mas.s62
lecture 15
discreet log contracts

2018-04-04

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schedule stuff

pset postponed due to science

next week start projects

time at the end of class today to form groups / ask about projects

today

discreet log contracts

- conditional payments
- oracles
- anticipated signatures
- building discreet log contracts

conditional payments

payment conditional on some external data

In this example, Alice and Bob bet on tomorrow's weather. If it rains, Alice gets 1 BTC. If it's sunny, Bob gets 1 BTC.

One problem: The bitcoin blockchain is not aware of the weather. (OP_WEATHER has not yet been soft-forked in)

"smart contracts" and oracles

LN is a simple script, enforcing the most recent tx

Made of smart contracts, but has no external state. Everything comes from Alice & Bob

If we want external state, need some way to get it, usually called an "oracle"

Simple oracle: 2 of 3 multisig

why oracles?

2 of 2 multisig means conflict freezes funds

Rich players at an advantage (lower time value of money)

Works great with friends, but bitcoin is the currency of enemies :)

A 3rd party can decide in case of conflict

2 of 3 multisig oracle

2 of 3 multisig oracle

3 keys: Alice, Bob, OIivia

If Alice and Bob are chill, they can both sign without contacting Olivia

If Alice and Bob fight or are unresponsive, one of them can ask Olivia to sign

Problem: It's sunny. Alice tells Olivia, "Hey, Alice. Say it's raining and I'll give you 0.8"

oracle interaction

2 of 3 multisig oracles are interactive

Not only do they see every contract, they decide the outcome of every contract, individually. (Can equivocate)

It'd be better if the oracle couldn't equivocate, and even better if they never saw the contracts. But how?

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

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

point and scalar operations

(Note also works on exponents mod n)

a, b lowercase = scalar

A, B uppercase = point

what operations can we do?

point and scalar operations

scalars are regular unleaded numbers

```
a+b a-b a*b a/b
```

everything is OK! just numbers!

point and scalar operations

Points have addition defined… but not multiplication and division (group)

A+B A-B OK   A*B A/B NO

add & subtract OK, but can't multiply two points, or divide a point by a point. Not defined.

point and scalar operations

Mixed operations

A+b A-b NO   A*b A/b OK

adding points and scalars is undefined

point times scalar OK; repeat the tangent doubling process. Division by scalar also possible.

point and scalar operations

roster of ops: what can we do

a+b a-b a*b a/b (obvious)

A+B A-B A*b A/b

point and scalar operations

roster of ops: what can we do

a+b a-b a*b a/b (obvious)

A+B A-B A*b A/b

Pick some random point G

That's the generator point

Everyone agrees on G

adding pubkeys

$(aG) + (bG) = (a+b)G$

sum of private keys gives sum of public keys! fun stuff ensues

adding pubkeys

$aG = A$, $bG = B$

$A+B = C = (a+b)G$

Alice knows a, Bob knows b. Neither can sign with C.

Bob can give b to Alice, then Alice can sign with C.

discreet log contracts

smart contracts in same channel construction as lightning

lightning: most recent tx is valid

DLC: non-interactive oracle determines valid tx

schnorr signature

```
public key A = aG

k <- $; R = kG (nonce for signature)

to sign, compute  s = k - h(m, R)a

signature is (R, s)

To verify  sG =? kG - h(m, R)aG

              =?  R - h(m, R)A
```

fixed-R signature

Pubkey: A signature: (R, s)

Pubkey: (A, R) signature: s

Same thing right? Just move the R.

But can only sign once!

k-collision

Signature 1 $s_1 = k - h(m_1,R)a$

Signature 2 $s_2 = k - h(m_2,R)a$

$s_1 - s_2 = k - h(m_1,R)a - k + h(m_2,R)a$

$= h(m_2,R)a - h(m_1,R)a$

$= (h(m_2,R) - h(m_1,R))a$

$a = (s_1 - s_2) / (h(m_2,R) - h(m_1,R))$

Fun fact: this is what brought down Playstation 3 code signing

anticipated signature

Given 'pubkey' (A, R) and a message m, you can't compute s.

(EC Discrete log problem)

but you CAN compute $sG = R - h(m,R)A$

sG is computable for any message!

signatures as private keys

It's an unknown scalar, but you know what it is times the generator point. Hmm! Sounds like a keypair!

Use for a 3rd party oracle to sign messages, revealing a private key.

signatures as private keys

Olivia's s as private key

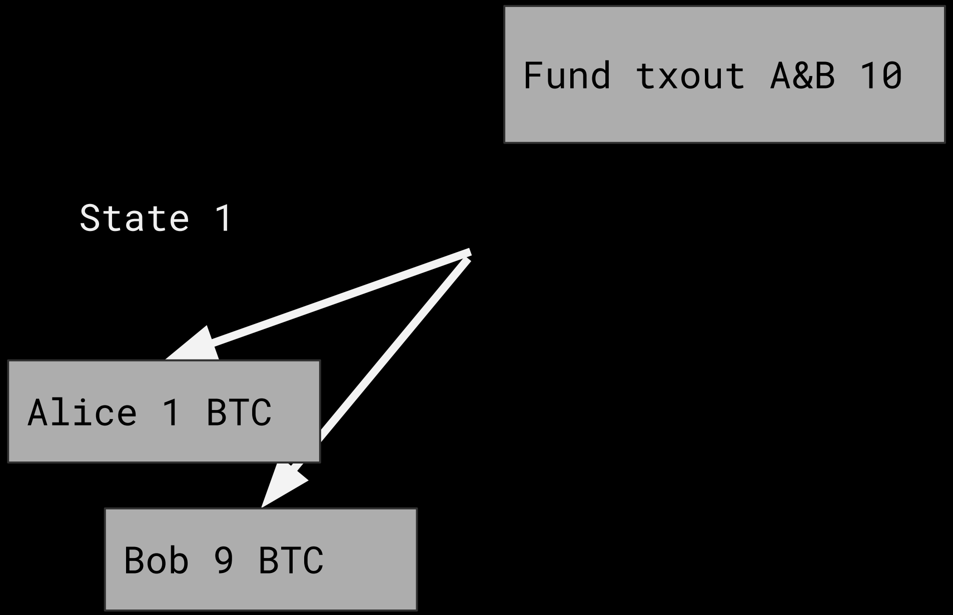
sG as public key

Mix with Alice and Bob's public keys

$$pub_{alice} + sG = pub_{contract}$$

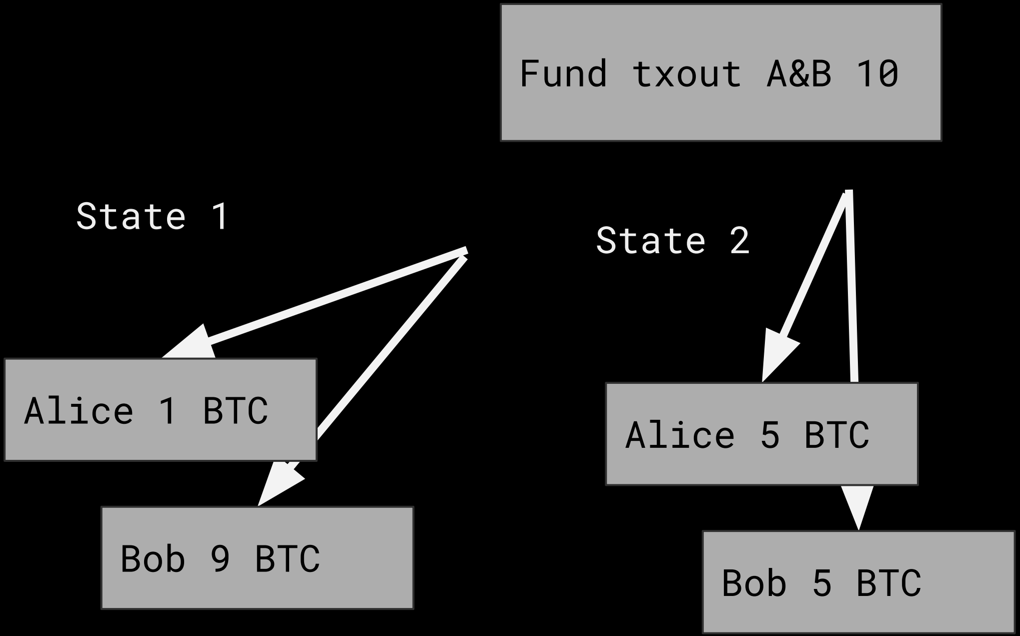
$$priv_{alice} + s = priv_{contract}$$

signatures as private keys



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

signatures as private keys



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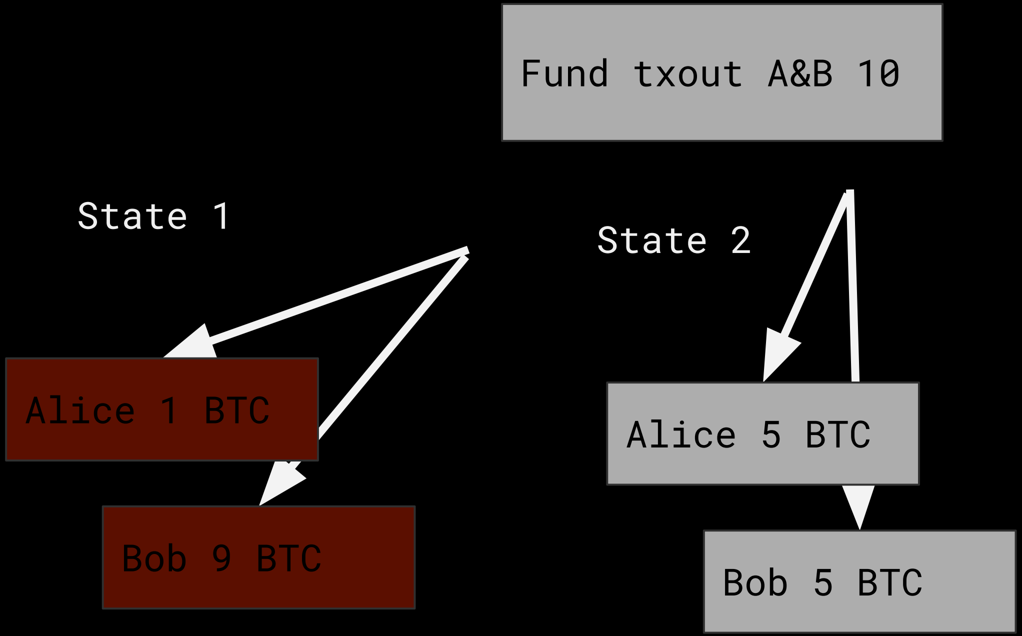


Fund txout A&B 10

State 1

Alice 1 BTC

Bob 9 BTC

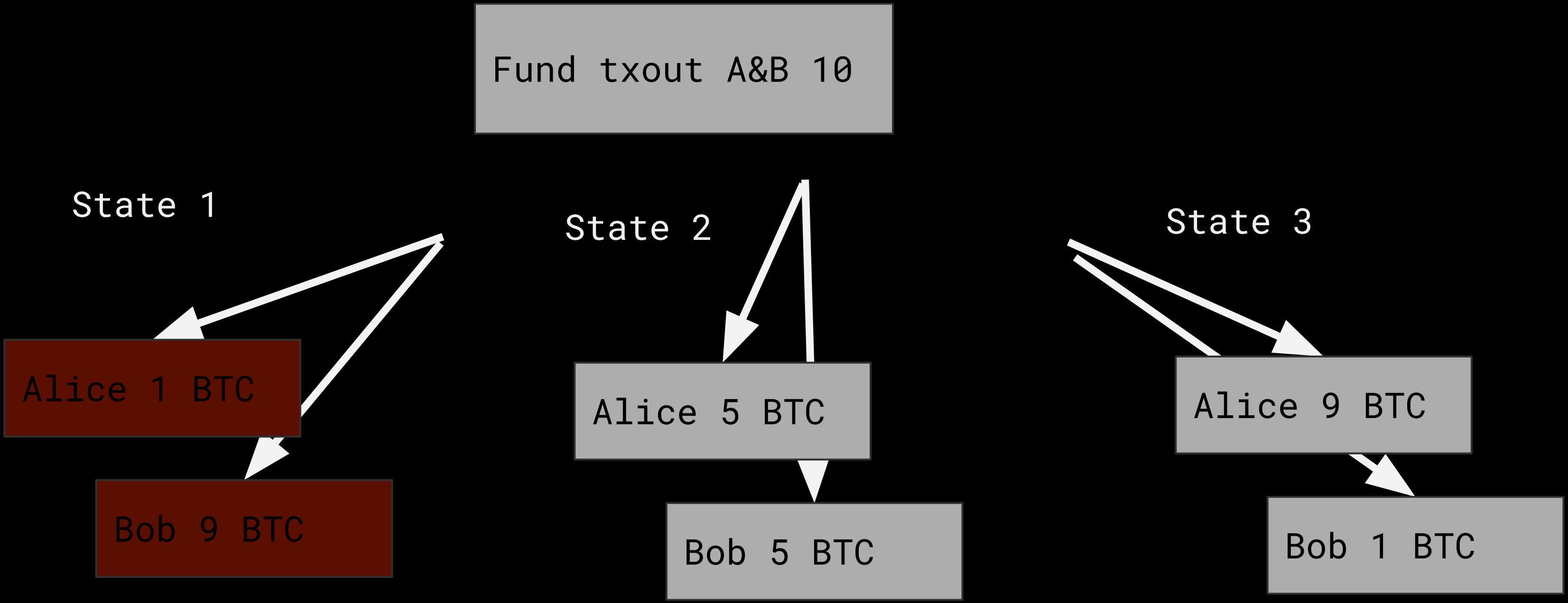
State 2

Alice 5 BTC

Bob 5 BTC

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

signatures as private keys



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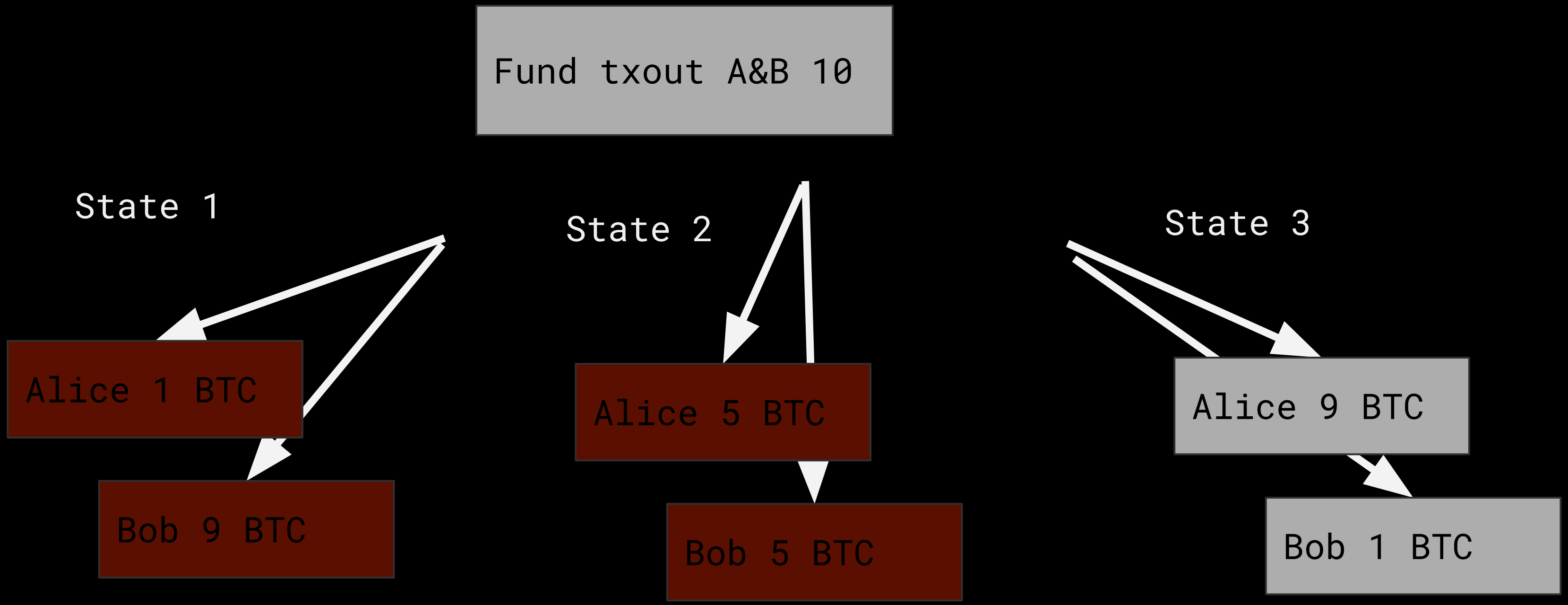
signatures as private keys



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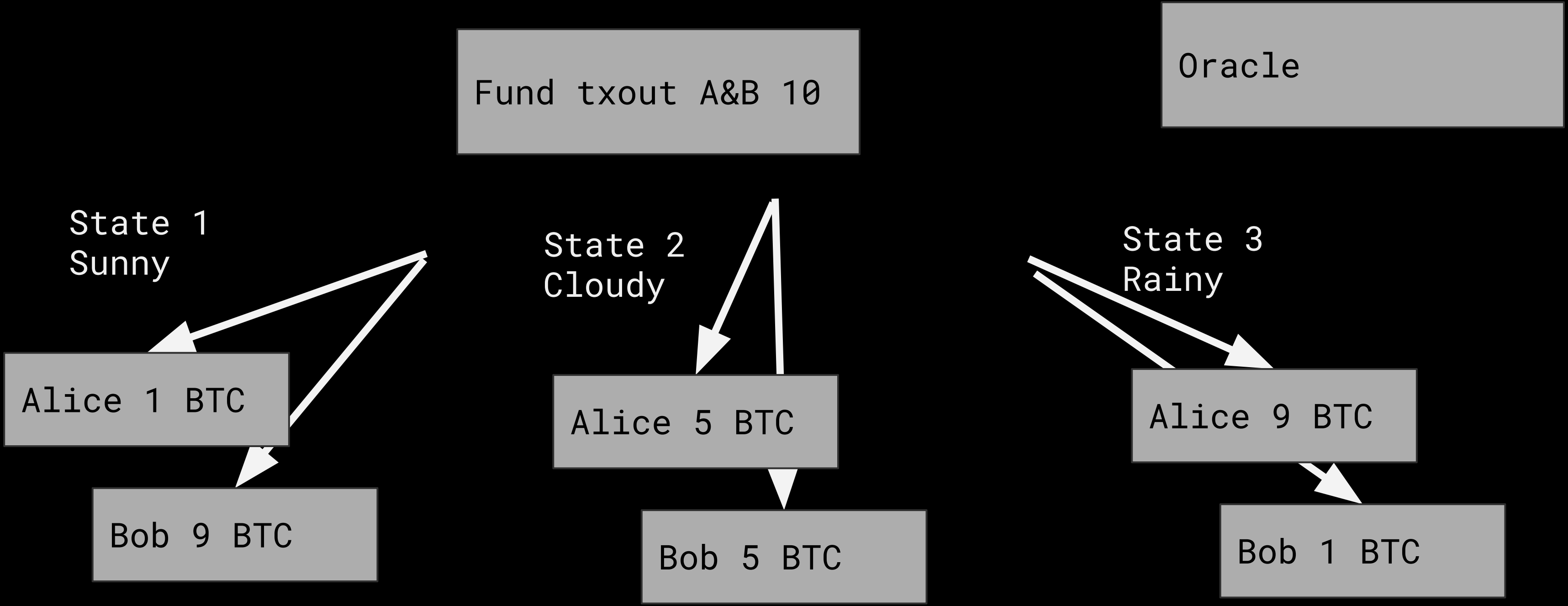
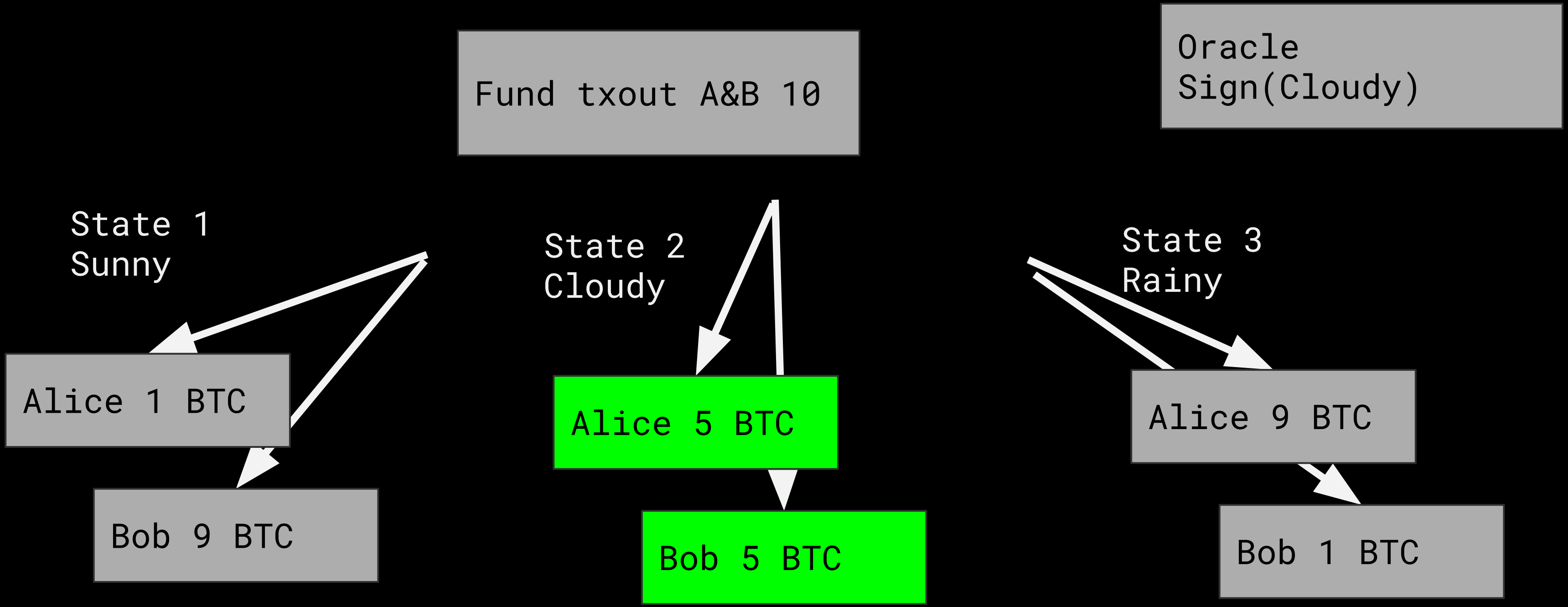
signatures as private keys



In DLC all states are created at the start. Validity is determined by a non-interactive oracle signature.

signatures as private keys



In DLC all states are created at the start. Validity is determined by a non-interactive oracle signature.

Same script as LN

PubR OR (PubT AND time)

In lightning, The "correct" use is the timeout, op_csv

In cases of fraud, the revocable key can be used (half the key revealed)

In DLC, timeout is "incorrect", when someone publishes the wrong tx.

time and DLCs

In LN, you need to always watch for fraud, as old states could be broadcast. Gotta grab that output.

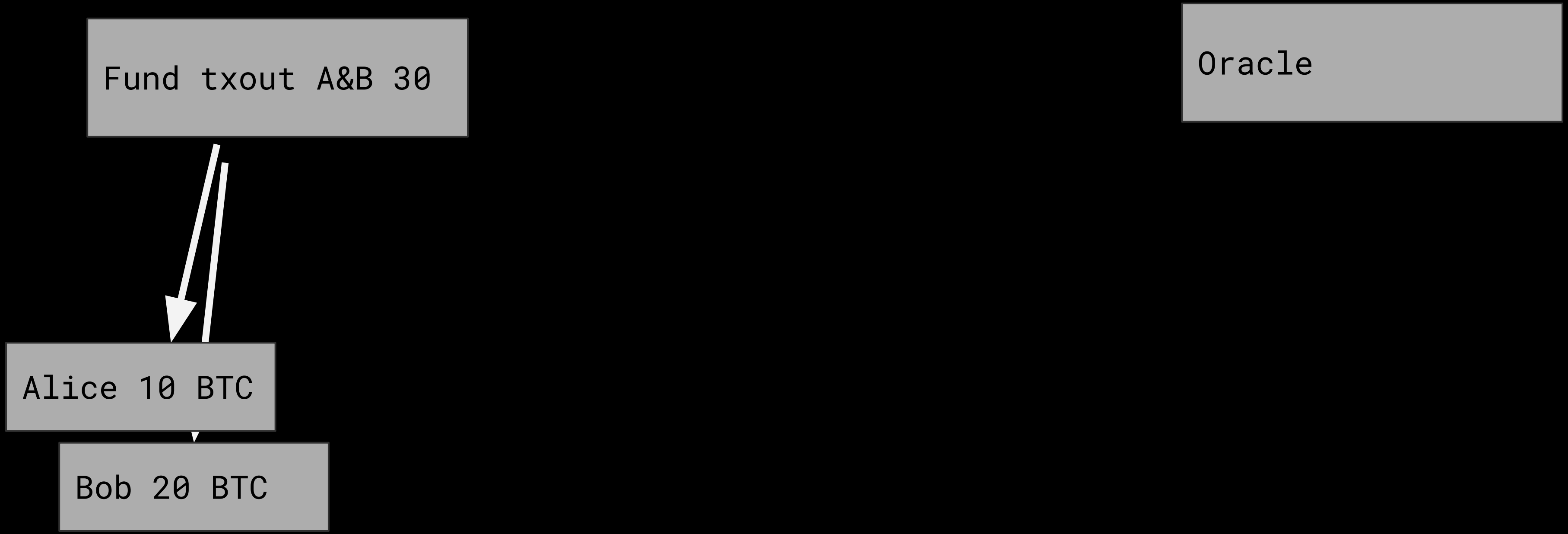
In DLC, you sweep the output as soon as you make it. Easier, and have the software broadcast both txs at the same time. No surprises.

DLCs within channels

Make a DLC output from an LN channel

If parties cooperate, 0 txs get broadcast to the blockchain

nested contracts



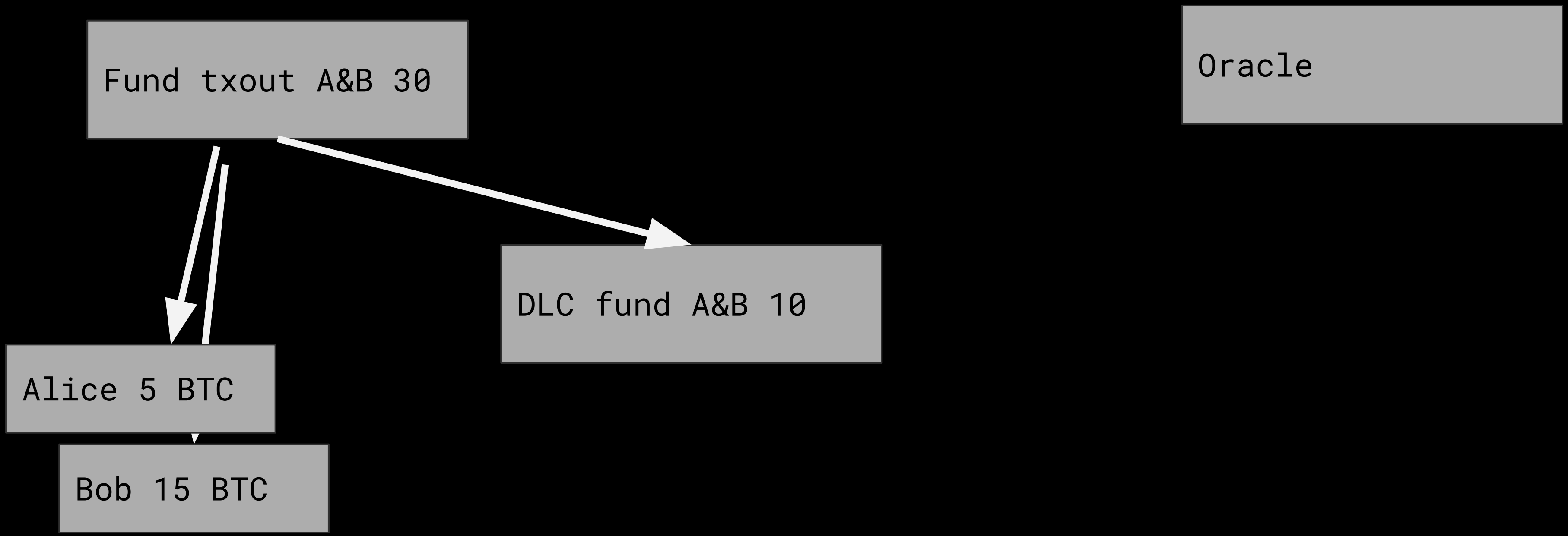
Fund txout A&B 30

Oracle

Alice 10 BTC

Bob 20 BTC

nested contracts



Fund txout A&B 30

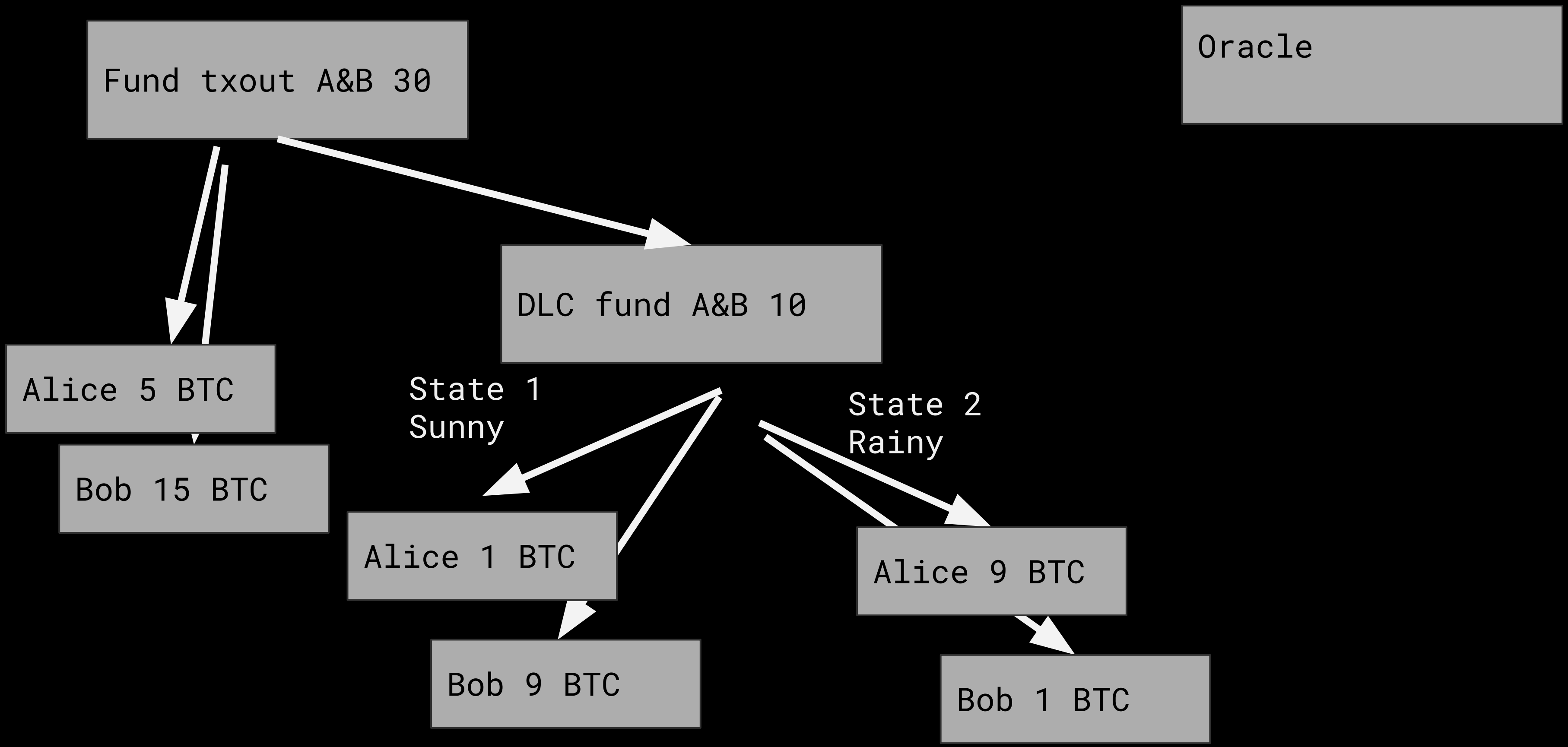
Oracle

DLC fund A&B 10

Alice 5 BTC

Bob 15 BTC

nested contracts



Fund txout A&B 30

Oracle

DLC fund A&B 10

Alice 5 BTC

Bob 15 BTC

State 1
Sunny

State 2
Rainy

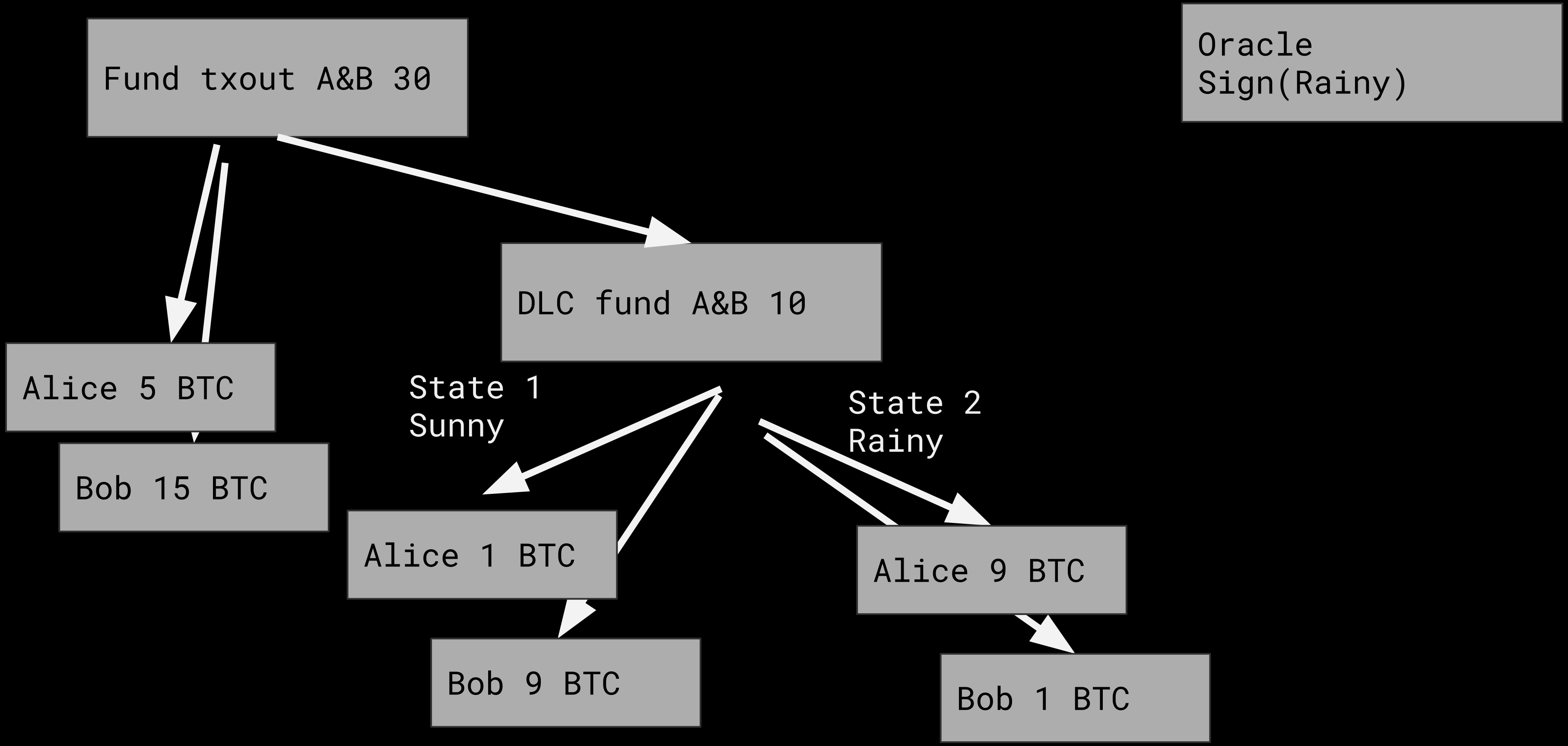
Alice 1 BTC

Bob 9 BTC

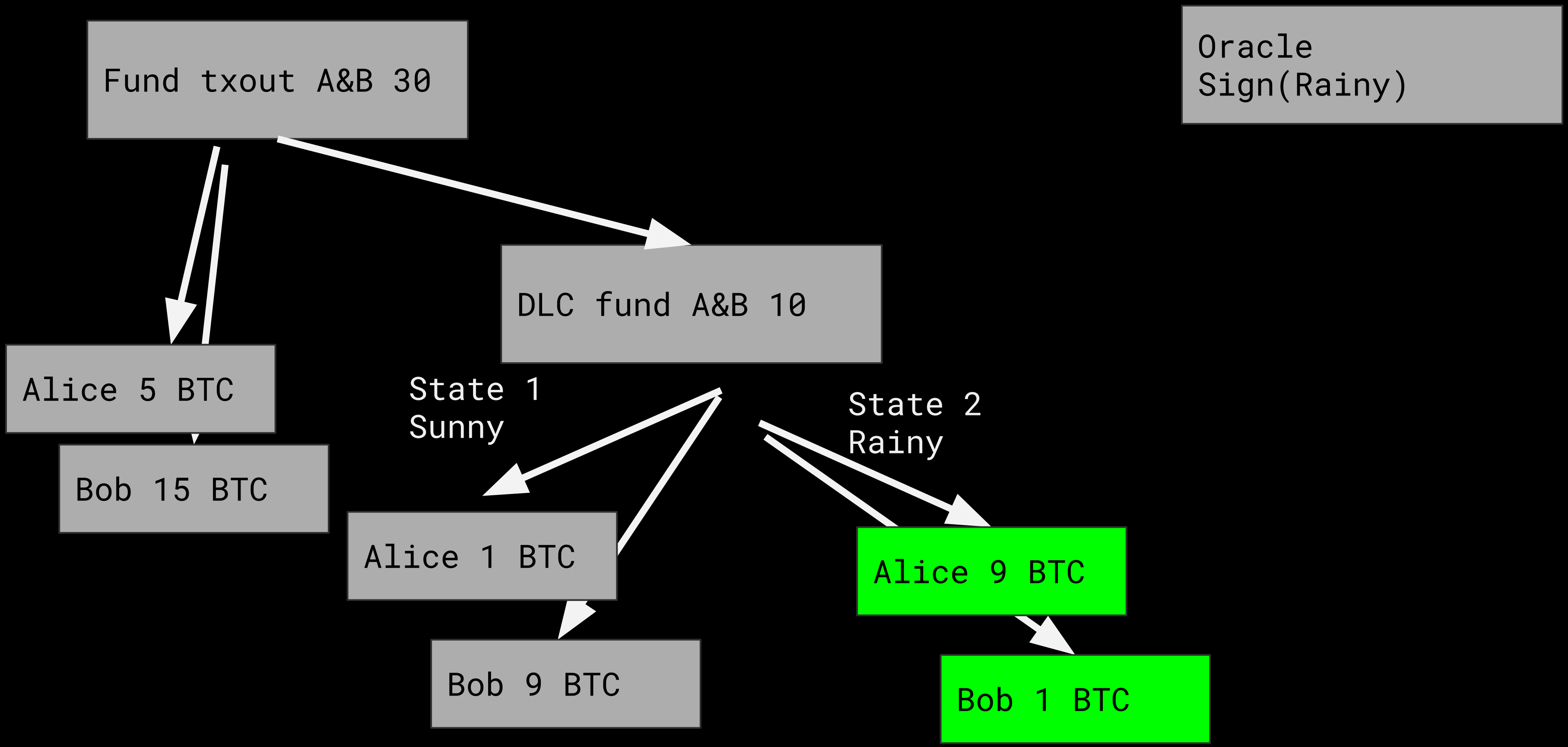
Alice 9 BTC

Bob 1 BTC

nested contracts



nested contracts



Fund txout A&B 30

Oracle
Sign(Rainy)

DLC fund A&B 10

Alice 5 BTC

Bob 15 BTC

State 1
Sunny

Alice 1 BTC

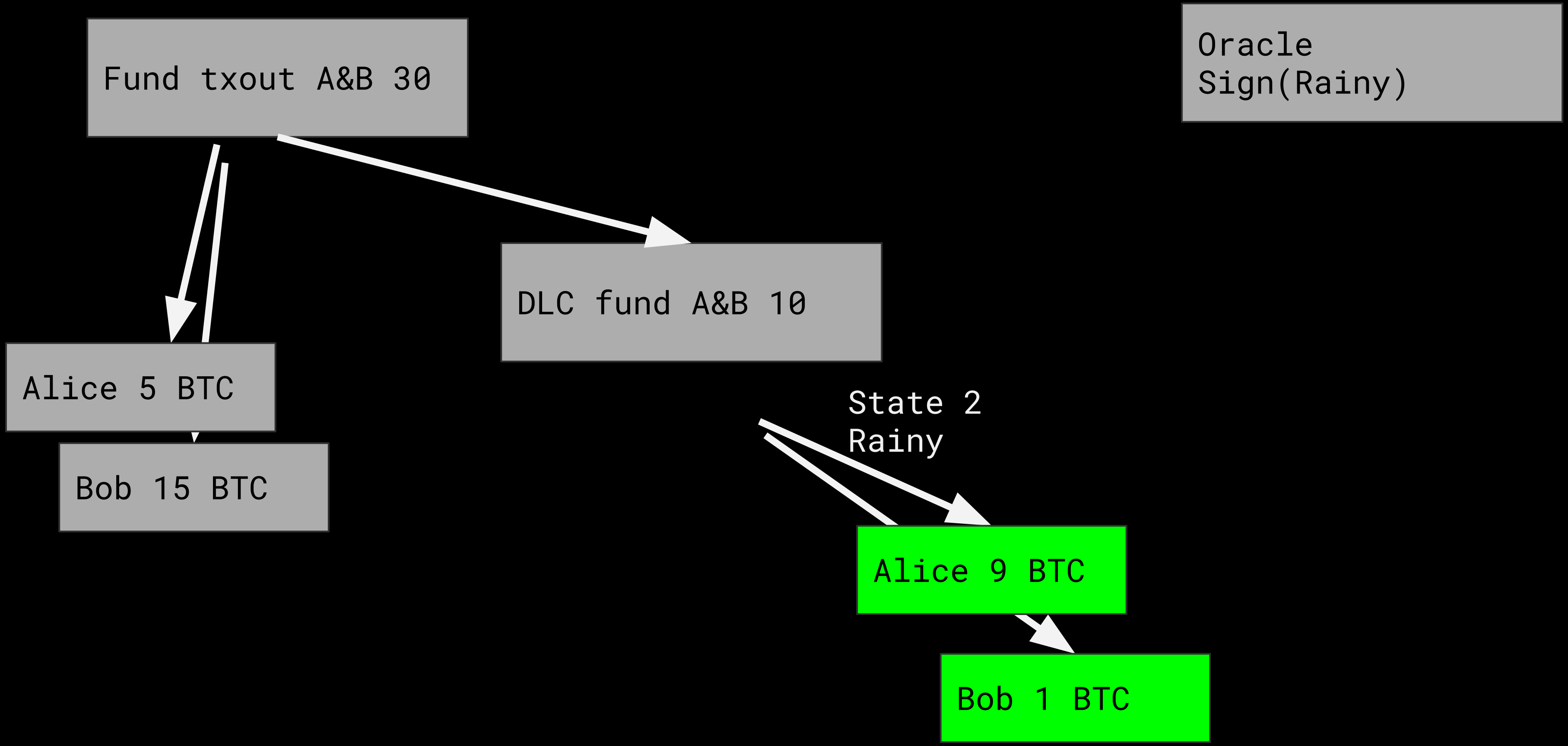
Bob 9 BTC

State 2
Rainy

Alice 9 BTC

Bob 1 BTC

nested contracts



Fund txout A&B 30

Oracle
Sign(Rainy)

DLC fund A&B 10

Alice 5 BTC

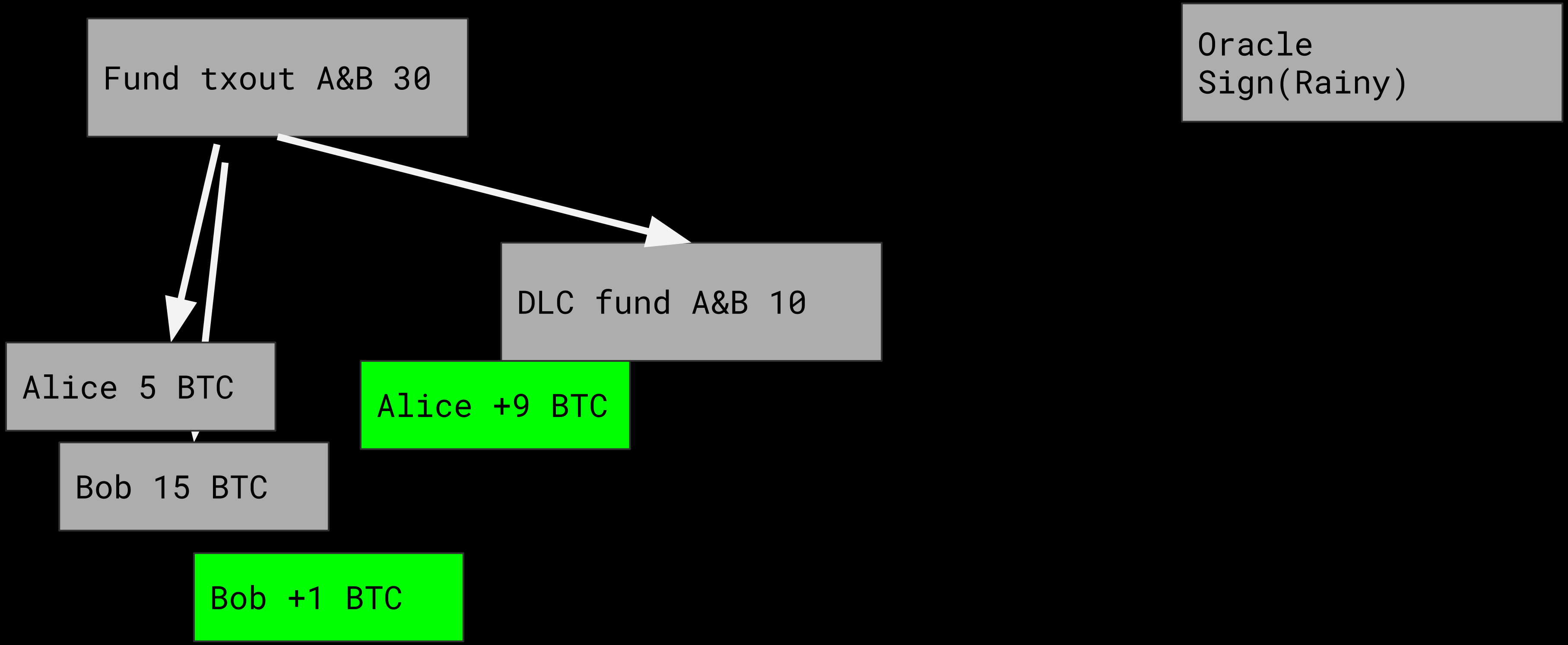
Bob 15 BTC

State 2
Rainy

Alice 9 BTC

Bob 1 BTC

nested contracts



Fund txout A&B 30

Oracle
Sign(Rainy)

DLC fund A&B 10

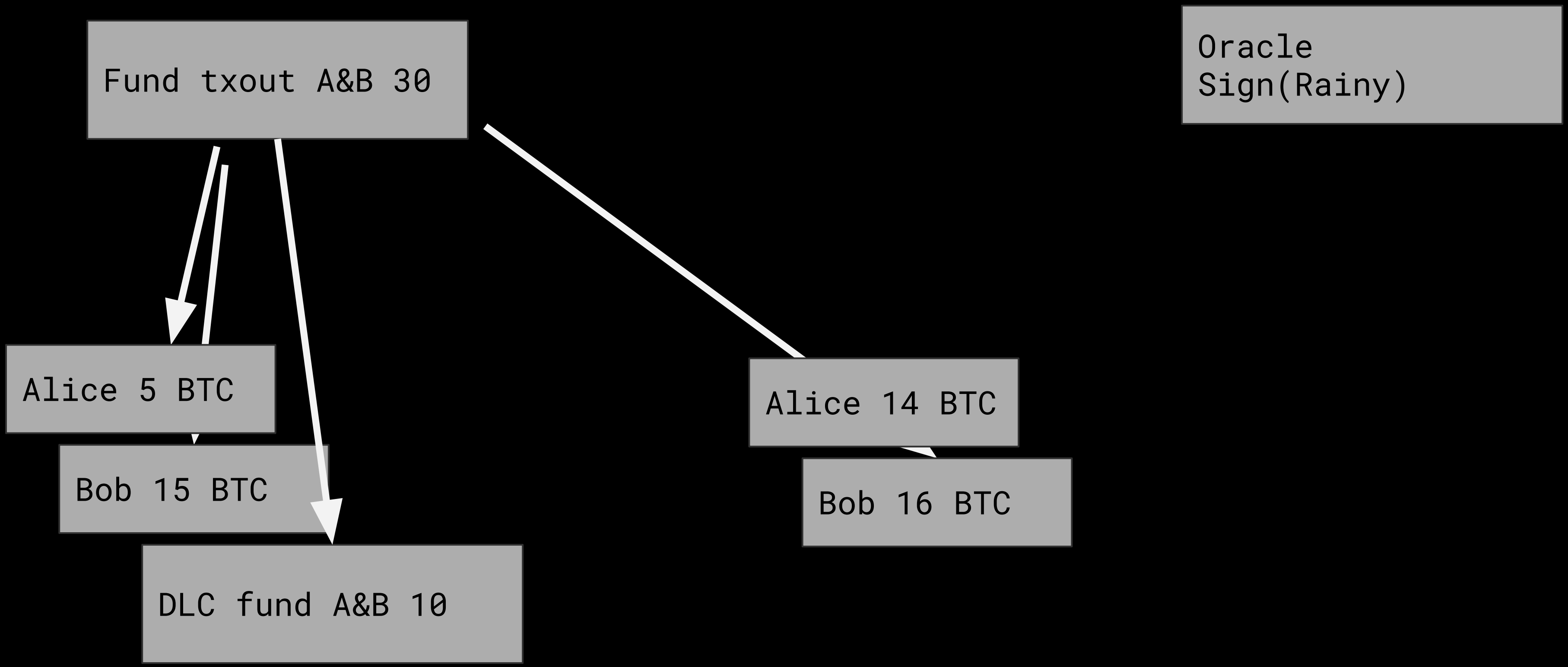
Alice 5 BTC

Alice +9 BTC

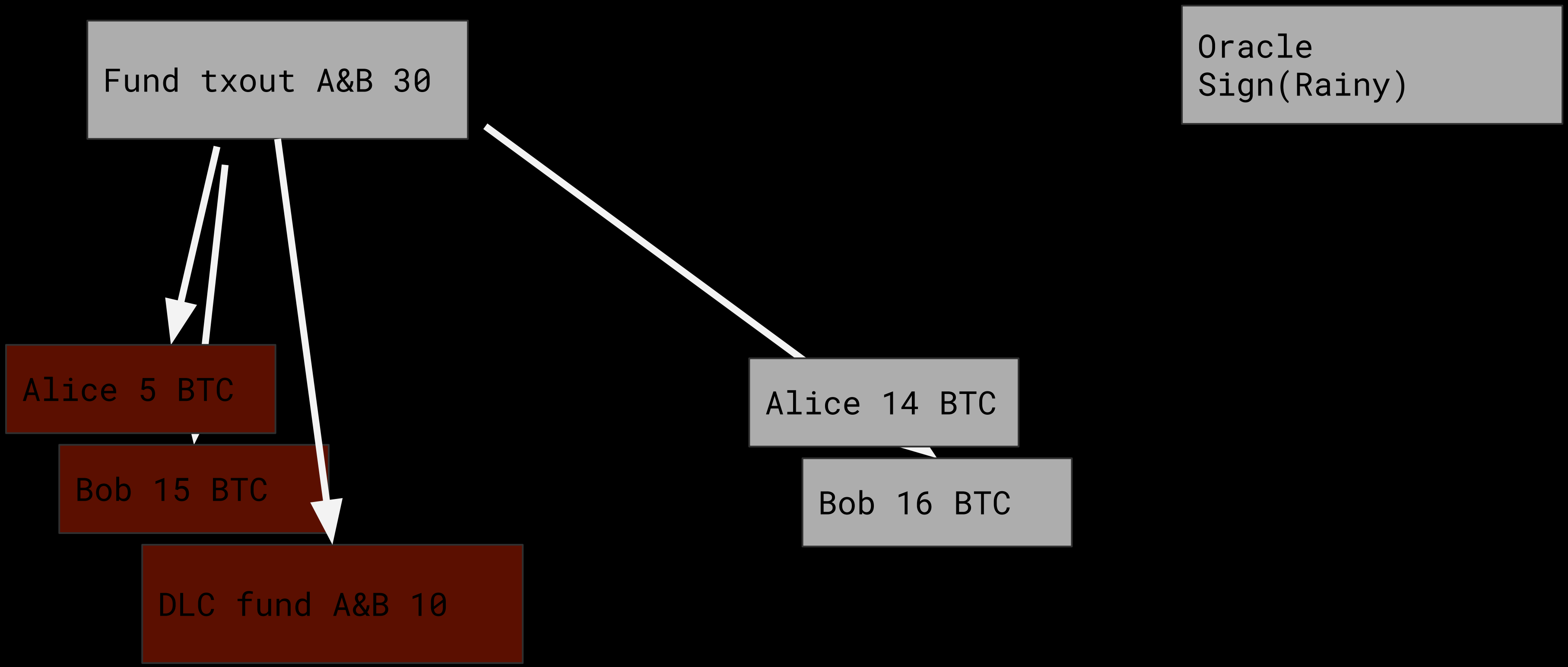
Bob 15 BTC

Bob +1 BTC

nested contracts



nested contracts



DLC scalability

Can split the R value (and message) in to a R-exponent and R-mantissa

Helps cut down the off-chain transactions needed in ranges which don't lead to different allocations

multi-oracle

Maybe Alice and Bob want to use 2 oracles. No problem.

$s_aG + s_bG = s_cG$

Just add the sG points. n of n, no size increase. (n of m, size blowup)

DLC use cases

Currency futures? Stocks?

Commodities? Sports? Insurance?

Pretty general; conditional payments based on any number or element from predetermined set.