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With most cryptocurrencies that are not based on Proof-of-Stake, there is a process called mining. This process is the foundation for a blockchain to grow and secure transactions within the network. ATMcash is no different, except that you use precomputed hashes to find values that can be used to forge a block. To fully understand this document, you should read the technical information to create plot files. This document is intended to be an overview of the processes. It is technical information, but not deep enough to be used as a reference for a programmer since information regarding subjects like AT, subscriptions, and assets is missing.

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Introduction

The new ATM Cash cryptocurrency was developed by a team of experts in crypto-finances and the new Digital Economy, IT engineers specialized in Artificial Intelligence, professionals in Digital Marketing, experts in payment Gateway, card processors, e-Wallet systems, etc.

With most cryptocurrencies that are not based on Proof-of-Stake, a mining process must be carried out. This process is the base of the Blockchain that allows to secure the transactions within the network. ATM Cash is no different, except that it uses pre-calculated hashes to find values that can be used to create the blocks in the chain, which makes this an easier process not only for those who have large servers dedicated mainly to this purpose, but for most users. Our purpose is to create a large community of ATM Cash miners, who interact with e-Commerce and Trading users in the other platforms that work with this new cryptocurrency.

Despite their technical possibilities, cryptocurrencies lack mass adoption because of two critical factors: usability and scalability.

While usability can be addressed with sufficient engineering and development effort, scalability is often a theoretical problem of its own.

Because excess storage space is common, hardware is cheap, and competition is less fierce, a more diverse group of people can become involved in PoC mining, meaning a more decentralized network.

The inherent features of a good cryptocurrency – decentralization and trustless design - often go contrary to traditional methods of upscaling centralistic processes. While Bitcoin’s pioneer achievement, the blockchain, solved the problem of decentralized trust, its inventor certainly left much headroom for scaling that concept for a truly global use.

ALGORITHMS AND ACRONYMS

- **Shabal / Sha256 / Curve25519**

  Shabal, Sha256 and Curve25519 are cryptographic hash functions used in this text. Shabal is the main one used by ATMcash. Shabal is a rather heavy and slow cryptographic hash function in relation to many others like SHA256. Because of this, it makes it a good crypto for Proof-of-Capacity coins like ATMcash. This is because we store the precomputed hashes, and it is still fast enough to do smaller live verifications. ATMcash uses the 256bit version of Shabal also known as Shabal256.

- **Hash / Digest**

  A hash, or digest in this context, is a result when computing data through a cryptographic hash function. If not said otherwise, the length of a hash is 32Bytes (256bit).

- **Plot files**

  When mining, you read precomputed hashes from files stored on a storage device. These files are called plot files.

- **Nonce**

  Within a plot file, there are one or more groups of data called nonces. One nonce contains 8192 hashes, and because of that, the nonces are 256KiB large. Each nonce has its own individual number. This 64bit number can range between 0-18446744073709551615 (264).

- **Scoop**

  Each nonce is sorted into 4096 different places of data. These places are called scoop numbers. Each scoop contains 2 hashes. Each of these hashes are xored with a final hash.

- **Account ID**

  When you create your plot file it will be bound to a specific ATMcash account. Because of this, all miners have different plot files.

- **Deadline**

  When you mine and process your plot files, you will end up with resulting values called deadlines. The values represent the number of seconds that must elapse since last block was forged before you are allowed to forge a block. If no one else has forged a block within this time, you can forge a block and claim a block reward.

- **Block reward**

  If you are lucky enough to forge a block, you will get ATMcash as a reward. This is called a block reward. The block reward decreases 5% every 10800 blocks. This is roughly every 30 days since each block is supposed to be forged every 4 minutes (360 blocks a day).

- **Base target**

  Base target is calculated from the last 24 blocks. This value adjusts the difficulty for the miners. The lower the base target, the harder it is for a miner to find a low deadline. It gets adjusted in a way that ATMcash can have an average of 4 minutes for each block.

- **Network Difficulty**

  Network Difficulty, or NetDiff in short, is a value that can be read as an estimate on the total amount of space in terabytes dedicated to mine ATMcash. Since this is a value that changes with every block in relation to base target, it should be taken into an average of at least 360 values before considered to be somewhat accurate.

- **Block Height**

  Every block forged gets an individual number. Every new block forged gets the previous block's number + 1. This number is called block height, and can be used to identify a specific block.

- **Block Generator**

  When a block is forged, an account has found a nonce and a deadline. Block generator is the account used when forging a block. This is the account from which a deadline has been found when forging a block. This is always the real account even if a reward assignment has been set.

- **Generation Signature**

  Generation signature is a base from the previous block generation signature and block generator. This value is then used by miners to forge a new block. Generation signature is 32bytes long.

- **Block signature**

  Every block is signed by the generator who forges a block. This is done by taking most parts of the block and signing it with the block generator's private key using both Sha256 and Curve25519. The result is a 64byte long hash.

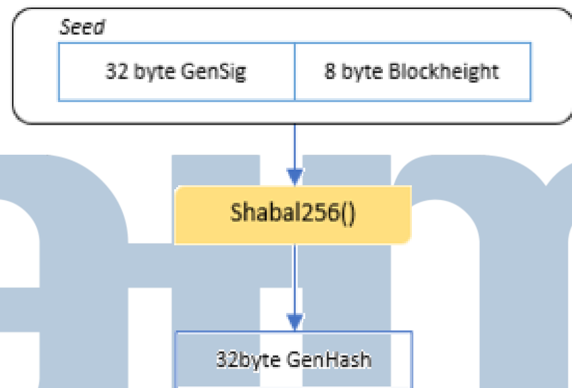
- **Reward Assignment**

  Reward assignment is frequently used when pool mining. When changing your reward assignment, you tell the network that another account (the pool account) is acting in your place for 2 specific features. The first feature is that all block rewards that should be given to your account will now be given to the pool account instead. Secondly, for the pool to be able to utilize the deadlines found from your plot files, it is also granted the action to sign the newly forged blocks with the account belonging to the pool.

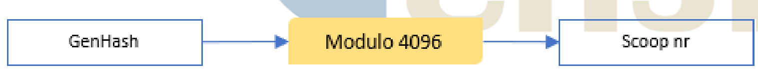
Mining Process

All references to wallet in this text can also be a pool depending on scenario.
All references to miner in this text is a software able to do a mining operation for ATMcash.

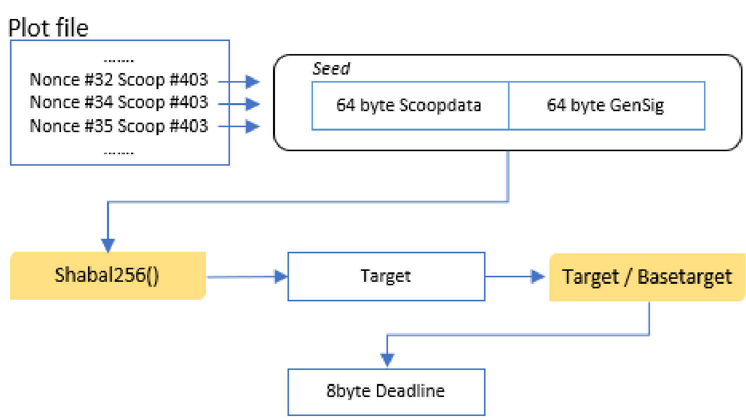
The first thing that happens when you start mining, is that the miner talks to the wallet and asks for mining information. This information contains a new generation signature, base target, and the next block height. Before the wallet sends over this info, it creates the generation signature by taking the previous generation signature together with previous block generator and runs this **through** shabal256 to get the new hash. The miner will now take the new 32byte generation signature, and the 8byte block height, and put them together as a seed for Shabal256. The result will be a hash value called Generation hash.



Now, the miner will do a small mathematical operation on this hash to find out which scoop number to use when processing the plot files. This is done by taking the generation hash modulo 4096, as there are only that many scoops.



Next step for the miner is to read all the 64-byte long scoops from all nonces in all plot files. It will process them individually through shabal256 together with the new generation signature to get a new hash called target. This target is now divided with base target and the first 8bytes of the result is the value deadline.



To prevent so-called "nonce spamming" to the wallet, the miner usually checks if the current deadline found is lower than the lowest one it has found so far. Usually there is also a max value that can be set, as ridiculously large deadlines are of no use to anyone. After these checks, the miner submits information to the wallet. This information contains the numeric account ID bound to the plot file, and the nonce number that contains the scoop data used to generate the deadline. If you are solo mining the miner also sends over the passphrase for the account id used in plot files. If the password is not sent when solo mining, the wallet would be unable to forge blocks for that account. When pool mining, the passphrase for the pool account id is used.

BLOCK FORGING PROCESS

HANDLING DEADLINES

The wallet has now received the information submitted by the miner, and will now create the nonce to be able to find and verify the deadline for itself. After this is done, the wallet will now check and see if an equal amount or more seconds has passed as defined by the deadline. If not, the wallet will wait until it has. If a valid forged block from another wallet is announced on the network before the deadline has passed, the wallet will discard the mining info submitted since it is no longer valid. If the miner submits new information, the wallet will create that nonce and check if the deadline value is lower than the previous value. If the new deadline is lower, the wallet will use that value instead. When the deadline is valid, the wallet will now start to forge a block.

FORGING

There are two limits for a block. First, a block can contain max. 255 transactions. The second is that a block payload can have max. 44880bytes (43KiB). The wallet will start by getting all of the unconfirmed transactions it has received from users or from the network. It will try to fit as many of these transactions possible until it hits one of the limits, or until all transactions are processed. For each transaction the wallet reads, it will do checks. For example, if the transaction has a valid signature, if it has a correct timestamp, etc. The wallet will also sum up all of the added transactions amounts and fees. The block itself will only contain the Transaction ID of each transaction and one Sha256 hash of all the transactions included. Complete transactions are stored separately. **Besides** this, a block contains many different sets of values.

BLOCK CONTENTS

Block version number. The version number is basically telling the wallet what a block can contain and how it is contained. This number changes each time a block gets a new format.

- **List of Transaction ID**

  A List of all transaction IDs that are included in this block.

- **Payload Hash**

  This is the Sha256 hash of all the data in the payload of the block.

- **Timestamp**

  A timestamp that will describe when the block was forged; derived from the birth of the blockchain. Birth date: 11 august 2014, Time: 02:00:00.

- **Total amount of coins**

  This is the sum of all transactions in the block.

- **Total amount of fees**

  This is the amount of fees that will be given to the block forger for generating this block.

- **The length of the payload**

  This is a number in bytes representing the length of the payload.

- **Public Key**

  This is a public key for the account that forges the block.

- **Generation Signature**

  The 32byte generation signature that was used to forge the block.

- **Previous block hash**

  A Sha256 hash of the contents from the previous block.

- **Previous block ID**

  This is the first 8 bytes in the previous block hash converted to a number.

- **Cumulative Difficulty**

  Used to prevent Nothing at Stake problems during potential forks. Calculated: Previous Cumulative Difficulty + (18446744073709551616 / base target).

- **Base Target**

  The base target used when forging this block.

- **Height**

  This block's height value.

- **Block ID**

  This is the first 8 bytes in block's hash converted to a number.

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- **Nonce**

  The nonce number used to forge this block.

- **AT**

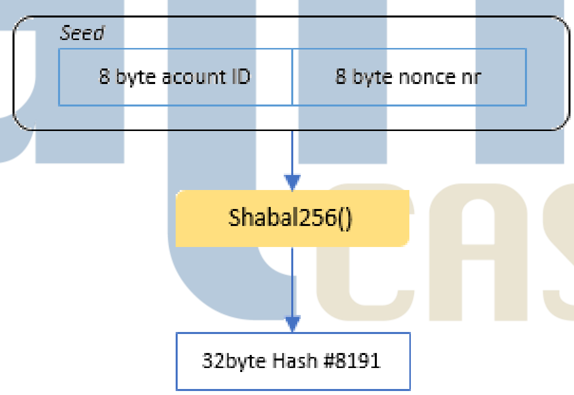
  If an AT is added to this block, this is the payload bytes for that AT.

- **Block Signature**

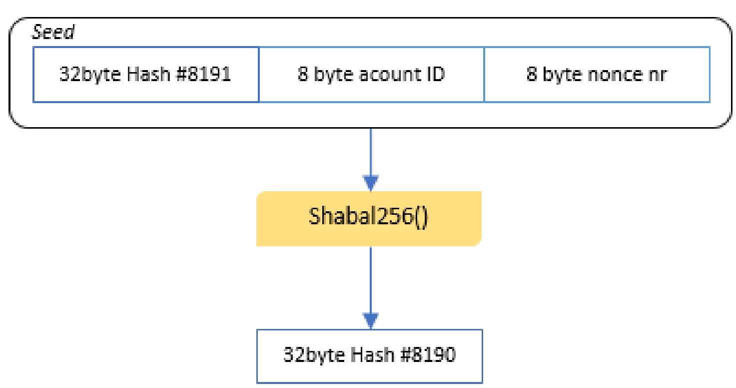
  This is a 64byte hash generated with the forger's private key and block contents. When this is done, it will be announced to the network. The wallet will connect to all peers and send the block over to them. The peer will receive the block and verify that all information is not spoofed.

Generating a nonce

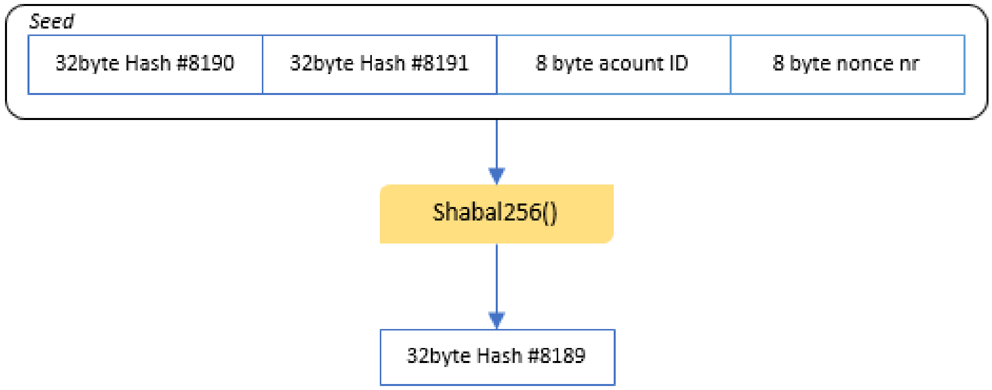
The first step in creating a nonce is to make the first seed. The seed is a 16byte long value containing the account id that we will be generating a nonce for and the nonce number. When this is done we start to feed the Shabal256 function to get our first hash.



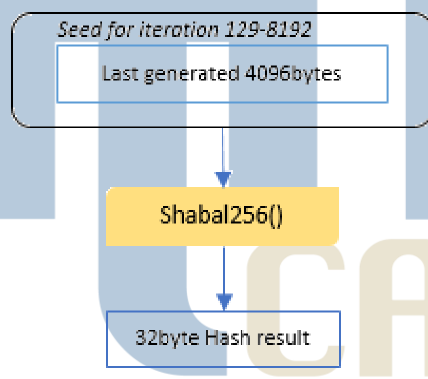
We have produced the first hash. This is the last hash in the nonce. Hash #8191. Now we take this produced hash (#8191) and pre-append it to the starting seed. The result will now be our new seed for the next round of shabal256 computation.



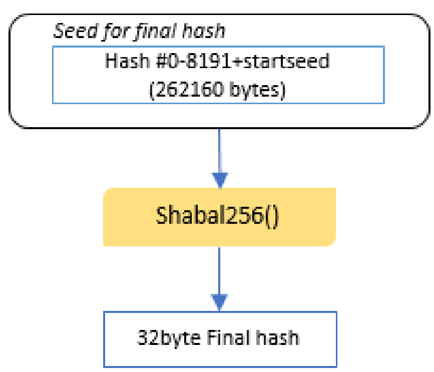
We now have produced two hashes. Hash #8191 and Hash #8190. This time we pre-append Hash 8190 to the last seed we used. The result will now be a new seed to feed Shabal256.



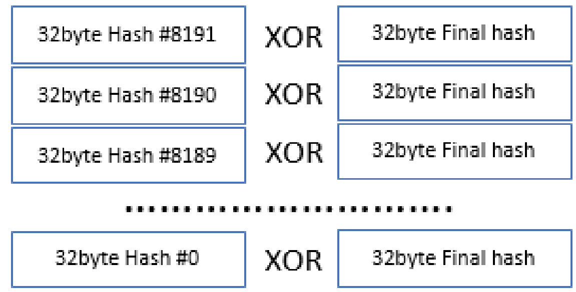
Once again, we have created a new hash. This procedure of pre-appending resulting hashes to a new seed will continue for all 8192 hashes we create for a nonce. After iteration 128 we have reached more than 4096 bytes in the seed. For all remaining iterations we will only read the last 4096 generated bytes.



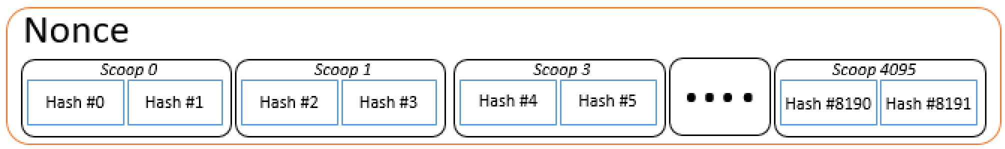
Once we have created 8192 hashes we are now going to make a Final hash. This is done by using all 8192 hashes and the first 16bytes as seed.



The final hash will now be used to xor all other hashes individually.



We have now created our nonce and can store it in a plot file before we continue to the next nonce.



PLOT STRUCTURE

When we are mining we read from one or more plot files. The miner software will open a plot file and seek the scoop locations to read the scoops data. If the plot file is unoptimized the scoop locations will be on more than one place. In the following example the miner will be seeking and reading scoop #403.

PRE-DEVELOPMENT

(This paper was written before actual devleopment, and another method was ultimately used. This is at least most of the math and explanation that was eventually made use of, and explanations therein. The ultimate design chosen follows all the mentioned rules and is superior to what is described here.)

A CRYPTOCURRENCY BASED ON PROOFS OF CAPACITY

(Sunoo Park, Krzysztof Pietrzak, Albert Kwon , Joel Alwen , Georg Fuchsbauer, Peter Gazi, with additions, clarification and formatting by ATMcash technical team post-development)

We propose a decentralized cryptocurrency calledATMcash, which is based on a blockchain ledger similar to hatof Bitcoin, but where the wasteful proofs of work are replaced by efficient proofs of capacity, recently introduced by Dziembowskiet al. Instead of requiring that a majority of the network's computing power is controlled by honest miners (as in Bitcoin), our currency requires that honest miners dedicate more net disk capacity than a potential adversary.

In ATMcash, once a miner has dedicated and initialized some capacity, participating in the mining process is very cheap. A new block is added to the chain every fixed period of time, and in every period a miner just has to make a small number of lookups to the stored capacity to check if she “wins”, and thus can efficiently add the next block to the chain and get the mining reward. In this paper, we detail the construction of ATMcash, analyze its security and game-theoretic properties, and study its performance. Our prototype shows that it takes approximately 25 seconds to prove over a terabyte of capacity, and it takes a fraction of a second to verify the proof.

I. INTRODUCTION

Bitcoin is a decentralized digital currency which was introduced in 2009 and now is by far the most successful digital currency ever deployed. The currency’s decentralized bookkeeping depends on maintaining a public ledger recording all transactions that occur. This ledger is implemented by a block chain: that is, a sequence of blocks each of which contains transaction records and some auxiliary information, which are generated by participants in the network. To encourage participants to contribute blocks, those who add a block to the chain are rewarded with some newly minted Bitcoin.

A principal difficulty when designing a digital currency is to provide security against double-spending: that is, the owner of a coin must be able to spend it exactly once. To prevent double-spending, it must be enforced that all parties in the network agree on the same blockchain (except possibly for the most recent few blocks). Before accepting a transaction, a recipient should wait until the transaction has been in the chain long enough that she can be reasonably sure it will stay there forever (that is, consensus has been reached).

The Bitcoin protocol achieves consensus by making it computationally hard to add a block to the chain: currently.

1. Accordingly, a Bitcoin block is considered to be a proof of work: that is, a proof that a certain amount of computational resources were invested.

The Bitcoin network mines a block approximately every 10 minutes, and so it consumes computational resources – and associated natural resources, primarily in the form of electricity – at a massive scale. Current network usage is estimated to be several 100 MW of power; moreover, most mining is currently done by dedicated hardware, which has no use beyond mining Bitcoins. For these reasons, Bitcoin is considered an “environmental disaster” by some.

The original idea behind basing Bitcoin mining on computational power was that anyone could participate in the network by dedicating their spare CPU cycles, which incurs little marginal cost in that it uses the idle time of already existing personal computers. However, the dynamics of modern Bitcoin mining have become very different: the majority of successful mining is done by large-scale mining farms, often in collaboration with electricity producers.

Without specialized mining ASIC hardware, you don’t have a chance: mining with your spare CPU cycles will lose money, due to overhead electricity costs. The nonlinearity of mining rewards in Bitcoin relative to resources invested has been quantified by Designing a cryptocurrency where the expected reward is more proportional to invested resources would be desirable for a number of reasons, including that the presence of "small players" can be important for the stability and decentralization of the currency.

To address these issues, in this paper we propose a cryptocurrency, ATMcash, which replaces the costly proofs of work underlying Bitcoin with proofs of capacity. In ATMcash, in order to mine blocks (and thereby mint coins), miners must invest disk capacity, rather than computational power.

2. Miners who dedicate more disk capacity have a proportionally higher expectation of successfully mining a block and reaping the reward. These days, tremendous amounts of disk capacity are lying around unused, and all of this storage capacity carries potential for mining. We note that in a capacity-based scheme, it is clear that miners will be incentivized to invest in hard drive capacity, just as Bitcoin miners are incentivized to invest in electricity. However, we highlight a couple of key differences:

a. In ATMcash, the investment is in the form of capital expenditure, and the mining process after the hard drives are bought incurs negligible overhead cost (both in terms of monetary and natural resources). In contrast, in Bitcoin, the mining process requires perpetual energy expenditure from miners.

b. In Bitcoin, resources are "used up" by mining: electricity is a depletable resource which once used is gone, and Bitcoin mining hardware is specialized, single-purpose resource that is not useful for anything once the need for Bitcoin mining is removed. In contrast, the resource consumed by ATMcash is recyclable, in that it can be used over and over, and multi-purpose, since hard drives have intrinsic value in their ability to store useful data.1 The distinction between capital expenditure and recurring overhead costs is significant also in that it changes the trade off between expected reward and mining resources invested.

   More concretely, due to the low marginal cost of mining a block, the shape of the curve depicted in Figure 1 will be much flatter for ATMcash than Bitcoin, and thus the profitable **area** would be spread more evenly over the horizontal axis.

A. Background and challenges

A "greener" cryptocurrency. The community has looked for alternative decentralized consensus protocols and found a potentially promising candidate in proofs of stake (PoStake).

In such schemes, the probability that a party mines the next block is proportional to the fraction of coins (out of all coins belonging to participating miners) that it holds. This idea is very appealing as no resources (like energy, hardware, etc.) are wasted, but unfortunately,

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making this approach actually work turns out much more delicate than for schemes based on proof of work (PoW).

Trying to adapt Bitcoin in a straightforward way by replacing PoW by PoStake, one runs into at least three major problems which are outlined below. Intuitively, the first two problems are related to the fact that producing a PoStake proof is computationally cheap and thus opens up potential for cheating in ways which are not possible in Bitcoin. We will see that analogous challenges arise from the computational ease of mining a block by proof of capacity, too; and our ATMcash construction will propose ways to resolve these challenges.

a. Multiple chains: In Bitcoin, a rational miner will always work towards extending the longest chain of which he is aware, as working on any other chain would only lower the probability that his mined block will end up in the block chain. When using PoStake instead of PoW, checking whether One may ask: won't ATMcash spur development of specialized types of storage which are tailored for mining, and thus end up in the same position as Bitcoin in this respect? We argue that this is unlikely; see Section IX one can extend a chain is very cheap, and thus miners may try extending many different chains in parallel. This **prevents** quick consensus finding, unlike in Bitcoin where all rational miners concentrate on the longest chain, and thus it always grows faster than others

Mining multiple chains:

Our approach is based on penalizing miners who work on more than one branch. It is important to discourage miners not only from announcing blocks on multiple chains, but also from "trying out" many different chains and choosing only the best one to announce. We suggest three variant solutions. In the first two schemes, a miner's block quality is fixed for any given time-step, so that trying many chains does not yield any benefit; and then we penalize miners who announce blocks on multiple chains. The third scheme takes a different approach, and introduces interaction between miners during the mining process, thus enabling detection of miners who try many chains.

Finally, we perform a game-theoretic analysis of ATMcash and find that it has at least as strong equilibrium properties as Bitcoin. We model the ATMcash protocol as an extensive game, and prove that miners are not incentivized to deviate from the rules as long as there is an honest majority. More formally, we prove that the protocol is a sequentially rational Nash equilibrium, which is the standard equilibrium concept for games which happen over many time-steps. Prior work related to equilibria in Bitcoin has given only an informal treatment of the problem: notably, [20] presents a thorough, but still informal, analysis of equilibrium strategies in Bitcoin, and concludes that honest mining is a Nash equilibrium in Bitcoin (if there is an honest majority).

Contribution. In summary, our contribution is as follows:

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• **Cryptocurrency from proofs-of-capacity:** ATMcash is a cryptocurrency based purely on proofs of capacity, and thus avoids the major drawbacks of existing proof-of-work based schemes as discussed in this section.

• **Addressing the "nothing-at-stake" problem:** We propose novel approaches to the known problems of grinding and mining multiple chains in non-proof-of-work based systems. Our solutions can also be extended to the proof of-stake setting where these issues were first encountered.

• **Evaluation of ATMcash and proofs-of-capacity:** We implemented a proof-of-capacity library and a prototype of ATMcash. It takes less than 20 seconds to prove over 1 TB of capacity, and a fraction of a second to verify.

• **Game theory of ATMcash:** Our game-theoretic analysis models ATMcash as an extensive game proves that the adhering to the protocol is a sequential Nash equilibrium.

II. RELATED WORK

Proofs of storage/retrievability. Other concepts similar to proofs of capacity are proofs of storage and proofs of retrievability. These are proof systems where a verifier sends a file to a prover, and later the prover can convince the verifier that it really stored or received the file. Proving that one stores a (random) file certainly shows that one dedicates capacity, but these proof systems are not proofs of capacity because the verifier sends the entire file to the prover, whereas an important property of POC is that the verifier's computation (and thus also communication) is at most polylogarithmic in the size of storage dedicated.

('Proofs of secure erasure' is another type of proof system which is related to POC.)

III. PROOFS OF CAPACITY

As briefly discussed in Section I, the goal of proof of capacity is for a prover to prove to a verifier that it is storing a certain amount of capacity. In this section, we first discuss two straw main approaches that do not work, and then present our variant of POC for the cryptocurrency setting.

A. Two simple approaches that don't work storing a function table. A tempting "solution" is to have a random-looking function, sorted by the output. The prover's challenge would be to invert the function on value f(x) for some random x? an honest prover can do this in time log by binary search. Unfortunately, this doesn't work due to time/memory trade-offs, which allow a cheating prover to only store roughly ⅔ input/output pairs and still linvert the function in time. Storing a random file. Another simple idea would be to send (pseudo)random bits during initialization, and simply query back for a random subsets of these bits during execution.

However, this requires bits of communication, whereas a POC requires that the verifier's efficiency depends on some security parameter, but must be basically independent of– and this property is crucial for all applications of POC discussed.

IV. OVERVIEW OF ATMCASH

A. High-level protocol description

Transactions. Transactions are performed basically identically to Bitcoin: each coin "belongs" to some public key pk. The block chain acts as a ledger that keeps track of which coins belong to which keys (but to prevent grinding, we propose a new design for the blockchain in Section VI where the transactions are decoupled from the proofs). To transfer a coin from pk to pk0, a transaction specifying this must be signed by sk (the secret key for pk), and then be added to the block. The nonce ensures that the same capacity cannot be used for two different proofs (this will be discussed later).

We also add special transactions to initialize miners (plotting), and a special type of transaction which penalizes a miner who extends two different chains using the same proof of capacity (which hasn't been implemented yet, but there are methods to verify and Remove incorrect chains.)

Incentivize mining. Like in Bitcoin, there are two ways to incentivize miners to contribute resources (disk capacity in ATMcash, computing power in Bitcoin.)

(1) a reward for adding blocks
(2) transaction fees.

Reward: For adding a block to the chain, a miner receives some freshly minted coins. The reward size is specified as part of the protocol, and typically depends on the block index.

In Bitcoin, the reward was initially 50 Bitcoins, but it halves roughly every 4 years, and is currently at 25.

In ATMcash the reward is a slowly declining curve that changes 10% per month, allowing for a release schedule that is not as drastic in cutting the reward to the miners. We believe this is a more adequate approach than that of Bitcoin and other currencies with use 'halving'.

Transaction fees: When generating a transaction, one can dedicate some (usually very small) amount of the transferred coins to the miner who adds the transaction to the blockchain. Initialize miner. If a miner wants to contribute N bits of capacity to the mining effort, she samples a public/secret key pair (pk, sk) and runs the POC initialization procedure. (Being in a non-interactive setting, there is no verifier to generate the unique nonce μ, so we simply use pk for this.)

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(?, S?) := Init(pk, N) .

The miner stores (S? sk) and generates a special transaction which just contains (pk,). Once this transaction is in the blockchain the miner can start mining as described next.

Mining. Blocks are added to the blockchain every fixed time period (say, every minute), and we require that all parties have a clock that is roughly synchronized. To add a block in time period i, the miner retrieves the hash value of the last block in the best chain so far (this chain has i - 1 blocks), and also a challenge c. This c is used as randomness to sample kp challenges cp and kcv challenges ccv.

Where, depending on which of the Pocapacity discussed in the last section we use, kp = O(1), kcv = log(n) or kp = O(1), kcv = ? · log(n). These challenges can be sampled by first using c as a seed to generate a sufficient amount of randomness (rp, rcv) := hash(c) for the challenge sampling algorithm to get cp := Challenge(n, kp, rp), ccv := Challenge(n, kcv, rcv).

How to derive the challenge c is the main difficulty we face. In our simplest solution we assume an unpredictable beacon that broadcasts a fresh random (or at least unpredictable) value from which the challenge is derived every minute (we also propose two solutions without assuming a beacon). The miner then computes the POC answer from cp: a: = Answer (pk, S? cp). For two valid proofs (pk, c, a) and (pk0, 0, c0, a0) we denote with (recall that N? is the size of the capacity committed by?) (a0, N? 0)? (A, N?) That the proof a is better than a0. We postpone the discussion on the precise definition of this ordering to Section V-B. For now, we only mention that the ordering should satisfy Pr[(a0, N0) ? (a, N)] = NN + N0

That is, the probability that a wins is proportional to its fraction of the total capacity. The probability is taken over the choice of random oracle used to compute the proof quality. If the answer a found by a miner is so good that there is a realistic chance of it being the best answer found by any miner, the miner creates a block and sends it out to the network in the hope that it will end up in the chain. A block must contain transactions, the POC proof and also the commitment verification output computed as acv: = Answer (pk, S? ccv).

Note that the commitment verification need **not to be** executed unless the miner has found an exceptionally good proof: thus, the computation of the vast majority of miners in the network will be very low, since they **only need to** check the quality of their proof, and most of them will not proceed with verification.

For the remainder of the one-minute time period, the miner doesn't need to do anything. As mining only requires a small amount of work (computation, communication and random access to the storage) in every time period, it can be run on any computer that has some free disk capacity and is connected to the internet, without incurring any noticeable slowdown.

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Quality of a Pocapacity Proof Consider some valid proofs (pk1,? 1, c1, a1), . . . ,(pkm, ?m, cm, am) for capacity s of size N1, . . . , Nm. We want to assign a quality to a proof (which will only be a function of ai and Ni), such that the probability (over the choice of the random oracle hash) that the ith proof has the best "quality" corresponds to its fraction of the total capacity , i.e. Pr hash[?j 6= i : (aj , Nj) ? (ai, Ni)] = P Ni m j=1 Nj

We observe that in order to achieve this, it is sufficient to achieve this for any pair of commitments, i.e., Pr hash [(aj , Nj) ? (ai, Ni)] = Ni Ni + Nj

If all the Ni were of the same size N, we could simply define (aj , N) ? (ai, N) ?? hash (aj) = hash(ai) That is, we map every ai to a random value hash(ai), and whichever value is largest wins. We want to allow for different Ni values, so miners who want to contribute capacity N0 only need one capacity commitment, and do not have to split it up in N0/N capacity commitments of size N, and then run a proof for each chunk separately.

For this, we define a distribution DN , N ? N which is defined by sampling N values in [0, 1] at random, and then outputting the largest of them.

DN ~ max {r1, . . . , rN : ri ? [0, 1], i = 1, . . . , N} (2) With DN (t) we denote a sample of DN (or rather, a distribution which is very close to it) using randomness t to sample.
We now say that (ai, Ni) is of higher quality than (aj , Nj) if (aj , Nj) ? (ai, Ni) ? DNj (hash(aj)) = DNi (hash(ai)).

It remains to show how to efficiently sample from the distribution DN for a given N. Recall that if FX denotes the cumulative distribution function (CDF) of some random variable X over [0, 1] and the inverse F-1 X exists, then F-1 X (U) for U uniform over [0, 1] has the same distribution as X. The random variable X sampled according to the distribution DN has CDF FX(z) = zN , since this is the probability that all N values ri considered in (2) end up being below z (and hence also their maximum). Therefore, if we want to sample from the distribution DN, we can simply sample F-1X (U) for U uniform over [0, 1], which is U1/N . In we want to sample DNi using randomness hash(ai), and hash outputs bit strings in {0, 1}256 instead of values in [0, 1], so we have to normalize: DNi (hash(ai)) :=hash(a)/2 2561/N

Note that this introduces a tiny imprecision due to the fact that hash (a)/2 256 is uniform over a discrete set instead of the continuous interval [0, 1], but this can be safely disregarded. Remark. Notice that the quality function described above has the property that the quality of block that a given miner pk can produce in a given time-step is fixed, regardless of which chain he chooses to extend. This property will be important to prevent the "mining multiple chains" attack which was described in Section I, as explained in the next section.

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VI. THE BLOCKCHAIN FORMAT

A block chain is a sequence of blocks ß0, ß1, . . . Each block ßi = (fi, si, ti) is created by a miner and consists of three main parts, which we call "sub-blocks". Each subblock starts with the index i that specifies its position in the block chain. Below, we outline the remaining components of the three sub-blocks of a block ßi, i > 0. The genesis block ß0 necessarily has a somewhat different format as it cannot depend on previous blocks:

- The HASH sub-block fi contains:
  - A 256-bit hash hash(fi-1) of the HASH sub-block from the previous block in the chain.
  - A "capacity proof" containing the miner's identity pk (more details on this are given below).

- The TRANSACTION sub-block ti contains:
  - A list of transactions (defined in more detail below).

- The SIGNATURE sub-block si contains:
  - The miner's signature Sign (sk, ti) on the TRANSACTION sub-block ti associated with this block.
  - The miner's signature Sign (sk, si-1) on the SIGNATURE sub-block si-1 associated with the previous block.

The links between consecutive blocks in the blockchain are illustrated in Figure 2. We will also refer to the hash subblocks as the proof chain, and the signature sub-blocks with the transactions as the signature chain. Solid arrows represent hashes, and dotted arrows represent signatures. Notice that while the signature and transaction sub-blocks are all linked together, the hash sub-blocks are only linked to each other and not to any signature or transaction sub-blocks.

A. Solution to the grinding problem:

By decoupling proofs from transactions we achieve security against grinding: for any capacity commitment (pk, ?), the miner pk cannot generate two (or more) correctly formatted hash blocks to be added to the proof chain.

The signature chain binds the transactions to the proof chain. If an honest miner (honest to be defined below) adds the ith block, the transactions corresponding to this proof To prove this, we require that it is computationally hard to find two distinct accepting transcripts for the same challenge. The POC of satisfies this property (finding two accepting transcripts in their schemes amount to breaking collision-resistance of the underlying hash function). The chain up to block i cannot be changed any more, even if an adversary controls all secret keys from miners that added the first - 1 blocks. Here the miner being honest means that she only signs a single block of transactions using the secret key sk corresponding to her identity pk, and moreover keeps sk secret. To see this, note that if we want to change the transactions in block j < i while keeping the current proof chain up to block i, then the signatures for blocks j, . . . , I must be re-computed, which requires sk.

B. Transactions ATMcash is based on a secure 12 signature scheme

S = (SigParamGen, SigKeyGen, Sign, SigVerify) and a POC protocol? = (Init, Challenge, Answer, Verify).

In the following we specify the three types of transactions (for payments, capacity commitments and punishments) that we allow in ATMcash. Payments. Coins are held and transfered by parties identified by a verification key in the support of SigKeyGen.

A transaction transfers coins from benefactors to n beneficiaries and has the formctx = (payment, txId,in, ~ out ~).

In order for a transaction to be considered valid, the following conditions must be satisfied:

- txId: A unique, arbitrary transaction identifier. That is, no two transactions in a blockchain can have the same Identifier.
- out ~ : A list of beneficiaries and the amount they receive. Specifically, out ~ = (out1, . . . , outm) with outi =(pki, vi), where:
  - pki is in the support of SigKeyGen and specifies a beneficiary, and – **vi is** the number of coins that pki is to be paid.
- A list of input coins to the transaction. Specifically, in~ = (in1, . . . , inn), a list of n benefactors, each comprised of a triple: inj = (txIdj , kj , sigj), where:
  - txIdj is the identifier of a past transaction
  - kj is an index that specifies a particular beneficiary pkkj of the transaction txIdj
  - sigj is a signature of (txId, txIdj , kj , out ~), which verifies under key pkkj proving ownership of the the beneficiary of transaction txId and binding the coin to the beneficiaries.

In Bitcoin, the specification of payments is more general: instead of specifying beneficiaries via their verification keys, recipients are specified by writing a script in a special (non-Turing-complete) scripting language called Bitcoin Script. The output coins of a transaction can then be redeemed by any party which can produce inputs which “satisfies” the script scr. In practice, ATMcash can be straightforwardly modified to accommodate such scripting; but in this work, for clarity of exposition, we assume that each payment recipient is specified by a verification key.

That is the kj th beneficiary of transaction txIdj is the jth benefactor of transaction txId.

txId is signed in order to avoid transaction malleability

https://en.bitcoin.it/wiki/Transaction_malleability

1) No benefactor is referenced by more than one transaction in the blockchain (to prevent double-spending).

2) The sum of the input values to the transaction (i.e. the sum of the amounts provided by each benefactor) is at least the sum of the amounts paid to beneficiaries.

Note that some of the beneficiary identities may belong to the creator of the transaction, who may thus transfer money back to himself as "change": e.g. if the sum of the input values exceeds the total payment amount he wants to transfer to other parties.

VII. INSTANTIATION (PLOTTING)

In this section we describe the concrete steps required for setting up, mining and paying in ATMcash. We give the instantiation for the second scheme (challenge from the past), outlined in Section V-C. The first (random beacon) scheme is almost identical, except that the challenge c is derived from the random beacon (and not by hashing a block from the chain). 16?0 is a Merkle-hash of all the labels in a hard to pebble graph. We can change? 0 to another value by simply changing a single label, which will not be noticed in the execution phase unless this particular label with its children is requested.

At setup we have to fix the security parameter? to be used for the signature and POC scheme. Moreover, we must specify parameters and functions:

- time ? N specifies the length of a timeslot in minutes. It should be sufficiently larger than the network propagation time, but otherwise as small as possible. time = 1 seems like a reasonable choice here.

- d ? N specifies that the challenge for block i is a function of block i - d. A reasonable value is d = 120.

- Reward is a function such that Reward (i) specifies the amount of coins a miner gets for mining the block.

- Quality is function that takes as input a capacity commitment (pk, ?) for capacity of size N together with a challenge/answer pair (c, a). If Verify (pk, ?, c, a) 6= 1 (i.e., it is not a valid POC proof transcript), the Quality function outputs -8. Otherwise the output is (with DN as defined in Section V-B):

  Quality (pk, ?, c, a) = DN (hash(a)) .

In order to decide which of two given proof chains is the "better" one, we also **need to define** the quality of a proof chain f0, . . . , fi, which we'll denote with QualityPC(f0, . . . , fi).

Each hash block fj contains a proof (pkj , ?j , cj , aj), and we let vj = DNj (aj) denote the quality of the jth proof in the chain. For any quality v ? [0, 1], we denote with N(v) = min{N ? N : Pr[v ? w | w ? DN] = 1/2} the capacity required to get a better proof than v on a random challenge with probability 1/2.

Note that N(vj) will usually be around the total storage of all miners that were active when the block was mined. With this definition, a natural measure for the quality of the chain would be simply the sum17 Pi j=1 N(vj).

The problem with this measure is that if some miner finds an extremely good proof, say N(v) is 1000 times larger than the total storage (this will happen roughly every 1000 blocks), then the miner could withhold his proof, and 1000 blocks later generate a fork using this proof followed by 999 arbitrarily bad proofs for the remaining blocks. To avoid such deep forks, we cap proofs that are too good by saying that vj cannot contribute more to the sum than, say 10 times the median of the last 101 blocks (the median gives a good approximation of the total capacity that is dedicated towards mining).

Formally, let Nˆ(vj) be recursively defined as Nˆ(vj) = max{N(vj) , 10·median(N(vj-101), . . . , N(vj-1)}

Another reason why defining the quality simply as Pi j=1 N(vj) is problematic, is that the total contributed capacity can increase drastically over time. In this case, in order to come up with a chain whose quality is better than the quality of the real chain it is sufficient to dedicate much less than the total capacity that is currently devoted towards mining. For this reason, we only take the last 1000 blocks into account when computing the quality:

Quality PC (f0, . . . , fi) = X j=max{1,i-1000} Nˆ(vj)

We start summing with j = 1, not j = 0, as the genesis block (still to be defined) will not contain a proof.

Finally, a genesis block ß0 = (f0, s0, t0) is generated and published; it has a format different from other blocks. The transactions block contains only one capacity commitment t0 = (commit, txId,(pk0, ?0)), the hash block f0 contains only some random string,18 and the signature block s0 contains the signature Sign(sk0, t0) of the transactions block (but not of the previous signature block, as there is none).

Initialize Mining. In order to dedicate N bits of storage for mining, a party generates an identity and a capacity commitment (pk, sk) ? SigKeyGen , (?, S?) := Init(pk, N) .

It stores S? (of size N) and sk locally. The miner then generates and publishes a transaction ctx = (commit, txId,(pk, ?)). Once ctx has been added as a transaction to the hash chain, the miner can start mining as described next.

Mining:

As we enter time slot i, the miner retrieves the so-far-best blockchain ß0, . . . , ßi-1 (that is, the chain maximizing Quality PC (f0, . . . , fi-1). We assume that the miner "honestly" stores capacity S? and the corresponding commitment (pk, ?) has been added to some transcription block tj , j = i-1 in this chain.

Next, the miner computes the randomness for the challenge sampling by hashing the hash block that is d blocks in the past c := hash(pk, fi-d).

From this c we then compute the challenges cp, ccv. The miner computes the POC answer a := Answer(pk, S?, cp) .

If q := Quality(pk, ?, c, a) is very high, so it has a realistic chance to end up as the best answer of the entire network, the miner generates a hash block fi = (i, hash(fi-1), pi), where Pi is 20 (pk, ?, c, j, q, a, acv), where acv := Answer(pk, S?, ccv) .is the output of the commitment verification (for efficiency reasons we only execute commitment verification at this point).

Then the miner retrieves transactions (typically, giving priority to the ones paying the highest fees), checks their correctness, and adds the valid ones to a transaction Block.

. It then computes the signature block si = (Sign(sk, si-1), Sign(sk, ti)) and publishes block ßi =(fi, si, ti), hoping that it will end up in the blockchain, earning the miner Reward(i) coins, plus the transactions fees of the transactions in the block.

Transaction. Any party can generate a transaction and publish it. If it is correctly generated, it should ultimately end up in the blockchain. We have already described the format and semantics of the three types of transactions.

Or better, some kind of timestamp like a sentence from a newspaper of the day, as is done in Bitcoin, to show that the genesis block was not generated before some date "publishes" and "retrieves" we mean that a party sends or downloads something from the network. Typically, there would be some servers that organize the data, i.e., keep track of the best chains and collect transactions, so a miner would only interact with one or a few such servers it trusts.

To evaluate ATMcash, we have implemented a prototype in Go, using SHA3 in 256-bit mode as the hash function. The prototype uses the graphs from [24], and forces a cheating prover to store at least? (N/ log(N)) bits in order to efficiently generate proofs. Given that the network infrastructure is very similar to Bitcoin, we are mainly interested in three quantities: time to initialize the capacity (graph), size of the proof, and time to generate and verify the proof. The experiments were conducted on a server equipped with an Intel i5-4690K Haswell CPU and 8GB of memory. We used an off-the-shelf hard disk drive, with 2TB of capacity and 64 MB of cache.

To start mining ATMcash, the clients must first initialize their capacity. This involves computing all the hashes of the nodes, and computing the Merkle tree over the hashes (plotting). In Figure 3, we show the initialization time for capacity s of size 8 KB to 1.3 TB. As expected the time to initialize grows linearly with the size of the capacity; at 1.3 TB, it takes approximately 41 hours to commit the graph. While expensive, we note that this procedure is done only once when the miner first joins the ATMcash network, and will use the initialized capacity over and over again. In fact, we require capacity initialization to non-trivial time, because an extremely fast capacity initialization would make re-using the same capacity for different commitments available strategy (Section V-C).

Size of the Proof. A proof (i.e., a full solution to the puzzle) in ATMcash consists of the hashes of the challenge nodes and their parents, in the Merkle inclusion proofs

Time to Generate/Verify the Proof. Unlike Bitcoin, generating an answer for a puzzle (i.e., generating a proof-of-capacity) takes little time.

In Bitcoin, the miner is expected to work through most of the epoch in an attempt to find a pre image of a hash with sufficient difficulty.
In ATMcash, assuming a **miner is storing** the capacity correctly, the miner needs to only perform (1) lookups in the disk to find their solution which takes fraction of a second.
For instance, it takes < 1 **ms to** read a single hash from the disk. Only if the miner believes its answer is of very good quality will it generate the full proof, but even this takes seconds, not minutes.

As outlined above, our proofs are substantially bigger than Bitcoin's, and require more than just one hash evaluation to verify. However, for an active currency, we can still expect the size and verification time for the proofs added with every block to be marginal compared to the size of the transaction added with every block, and the time required to verify that the transactions are consistent. This indeed shows that though it may take seconds to generate the proof, verification takes a fraction of a second.

Energy:

Though our prototype was evaluated using a full CPU which wastes a lot of energy, one could in principle run the prover and the verifier on **an** energy-efficient device such as Raspberry Pi [3]. An efficient microcontroller consumes less than 10 W of power, and most miners will only open one node per time-step since the quality of their answers will likely be bad. To get an upper bound on the power requirement, let us assume that there are 100,000 miners, each with 1 TB of capacity, and about 1% of the miners mine "good" answers which they will want to generate a full answer. Then we have 10W · 100000 · 0.01s + 10W · 1000 · 20s = 210000J/block which translates to 210 kJ/min if we add one block a minute. In contrast, Bitcoin on average uses 100 MW, so it consumes 6 GJ/min, which is several orders of magnitude larger. We note that this 1% figure is a very conservative bound, so the difference could be even larger in practice.

GAME THEORY OF ATMCASH

The miners in a cryptocurrency are strategic agents who seek to maximize the reward that they get for mining blocks. As such, it is a crucial property of a cryptocurrency that "following the rules" is an equilibrium strategy: in other words, it is important that the protocol rules are designed in such a way that miners never find themselves in a situation where "cheating" and deviating from the rules yields more expected profit than mining honestly.

Intuitively, ATMcash mining is modeled by the following n-player strategic game. Game-play occurs over a series of discrete time steps, each of which corresponds to a block being added to the blockchain. At each time step, each player (miner) must choose a strategy, specified by:

- which blocks to extend (if any), which transactions to include in the new blocks, and
- which extended blocks to publish (if any).

We present the details of our game-theoretic analysis in the unpredictable-beacon model, and remark that the analysis can be extended to cover the other models too.

A. Game-theoretic preliminaries

The standard game-theoretic notion for a strategic game which occurs over multiple time steps (rather than in "one shot") is the extensive game. In order to accurately model the probabilistic aspects of the ATMcash protocol (e.g. the unpredictable beacon), we consider extensive games with chance moves: this is the standard game-theoretic notion to capture extensive games which involve exogenous uncertainty. The uncertainty is modeled by an additional player called Chance which behaves according to a known probability distribution. In the ATMcash setting, every player (including Chance) makes an action at every time step. A player's action consists of choosing whether and how to extend the blockchain, and the action of Chance determines the value of the unpredictable beacon for the next time step.

An extensive game is commonly visualized as a game tree, with the root node representing the start of the game. Each node represents a state of the game, and the outward edges from any given node represent the actions that players can take at that node. Leaf nodes represent terminal states: once a leaf is reached, the game is over. In accordance with the literature, we refer to paths in the game tree (starting at the root) as histories; and histories which end at a leaf node are called terminal histories.

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Definition X.1 (Extensive game).

An extensive game G =hN, H, fC, I~, ~ui is defined by:

- [N], a finite set of players.
- H, the set of all possible histories, which must satisfy the following two properties:
  - the empty sequence () is in H, and
  - if (a1, . . . , aK) ? H then for all L = K, it holds that (a1, . . . , aL) ? H.

We write Z ? H to denote the subset consisting of all terminal histories. For any history h,A(h) = {a : (h, a) ? H} = ×i?[N]Ai(h) denotes the set of action profiles that can occur at that history, and Ai(h) denotes the set of actions that are available to player i at history h.

- f(·, h) is a probability measure on AC(h), where h ? H and C denotes the Chance player.

- I~ = (I1, . . . , IN), where each Ii is a partition of H into disjoint information sets, such that Ai(h) = Ai(h0) whenever h and h0 are in the same information set I ? Ii. Let Ai(I) denote the set of actions that are available to player i at any history in information set I.

- ~u = (u1, . . . , uN), where each ui: Z ? R is the utility function of player i.

Imperfect information and information sets. An extensive game is said to have perfect information if at any point during game-play, every player is perfectly informed of all actions taken so far by every other player. In the context of ATMcash, players are only aware of each other's announced actions: for example, if Alice tries extending several blocks and then only announces one of them, then Bob does not know about the other blocks that Alice tried to extend. Thus, ATMcash is a game of imperfect information.

The information that players do not know about other players' actions is modeled by the partitions I~ = (I1, . . . , IN) in Definition X.1. Each Ii is a partition of H into disjoint information sets, and for each i ? [N] and any pair of histories h, h0 ? I in a particular information set I ? Ii, player i cannot tell the difference between game-play at h and at h0.

Example X.2 ("Match my number" game).

Consider a simple two-player game in two rounds: in the first round, player 1 chooses a number a ? {0, 1, 2}. In the second round, player 2 chooses a number b ? {0, 1, 2}. Player 2 wins if b = a, and player 1 wins otherwise. Clearly, player 2 can always win if he knows a.

However, we consider a game of imperfect information where player 2 must choose b without knowing a: in particular, suppose player 2 only learns whether a = 0. Then, the histories (a = 1) and (a = 2) are in the same information set in the partition A strategy of a player in an extensive game is defined by specifying how the player decides his next move at any given history. In games of imperfect information, the player may not know which history he is at, so we instead specify how the player decides his next move at any information set.

Definition X.3 (Strategy profile).

A strategy profile ~a =(a1, . . . , aN) of an extensive game G = hN, H, fC, I~, ~ui specifies for each player i ? [N] and each information set I ? Ii a probability distribution ai(I) over the action set
Ai(I). We say that ai is the strategy of player i.

Let I(h) denote the information set in which history h lies.

The probability that a history h occurs under strategy profile a is denoted by Pr~a[h], and the probability that a history h0 occurs given that h occurred is denoted by Pr~a[h0 |h].

Recall that the utility functions u1, . . . , uN were originally defined on inputs in Z, the set of terminal histories. For each ? [N], we now define ui(~a) to be the expected utility of player i given the strategy profile ~a. That is,ui(~a) = Xh ?Z ui(h) · Pr ~a[h].

Moreover, we define ui(~a|h) to be the expected utility of player i given ~a and given that history h has already occurred. That is,ui(~a|h) = X h0?Z ui(h 0) · Pr ~a[h 0 |h].

Equilibrium notions. The most widely known equilibrium concept for a strategic game is the Nash equilibrium [23], given in Definition X.4. Intuitively, in a Nash equilibrium, each player's strategy is a best response to the strategies of the other players.

For a strategy profile ~a, we write ~a-i to denote (aj)j?N,j6=i, that is, the profile of strategies of all players other than i; and we use (a 0 i, ~a-i) to denote the action profile where player i's strategy is a 0 i and all other players' actions are as in ~a.

Definition X.4 (Nash equilibrium of an extensive game).

Let G = hN, H, f, I~, ~ui be an extensive game. A strategy profile ~a is a Nash equilibrium of G if for every player i ? [N] and every strategy a 0 i of player i, ui(~a) = ui(a 0 i, ~a-i).

The Nash equilibrium concept was originally formulated for one-shot games, and it is known to have some shortcomings in the setting of extensive games. Informally, the Nash equilibrium does not account for the possibility of players changing their strategy partway through the game: in particular, there exist Nash equilibria that are not "stable" in the sense that given the ability to change strategies during the game, no rational player would stick with his equilibrium strategy all the way to the end of the game.

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Example X.5 ("Unstable" game).

Consider a simple two player game in two rounds: in the first round, player 1 chooses either strategy A or B. In the second round, player 2 chooses either strategy C or D. The game tree is given below, where the notation (x, y) at the leaves denotes that player 1 gets payoff x and player 2 gets payoff y if that leaf is reached.

To address these shortcomings of the Nash equilibrium concept for extensive games, an alternative (stronger) notion has been proposed: the sequentially rational Nash equilibrium. This stronger concept ensures that players are making the best decision possible at any point during game-play. In a game with imperfect information, it is necessary to consider not only the strategy profile, but the players' beliefs at any point in time about how game-play arrived at the current information set. A strategy profile which takes into account players' beliefs is called an assessment.

Definition X.6 (Assessment).

An assessment in an extensive game is a pair (~a, ~µ) where ~a = (a1, . . . , aN) is a strategy profile and ~µ = (µ1, . . . , µN) is a belief system, in which each µi is a function that assigns to every information set in Ii a probability measure on histories in the information set.

In Definition X.6, µi(I)(h) represents the probability that player i assigns to the history h ? I having occurred, conditioned on the information set I ? Ii having been reached.
For each i ? [N], we now define ui((~a, ~µ)|I) to be the expected utility of player i at the information set I ? Ii, given the strategy profile ~a and belief system ~µ. That is, ui((~a, ~µ)|I) = X h?I ui(~a|h) · µ(I)(h).

We write ui((~a, ~µ)) to denote ui((~a, ~µ)|{()}), that is, the expected utility for player i at the beginning of the game. An assessment (a, µ) is said to be sequentially rational if for every i ? [N] and every information set I ? Ii, the strategy of player i is a best response to the other players' strategies, given i's beliefs at I. A formal definition follows.

Definition X.7 (Sequentially rational assessment).

Let G = hN, H, f, I~, ~ui be an extensive game. An assessment (~a, ~µ) is sequentially rational if for every i ? [N] and every strategy A 0 i of player i, for every information set I ? Ii , it holds that ui((~a, ~µ)|I) = ui(((a 0i, ~a-i), ~µ)|I).

Definition X.7 almost fully captures the idea players should be making the best decision possible given their beliefs at any point during game-play. To fully characterize a sequentially rational Nash equilibrium, we require additionally that the beliefs of the players be consistent with ~a. For example, if an event occurs with zero probability in ~a, then we require that the players also believe that it will occur with zero probability.

Definition X.8 (Consistent assessment).

Let G = hN, H, f, I~, ~ui be an extensive game. A strategy profile ~a is said to be completely mixed if it assigns positive probability to every action at every information set.

An assessment (~a, ~µ) is consistent if there is a sequence
((~an, ~µn))n?N of assignments that converges to (~a, ~µ) in Euclidean capacity, where each ~a n is completely mixed and each belief system ~µ n is derived from ~an using Bayes' rule.

Finally, we arrive at the definition of a sequentially rational Nash equilibrium.

Definition X.9 (Sequentially rational Nash equilibrium).

An assessment is a sequentially rational Nash equilibrium if it is sequentially rational and consistent.

B. Game-theoretic analysis of ATMcash

The game-theoretic analysis of ATMcash In order to analyze the game-theoretic properties of ATMcash mining, we define an extensive game, ATMcashGame, which models the actions that miners can take, and the associated payoffs. To facilitate analysis, we simplify the action capacity of the game as much as possible while still accurately modeling the incentives of

ATMCASH MINERS.

Concretely:

- We do not include the action of creating a capacity commitment because (as discussed in Section V-A under "Mining") we can assume that rational miners will commit to all the capacity they have, and nothing else.
- We do not include the action of creating transactions because such actions do not affect the rewards that players receive from mining blocks, except in the case of punishment transactions. To deal with the case of punishment transactions, we define the payoff of a player who mines multiple blocks in the same time step to be zero. This payoff function exactly captures that of a miner in the actual ATMcash protocol, because it is a dominant strategy for each other miner to create a punishment transaction (including a positive transaction fee) if she sees that a cheating player has mined multiple blocks in a time step, and hence we can assume that the cheating player will surely be punished at a later point in the protocol. Since the punishment penalizes the cheating player by the amount of the mining reward, it follows that the cheater's overall utility for the time step in which he cheated is zero.

- We do not explicitly model the amount of capacity that each player has. Instead, we study the two critical cases: in our initial analysis, we assume that no miner controls more than 50% of the capacity committed by active miners. Then, we discuss potential issues that arise if a miner does control a majority of the capacity.

Let B denote set of all blocks as defined in Section VI. For any number of players N ? N, any number of time steps K ? N, and any reward function?: N ? N, we define the extensive game

ATMcash Game?,K,? = hN, H, fC, I~, ~u i as follows:

- The set H of histories is defined inductively as follows:

  - The action set of the Chance player AC(h) ={0, 1} m is the same for every history h.
  - The empty sequence () is in H, and Ai(()) = {(Ø, Ø)} for each i ? [N].
  - Let h = (h 0, a) be any non-terminal history where the latest action profile a = (a1, . . . , aN , aC) consists of the actions of each player in [N] ? {C} at Later in this section, we address what happens if a miner gains additional capacity (or loses some capacity) during the game.

We remark that the standard way to model this would be to assign a type to each player, representing how much capacity he has.

history h 0, and for each player i ? [N], the action ai = (Si, Ti) is a pair of sets. Then for any i ? [N], the action set Ai(h) of player i at h is Ai(h) = P(T) × B where T =[i?[N] Ti An action ai = (Si, Ti) can be interpreted as Follows:

The set of blocks from the previous time step which player i attempts to extend in this time step, and Tiis the set of extended blocks which player i announces in this time step.

- The probability measure f(·, h) is uniform over {0, 1} m.

- For each i ? [N], we define the partition Ii by an equivalence relation ~i

- The equivalence relation ~i is defined inductively as follows (we write [h]I to denote the equivalence class of h under ~i):

  - [()]i = {()}, that is, the empty sequence is equivalent only to itself.

  - [(h,((S1, T1), . . . ,(SN , TN), aC))]i = {(h 0,((S 0 1, T0 1), . . . ,(S 0 N , T0 N), a0 C)) ? H : h ~i h 0 ? Si = S 0 i ? Ti = T 0i ? aC = a 0 C ??j 6= i, Tj = T 0 j

    - where h and h 0 are histories and the pairs (Sj , Tj) and (S 0 j , T0 j) are actions of player j. That is, two histories are equivalent under ~i if they are identical except in the “first components” Sj of the actions (Sj , Tj) taken by the players other than i.

- ~u = (u1, . . . , uN), where each ui : Z ? R is defined as described below. For a history h, let beac (h) denote the sequence of actions taken by the Chance player in h, and let beacj (h) denote the jth action taken by the Chance player in h. For a block B, let B.c denote the challenge We define Quality (B, c) = (Quality(B) if B.c = c0 otherwise.

  Similarly, let QualityPC ((B1, . . . , BL),(c1, . . . , cL)) = (QualityPC ((B1, . . . , BL)) if ?i ? [L], Bi .c = ci 0 otherwise.

  Let blocks (h) denote the sequence of "winning blocks" at each time step in the game, defined inductively:

  - blocks(()) = () – blocks(h = (h 0 ,((S1, T1), . . . ,(SN , TN), aC))) = arg maxB?T (Quality(B, beac|h|(h))), where T = ?i?[N]Ti

Let blocksj (h) denote the jth block in the blockchain.

We assume that the winning block is unique at each time Let winners (h) denote the sequence of players who announce the winning block at each time step in the game, defined inductively as follows:

This can be achieved by breaking ties between blocks in an arbitrary way.

Note that it is not possible for two different players to announce exactly the same (valid) block, because each block contains the miner's identity.

  - winners(()) = () – winners(h = (h 0 ,((S1, T1), . . . ,(SN , TN), aC))) = arg maxi?[N] maxB?Ti (Quality(B, beac|h|(h))).

Let winnersj (h) denote the jth winner in the sequence winners (h). Let only one j (i, h) be an indicator variable for the event that player i's jth action (Si, Ti) in the history h does not mine multiple blocks, i.e. |Ti | = 1.

Finally, the players' utility functions are defined as follows: for a terminal history h of length K, ui(h) = X j?[K] di,winnersj (h) ·onlyonej (i, h)·?(blocksj (h)), where di,j is the Kronecker delta function26. That is, a player's utility is the sum of the rewards he has received for announcing a winning block (in the time steps where he has announced at most one block).

By Definition X.10, for any i ? [N], for any histories h, h0 in the same information set I ? Ii, it holds that blocks (h) = blocks(h 0).

Thus, we can associate a unique blockchain with each information set: we define blocks(I) to be equal to blocks(h) for any h ? I. Similarly, beac(h) = beac(h 0) for any h, h0 ? I in the same information set I, so we define beac(I) to be equal to beac(h) for any h ?For a block B ? B and a challenge c ? Challenge, **we define** Extendi(B, c) to be the block generated by player i when mining the next block after B using the POC challenge c (see Section VII for exact block format).

Theorem X.11.

For any number of players N, any number of time steps K ? N, and any reward function ? : N ?

N, let ~a = (a1, . . . , an) be a pure strategy profile of ATMcashGame?,K,?, defined as follows: for each i ? [N], for any information set I ? Ii such that I 6= {()}, ai(I) (({blocksj (I)} , {Extendi(blocksj (I), beacj (I))})) = 1, where j = 1 is the length of the histories in information set 27. That is, player i's next action at information set I is aˆi = ({blocksj (I)} , {Extendi(blocksj (I), beacj (I))}).

Then ~a is a Nash equilibrium of ATMcashGame?,K,?.

Proof. Take any player i ? [N]. By the definition of Extend, for any information set I ? Ii with I 6= {()}, the quality v of the extended blockchain v = QualityPC((blocks(I), Extendi(B, beacj (I))), beac(I)) is the same for any block B which was announced at time step j. Therefore, no utility can be gained by choosing any block B over any other block B0 to extend: that is, ui(~a) = ui(a 0 i, ~a-i) for any strategy a 0 i which distributes probability over actions of the form (S, T) where |S| = 1.

Moreover, not extending any block or extending multiple blocks precludes a player from being the "winner" and receiving the reward in this time step, so extending a block is preferable to not extending any block. That is, ui(~a) = ui(a 0 i , ~a-i) for any strategy a 0 i which assigns non-zero probability to anyaction of the form (S, T) where |S| 6= 1.

Kronecker delta function: di,j = 1 if i = j, and 0 otherwise.

27All histories in an information set must be of the same length.

We have shown that ui(~a) = ui(a0 i , ~a-i) for all strategies A 0 i of player i.

The theorem follows.Theorem X.12. Let ? = {Init, Challenge, Answer, Verify} be a proof of capacity . For any number of players N, any number of time steps K ? N, and any reward function ? : N ? N, let (~a, ~µ) be an assessment of ATMcashGame?,K,? Where:

- ~a and aˆi are defined as in Theorem X.11, and for each n ? N, we define ~a n to be the completely mixed strategy profile which (at history h) assigns probability 1/|Ai(h)| n to every action except aˆI , and assigns **all remaining** probability to aˆi.
- ~µ is derived from ~a using Bayes' rule in the following way: ~µ = limn?8 ~µ n, where for each n ? N, ~µ n is derived from ~an using Bayes' rule.

Then (~a, ~µ) is a sequentially rational Nash equilibrium of ATMcashGame?,K,?.

Proof. Let I ? Ii be any information set of player i in ATMcashGame?,K,?, and let L be the length of histories in I. It follows from Definition X.10 that the expected utility of player i at I is ui((~a, ~µ)|I) = X j?[L] di,winners · only one j (i, h) · ?(blocksj (h)) + u 0 I ((~a, ~µ)),where u 0 i is the utility function of player i in the game ATMcashGame?,K-L,?. Since winners, onlyone, and blocks are invariant over histories within any given information set, the summation term can be computed explicitly by player i at I. Hence, in order to maximize his expected utility at I, the player needs simply to maximize u 0 I ((~a, ~µ)). Let (~a|K-L, ~µ|K-L) denote the assessment (~a, ~µ) for the first K - L time steps of the game. By Theorem X.11, ~a|K-L is a Nash equilibrium of ATMcashGame?,K-L,?. Since ~µ is derived from ~a by Bayes' rule, it follows that ui((~a, ~µ)|I) = ui(((a 0 i, ~a-i), ~µ)|I) for any strategy a 0 i of player i.

Applying this argument for every I, we conclude that (~a, ~µ) is sequentially rational in ATMcashGame?,K,?.

By construction, limn?8 ~a n = ~a and ~µ = limn?8 ~µ n, so (~a, ~µ) is consistent. The theorem follows.

Parameters:

The ATMcash Game is parametrized by N and K. It is natural to ask: do we require that the number of miners N is fixed in advance, or that the blockchain will end after a certain number K of time-steps? The answer is no.

Theorem X.12 gives a sequentially rational Nash equilibrium in which each player's strategy is independent of N, and so it makes sense for each miner to play this strategy even if N is unknown or changes over time. In light of this, from each rational player's point of view, K can be considered to be the number of time-steps that he intends to participate in the Buying of capacity. Players' strategies in equilibrium do not depend on the amount of capacity that (they believe) other players possess. Also, we showed above that the equilibrium strategies are robust to changes in N. Hence, if a player's amount of capacity changes (e.g. he buys/sells a hard disk), then he can simply create a new capacity commitment, and then behave as a "new player" with the new amount of capacity.

The "51% Attack".

If a player P controls more than half of the total capacity that belongs to active miners, then following the protocol rules is no longer a Nash equilibrium, because whichever branch of the blockchain P chooses to mine on will eventually become the highest-quality chain. Thus, P can decide arbitrary rules about which blocks to extend, and the other players will be incentivized to adapt their strategies accordingly. Moreover, P can prevent certain transactions from ever getting into the blockchain, by refusing to extend blocks which contain these transactions – as a consequence, P can mine multiple blocks per time-step without ever being punished. This attack was first analyzed by [20] in the context of Bitcoin, which suffers from the same problem (with respect to computing power rather than capacity).

It may seem unrealistic that a single party would control more than half of the total capacity that belongs to active miners in a widely adopted currency. A more realistic concern could be that a large group of miners (in a mining pool) may acquire more half of the total capacity. However, under the assumption that each miner is an individual strategic agent, we consider it unlikely that such a mining pool could do much damage: for this, a large group of self-interested and relatively anonymous agents would have to coordinate and trust each other throughout the duration of an attack. In particular, each rational miner in the pool must be convinced that he will get his share of the attack profits, and it seems highly unlikely that a large group of anonymous people would all trust each other so. The improbability of a 51% attack by a mining pool is supported by recent events: when a large mining pool (ghash.io) was nearing 50% of Bitcoin computing power in 2014, self-interested miners started leaving the mining pool in order to avoid destabilizing the currency

COMMERCIAL ASPECTS

Despite their technical possibilities, cryptocurrencies lack mass adoption because of two critical factors: usability and scalability.

While usability can be addressed with sufficient engineering and development effort, scalability is often a theoretical problem of its own.

Because excess storage space is common, hardware is cheap, and competition is less fierce, a more diverse group of people can become involved in PoC mining, meaning a more decentralized network.

The inherent features of a good cryptocurrency – decentralization and **trustless** design - often go contrary to traditional methods of upscaling centralistic processes. While Bitcoin's pioneer achievement, the blockchain, solved the problem of decentralized trust, its inventor certainly left much headroom for scaling that concept for a truly global use.

We observed the cryptocurrency ecosystem for years, and we have seen the majority of projects go astray because of misleading policies and questionable ethics.

OUR MISSION

In ATMCash, we take pride in the fact that we strongly believe in flawless fundamentals, decentralization and innovation and that we favor long-term strategies over short-term greed. Did you know ATMCash was released without any ICO or premine?

White Paper

Our Vision

In ATMCash, we take great pride in the fact that we strive for innovation, paving the way of the future with our technology. We have been the first in the world capable of making the following things work:

The Team

The PoC ATMCash – the development team – is a group of entirely self funded and highly skilled computer scientists who made a pledge to lead ATMCash based as facilitator of digital disruption to its rightful place among the top cryptocurrencies.

The future is what we make it

Our ATMCash roadmap helps us share what we're working on next and the direction that we're taking this project in. We decided to come up with something accessible and clear enough to help us open up a practical to future dialogue with the community after lunch June 2018.

A disruptive purpose

The ATMCash became the backbone of the truly global network of payment channels everyone has been waiting for.

Yet ATMCash is not simply an environmentally friendly cryptocurrency or a payment system; it is a revolution in the way we perceive our economy. ATMCash is the new digital system that removes the need to trust a middleman. It is the birth of a true peer-to-peer economy, backed by smart contracts, tokens and digital assets.

Core improvements

Code refactoring - Improving structure and readability with a focus on simplicity and flexibility. Getting rid of old code from the NXT wallet. Paving the way for more advanced modifications.
Improving stability and reliability - Improving the overall stability of wallets and nodes in order to maximize the security and reliability of the network.
Better debugging and logging

Usability

WEB and Mobile Payment infrastructure - Bringing ATMCash closer to the 'real economy' by enhancing WEB and mobile payments in future, a vital feature for merchants, based in BitsClub License Systems and BitsClub App.

Accessibility

Simplified softwares - Facilitating the installation and deployment of the ATMcash softwares and packages for the end user.

Infrastructure

New tools and services - Providing the current explorers and observers with new tools and infrastructure.

Websites overhaul - Updating and improving the content, organization and aspect of the main ATMCash websites.

Disclaimer: this roadmap is likely to be subject to future revisions and modifications. It does not represent a promise of development of any sort, but rather an indication of the direction taken by the development team at a given time.

The new economy is here

We are converting contracts to computer code, stored and replicated on the blockchain and supervised by the network of miners.

What are smart contracts ?

Smart contracts are computer programs that can automatically execute the terms of a contract. Anyone familiar with computer programming would be aware of what is known as an if-then-else statement, where a program executes a certain task if certain conditions are met and does not if the conditions are not present. Smart contracts implement this on the blockchain in a completely decentralized and trustless way.

Smart contracts help you exchange money, property, shares, or anything of value in a transparent, conflict-free way while avoiding the services of a middleman.

The reason for Smart Contracts' name is that they allow people to agree on a piece of code ahead of time and trustlessly know that if they submit the code to the network, then it will be completed as requested. The code's arguments can be modified as desired, before its submission to the network.

In 2014, Burst, technology inspired for ATMCash, was the first ever cryptocurrency to implement working, turing complete smart contracts in a live environment in the form of Automated Transactions (AT).

ATMCash use the same Smart Contract technology from Automated Transactions (AT).

How it works

With ATMCash, smart contracts are implemented using Automated Transactions (AT), a technology created by the CIYAM developers. Automated Transactions are turing-complete and thus have a potentially infinite number of use cases.

If you are interested in ATMCash smart contracts and want to learn how to create one yourself, please have a look at the documentation provided by CIYAM and at the wiki created by a ATMCash community member soon

Proof-of-Capacity, The Green Alternative?

Where Proof-of-Work is power hungry, and Proof-of-Stake can skew towards centralization, is Proof-of-Capacity the holy grail of Blockchain consensus algorithms? click here:

Proof-of-What?

When reading about Bitcoin or other blockchain technologies, the phrases Proof-of-Work and Proof-of-Stake are often mentioned. In the case of Bitcoin, Proof-of-Work as one of the reasons for its astronomical energy consumption. These "Proof" algorithms are used by cryptocurrency networks to reach a consensus of the current state of their respective blockchains in a process called mining. Put simply, mining is the process in which a group of unaffiliated, distributed transaction processors validate the transactions that have taken place on the network. Before I get into ATMCash (ATM$) and what its Proof-of-Work Algorithm means and why it's significant, I will describe what these other "Proof" algorithms mean and how they came to be.

Proof-of-Work

Users: Bitcoin, Litecoin, and damn near everyone else.

1*vUS1xHNn4jCfsSKVQ8ShpQ.png

Proof of Work

Proof-of-Work (PoW) was first given serious attention in the Bitcoin whitepaper in 2008. The beauty of Proof-of-Work, when it was announced, was that it was the first mechanism that allowed for consensus among distributed parties with no central trust. While nowadays we have several solutions to this problem, at the time a working solution to this foundational problem had never been proposed.

White Paper

Terminology

Hash: A hash is a cryptographic function that is meant to be a one-way function. A hashing algorithm should be able to take any amount of data and return a fixed length string that should be completely unique to that particular input.

Nonce: A nonce is an arbitrary number that can only be used once.

Miner: One of the independent transaction processors in the cryptocurrency network whose goal is to validate transactions. Also sometimes called a Full Node or Node.

Generally, PoW as it operates in Bitcoin and many other cryptocurrencies functions in the following way:

A collective difficulty level is set. This usually refers to some characteristic that the resulting "product" or "answer" must posses (e.g. the resulting hash must start with 3 consecutive 0's). Each miner (or node) starts generating guesses for the answer. They test their guesses by generating a new hash from the current unconfirmed transactions, the hash of the previous block, and a nonce of their choosing.

When a miner finally generates a hash that meets the conditions from step 1, it broadcasts its answer to the rest of the network to verify. If the answer is found to be valid, the miner that generated the answer is said to win the right to mine the block.

The power consumption concerns come into play because each "guess" a miner makes takes a set tiny amount of energy for a computer to produce. Currently the hash rate for the entire bitcoin network is ~17,000,000 tera hashes per second, that is 17,000,000,000,000,000,000 guesses per second for the entire network. The energy required to do this kind of computation is roughly the same as the consumption of the country of Hungary.

Proof-of-Stake

Users: Dash, NEO, Lisk, etc.

1*JuZ94vIVcCWvYmOweiHl3w.png

Proof of Stake

Proof-of-Stake was first introduced in 2012 with the introduction of Peercoin. PoS was seen as a solution to the inherent waste occurring in PoW currencies. PoS also solves the problem of distributed consensus, albeit in via a different path.

Generally, PoS works by using a randomization algorithm to select a mining node based on its public attributes such as its age, or the amount of the native currency that the node possesses. This makes the mining process, at least computationally, much less expensive than

PoW algorithms. Keep in mind this is a very brief overview of PoS, interested readers will find the topic has much more depth and complexity than I give here.

While it is considered much "greener" than PoW, there are some drawbacks to consider when looking at PoS systems. The greatest of these being the argument that such networks can quickly become unfairly distributed if too much weight is given too very wealthy or old nodes.

Proof-of-Capacity

Users: Burst, BitCoinore, ATMCASH.

1*S6vrVlaEIqiCBNoGfLDtzA.png

Proof of Capacity

Proof-of-Capacity, which has also been referred to as Proof-of-Space, was first proposed in 2013.

PoC is not so very different from PoW except for one major differentiator, in PoC, rather than doing a large amount of work in order to verify each block, the work is done up front in the process called "plotting" and the results from this process are used later to verify each block.

The basic idea to take away from this is that in PoC the "work" is done once during plotting rather than with each new block, allowing PoC to realize a huge efficiency savings over PoW systems. The amount of "work" a miner will end up doing depends on the amount of free disk space they have available to devote to the plotting process.

How Does It Work?

If you'd like to avoid the nitty-gritty of how plotting and mining work in ATMCash PoC system, feel free to skip on to the next section.

Plotting is the process of generating plot files, which are just files storing a large number of pre-computed hashes. Each plot file contains one of more groups of 8192 hashes, these groups are called nonces. Anonce is exactly 256KiB in size (8192 x 32 bytes per hash). Additionally, each nonce is divided into 4096 pairs of hashes, the pairs are referred to as scoops. Each nonce can also be identified by its index number, ranging from 0 to 2^64.

1*wDIWEV99RzQ1LSdB6q5CjQ.png

The plotting process takes the miner's burst address as an input, which ensures that plot files can only be used by a single miner.

For an even lower level look at how plot files are generated you can read this.

Once the plot files have been generated, the actual mining process can take place. The miner will first fetch the relevant information from the wallet for the current block, this includes a 32 byte hash called the "generation signature" from the previous block, the block height (index of the current block), and something called the "base target" which is calculated based on the last 24 blocks and can be considered as the "difficulty level" of the block.

With this information the miner can then generate a new "generation hash" which will use to **determine which** scoop to check in each nonce. With each of the applicable scoops, the miner will then perform an additional hash with the new generation signature before dividing the hash by **the base** target, which results in the "deadline" being returned. The deadline represents the number of seconds since the previous block was mined before the miner would be allowed to mine the next block. The miner with the smallest deadline wins the right to mine (also called forge) the next block.

Why Does PoC Matter?

Proof of Capacity is Efficient.
PoC is very efficient when compared to PoW miners that use ASICs to mine. ATMCash transactions on average use 1/550 the energy used per Bitcoin transaction.

Proof of Capacity is Cheap.
You can get started mining Burst with an extra laptop and external HDD, compared to the expensive, specialized ASIC rigs or GPUs needed for most PoW mining.

Proof of Capacity is Distributed, Because excess storage space is common, hardware is cheap, and competition is less fierce, a more diverse group of people can become involved in PoC mining, meaning a more decentralized network.

FUTURE VISION

The Comercial Projection

The projected vision visualizes the currency as # 1, in the terms described in the previous paragraph, focusing on security and stability in operations and enhancing the user's economic benefits through e-Commerce, Trading and Exchange, and through support in Attraction Marketing Campaigns for both businesses and users.

The so-called "360 Degree Attraction Marketing Plan is deployed through the fundamentals of Marketing 3.0: marketing focused on values, of a multidirectional character, communicated through interactive media, and wholly focused on the integral human being: with mind, heart, and spirit, in hopes of creating a better world. Through the organic and systematic integration of the different activities and the adoption of Incident and Consequential Strategies in the different elements that make it up, specific objectives are achieved through the stimulation of the hidden aspects in the mind of the Consumer:

thinking, feeling and acting, empowering them towards the Creation of Competitive Advantages for the Brand, through nourished and transparent dialogue, resulting in trust and credibility, which in turn promotes the creation of Strategies formulated on the basis of winning ideas resulting from the constant evaluation and contributions of the followers, in a digital interactive communication environment, also greatly stimulated by the integration of Gamification and an attractive Plan of Prizes, structured around ATM Cash. The favorable disposition of the Qualified Followers generates a multiplier effect in Social Networks, through the propensity of these to endorse the brand.

The Brand would receive benefits of diverse order, preliminarily defined as follows:

a) **Brand Social Footprint:** Represented in a base of direct Customers and brand ambassadors, estimated at the end of five years in the range of 2.5 - 3.5 million, valued at $10 / Customer, which would represent an economic value of US$25 - US$35 million.

b) **Brand Value:** Based on a discount scheme and the application of the Financial concept of Capitalized Cost, this would have a value in the range of US$85 - US$100 million.

c) **Productivity in Business with Strategic Allies:** This calculation is estimated at US$150 - US$175 million.

The different programs being developed projects the creation of 4.89 to 7.30 million Customers for ATM Cash, during the three years of the process, plus the Residual Period, where the benefits of the different developments will still be perceived.

The progressive average of growth of the base of followers created with the Strategic Positioning Program is expected to be the following:

ATMCash	% Participation	Lower Rank	Upper Rank
First Year	25.00%	610,645	912,600
Second Year	30.00%	732,774	1,095,120
Third Year	25.00%	610,645	912,600
Fourth Year	15.00%	366,387	547,560
Fifth Year	5.00%	122,129	182,520

The Estimated Economic Benefits in Five (5) Years is the range: US$260 - US$310.00 million.

APPLICATION PLATFORMS

BITSHOP APPLICATION

The BitShop App (for User and Vendor), which contains the main Market Cryptocurrencies, including ATM Cash, can be downloaded in IOS, Android or through the link:

https://www.bitshopclub.com

White Paper

MINNUT

Minnut is a technology based on BI integrated to ATM Cash and which belongs to the firm ClickFriend Digital Market LLC, which will be the first social network and social commerce which will pay its members for followers and in ATM Cash and can be downloaded in iOS and Android or through the link:

https://www.minnut.com

BITS CLUB

A worldwide system of licensing for Crypto Exchanges, whose purpose is to decentralize the Purchase / Sales / Transfers transactions and P2P among the main cryptoactive parities in the market, being a safe and more efficient channel of ATM Cash distribution and marketing, allowing the P2P asset management among all its local, regional, national and international users.

CONCLUSION

We have presented ATMcash, a cryptocurrency that uses efficient proofs of capacity instead of energy-intensive proofs of work to maintain a public ledger of all transactions. We have described a variant of a proof-of-capacity protocol that is more suitable for cryptocurrencies, and modified the structure of the hash chain and transactions to address some of the issues of other cryptocurrencies. We have also demonstrated the feasibility of ATMcash through a prototype, and **showed** that maintaining a public ledger could be much more efficient with proof-of-capacity. Finally, we do a game-theoretic analysis of ATMcash modeled as an extensive game, and prove that it satisfies strong equilibrium properties.

A. Proof-of-capacity Parameters

The two Pocapacity constructed in have the following efficiency/security properties. Below thash denotes the time 17required to evaluate the underlying hash function hash:

{0, 1}* ? {0, 1} L on inputs of length 2L (to hash an input of length m · L takes time m · thash by using Merkle - Damgard), ° For a given n, the number of nodes of the underlying graph, an honest prover P must dedicate N = 2 · n · L bits of storage (L · n for the labels, and almost the same for the values required to efficiently open the Merkle tree commitment).

ATMcash uses the Shabal256 hash function, which below we will denote with H(·). To mine ATMcash, a miner first initialises his disk capacity as follows: he picks a nonce μ and an account identifier (which is a hash of a public key) Id, and then computes iteratively 4096 values x0, x1, . . . ? {0, 1} 256 As x0 = H(Id, µ) and (4) xi+1 = H(xikxi-1k . . . kx0) for i = 0, . . . , 4095 .

The miner then stores s0, . . . , s4095 where si = xi ? x4096. Each block is called a “scoop”, and the 4096 scoops together are called a “plot”. The miner is supposed to store as many plots as he can (using different nonces) until all the dedicated capacity is filled. To compute a plot, one must hash 4096·1+40962 ˜ 8 million 256-bit blocks. In the following we assume for simplicity that there is just one plot s0, . . . , s4095. Efficiency. Once every few minutes, a new block gets added to the hash-chain. At this point the miner can compute a designated (public) index i ? {0, . . . , 4095} and must look up the value.

This then determines if the miner “wins” and thus can add the next block to the block chain30. Note that this requires accessing a constant fraction of the entire dedicated disk capacity (i.e. one block per plot, or 0.024%), every time a new block gets mined. Moreover, in order to verify that a miner “won” and can add a block, it is necessary to recompute the entire plot from the initial inputs (Id, µ), which, as mentioned above, involves hashing over 8 · 106 blocks.

Time-memory trade-offs. We observe that ATMcash allows for a simple time-memory trade-off: instead of storing an entire plot s0, . . . , s4095, a miner can initially compute and store only the value x 4096. The miner then re-computes the required scoop si at a given time-step, but only if i is sufficiently small (say, i = 10). This would require hashing only at most 50 blocks. Thus, the miner will get a shot at adding a block only at 10/4095 ˜ 0.25% of the time slots, but now also only requires a 1/4095 ˜ 0.025% fraction of the Note that in equation (4), a freshly computed block xi is prepended to the previous input. This is important as Shabal256 is an iterated hash function: appending instead of prepending would bring the number of hashes required to compute a plot down to linear (instead of quadratic) in the length of the plot, but at the same time would allow for much more dramatic time-memory trade-offs than the ones outlined below.

To be precise, the miner computes x0, . . . , xi and sets si = xi ?x4096.

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