Decentralised Mining Pool for Bitcoin (Draft 0.2)

Abstract

Bitcoin p2pool's usage has steadily declined over the years, negatively impacting bitcoin's decentralisation. The primary problems with p2pool are twofold. First, the variance in earnings for miners increases with total hashrate participating in the pool. Second, payouts to miners require a linearly increasing block space with the number of miners participating in the pool. There are two different proposals under discussion that address these problems, (i) building a directed acyclic graph (DAG) of miner's shares such that miners are rewarded for all their proof of work, and (ii) using payment channels to distribute payouts to miners. In this paper, we present a solution that builds on these two proposals. A DAG of shares is maintained as a replicated database by all miners and the DAG is then used to compute rewards for miners. These mining rewards are paid out by an anonymous hub communicating with the miners using Tor's hidden services. Using the payment channels construction, neither the hub nor the miners can cheat. We show that our approach is incentives compatible and describe how the hub maintains its anonymity to resist DDoS attacks.

1 Motivation

P2Pool [1] helps bitcoin's decentralisation by allowing miners to select the transactions they mine. This avoids any potential transaction censorship by pool operators. However, the construction used by P2Pool faces a number of problems that has resulted in miners abandoning the pool. The most often cited problems are:

1. large variance in earnings for miners,
2. large number of stale blocks, and
3. large block space requirement for payouts.

The first two problems are a direct consequence of the shares block rate limited to 30 seconds on the bitcoin p2pool. Intuitively, as the hash rate participation in the pool goes up, the difficulty for 30 seconds block rate goes up and smaller miners find it harder to find shares within a 30 second period. This results in an increase in the variance for shares found by miners and thus for the rewards earned by the miners. Ethereum's inclusive protocols [8] address

the problem by building a DAG of blocks and rewarding blocks that otherwise would have been left out as stale blocks. As miners get rewarded for more of their work, the variance on their earnings reduces enabling smaller miners to remain economically viable.

Payouts in P2Pool are included in the coinbase of the block being mined. As the number of participants in P2Pool increase the size of the coinbase transaction increases taking up valuable block space that the miners could have earned fees from instead. This imposes an upper bound on the number of participants in P2Pool.

Knowing the challenges faced by P2Pool, we list the goals of a new decentralised mining pool as:

1. Reduce variance for miners with increasing pool hash rate.
2. Make payouts to miners with constant size block space requirement.
3. Allow miners to select transactions they want to mine, with no potential for a censor to deny payouts.

2 Current Proposals

TeraHash Coin [9], Jute [16] and Spectre [15] use a DAG for faster block times and focus on changing the consensus layer of bitcoin. These proposals allow miners to produce shares that include conflicting transactions and then apply rules to find a set of transactions acceptable at various cuts of the DAG, such that the bitcoin consensus rules are not violated.

Braiding the blockchain proposal [9] shows how, smaller more frequent blocks can form a DAG of blocks, called a braid, with each block pointing to one or more one previous blocks. Blocks in the braid are called beads and can have transactions repeated in different beads. The proposal describes how duplicate and double spend transactions can be resolved to reach a decision on the state of the ledger at any cut of the DAG.

In the proposal, miners earn a coin native to the braid blockchain, called TeraHash Coin. This coin can then be swapped for BTC. The proposal doesn't yet define how this native coin will be swapped for BTC. Some of the suggestions under discussion include using atomic swaps, burning the TeraHash Coin, or using financial instruments like futures of the bitcoin's hash rate to swap TeraHash Coins for BTC. The problems with the atomic swap approach is the need for $O(n)$ block space in number of miners, as we need two transactions to execute a swap with each miner payout. Burning TeraHash Coins for BTC requires a trusted third party to execute the burn. Finally, trading TeraHash Coins for BTC futures has the problem of introducing centralisation on the futures market operator. There is some discussion around using DEXes for executing futures contracts, but these are initial ideas and we will evaluate them in the future for incorporating them into our proposal once they have been developed further.

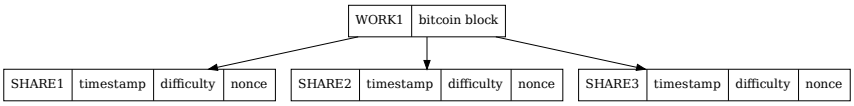

Figure 1: Each WORK generated and shared by a miner is then followed by the SHAREs the miner finds.

Belcher [3] proposes using payment channels to avoid using block space for making payouts to miners. The construction uses payment channels between federated hubs to pay miners after a block has been successfully mined. The payouts are made after a long period, similar to the 100 blocks requirements for spending from coinbase transactions. The hub locks in BTC for each miner by opening payment channels for each of the miners. The construction shows how both miners and the hub can not cheat and how the funders of the hub earns rewards for funding the payment channels.

The two ideas of using a DAG and payment channels for rewards payouts together present a potential path for rebooting P2Pool. In the rest of the paper we present a modified version of TeraHash Coin and show how the various components work together.

3 Decentralised Bitcoin Mining

In this section we present a modified version of TeraHash Coin. We propose building a DAG of miner's shares and use that to determine the payout distribution between miners. We then show that miners are rewarded for shares that they broadcast to the p2p network in a timely manner.

3.1 A DAG of Shares

Each miner builds their own block, selecting transactions according to their own criteria. We call this block the WORK and it is derived from the results of the `getblocktemplate` bitcoin API call. The WORK definition leaves out the merkle root, timestamp and the difficulty. Instead it includes the coinbase transaction so that other pool participants can verify that the WORK definition includes the correct payout scripts. Table 1 shows the WORK built by miners and then broadcast to the entire p2p network. The transactions field is compressed using the same techniques as specified in the compact block specifications [4].

The miner then starts mining on WORK and generates SHAREs. Figure 1 shows the relationship between WORK and its SHAREs. Each WORK created by a miner can result in multiple SHAREs and both the WORK and SHAREs are broadcast to the p2p network. When a miner receives a WORK from other miners

WORK

Field	Description	Size in bytes
Version	Bitcoin block's version field	4
Previous block	Hash of the previous bitcoin block	32
Coinbase	Coinbase for payment channel setup, see Section 3.4	38
Transactions	Transaction ids included in the block	variable
WORK hash	Hash of the above fields	32

Table 1: The structure of WORK broadcast by miners. Timestamp, difficult and nonce are left for the SHARE to specify

it validates this WORK using a local bitcoin node. When a SHARE is received by a miner it is validated against the WORK referenced by the SHARE.

Table 2 shows the structure of SHAREs broadcast by the miner. Each SHARE includes the hash of the WORK the miner is working on, along with the current target difficulty used by the miner, the public keys that the hub uses to setup payment channels, and finally the pubic key for the Tor hidden service run by the miner. The Tor hidden service is used for facilitating anonymous communication between the hub and the miners as described later in Section 3.7.

Miners broadcast their SHAREs to the network using a gossip protocol and all the miners maintain the DAG of SHAREs as a replicated database. Each node on the DAG is a SHARE generated by a miner and all miners track the most recently received SHARE from all other miners. Miners include a hash pointer to the most recent known SHAREs from all miners in its own SHARE. This leads to all edges in the DAG pointing from a SHARE to all the SHAREs known by the miner when it started mining the WORK. This construction of the DAG ensures that the DAG is eventually consistent on all p2p participants. Since one of the shares eventually satisfies the then bitcoin difficulty requirement the DAG also includes valid bitcoin blocks.

The DAG builds a "found before" relationship between shares which enables the reward calculation presented in Section 3.2. Using the DAG results in the size of SHARE increasing linearly with the size of the network and will lead to an upper bound on the size of the pool. With $N = 10,000$, the size of the share is $320kB$, which is small enough for fast propagation across a $10,000$ node peer to peer network [5]. However, scaling by another order of magnitude will require optimisations to the SHARE structure.

Each SHARE that matches or exceeds the current bitcoin difficulty starts a new *epoch* for the p2p mining pool. Figure 2 shows a DAG with three miners participating in the pool, a, b and c. The nodes in the DAG are the shares generated by the three miners. Nodes l and r are two valid bitcoin blocks that have been mined such that they meet bitcoin's difficulty at the time, and all the blocks between l and r are in the same *epoch*. All shares in an epoch have

SHARE

Field	Description	Size in bytes
WORK hash	Hash used to identify the WORK for this share	32
Nonce and extra nonce	Nonces used	$4 + 8$
Merkle root	New merkle root to include extra nonce	32
Timestamp	UNIX timestamp used	4
Difficulty	Claimed difficulty miner is using, if different from last share.	4
Public keys	Two pubkeys used by the hub to for channel management	66
list < SHARE hashes >	List of share hashes referenced by this SHARE	$N \times 32$
Tor Service	PubKey for onion service address, see Section 3.7.	32
Total size		$138 + N \times 32$

Table 2: The structure of SHAREs broadcast by miners. Size of the SHARE is dependent on the size of the network.

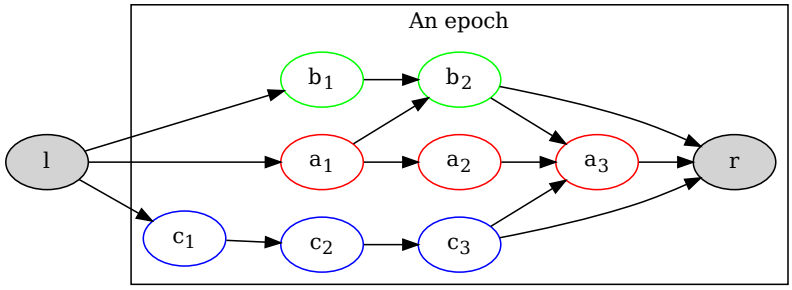

Figure 2: A epoch is defined as all the SHAREs mined between two bitcoin blocks. Here all the SHAREs between l and r are in the same *epoch*.

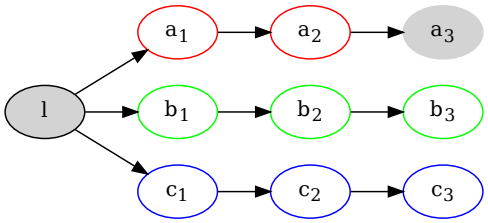

Figure 3: a discovers a share and the reward is not shared with any other miner.

a path from l to itself and a path from itself to r. Any shares that don't have a path from l and to r are not considered to be part of the *epoch*.

3.1.1 Miner Defined Difficulty

The nodes in the DAG are SHAREs mined at difficulty level selected by the miner. This difficulty can be dynamically changed by the miner after each SHARE, depending on the miner's observation of the p2p network's hashrate. This dynamic difficulty adjustment allows miners to adjust the rate at which they produce SHAREs. This is important as smaller miners can produce low difficulty shares to match the share rate of the larger miners in the pool. Even if smaller miners earn a smaller reward, they will earn these rewards for all their work.

In the next section we then describe how all peers compute their fair share of profits using the DAG of shares. We then show how our reward computation algorithm is incentives compatible [14].

3.2 Incentives Compatible Rewards

Each participating node, which includes the miners and the hub, maintains a local replica of the the SHAREs DAG. Each SHARE includes a reference to the shares the miner was aware of when the SHARE was found. If a miner a doesn't include the SHAREs of miner b, it signals a failure of communication between the two miners and we require that miner a in such a situation should stop including references to b's SHAREs. With this rule in places, miners are no longer incentivized to find optimal strategies for broadcasting their shares to the rest of the miners. They have a simple strategy to follow, which is to make sure their shares reach all other miners as soon as possible.

With the above rule in place all miners should include the SHAREs discovered by other miners, as otherwise they will be excluded by other miners and they will lose the opportunity to be rewarded for their work. We identify a degenerative

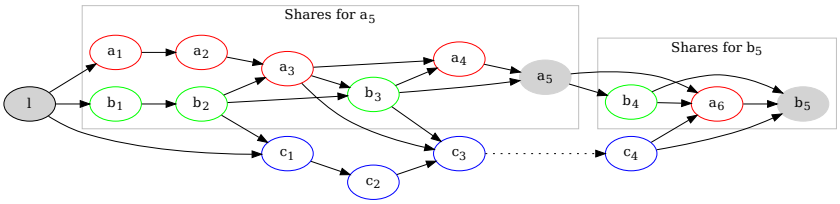

Figure 4: Two epochs in a DAG of shares mined by three mines — a, b and c. The shares in grey meet the bitcoin difficulty at the time they were mined.

case as "isolated miners" and argue that miners have no incentives to act in this manner. Figure 3 shows a DAG where all three miners a, b and c are working independently. In such a situation when the miner a discovers a share a_3 that is a valid bitcoin block the reward is not shared with any other miner as a_3 does not include any references to shares from other miners.

With the above understanding of why miners will co-operate, we now state the rules to calculate how the block reward should be divided between miners.

1. Traverse the DAG in reverse order from the SHARE that found a bitcoin block to the previous bitcoin block found and collect this set of shares.

2. From the above set of shares remove all shares that don't have a reverse path to the previous bitcoin block.

3. Distribute the reward between miners weighted by the sum of the difficulty of all SHAREs found by miners.

As an example, consider the p2p network of miners a, b and c with the DAG of shares as shown in Figure 4. In the DAG, the set of shares that receive reward proportional to their difficulty are $\{a_1..a_5, b_1..b_3\}$. The shares $\{c_1..c_3\}$ do not receive any reward as they are not reachable from the bitcoin block, a_5, even if they are reachable from l. In other words, since the shares $\{c_1..c_3\}$ are not part of the *epoch* terminating in a_5 the miner c is not rewarded for those shares. We exclude the shares $c_1..c_4$ from the set of shares to be rewarded to avoid miners indulging in selfish mining [7].

For the second bitcoin block b_5 only the miners a and b receive rewards in proportion to the difficulties of their shares $\{b_4, b_5, a_6\}$. c doesn't receive any reward for c_4 as it again is not part of the *epoch* terminating in b_5.

Given the above rules, we show how they together provide an incentives compatible reward function [14]. We present an outline of proofs that will be be formalised in future work.

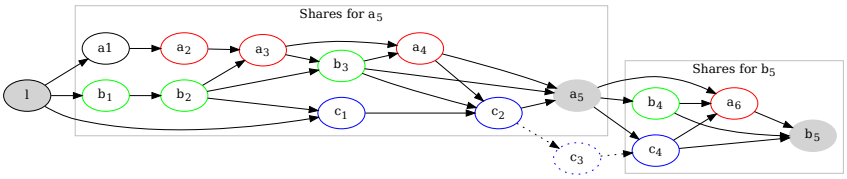

Figure 5: Share c_3 is a stale share that c earns no reward for.

3.2.1 Incentive Compatibility

A reward function is defined as incentive compatible if every miner's best response strategy reports full solutions immediately [14]. Where a "full solution" is a share that meets the bitcoin network's difficulty requirement.

Given the rules in Section 3.2, if a miner finds a bitcoin block the miner wants to get maximum reward possible based on all the shares it has found and therefore is incentivized to announce their SHARE as soon as it finds the block. The longer a miner waits to announce the bitcoin block to the bitcoin network, the higher the probability that some other miner on the pool will find a different bitcoin block that doesn't reward their latest shares that haven't reached the other miner. Further still, the rewards calculation can be adjusted to give an extra reward to the miner that finds the block. This is similar to what p2pool does and Belcher also mentions in his proposal.

3.2.2 Proportional Payments

Proportional payments [14] property requires that the pool pays miners in proportion to the amount of work they have performed. According to our rewards calculation rules, payouts are calculated at the end of an epoch and each miner is incentivized to include hash pointers to the most recent shares seen from all miners. It directly follows that all miners are guaranteed payments for their shares that have reached the miner who found the block. Therefore the pool satisfies this requirement.

3.2.3 Budget Balanced

Budget balanced [14] property requires that the pool operator should never incur a deficit. Again from the rules above, since rewards are paid at the end of the epoch, a hub pays out rewards without losing or retaining any amount. The hub therefore does not make an unaccounted for profit or loss.

3.3 Lost Work or Stale Shares

We define a share to be stale share if it is not included in two consecutive epochs. In Figure 5 the share c_3 is a stale share as it is not included in the *epoch*s terminating in either a_5 or b_5. We don't reward miners for these stale shares as that allows miners to indulge in selfish mining [7]. In this section we present rough estimates on the work lost by the miners for not being reward for these stale shares.

The details of the p2p network to transmit shares is not yet specified, and we don't have simulations results to observe the impact of the the pool size both in terms of number of miners and the total hash rate of the pool. For now, we present a high level analysis of the work lost from stale shares.

Say t_s is the time in seconds to transmit a share to all other participants in the network. Let t_b be the time it takes for the pool to find a block. It follows that, in the worst case, each miner will waste t_s/t_b amount of work for the time when its work fails to reach the miner who finds the next block.

We work with estimates from observations about block transmission on the bitcoin p2p network [5] but keep in mind that those observations included the time to verify the block and that SHARE size at $320kB$ for a p2p network with $N = 10,000$ is much smaller than a bitcoin block.

Given the caveats we proceed to use the same propagation delays from the study to capture upper bounds of the work lost and assume a 10 second delay for a SHARE to reach all other nodes on the p2p network. We also assume that $10,000$ miners pool reaches 2% of the global hashrate. This is similar to $12,000$ miners achieving 2% hashrate by Slushpool [2]. With this assumption we can say that the pool finds a block every 50 blocks, or approximately every 500 minutes.

From the above, we get $t_s = 10$s and $t_b = 500$ minutes and get the lost work of around 0.03%. Adding the 0.1% fees the miners pay to the hub, the miners end up paying 0.13% in costs as compared to paying $2 - 4\%$ to the mining pools, which is still a saving of around 93% in fees for the miner when using a decentralised pool.

3.4 Payment Channels

We propose using Payment Channels for paying miners based on the proposal by Belcher [3]. The construction of the payments channels we present is similar to Belcher's construction, but there are a few changes and we highlight them before describing the details.

- In the Belcher proposal, the pool had to predict how much work miners will be able to contribute for the next block. Instead our DAG based scheme results in an incentives compatible distribution of rewards among miners.
- Belcher proposes uses multiple hubs to prevent DDoS attacks on hubs, we instead use a single hub, and prevent DDoS attacks by keeping the hub

Coinbase	
`2 H M 2 CHECKMULTISIG`	(cb_1)
`OR`	
`hash(X) + Hub P2WPKH`	(cb_2)
`OR`	
`M and CHECKSEQUENCEVERIFY 6 months`	(cb_3)

Table 3: Coinbase transaction with hub and miner public keys.

hidden using Tor's v3 hidden services [6] for communication between the hub and miners.

The rest of the construction is similar to the early versions presented by Belcher — there is a one-way channel between the hub and each of the miners. The hub updates the state of each channel with appropriate reward after each block is found.

3.4.1 Coinbase

We use Belcher [3] construction where each miner builds a coinbase transaction that can be spent in one of the following three ways:

1. Co-operatively by Hub and Miner, or
2. By the Hub with a hash lock for pre-image `X`, or
3. By the Miner that found the bitcoin block, but after waiting for six months.

The scriptPubKey for the above conditions in the coinbase is shown in Table 3. These conditions mean that the hub can not spend the coinbase without revealing the pre-image X. This pre-image is included in the construction of payment channels, as we will see in the next section. This use of pre-image in both the coinbase and the payment channel definition guarantees that miners get paid for their accumulated payouts if the Hub defects and spends through the cb_2 branch. We discuss how the miner and the hub don't gain by defecting in Section 3.6.

3.4.2 One-way Channels

One-Way payment channels between hub and all miners allow miners to receive payouts while consuming a constant size block space in the bitcoin block they mine. The use of payment channels is what makes the pool scale without losing block space. The miners therefore avoid losing the fees that can be earned from the block space.

Just like in the early versions of proposal by Belcher we use one-way payment channels. One-Way payment channels solve the problem of aggregating a miner's

Fund Transaction

Input	Output	

Hub's UTXO
(Signed by the hub)
	`2 H M 2 CHECKMULTISIG`
	`OR`
	`2 H' M' 2 CHECKMULTISIG + Hash(X)`
	(R coins)
		(f_1)
		
		(f_2)

Table 4: Fund transaction for payment channel between hub and miner.

payouts and require only a single blockchain transaction for spending multiple payouts earned from their PoW shares.

We use one-way instead of bidirectional payment channels as an initial implementation. If required we can switch to bidirectional channels [13] allowing miners to spend their mining payouts over the lightning network. However, for now, we deliberately stay away from the complexity of making the hub a lightning node. If there is interest from miners to use the lightning network, we can build it in the future.

Each miner has a one-way payment channel with the hub using a two of two multisig with a time lock of six months. For each payout a miner receives over the payment channel, the hub will charge an agreed upon fees between the miner and the hub. Belcher's proposal recommends a 0.1% fees for the hub.

3.4.3 Payment Channel Transactions

The hub creates a funding channel for each miner and locks R bitcoin in the channel. The miner then creates a refund transaction, spending the funding transaction and sending the R bitcoin back to the hub. The refund transaction has a locktime of six months allowing the miner to accumulate their payout over the six month period. The protocol can be extended to allow each miner to agree upon a locktime with the hub. In this case, the trade-off will be between the fees charged by the hub and the length of the locktime.

The funding transaction includes an input from the hub and an output that can be spent in one of the two conditions shown in Table 4. `H` and `M` are the public keys for hub and miner, they are called the co-operative keys by Belcher. While `H'` and `M'` are alternative public keys for hub and miner, and are called the uncooperative keys in the Belcher proposal.

The hub doesn't broadcast the funding transaction, instead it waits for the miner to create refund transaction. This is the same as any other timelocked one-way channel construction, i.e. the miner creates a refund transaction with a timelock, signs it and sends it to the hub. The refund transaction is shown in Table 5.

With the refund transaction, if the miner stops responding, the hub can get a refund in six months time. However, the hub can be attacked by sending requests to open new channels and locking up the hub's liquidity. We resolve this

Refund Transaction. Locktime 6 months

Input	Output
Fund Tx (Signed by miner)	`P2WPKH Hub's address` (R coins)

Table 5: Refund transaction signed by miner and held by hub.

Payment Transaction

Input	Output	

Fund Tx
(Signed by the hub using H')
	`2 H M 2 CHECKMULTISIG`
	`OR`
	`2 H' M' 2 CHECKMULTISIG + Hash(X)`
		(p_1)

	(Hub: $R - earnings$; Miner: $earnings$)	(p_2)

Table 6: Payment channel update transaction sent from hub to the miner.

by requiring the hub to open a channel to a miner only after it has contributed enough shares. This can be a parameter of the pool instantiation, with values anywhere between one to 100 bitcoin blocks. The threshold number of shares required before opening the channel is a configuration parameter for the hub. The miner will still receive the payouts for the shares generated, it is only that the channel opening is delayed.

On receiving the refund transaction, the hub broadcasts the funding transaction. Once the funding transaction is confirmed, the hub can start sending payouts to the miner. These payouts are determined in proportion to the shares found by the miner and included in the DAG as described in Section 3.2.

The payment transactions are updates to the channel where each update increases the earnings of the miner. The payment transactions are signed by the hub using the non-cooperating key, `H'`. Table 6 shows the structure of the payment transactions. In the next section we present how the payouts are distributed, we then show how the hub and the miners are dis-incentivized to cheat.

3.5 Channel Updates for Payouts

Once a miner mines a share that also meets the current bitcoin difficulty, the miner immediately broadcasts the block to the bitcoin network. The coinbase of this block is shown in Table 3 and can now be spent by one of the following branches:

Co-operative Branch: (cb_1) The miner and the hub by both signing the first branch co-operatively.

Hub Branch: (cb_2) The hub alone, by publishing the pre-image `X`.

Miner Branch: (cb_3) the miner alone, after waiting for six months.

The proposal by Belcher specifies a payout algorithm that requires the hub updates the state of all channels, i.e. make payment to all miners. Once it has done so, the miner who found the block signs the first branch of the coinbase transaction and hands the coinbase to the hub. The hub can now redeem the entire payout. We use the same approach, requiring the miner to receive all channel updates from the hub before signing the co-operative branch. The miner first verifies that that the channel updates are properly signed by the hub, and there is one update for all miners in proportion to the rewards distribution algorithm.

3.6 Defecting Does Not Pay

Using the above construction of the payment channel and the distributed payout algorithm, we now show that defecting by the hub or the miner doesn't pay.

3.6.1 Hub Defects

If the hub defects and pays itself from the coinbase it uses the cb_2 branch of the coinbase. In doing so, the hub has to reveal the pre-image `X`. With the pre-image available, all miners will use the p_2 branch of their payment channel transactions and close their channels receiving all the payouts earned up to that block.

It is possible that the hub defects on the very first block mined and the miners lose their earnings for that single block. But that will end the pool before it could be useful.

The hub could defect after a few blocks have been mined. In such a case the miners will receive their fair share of earnings for all previous blocks, but it will again be the end of life for the pool.

We recall that the hub charges fees to fund the payment channels between the itself and the miners. When the pool ends, the hub loses a profit making opportunity. We argue that the incentive to defect reduces as the size of the pool grows.

It is worth noting that if the hub is co-opted, all it can do is deny miners a payout for the number of blocks the pool delays the payments by. We introduced the idea of this ranging from one to 100 blocks. Further, if the hub is co-opted, all miners will immediately close their channels, collect their payouts and re-organise with a different hub.

3.6.2 Miner Defects

A miner that found the block could chose to not sign the co-operative branch (cb_1) of the coinbase. In such a case, the hub will wait for a timeout period much shorter than the locktime on the miner branch (cb_3) and receive the payout using the (cb_2) branch of the coinbase. In response to this, all other miners will close their channels by signing the (p_2) branch of the payment transaction by using

the pre-image `X` included in (cb_2) broadcast by the hub. This will close all channels and require that all these channels are opened again. Such an attack by the miner will hurt miners on the network who have not yet earned enough payouts to amortise the cost of closing the channel.

Say a miner starts participating in the pool, and after N blocks successfully mines a bitcoin block, but refuses to sign the co-operative branch of the coinbase allowing the hub to claim the coinbase reward. In such a case all miners have to close their channels and claim the rewards they have earned. Miners who recently joined the pool stand to lose the most because of the forced closure of channels.

However, the miner also loses any payouts for all the shares it mined since the last block was found by the pool. A malicious miner could contribute a large portion of the pool's hash rate and then refuse to sign the co-operative branch. This will disrupt the functioning of the pool and a well funded censor could be willing to execute such an attack. The only defence here is that the miners re-organise and start a different instance of the pool hiding their activity using Tor's hidden services. We elaborate on our use of Tor's hidden services in Section 3.7.

3.6.3 Hub and Miner Collude

The hub and the miner could collude where they co-operate to spend the coinbase to themselves without requiring that the hub pays all other miners as per the reward schedule. The motivation for the miner is a big payout it can receive. However, such an action by the hub will end the pool and the stream of future profits for the hub.

3.6.4 DDoS on the Hub

The hub can be attacked using a distributed denial of service attack rendering it unable to process requests to open new channels and to distributed payouts to miners. Belcher in his proposal suggested the use of multiple hubs as a defence against such an attack. The proposal also points out that using multiple hubs will also reduce the liquidity required to open channels with miners.

According to Belcher's proposal, with multiple hubs available on the p2p network, miners will open channels to all hubs and receive payouts from all of the hubs. The coinbase is split between hubs in such a way that if any hub defects, the other hubs can still spend the coinbase and split the block reward between them. In this way all miners receive payouts in proportion to the shares contributed by them.

Creating a larger coinbase for multiple hubs scales if we can use Taproot [12, 10, 11] once it is activated. The solution uses staggered timeouts for hubs to spend the coinbase in case of hubs defecting or coming under DDoS attacks. The only problem is that in case of hubs defecting, the staggered timeouts can result in a large wait for the payouts to be distributed.

We propose a different solution that requires a single hub. The advantage is a simpler channel construction and allow us to build the mining pool without waiting for Taproot activation. The single hub approach required that all miners run a Tor v3 hidden service and publish the public key used to generate the service's address. The public key is published in each share the miner publishes. The hub can now contact the miners anonymously as a client and therefore avoids DoS attacks on the hub or on the miners hidden services.

3.7 Anonymous Hub Miner Communication

The hub and the miner need to exchange messages at the time of channel creation as well updating the channel state when the hub makes a payout to the miners. The channel management messages are exchanged infrequently as compared to the SHAREs broadcast messages and don't have the same timeliness requirements as the shares broadcasts. We propose adopting a solution that doesn't compromise on the hub's anonymity and makes a trade-off with increased latency of the channel management messages. We use Tor's hidden services to avoid compromising the hub's anonymity.

Miners will run a Tor hidden service next to their mining controller. Once the service is ready, miners include their service's public key in their share headers. The hub can then communicate anonymously with the miners to create payment channels and to update the payment channels. The hub also publishes a well known public key on a publicly accessible location like a github repository or an IRC channel. The hub then participates in the shares broadcast p2p network and identifies a new miner along with the new miner's hidden service address. Once the miner has mined for a certain time period, the hub contacts the miner to set up the payment channels. The hub signs all their messages using their well known public key.

To send payouts as channel state updates, the hub sends the updates to all miners using their hidden service address. The hub sends all miners the updates to all payment channels, allowing the miner who discovered a block to verify that the hub has paid everyone.

4 Future Work

Our proposal presents an approach to enable decentralised mining for bitcoin. Apart from the work of describing the various components in detail, we also want to provide results from simulations, formalised proofs of rewards schemes and possible extensions to using multiple hubs.

Before we work on implementing the system, our next step is to simulate p2p mining network and make informed decisions about how large a network a single hub can support. The observations we want to make are how large a p2p network can be sustained without an increase in work lost by miners. Each instance of the pool uses a single hub and the p2p network of miners can grow as long as miners can communicate WORK and SHAREs with each other

within bounded latencies. We want to find the bounds of these limits using a simulation.

We will also specify the p2p protocols and the message formats for both the SHAREs propagation and channel management networks. By publishing the specifications separate from the source code, we aim to receive more feedback from the community. We want to use the model presented in [14] to provide proofs for how the rewards distribution is incentives compatible. We would like to build further on the multiple hubs construction described by Belcher once Taproot is activated on bitcoin.

5 Conclusion

We presented an architecture for a new decentralised mining pool for Bitcoin. The architecture enables miners to build their own blocks and earn frequent payouts as the mining pool grows. We showed that the pool can grow up to 10,000 miners and that miners can save close to 90% in mining pool fees by participating in the decentralised pool.

6 Acknowledgements

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