SECURE THE BAG

Jeremy Rubin

Why are we here?

What is Scaling?

Increasing Transaction Throughput

Scaling = Tradeoffs

- Decentralization
- Redundancy
- Privacy
- Censorship Resistance
- Layerization Complexity
- Latency
- Cost
- Peak/Trough Provisioning
- Reliability
- Interactivity
- Bandwidth Requirements
- Storage Requirements
- Fairness
- "Scanability"
- Homogeneity of use
- Collateralization
- Smart Contract Complexity
- Quantum Resistance
- Reorg Safety
- Orphan Rates
- Etc...

Acceptable tradeoffs?

Block Size Increases

PRO

Conceptually Simple

CON

Reliability/DoS

Centralization

Hard-Fork

Storage Requirements

Bandwidth

Orphan Rate Increase

Lightning Network

PRO

Low Latency

Privacy

Low On-Chain Usage

CON

Contract Complexity

No Settlement Finality

Collateralization

Interactivity

Intermediation/Middle Men

No Reorg Safety

מַה זֶּה ???

PRO

Conceptually simple

Low Latency

Privacy

Immediate Settlement Finality

No over-collateralization

Low contract complexity

Non Interactive

Real time Bandwidth reduction

Soft Fork

Reorg Safety

etc...

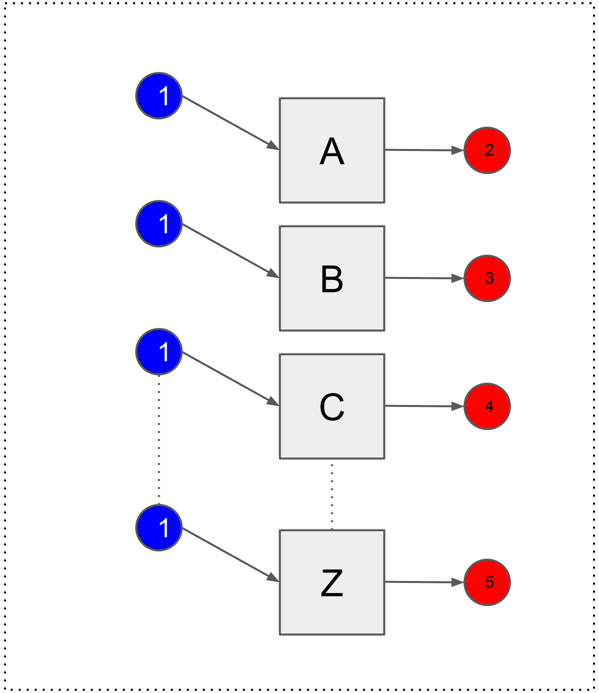
CON

N.A.

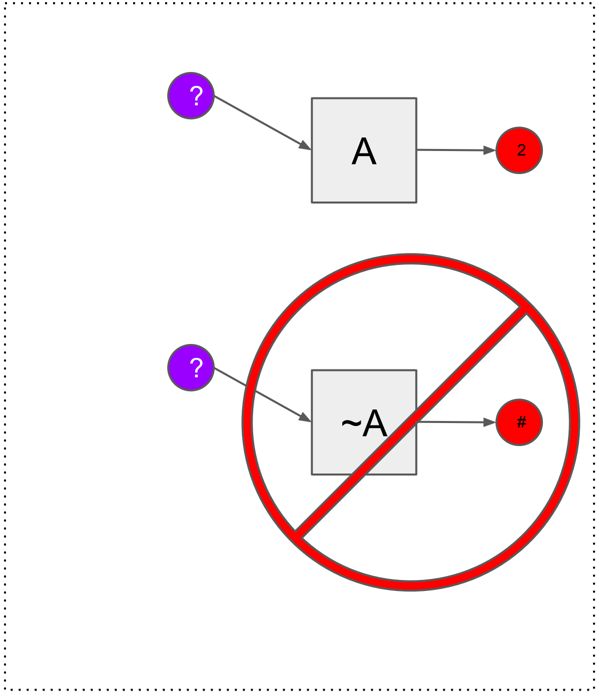
Intuition Building

Intuition Building:
Committed UTXOs / "Certified Cheques"

Normal

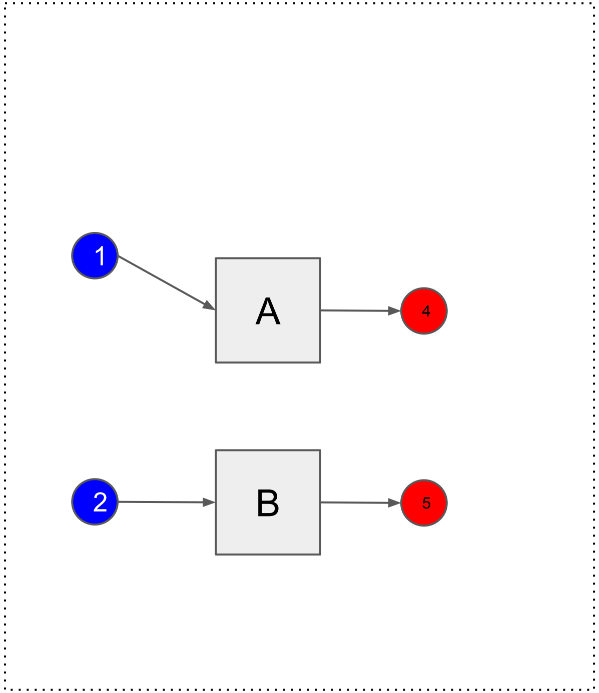


Committed

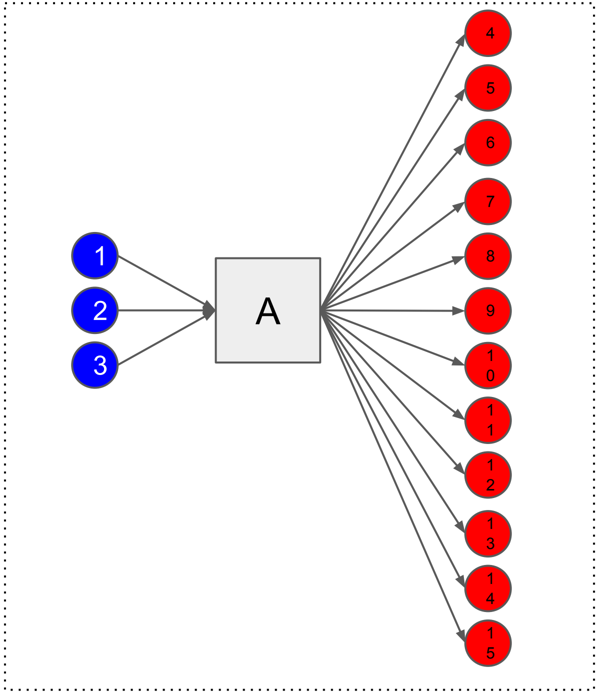


Intuition Building: Batched Payments

Payment

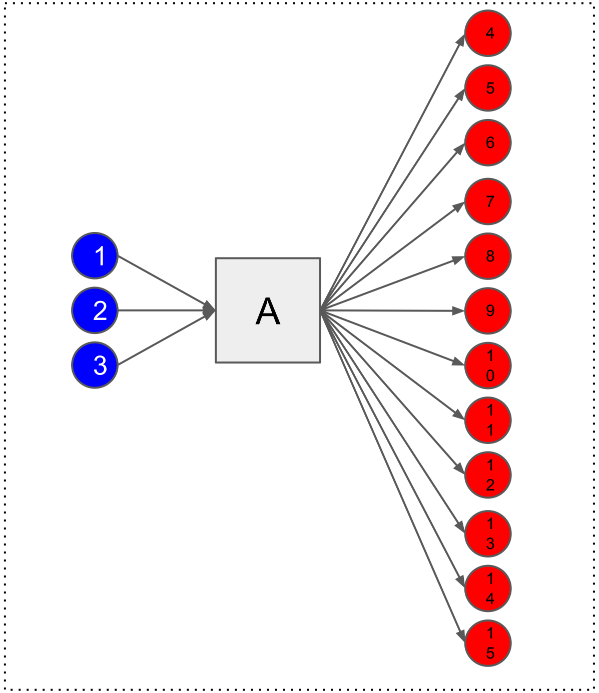


Batch Payment



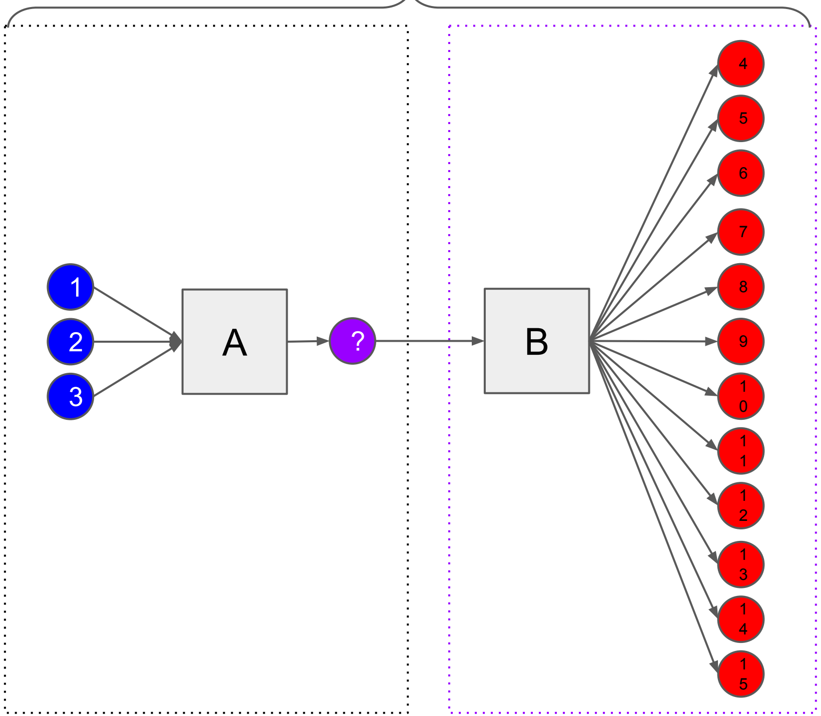
Intuition Building: Two Phase Payments

Batch Payment



Pay Phase 1:
Spend(3); Create(12);

2-Phase Payment



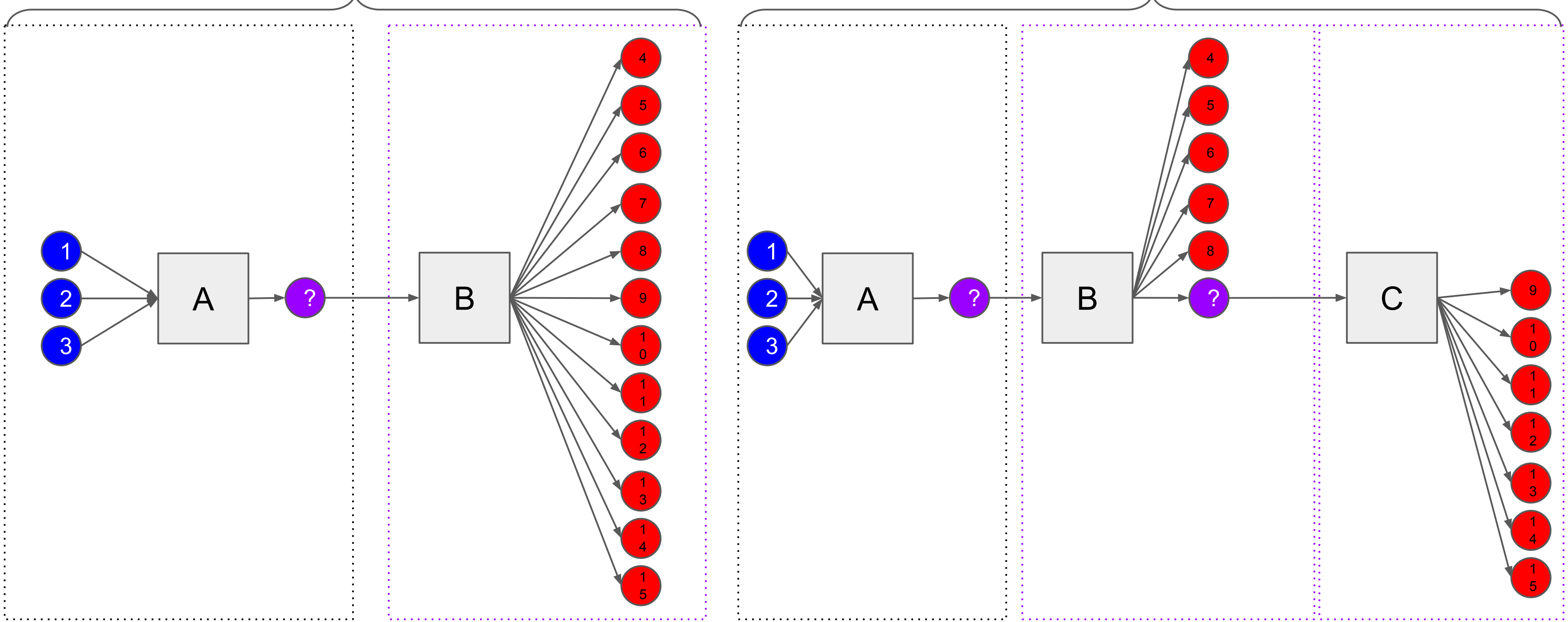
Spend Phase 1:
Spend(3); Create(1);

Receive Phase 2:
Spend(1); Create(12);

Intuition Building: Multi Phase Payments

2-Phase Payment

Chained Payment



Spend Phase 1:
Spend(3); Create(1);

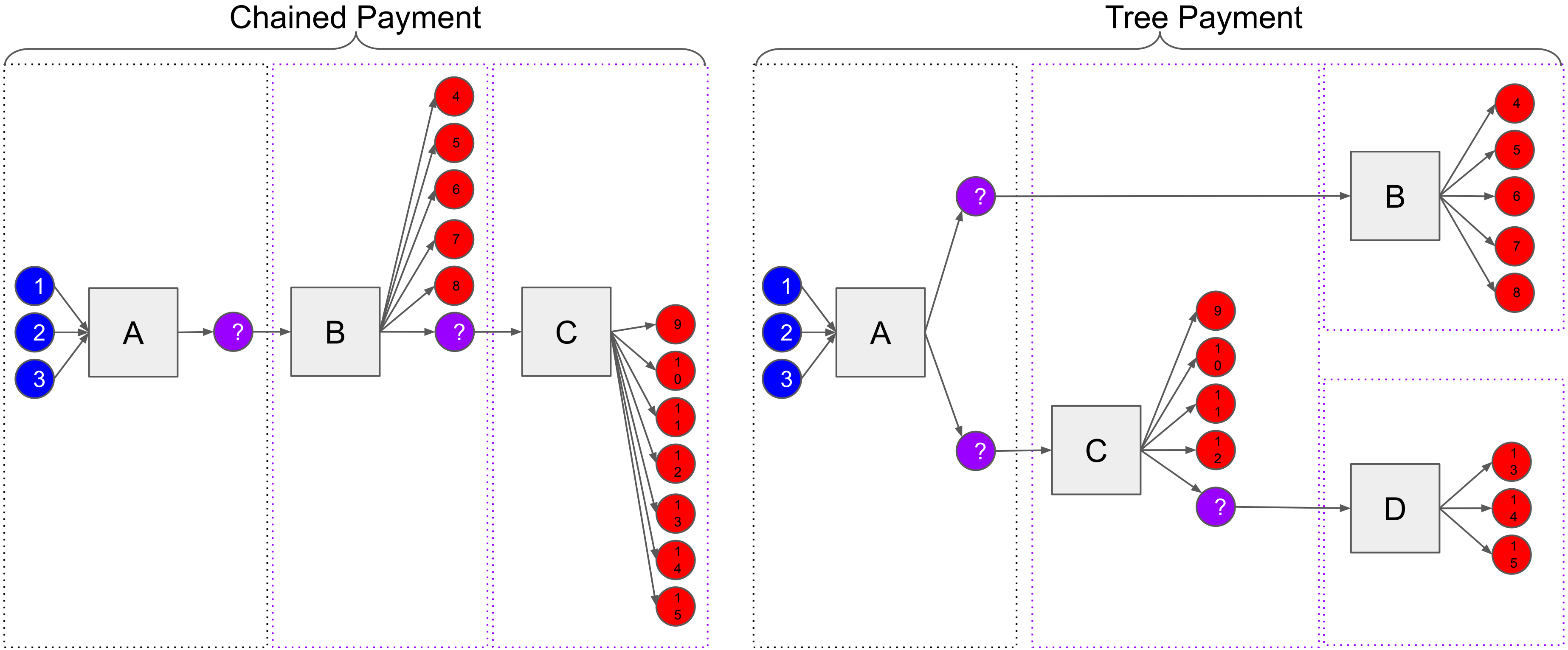
Receive Phase 2:
Spend(1); Create(12);

Spend Phase 1:
Spend(3); Create(1);

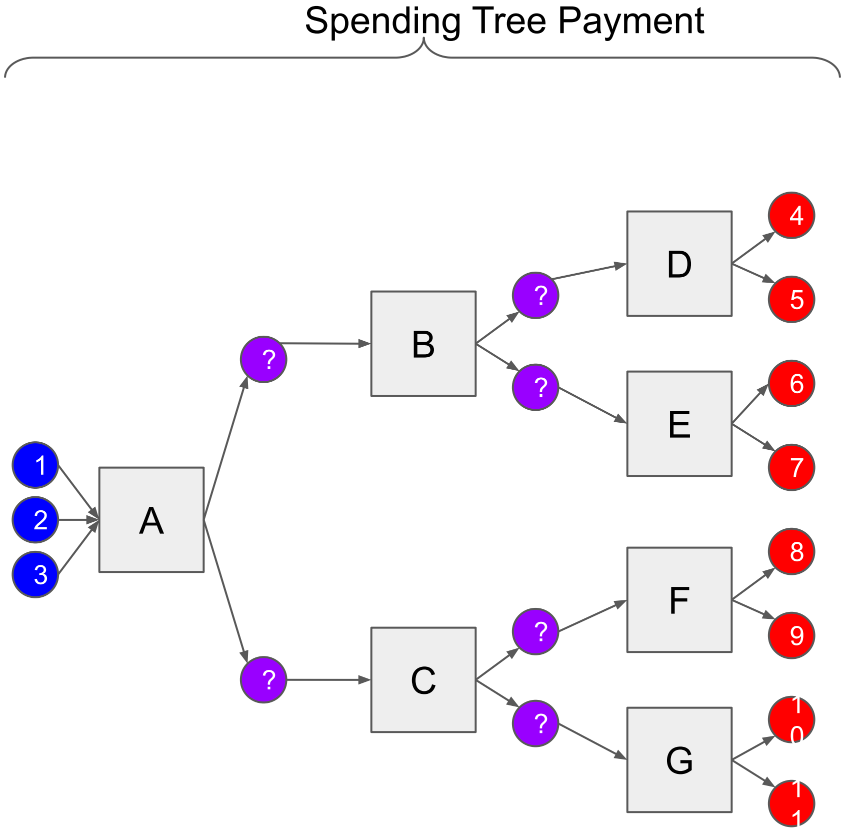
Receive Phase 2:
Spend(1); Create(6);

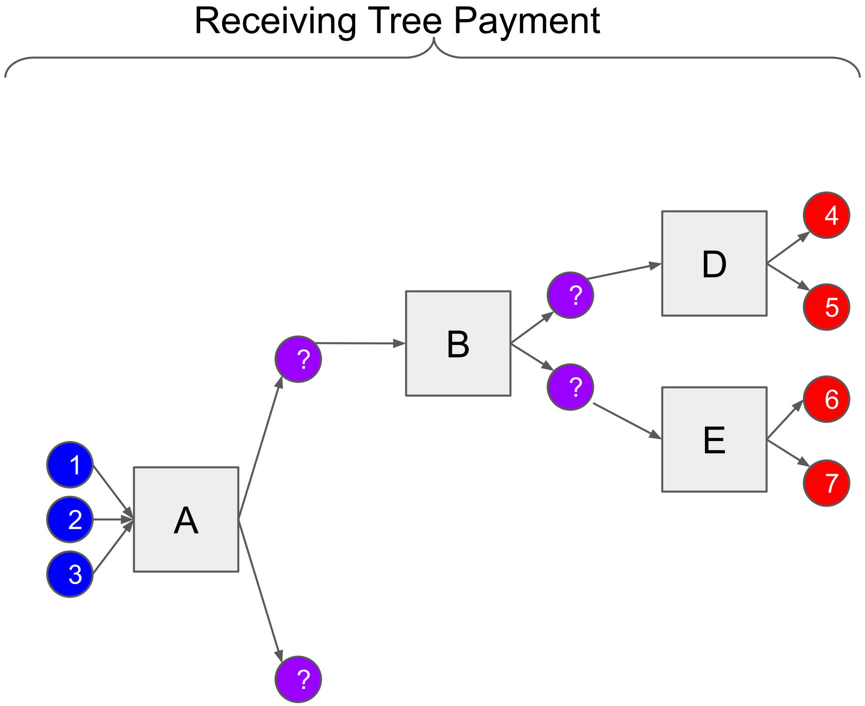
Receive Phase 3:
Spend(1); Create(7);

Intuition Building: Tree Payments



Intuition Building: Receiving Tree Payments





What's the magic?

Four Options

- 👎"Covenants" (OP_COV)👎
- 👎Pubkey Recovery (CHECK.SIGFROM.STACK, ANY.PREVOUT/NO.INPUT)👎
- 👎Presigned Transactions👎
- 🆕👍OP_SECURE.THE.BAG 👍🆕

Alternatives? 👎👎👎

- OP_COV
  - Too Powerful → Too Much Technical Risk
  - Covenant "viruses"
  - Complex implementation rules
  - Specific outputs
- Presigned Tx Multisig
  - Interactivity OR Trusted Third Party
  - Fancy ECDSA OR Schnorr protocols (fairness impossibility problems)
  - Can't prove receiving guarantee to third party
  - Key Deletion "Toxic waste"
- Pubkey Recovery (CHECKSIGFROMSTACK, ANYPREVOUT/NOINPUT)
  - Possible recursion with OP_ECTWEAK
  - Abstraction violation "Keys should be Keys, Signatures, Signatures"
  - Incompatible with message digest including pubkey; related key attacks

OP_SECURETHEBAG

- Multibyte OpCode: `OP_SECURETHEBAG 0x20 **<arg>**`
- **STB**(tx) = **H**(tag || ver || locktime || **H**(outs) || **H**(seqs) || # inps || scriptSigs)
- **STB**(tx) commits info which mutates TXID **except** input COutpoints
- OP_STB verifies **STB**(tx) matches what can be computed from tx
- Multibyte Op structure ensures the desired TX is known at spend time
  - Disallows all recursive covenants
  - Future safe w.r.t. Above: *There is no set of pure extensions* to script E such that enabling E and OP_SECURETHEBAG as proposed enables recursive covenants, but E alone does not enable recursive covenants?*
- Multiple inputs allowed
  - *Generally not safe to use #inps > 1! -- "half spend problem"*
- Deployment: inside of Tapscript or standalone

Implementation Progress

- Draft BIP
- Proof of Concept Code for Opcode Available
- Experimental core wallet support in progress
- Minor BIP options in flux (pushless multibyte opcode v.s. taint tracking v.s. …)
- Deployment Strategy T.B.D.

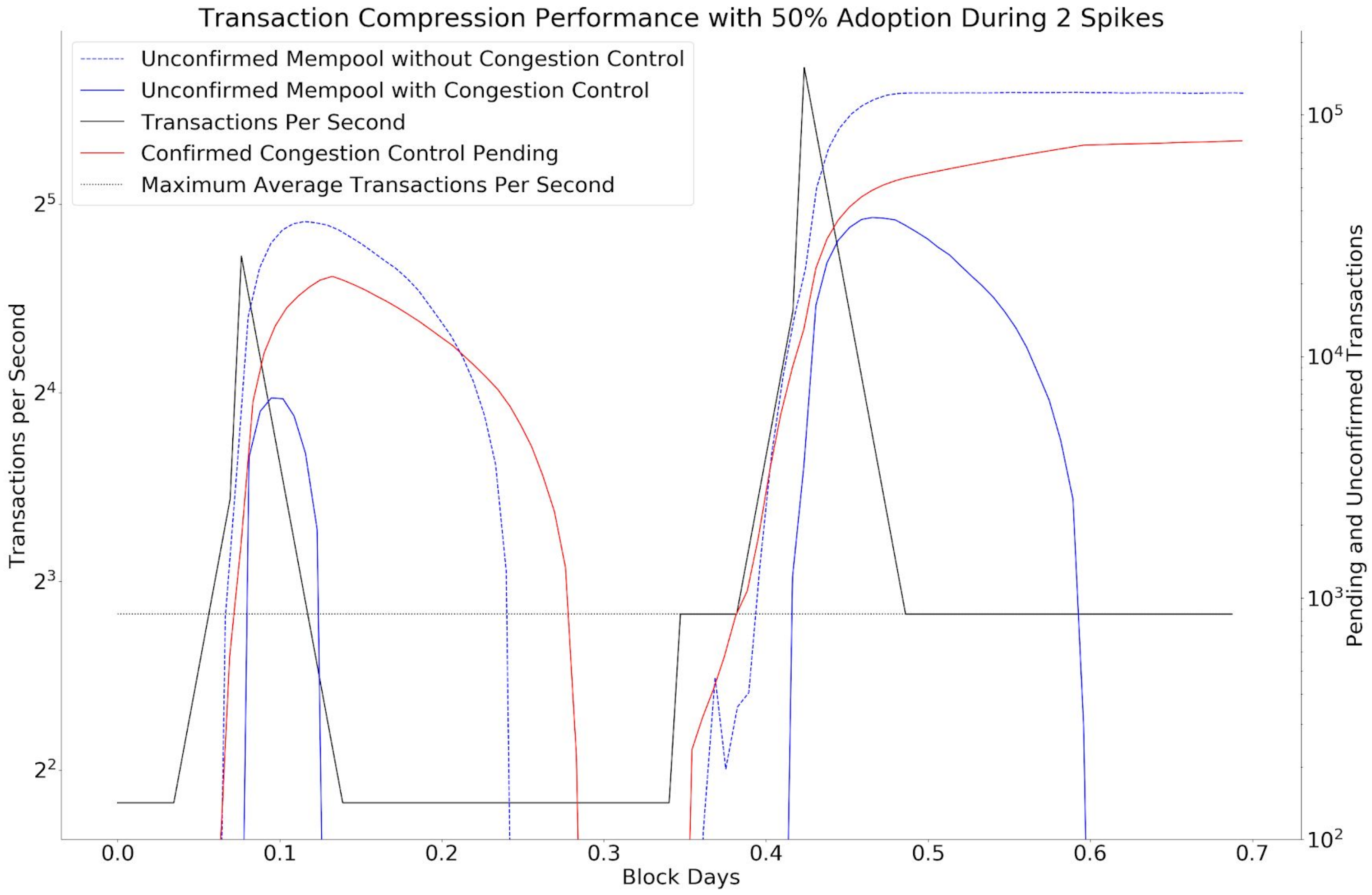
Impact

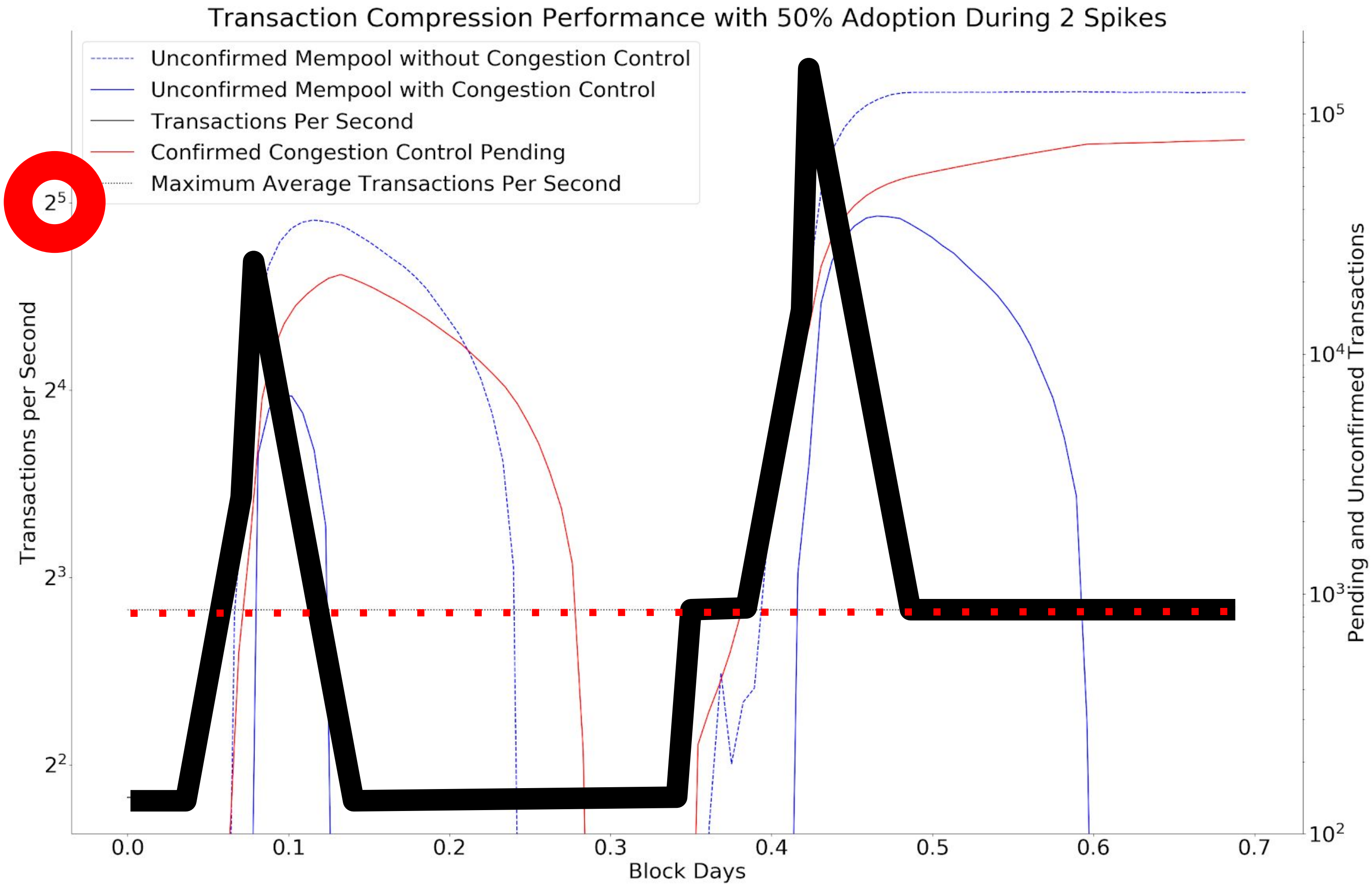
⚠️WARNING⚠️

Simulated Results
May Not Match Reality

⚠️WARNING⚠️

This message brought to you by respect for the scientific process;
results reproducible from https://github.com/JeremyRubin/bips/blob/op-secure-the-bag/bip-secure-the-bag/simulation.py


Transaction Compression Performance with 50% Adoption During 2 Spikes
Unconfirmed Mempool without Congestion Control
Unconfirmed Mempool with Congestion Control
Transactions Per Second
Confirmed Congestion Control Pending
Maximum Average Transactions Per Second
Transactions per Second
2^2
2^3
2^4
2^5
Pending and Unconfirmed Transactions
10^2
10^3
10^4
10^5
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Block Days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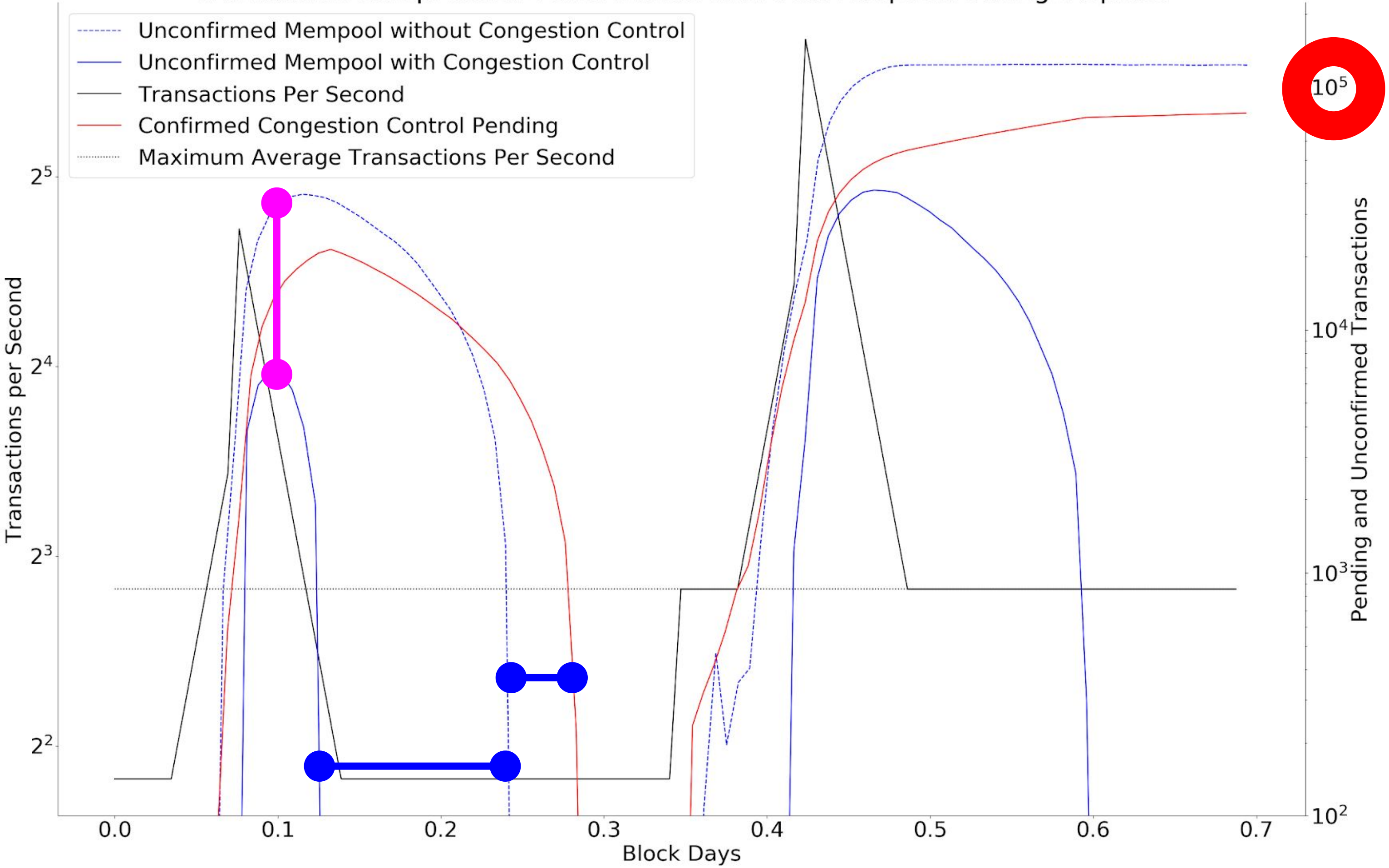

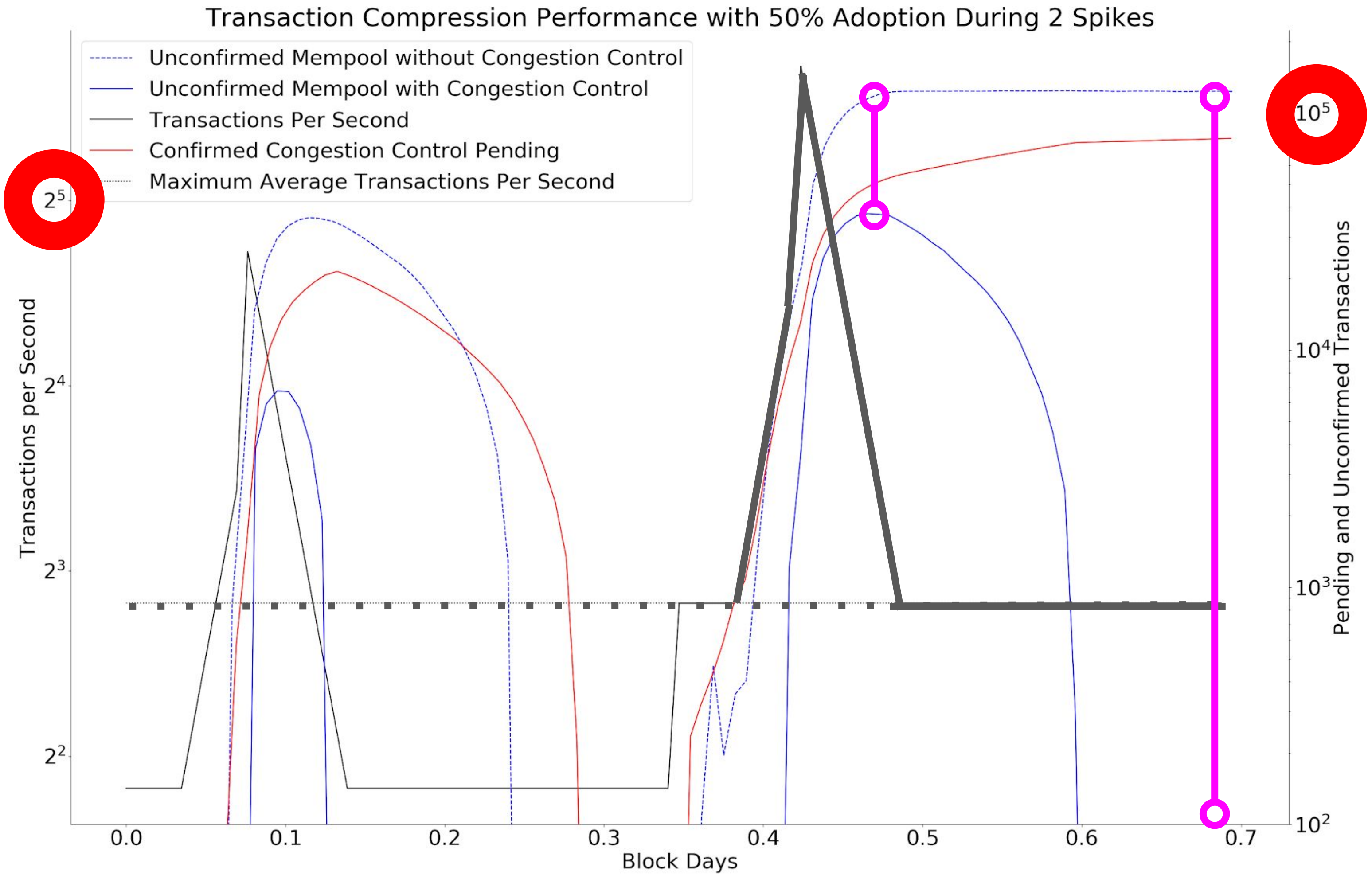

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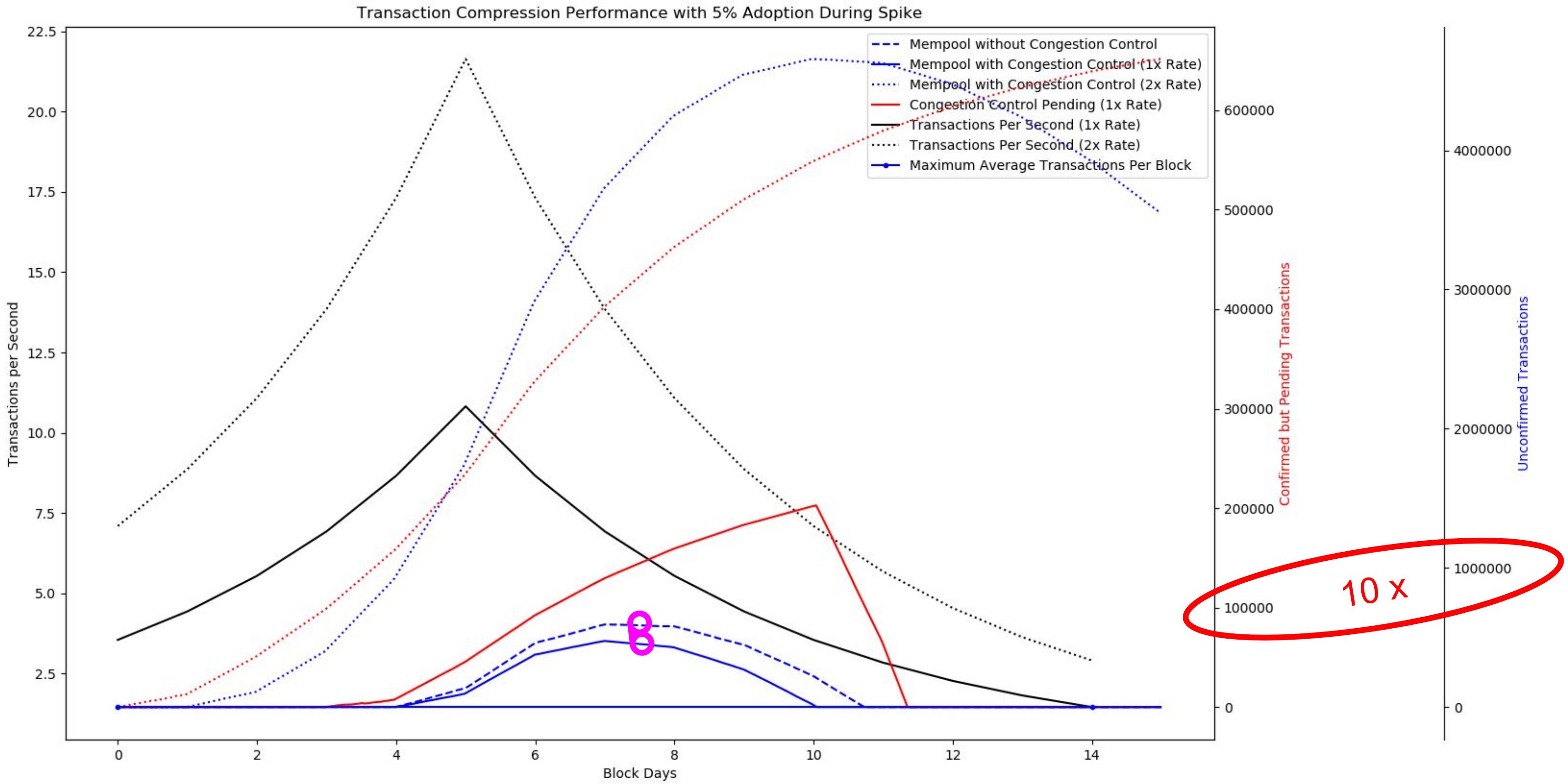
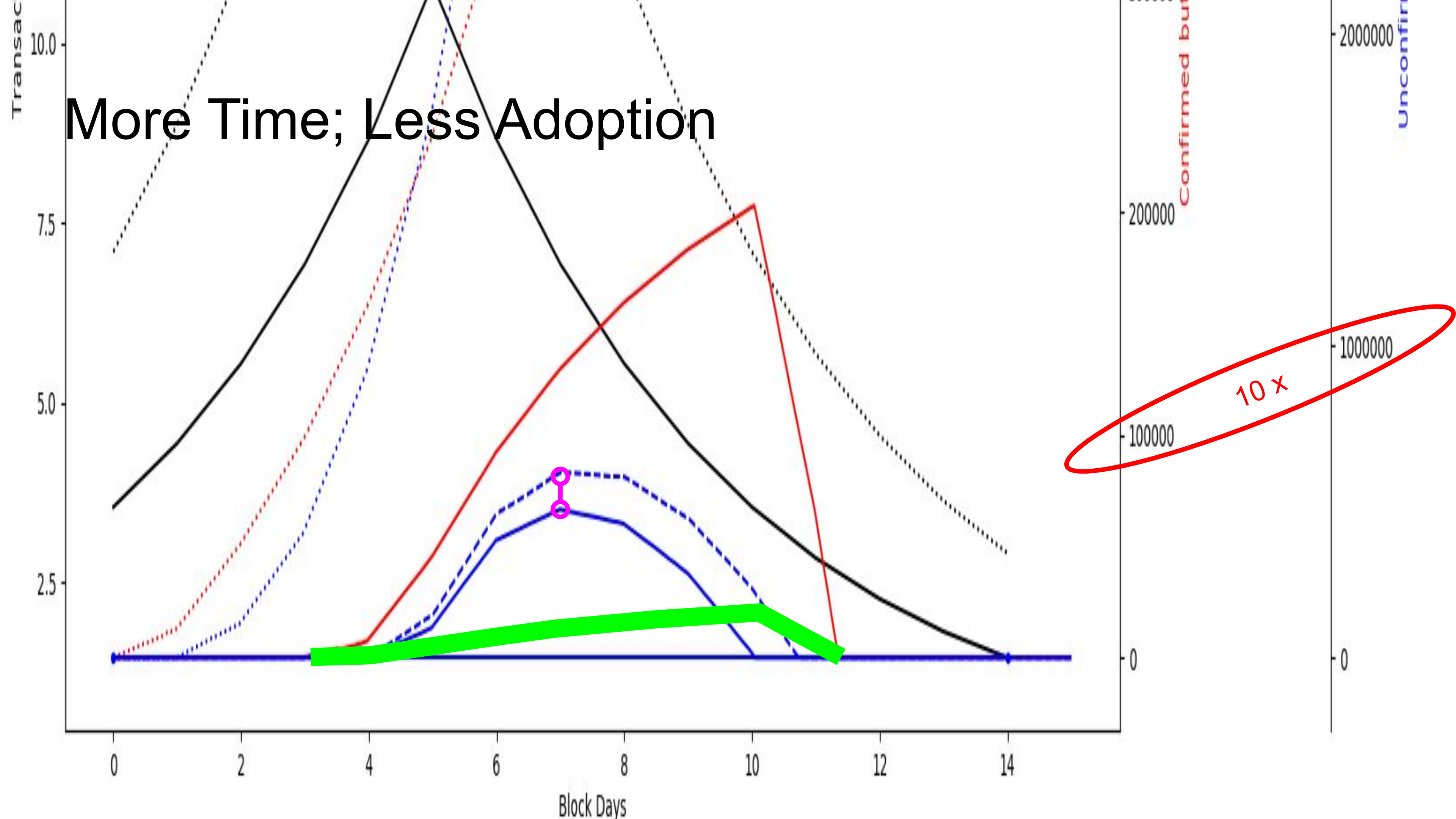
0.7
Block Days

More Time; Less Adoption

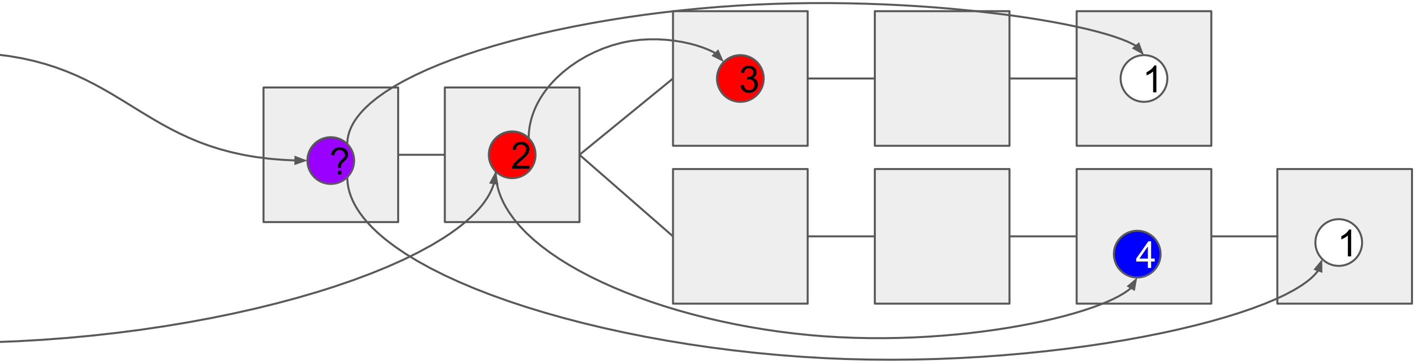


More Time; Less Adoption



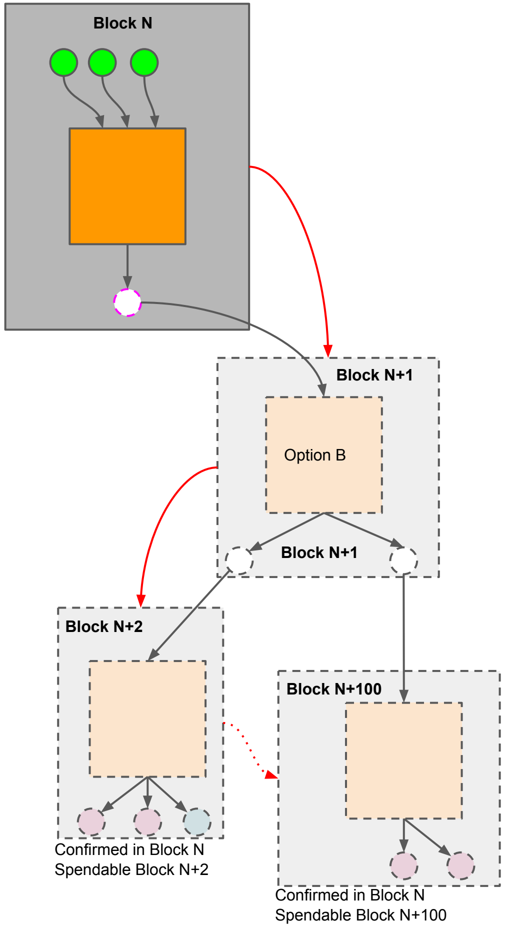
Summary: OP_STB is a Txn Bypass Capacitor

- Smooths out the Backlog
- Soaks up excess txs, releases them later
- **Private benefit large even with small adoption**
- Private use benefits entire public (mempool decongestion)
- Healthier backlog of low-priority transactions
- Reorg Safety:

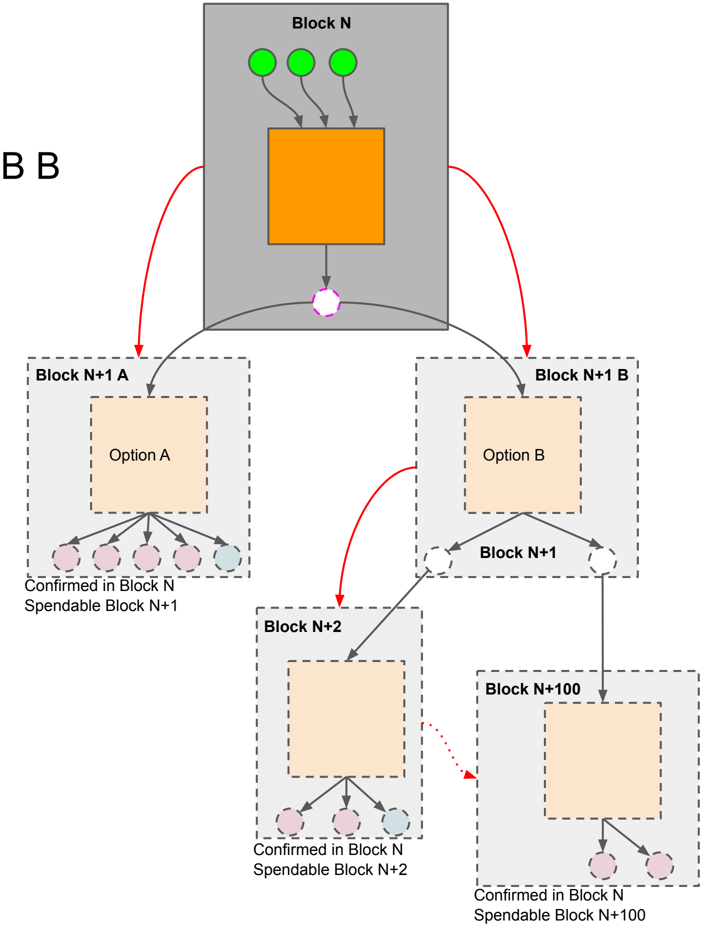


What's the catch?

First: Multi-Radix Congestion Controlled Transactions



IF STB A
ELSE STB B



Probably True Claim; Fancy Way of Saying No-Cons

Given:

- O(1) overhead amortized per input & O(n) overall, where w/o STB cost is O(n) also
- Multi-radix setups (OP_IF, OP_MBV, or Taproot) (Huffman Encoded)
    - Simple radix-2 and radix-N expansion **IF** **P(radix-2 used) = O(1/n)** is E[O(c)] overhead
- Ability to defer and wait for *'asymptotically cheaper'* blockspace (**fees discounted O(1/n)**)
- Smaller Size/verification of interior node txns compared to normal txns (no signatures)
- Prunability of interior nodes (recomputable from leafs)
- Optimal Tree Structure (leafs at different depths)
- Subtree application of the above principles

The overhead of OP_STB is E[O(*c*)], where the actual overhead *c* is a small constant.

Quickfire: Advanced Topics in Secure The Bag

Inter Business Traffic

OP_STB withdraw from Exchange A can be immediately credited to Exchange B

Funds are effectively in "cold storage"

Businesses can manage their liquidity

Let users receive goods/trade once confirmed.

Ball Lightning

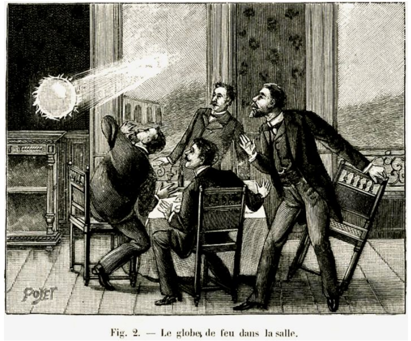
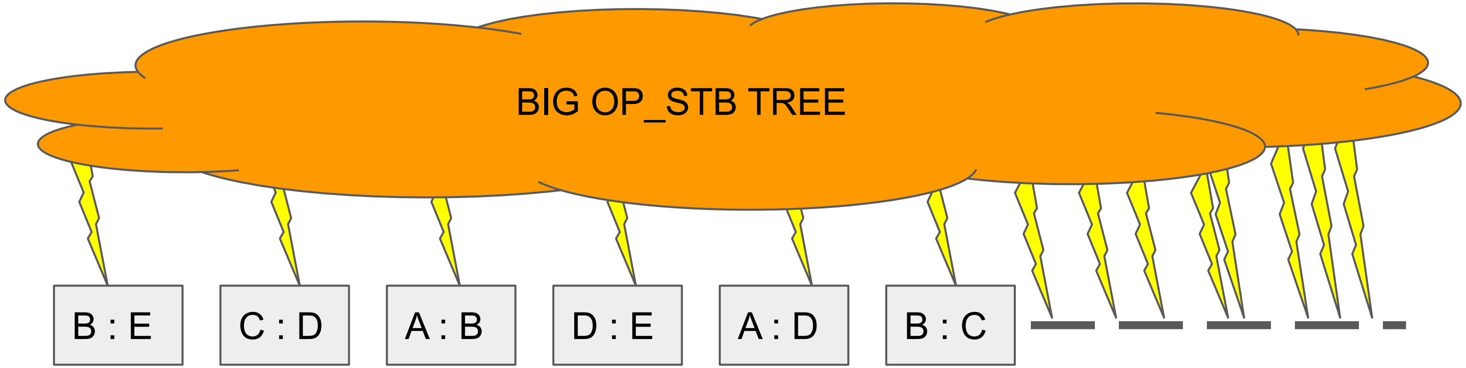
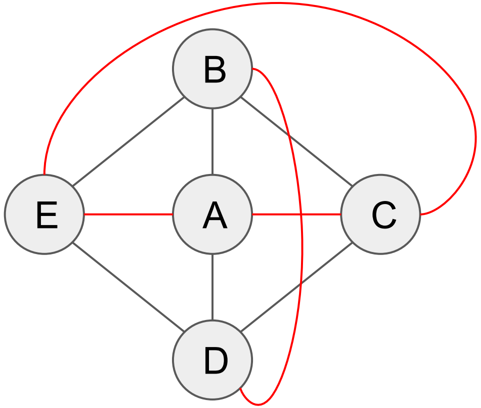


Fig. 2. — Le globe de feu dans la salle.



N participants; O(N log N) channels
Setup: O(1)
Closing 1 Channel: O(log(N log N)) = O(log(N) + log log N) = O(log(N))
Closing all of a User's Channels: O(N log N / N) = O(log N)
Closing Channels Amortized Per Channel: O(N log N / N log N) = O(1)

N participants; O(N^2) channels
Setup: O(1)
Closing 1 Channel: O(log(N^2)) = O(log(N))
Closing all of a User's Channels: O(N^2 / N) = O(N)
Closing Channels Amortized Per Channel: O(N^2 / N^2) = O(1)



Smart Contracts

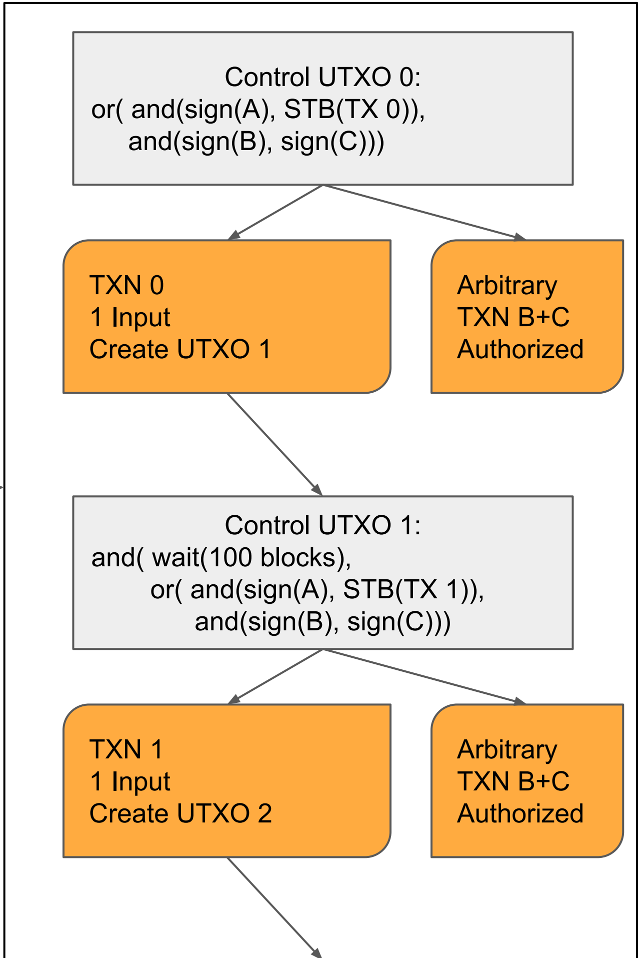
OP_STB unroll looped programs into finite steps

Original Program Intent

```
while (true):
  if (sign key A):
    wait(100 blocks)
  else if (sign key B & C):
   return ALLOW_SPEND
```

Pick large RUN_LIMIT
Pick acceptable default action

```
for int i = 0; i < RUN_LIMIT; ++:i
  if (sign key A):
     wait(100 blocks)
  else if (sign key B & C):
    return ALLOW_SPEND
wait(sign key B & C)
```



Control UTXO 0:
or(and(sign(A), STB(TX 0)),
and(sign(B), sign(C)))

TXN 0
1 Input
Create UTXO 1

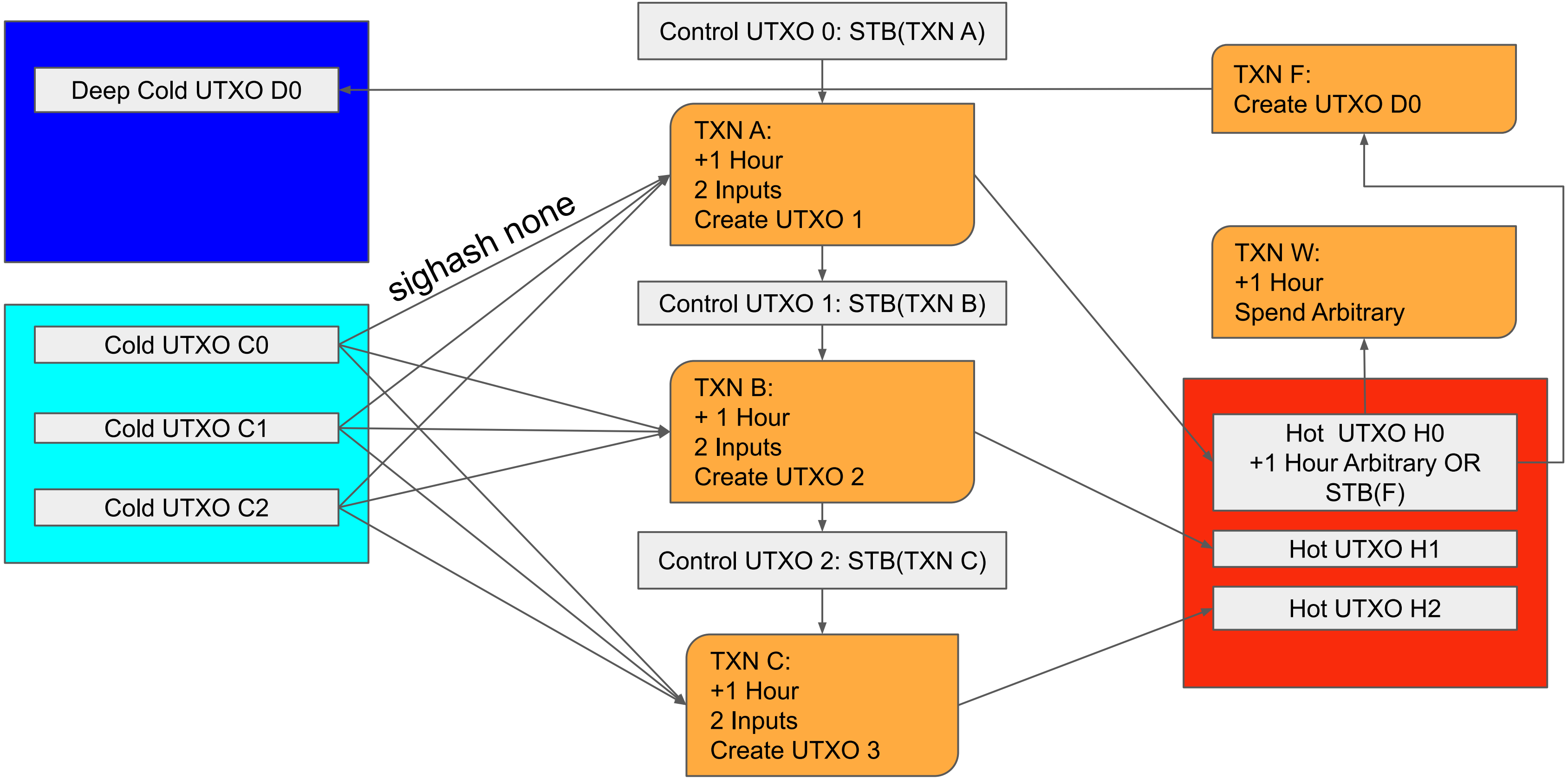
Arbitrary
TXN B+C
Authorized

Control UTXO 1:
and(wait(100 blocks),
or(and(sign(A), STB(TX 1)),
and(sign(B), sign(C)))

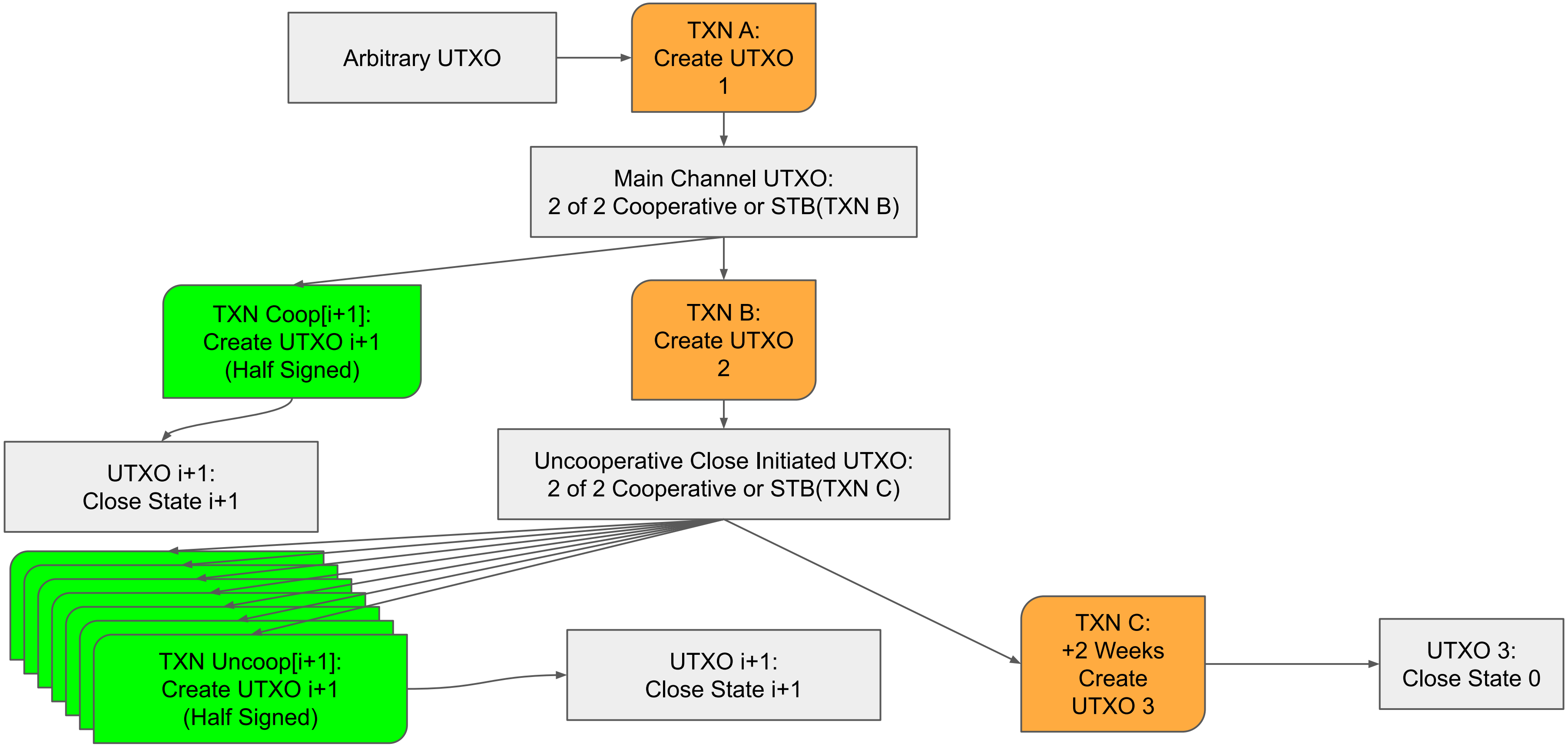
TXN 1
1 Input
Create UTXO 2

Arbitrary
TXN B+C
Authorized

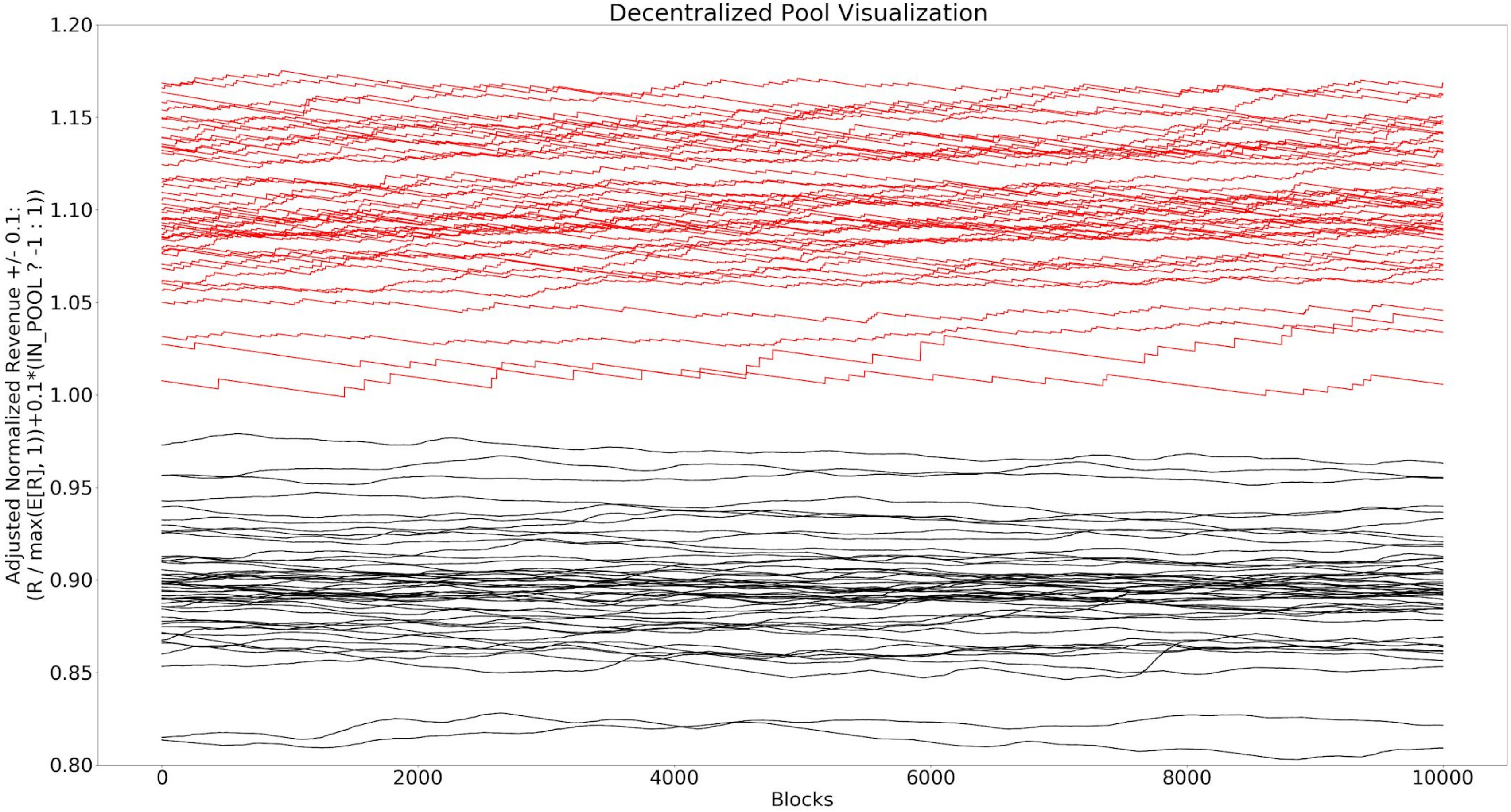
Smart Vaults: Using Control Programs



Non Interactive Channels (works w/ Ball Lightning)



Coordination Free Decentralized Mining Pool Payouts



Summary:
OP_STB "סבבה"

Deployment

Do we **need** this feature?

Yes

How Urgently?

Later

Fees are low right now.

Other exciting changes on the way.

Limited engineering resources.

NOW

Why wait for the sickness?

Changes are slow, better to push when not suffering.

Exchanges spend millions per year on BTC fees; invest more eng time in reducing fee burden.

Healthy backlog of low priority important as halving approaches.

Options

Tapscript Extension

Pro

- Merkle Branch Lookups
- Easier to change opcode semantics

Con

- Delay
- Can't use with legacy scripts

Standalone OP NOP Upgrade

Pro

- Available broadly
- Don't need to wait for Taproot

Con

- Can't use Tapscript OP_SUCCESS
- Less "forced" Taproot privacy benefit
- Messier OpCode semantics

FIN

How to Get Involved:

Review the BIP.

Sponsor me: I'm a starving independent researcher.

Work on the implementation.

Work on integrating OP_STB in your products.

Chime in on the mailing lists.

Follow @JeremyRubin / Tweet your support!

Work partially supported

BINANCE
— X —
FELLOW