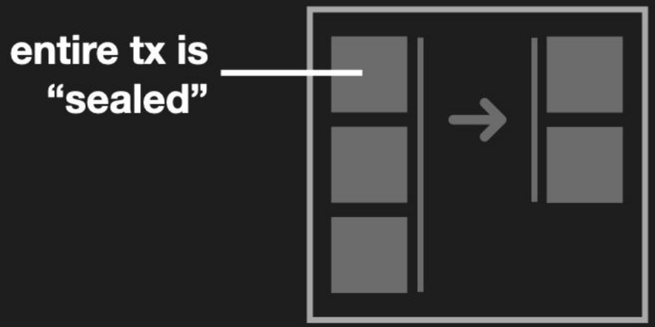

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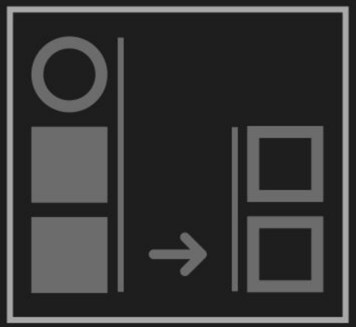

what we want:
late binding

how do we recover **late binding?**

entire tx is
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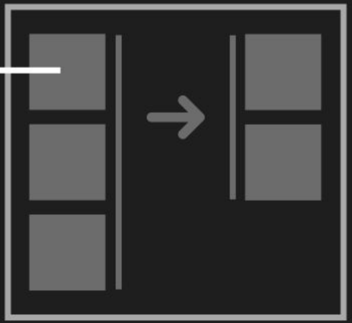

what we have:

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when tx is
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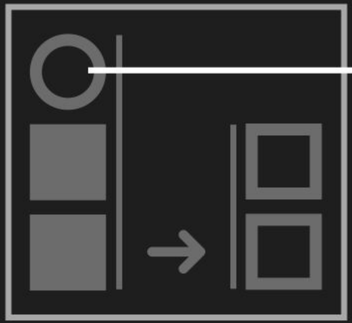

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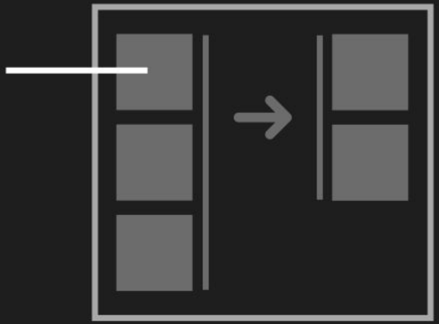

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what we have:
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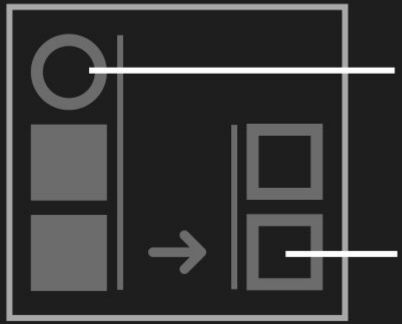

when tx is
executed,
shared state
goes here

and determines
these outputs

what we want:
late binding

we need a better

concurrency model

for **shared state**

what if we model concurrency
with message passing
instead of locking?

an actor model for blockchains

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transactions pass messages to contracts

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each contract executes once per block, on all messages, allowing batch processing

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user state executes async, off-chain, in zk

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user state executes async, off-chain, in zk

unlocks scalability *and* privacy!

async zk execution via message passing

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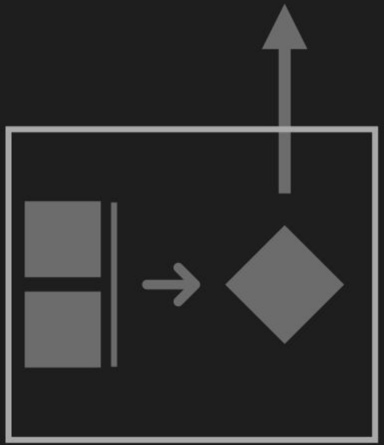

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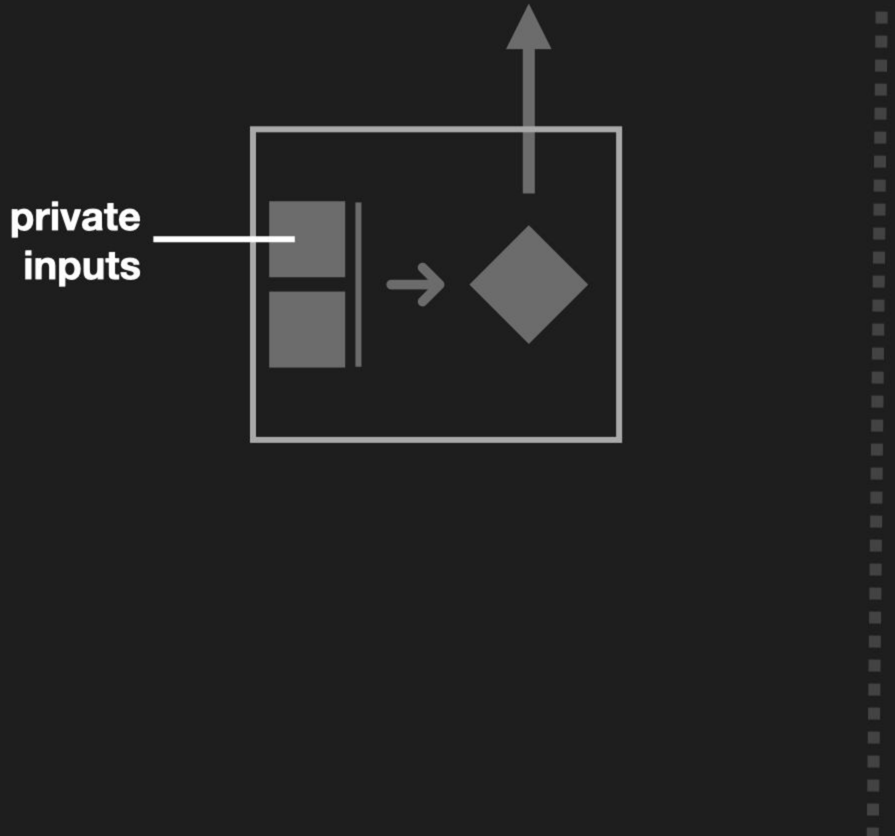

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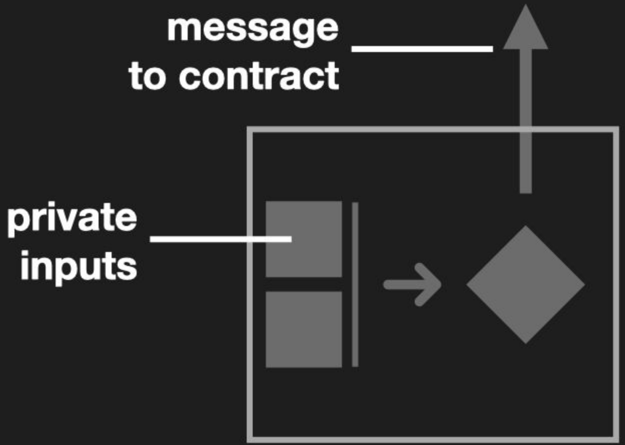

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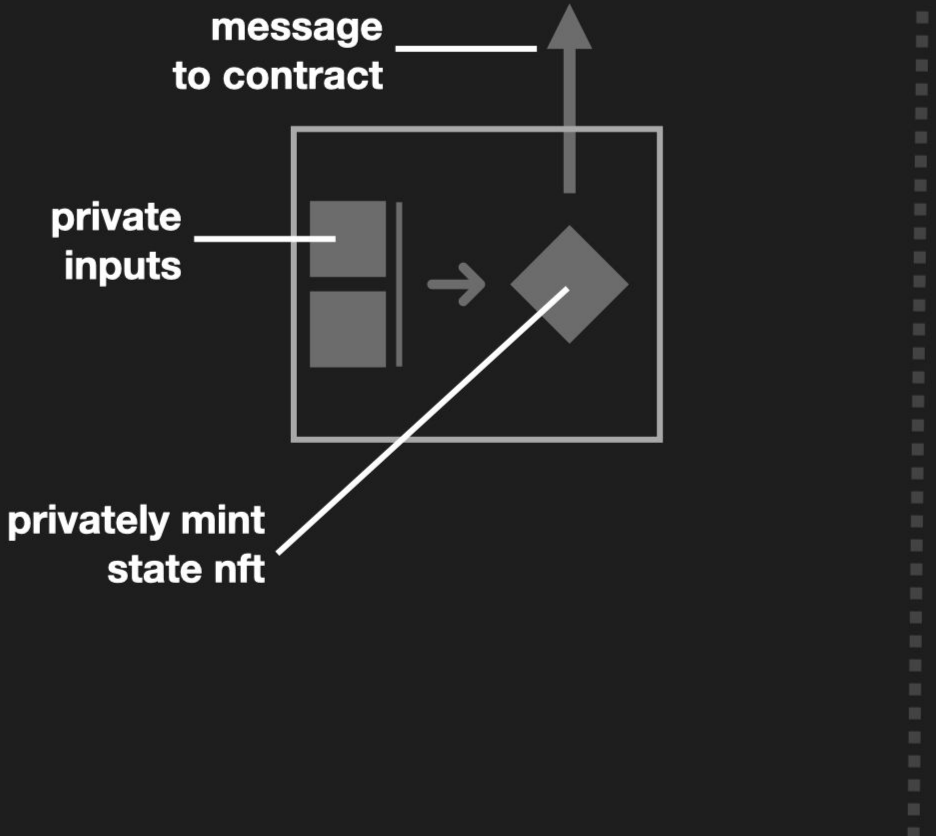

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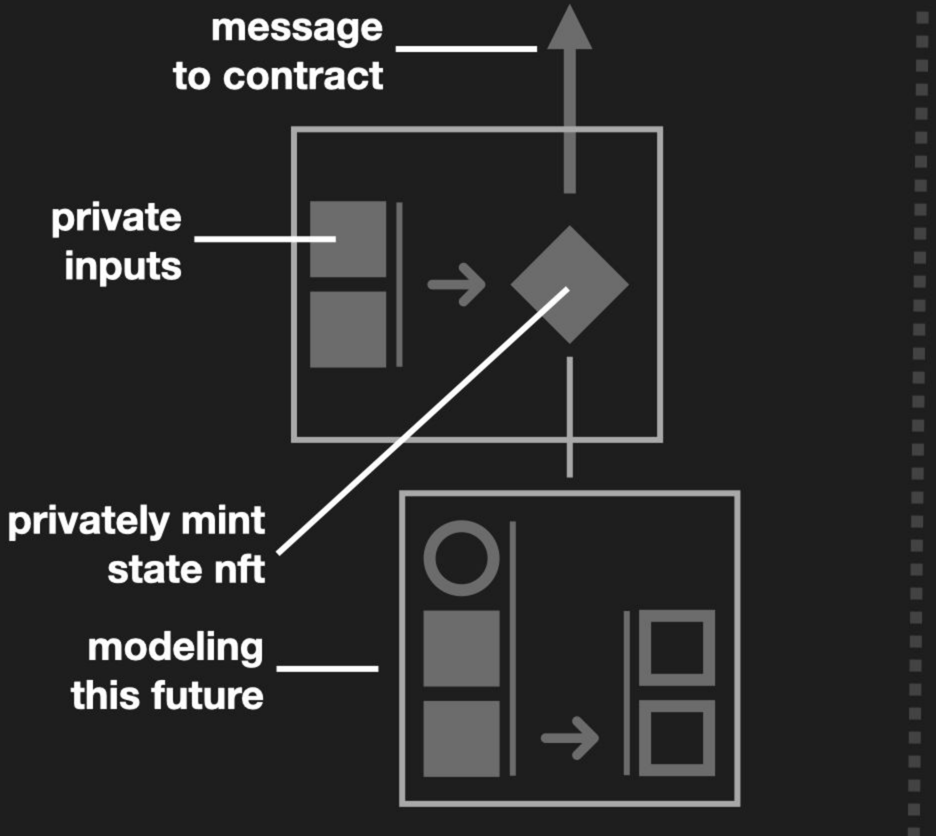

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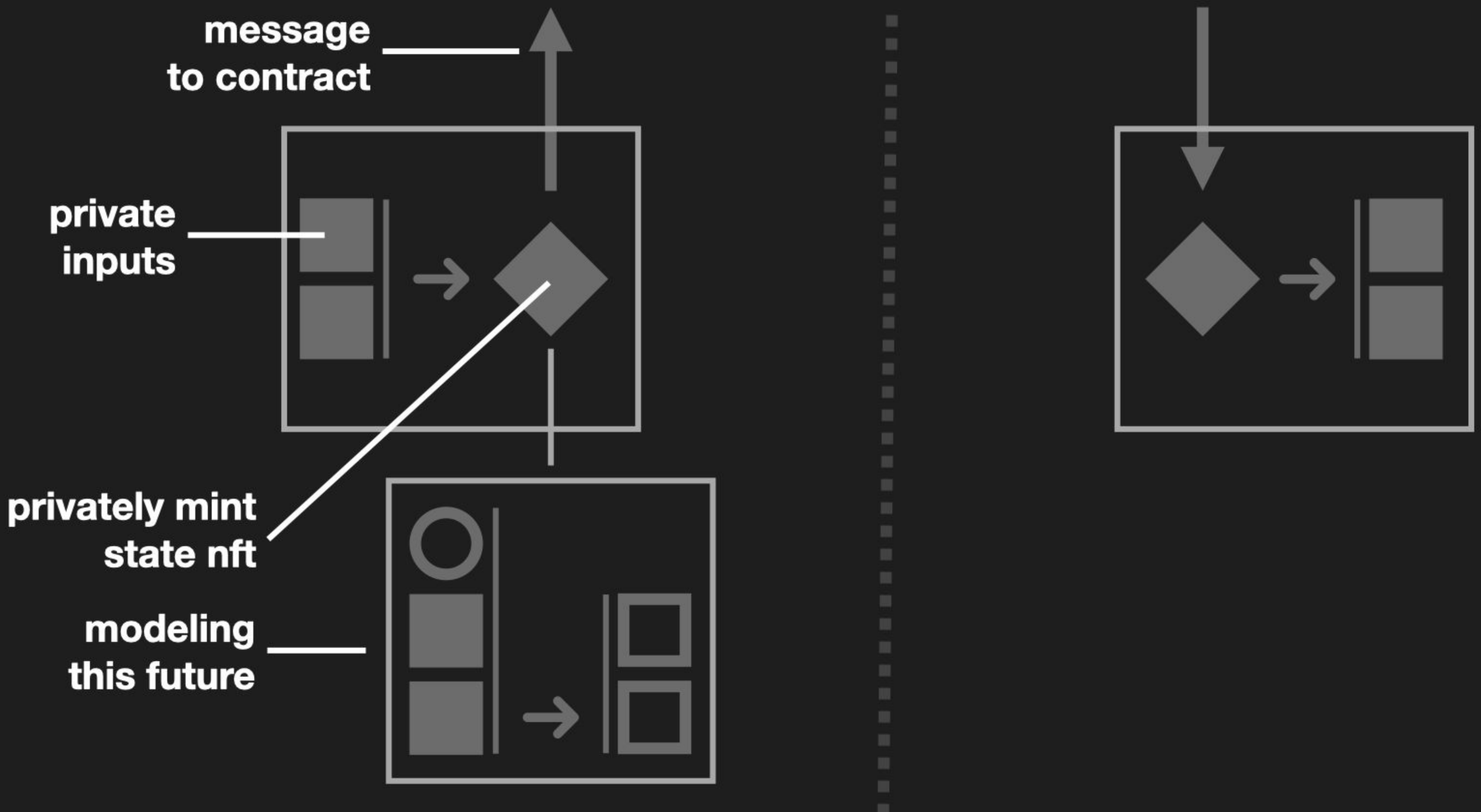

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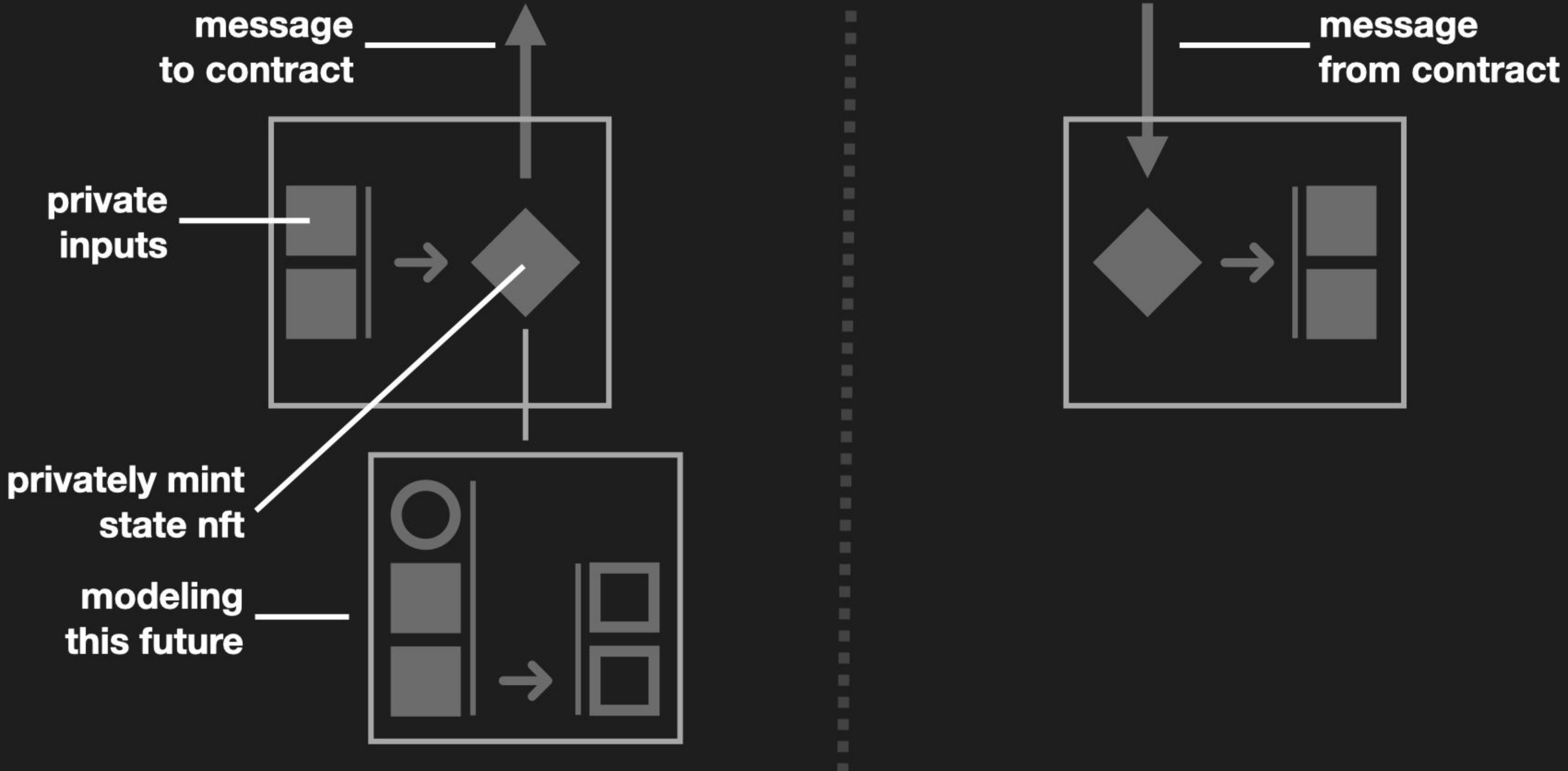

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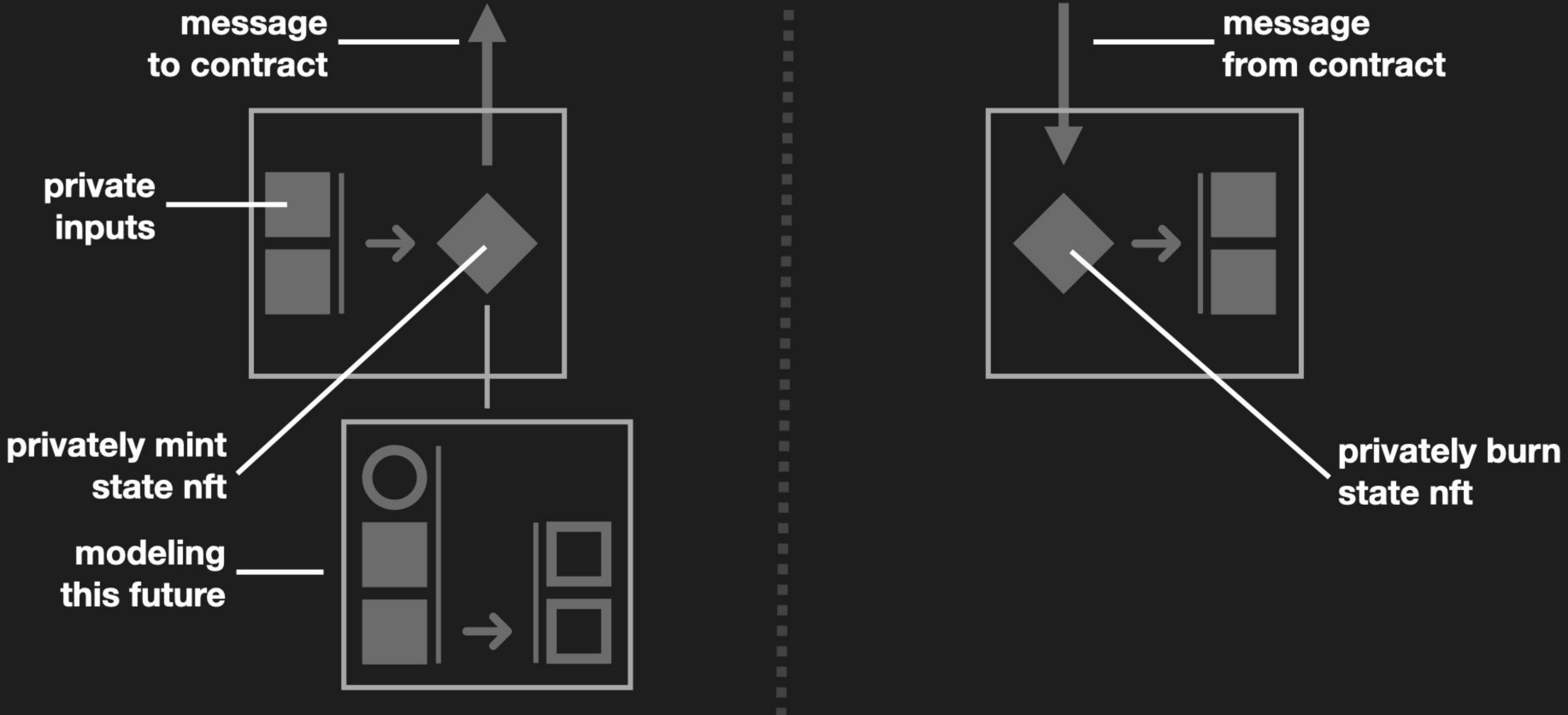


message to contract

private inputs

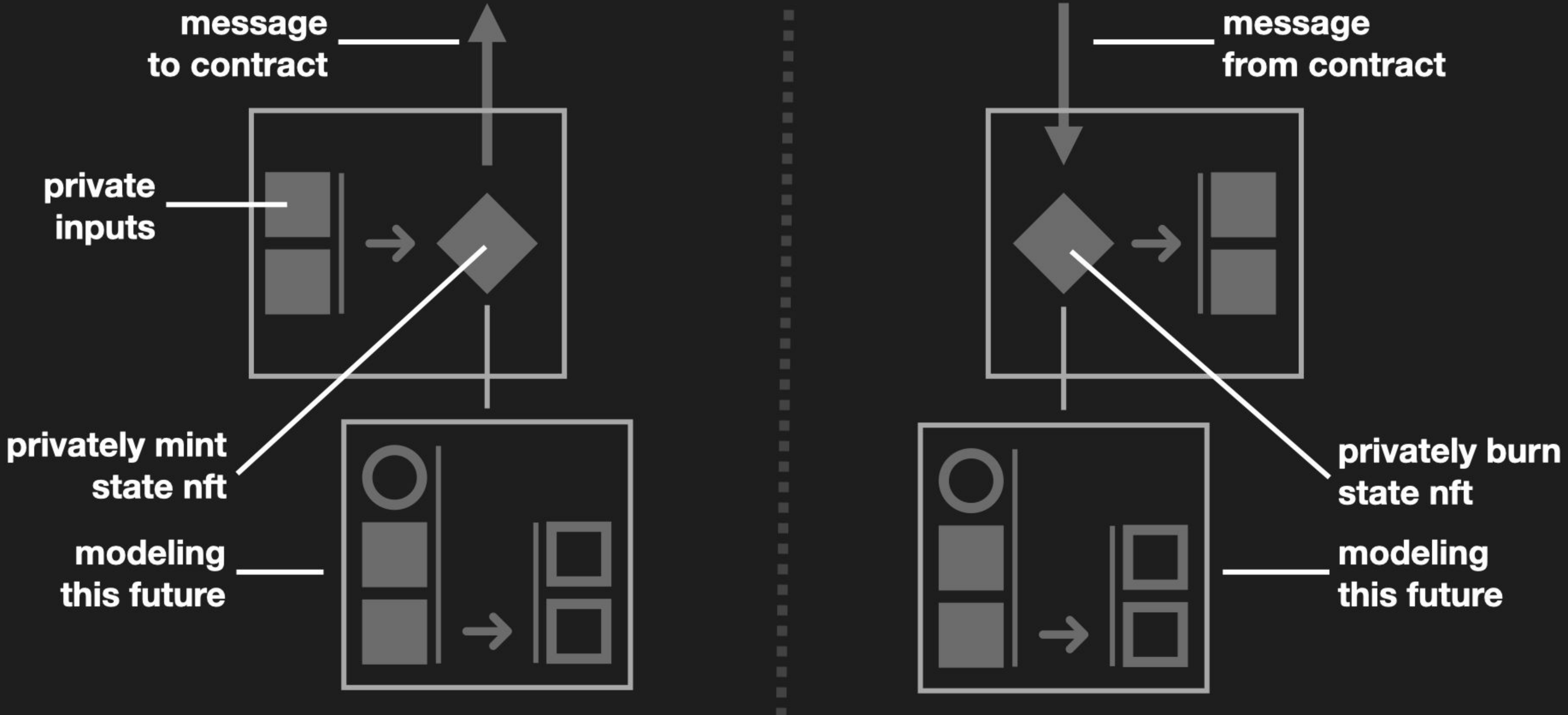
privately mint state nft

modeling this future

message from contract

privately burn state nft

async zk execution via message passing



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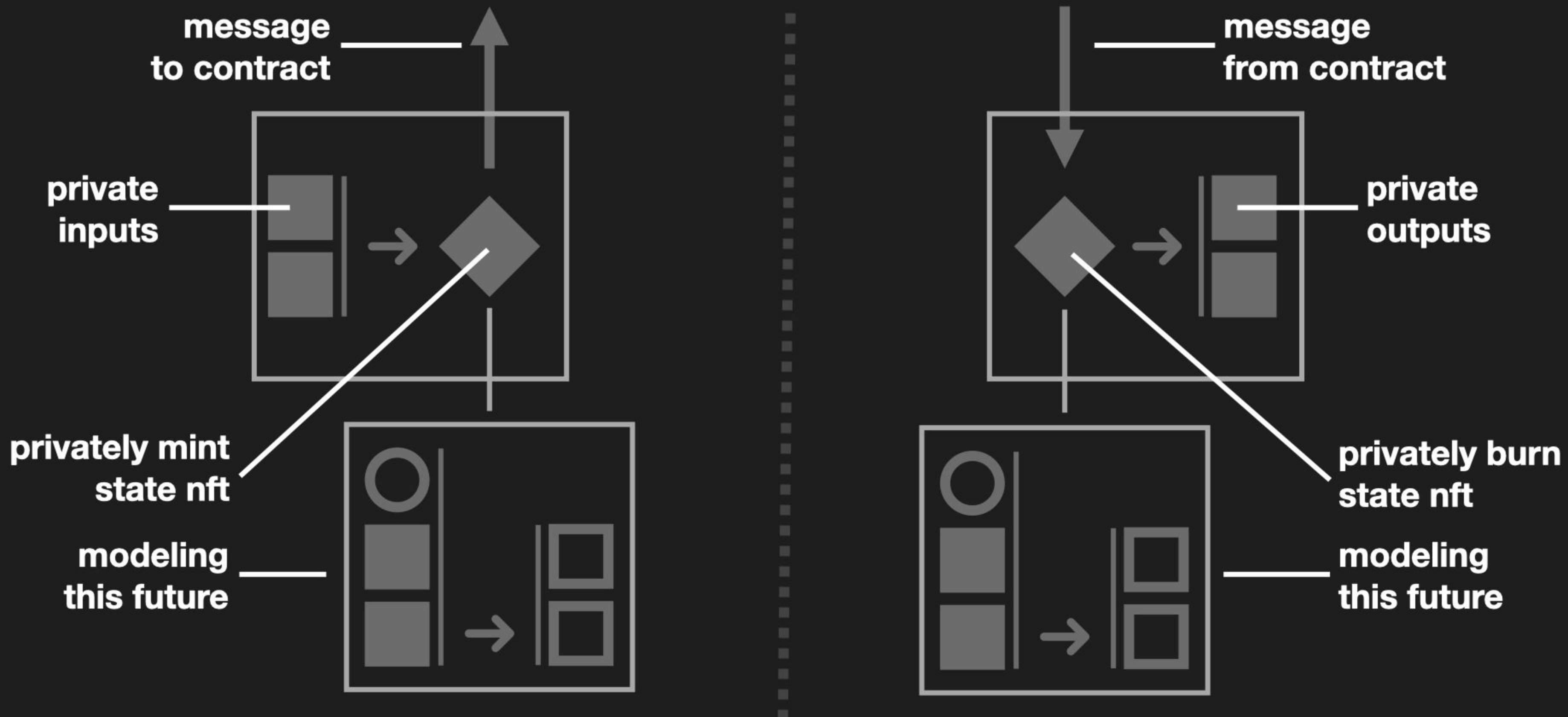


second challenge: privacy model

useful blockchains

revolve around

public shared state

how do we allow

private interaction

with public shared state?

two basic strategies:

two basic strategies:

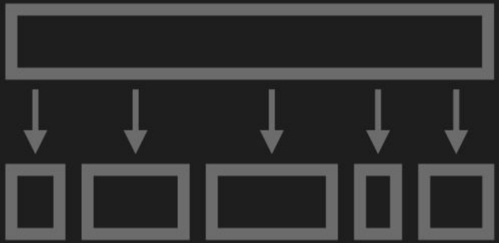
splitting flows

two basic strategies:

splitting flows

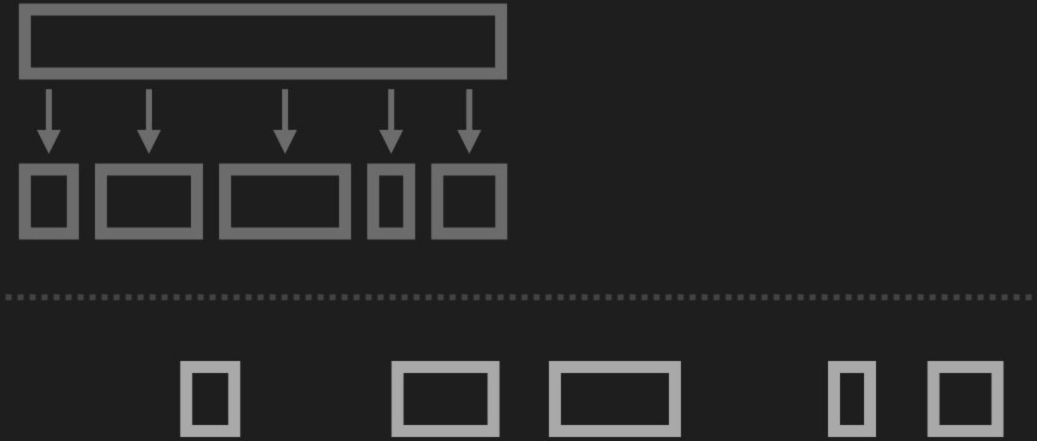
batching flows

splitting flows



splitting flows

split value into randomized sub-amounts



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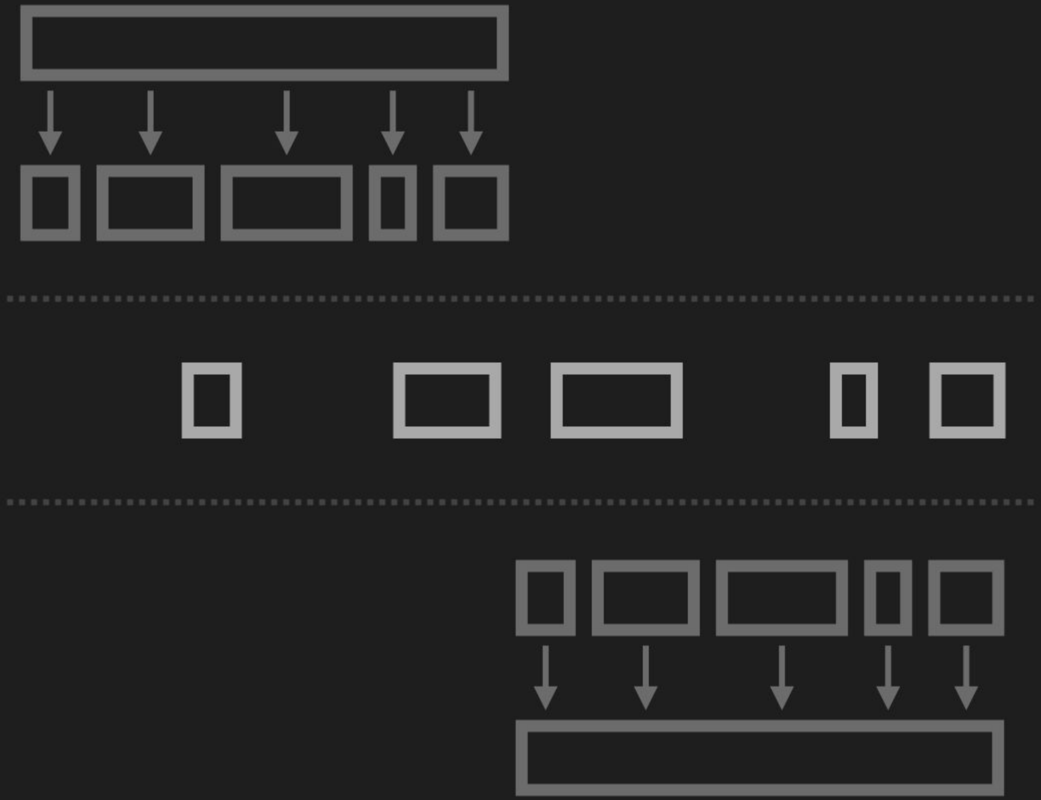
split value into randomized sub-amounts

reveal in distinct transactions



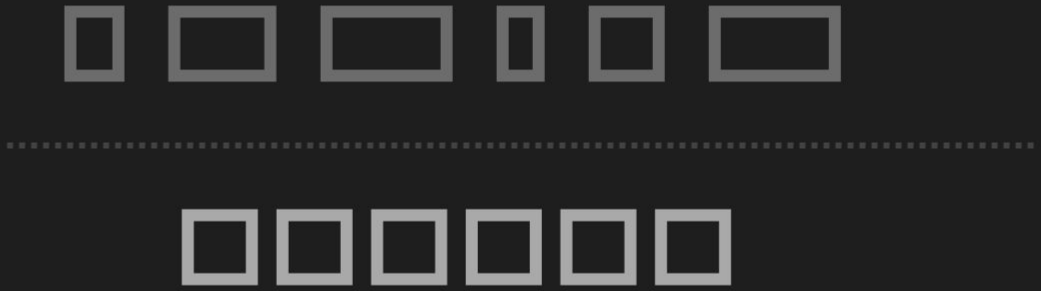
splitting flows

split value into randomized sub-amounts

reveal in distinct transactions

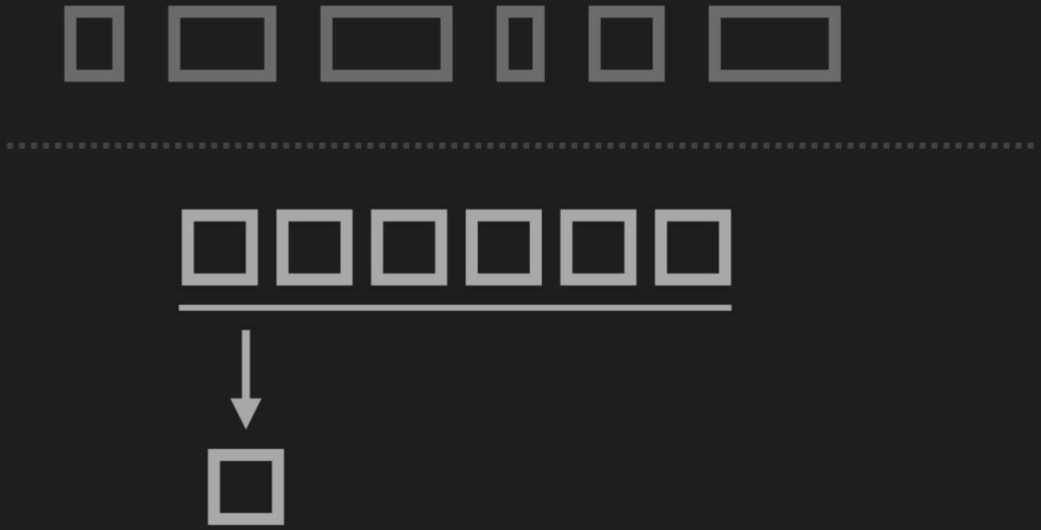
only works with shielded base layer

batching flows



batching flows

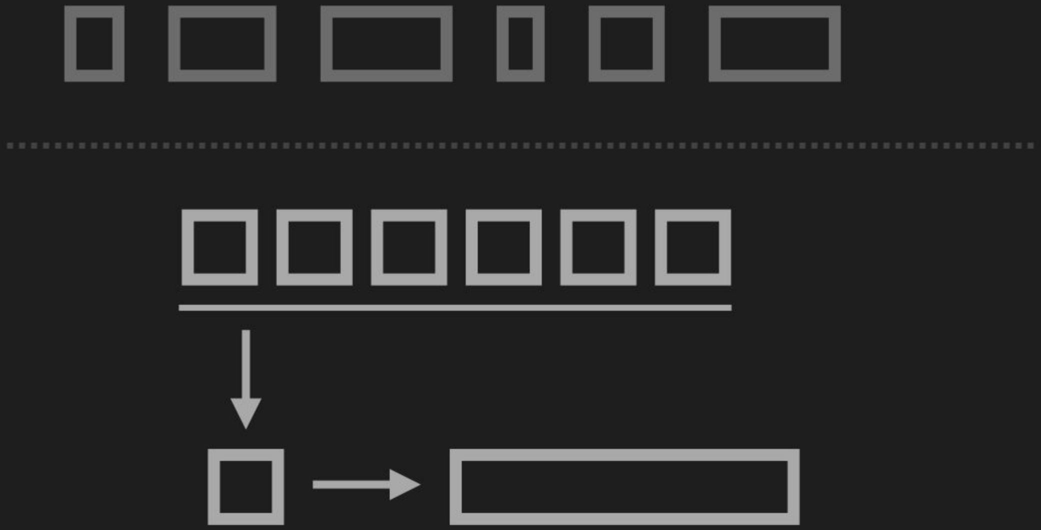
users encrypt
integer amounts
with **flow encryption**



batching flows

users encrypt integer amounts with **flow encryption**

validators sum encryptions and **decrypt batch total**



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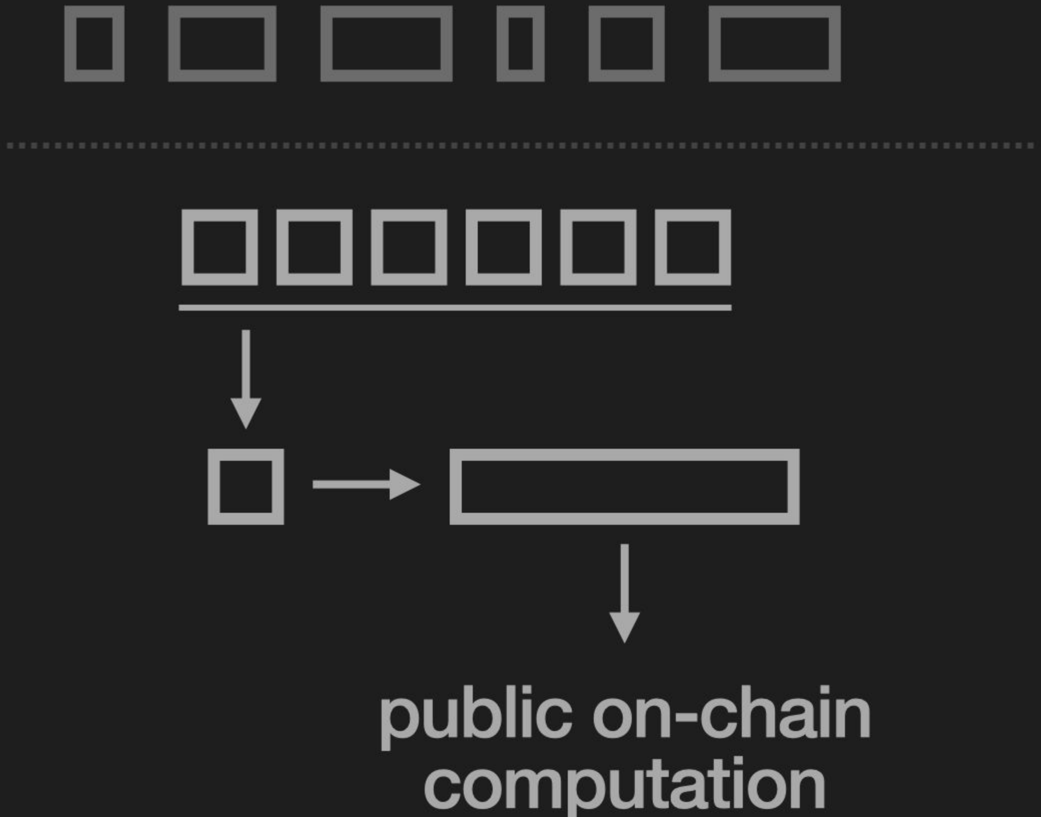
individual txs have **long-term privacy**



batching flows

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individual txs have **long-term privacy** example:

sealed-input batch swaps

on penumbra

sealed-input batch swaps on penumbra (private state)

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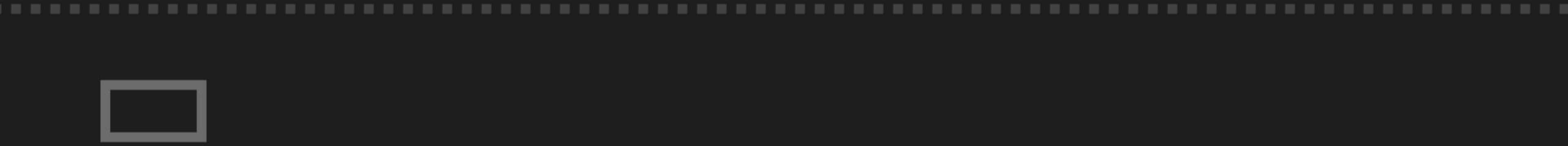
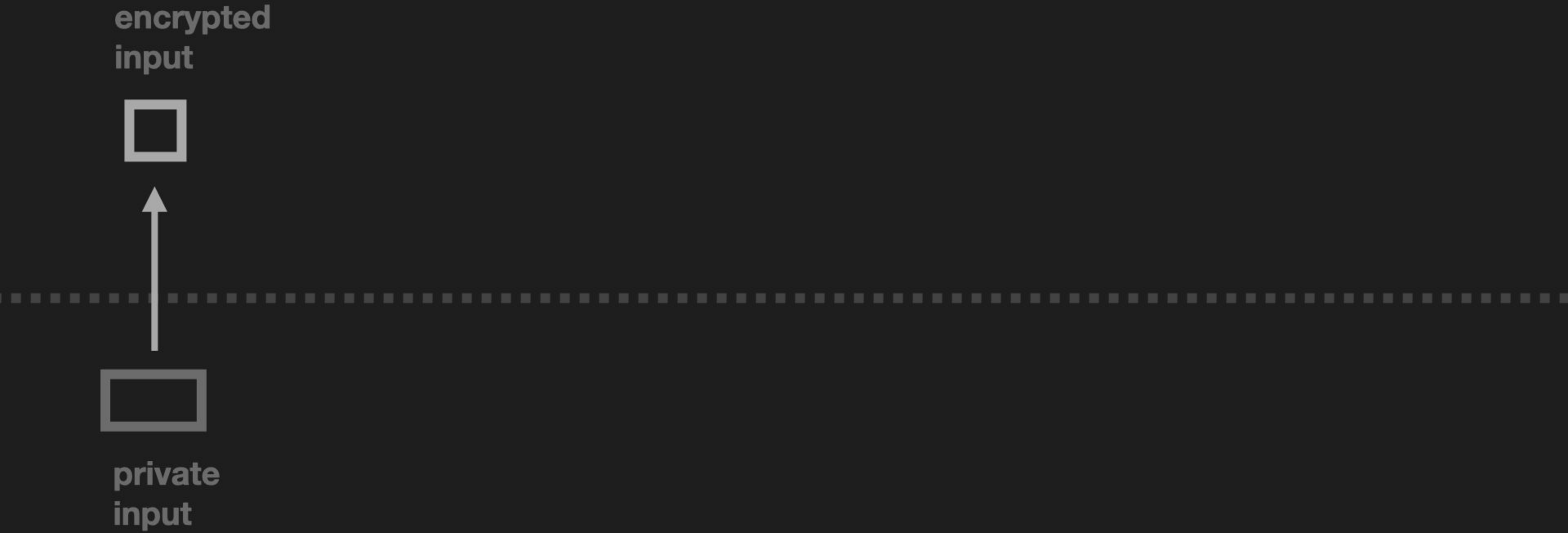


private
input

sealed-input batch swaps on penumbra (private state)



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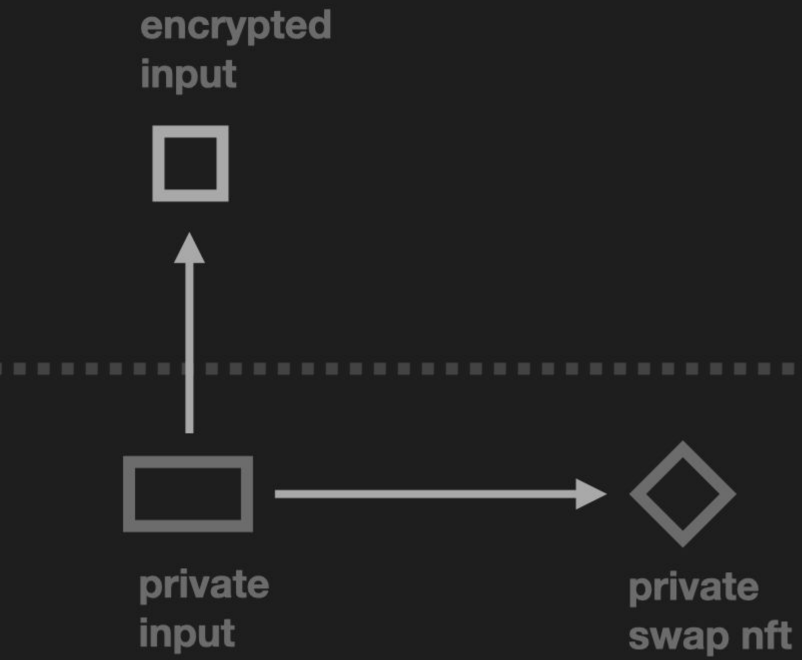

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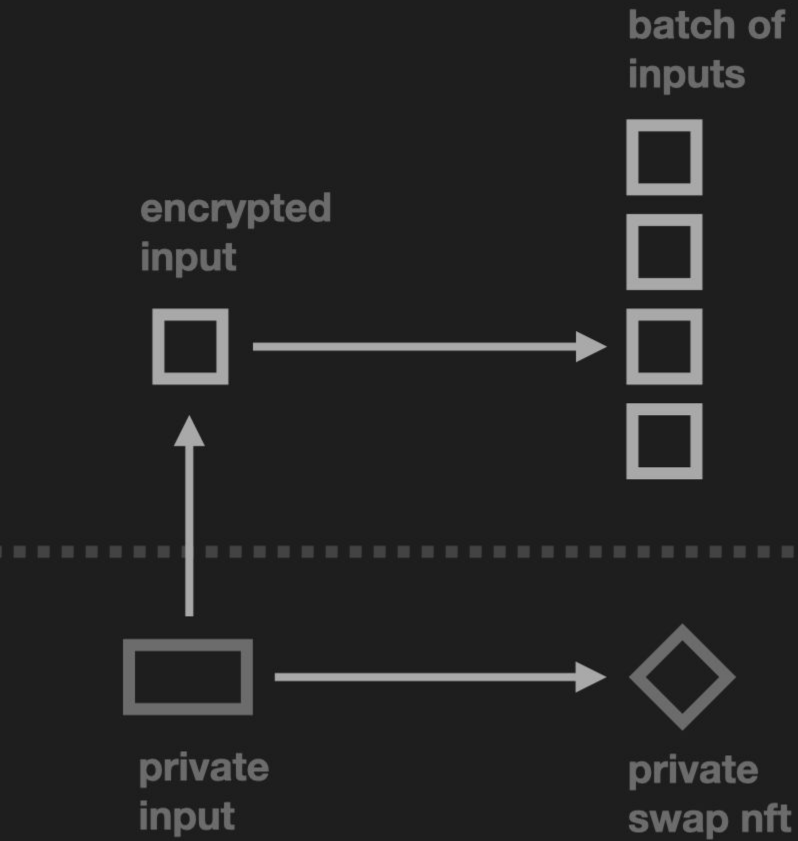

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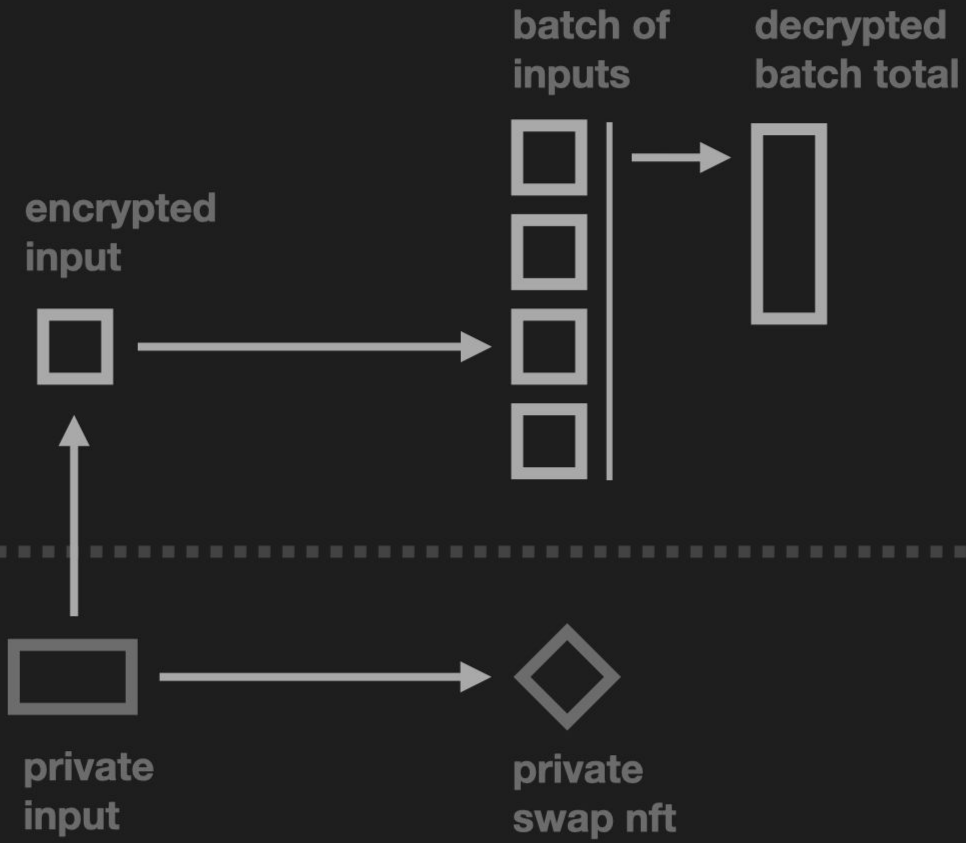

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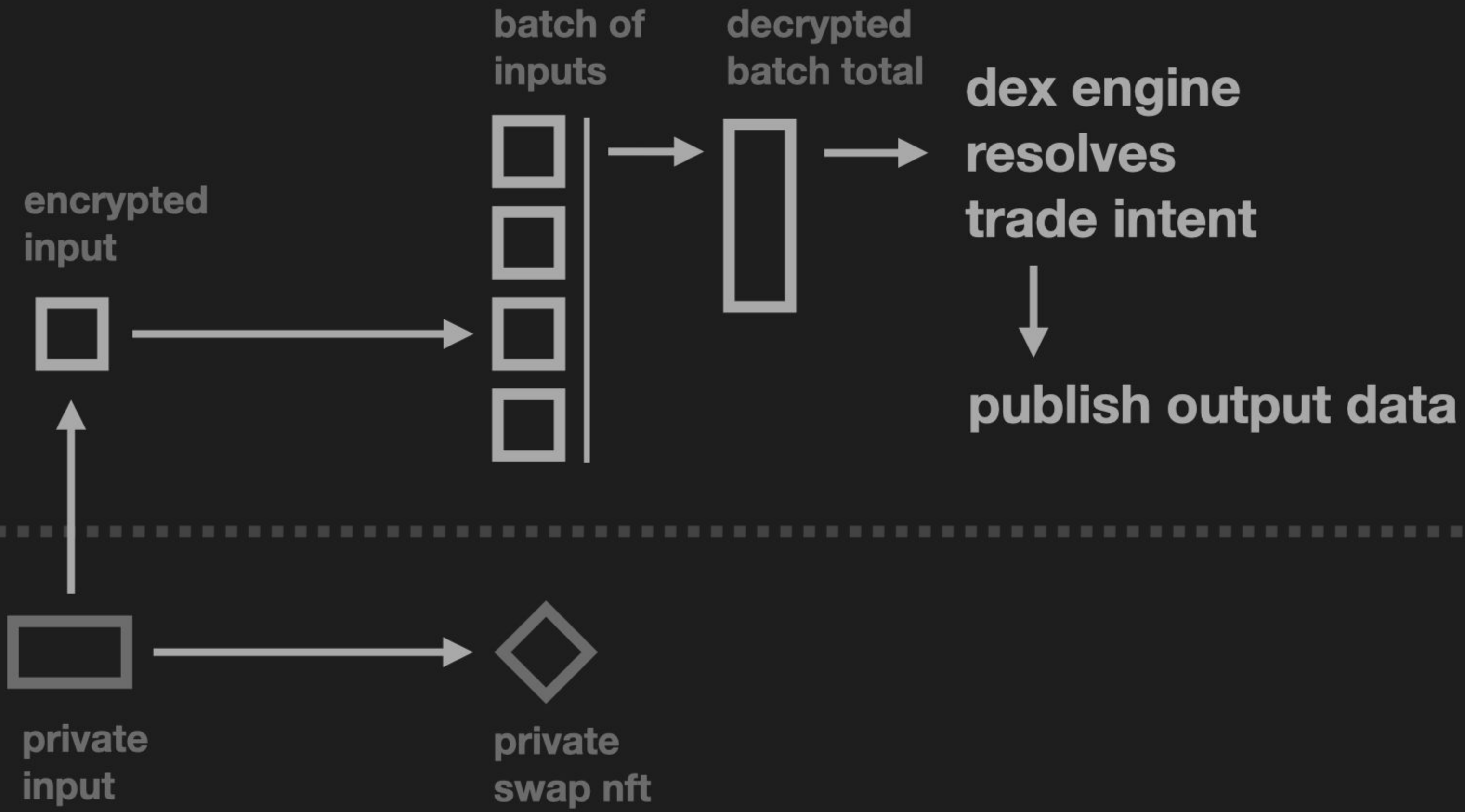


batch of inputs

decrypted batch total

dex engine resolves trade intent

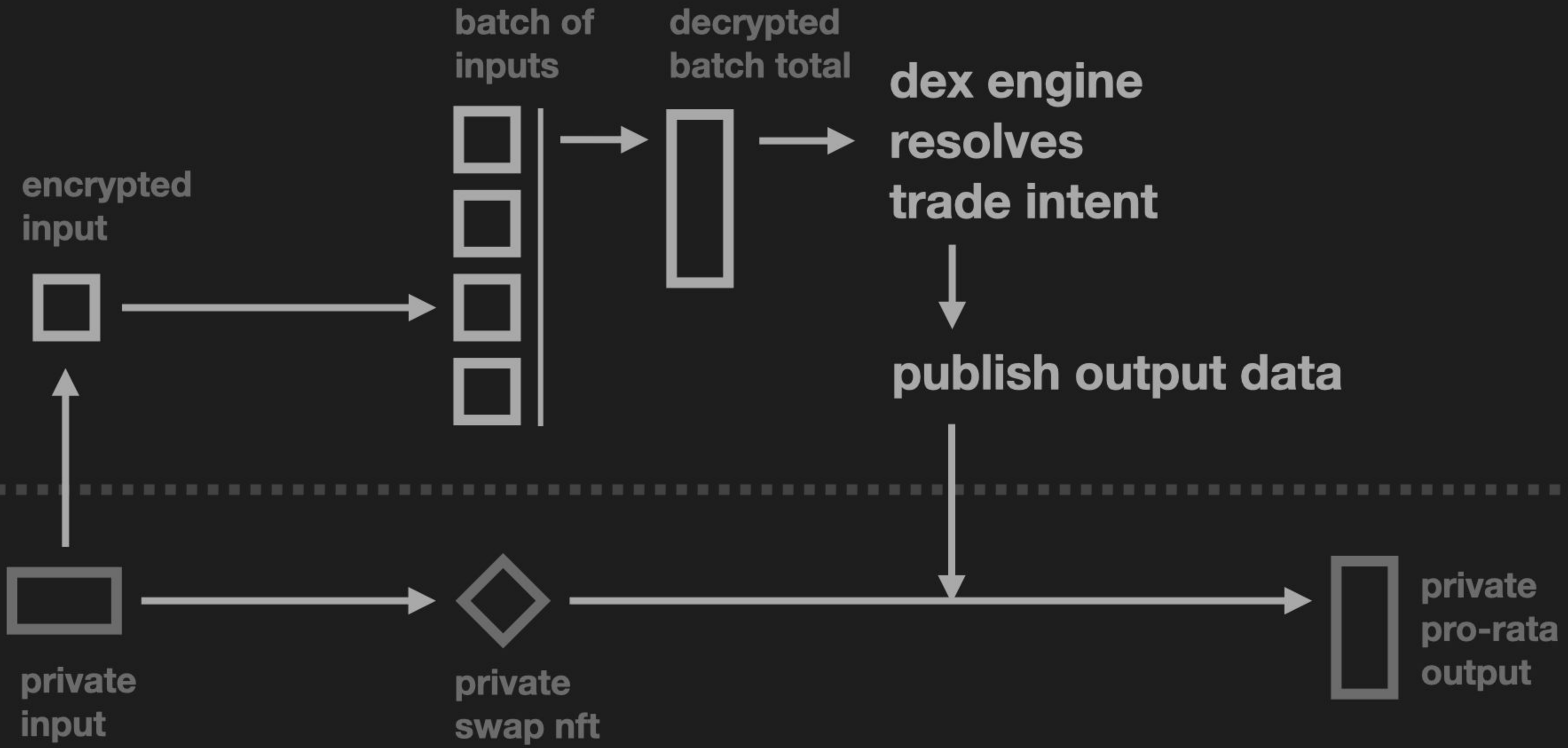
publish output data

encrypted input

private input

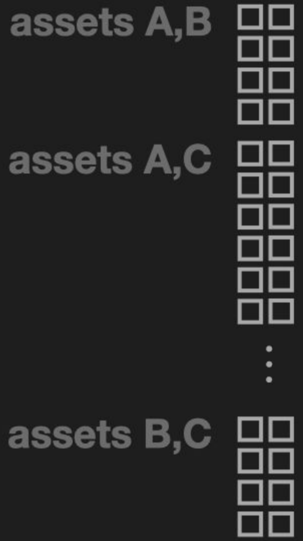
private swap nft

sealed-input batch swaps on penumbra (private state)



sealed-input batch swaps on penumbra (public state)

sealed-input batch swaps on penumbra (public state)



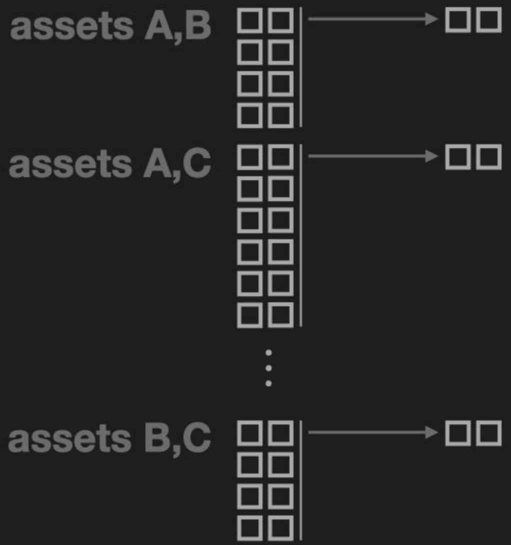
assets A,B

assets A,C

assets B,C

group
inputs
by pair

sealed-input batch swaps on penumbra (public state)



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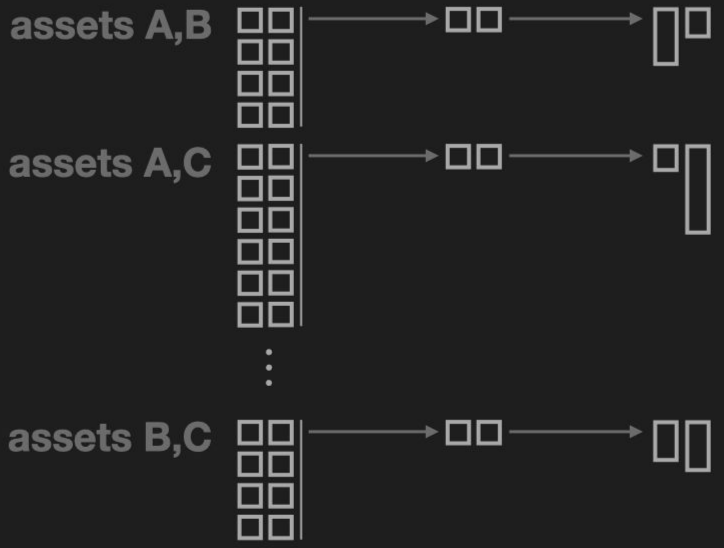

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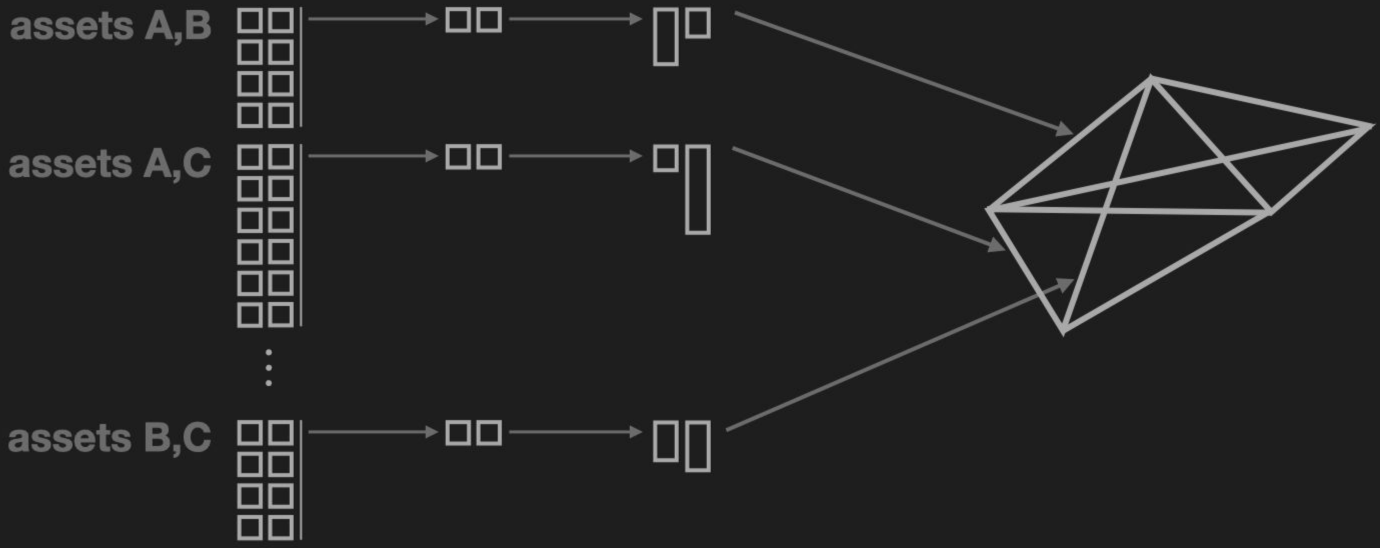

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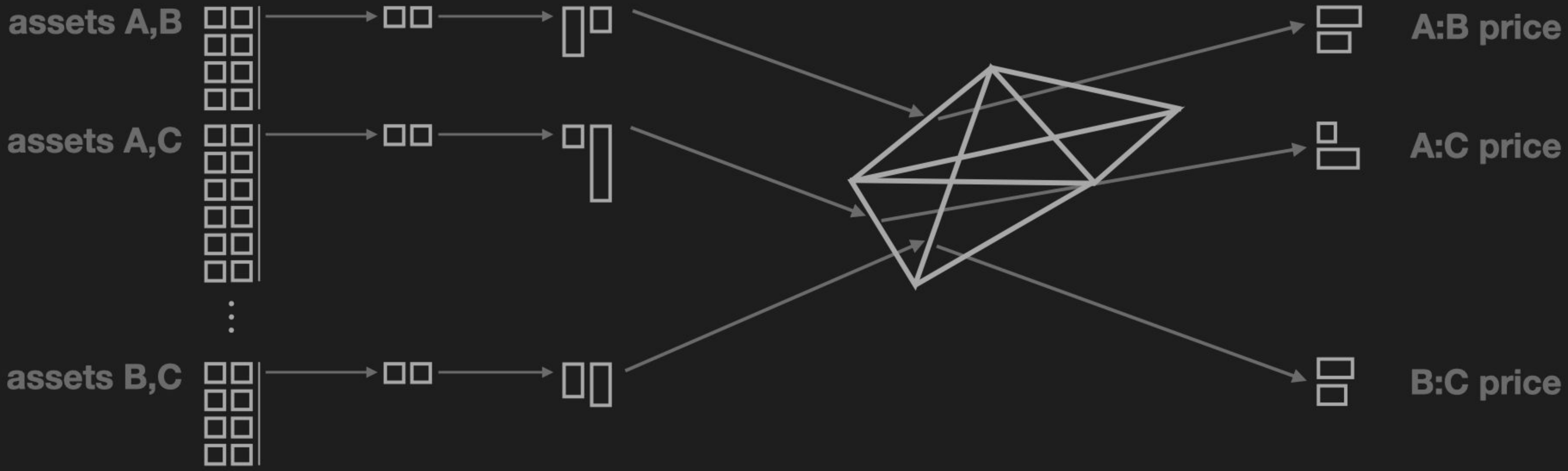

assets A,B

assets A,C

assets B,C

A:B price

A:C price

B:C price

group inputs by pair

batch encrypted inputs

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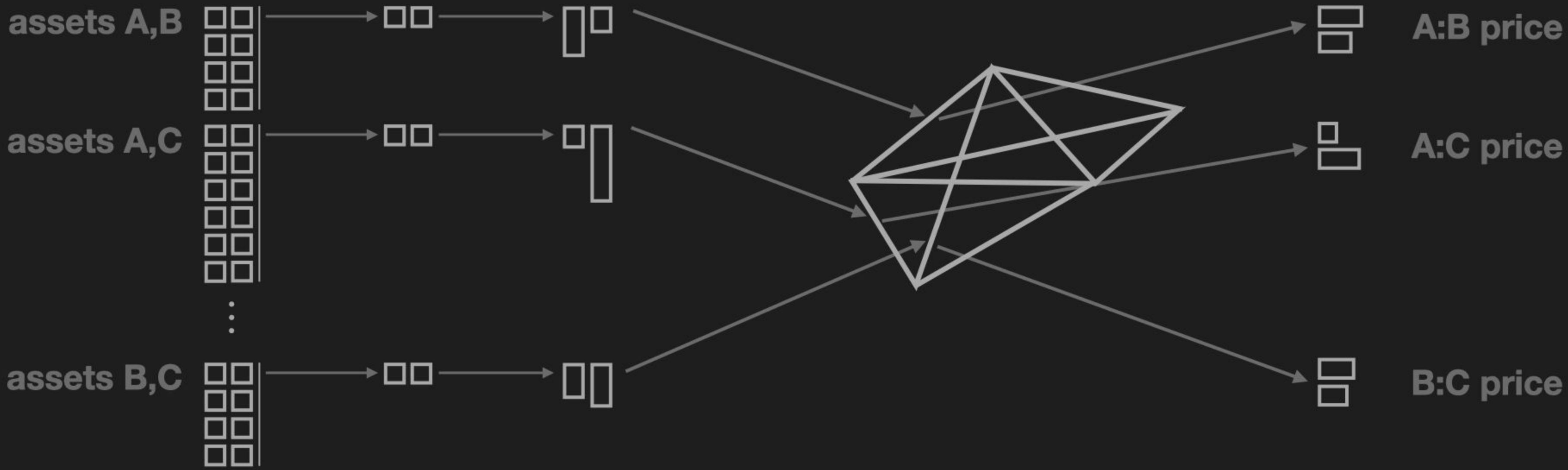

group inputs by pair

batch encrypted inputs

decrypt batch totals

globally resolve all trading intent with optimal arbitrage

shielded swaps are live
on weekly penumbra testnets

discord + github links	penumbra.zone
design docs	protocol.penumbra.zone
testnet instructions	guide.penumbra.zone
dashboards	testnet.penumbra.zone