A new proposal of distributing tokens on blockchain: Proof of Mint

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Abstract

The concept of Fair Mint (or Fair Launch) has gained significant traction within blockchain communities, yet it faces critical issues such as Sybil attacks, insufficient time for building community consensus, fraud, and lack of market value management.

This paper introduces a new solution, Proof of Mint (PoM), inspired by Bitcoin's mining difficulty mechanism. PoM aims to address the fairness concerns by transforming hash power into minting participation levels, thereby mitigating the impact of Sybil attacks and providing ample time for community consensus building.

The proposed PoM is designed to approach ensures a stable minting process, discourages speculative and cheating behavior, incentivizes real user. The paper provides a detailed analysis of the PoM mechanism, including core formulas for calculating the difficulty coefficient, and mint size per Epoch etc.

The paper also presents simulation test parameters and results, showcasing the PoM's effectiveness maintaining a stable minting curve. Additionally, it discusses the total supply calculation based on Eras, Epochs, and reduction factors, as well as the estimated total minting time.

The paper proposes a significant advancement in the Fair Mint paradigm, offering a more equitable and community-driven approach to token minting and distribution. The PoM has the potential to reshape the landscape of decentralized finance by ensuring a fairer and more sustainable minting process.

1- Issues

In the past two years, the Fair Mint (or Fair Launch) in the blockchain communities has become extremely popular. Numerous tokens have quickly completed the minting process and were subsequently listed on decentralized exchanges for trading. However, their price trends often exhibit a common pattern: after an initial rapid increase, the prices continue to decline incessantly.

Over two years of observation and research on various Fair Mint platforms and projects, we have identified the following issues:

1.1 - Sybil Attack

According to relevant data, the proportion of real participants of such Fair Mint games is as high as 90%. However, it is surprising that over 95% of the tokens are actually minted by a minority of individuals proficient in blockchain technology. Consequently, the vast majority of ordinary real participants can only obtain a very small amount of tokens.

This technical method is commonly known as “Sybil Attack”, which robs Fair Mint of its “fairness”. A few individuals control a large number of tokens obtained at very low cost, and they manipulate the market by rapidly driving up the token prices and then selling them out at high prices to reap substantial profits, which is called “Pump and Dump”.

1.2 - Insufficient time to build consensus

The communities have insufficient time to build consensus. Due to the rapid speed of token minting, the price often begins to decline while the community is still in the process of building, leading to the disintegration of community consensus and ultimately the dissolution of the community.

1.3 - Fraud

Members of some projects participate in minting through technical means themselves, creating a false impression of market "excitement" and obtaining low-cost tokens, manipulating the market to gain huge profits, turning Fair Mint into a tool for fraud.

1.4 - Lack of Market Value Management(*MVM*)

There is a lack of effective market value management measures. Given the exceptionally fast minting speed and the fact that usually 100% of the tokens are directly (or after the completion of minting) put into circulation, market value management becomes crucial. However, the "ownerless" feature of tokens associated with Fair Mint requires the community to spontaneously organize MVM. Unfortunately, due to the rapid minting speed, MVM often cannot be implemented in time before the collapse of the token price.

1.5 - Does liquidity management workable?

Some Fair Mint platforms have introduced liquidity management mechanisms, such as charging a certain fee during minting, which is locked in a smart contract and automatically added to the liquidity pool of decentralized exchanges after certain conditions are met (such as reaching a target amount or completing all minting).

However, we have observed that in the initial rapid price increase of these projects, the funds in the liquidity pool account for a very low proportion of the total liquidity pool; and when the price falls, the funds in the liquidity pool are far from sufficient to withstand the sell-off.

1.6 - Does Time Locker workable?

Some smart contracts introduce Time Locker to prevent Sybil-attacks, which can indeed prevent batch minting using the same account, but they still cannot prevent those who implement batch minting using different accounts.

1.7 - Mempool and *MEV*

Most of blockchains are mostly based on Ethereum EVM, and the **mempool** of EVM allows a large number of Bots to "peek" at users' intentions before the new block is packed and take the lead in on-chain actions, such as minting and trading. We have observed that there is a large amount of such behavior on both Ethereum (with a block packing interval of about 12 seconds) and Layer 2 networks like Arbitrum (with a block packaging interval of about 0.25 seconds). This type of behavior is well known as: **Maximal Extractable Value (MEV)**. It is estimated that since January 1, 2020, the total amount of **MEV** has exceeded 730 million US dollars, most of which has flowed to robots and miners. The existence of MEV is technically driven and, although understandable, it greatly affects the fairness of on-chain actions.

We believe that effectively preventing technical means such as Sybil attacks and giving sufficient time for the establishment of community consensus have become the most serious challenges. Although many Fair Mint platforms have realized the seriousness of this issue and have tried to take corresponding measures to prevent various types of cheating, the actual effects achieved are quite limited.

To effectively prevent Sybil attacks, some platforms or projects have adopted tech such as **KYC authentication** or relying on servers controlled by the project team to provide **authorized signatures** requiring minters to have this signature to mint. However, these methods are too centralized and therefore difficult to be accepted widely and supported from the crypto community.

2- Proposal

We believe that, given the current blockchain technology, it is very difficult to completely eliminate these issues. However, some new mechanisms can alleviate these problems and enhance the fairness of Fair Mint and build better community.

This paper proposes the following solutions:

2.1 - The Difficulty Mechanism of Bitcoin Mining

This proposal draws on the difficulty mechanism of Bitcoin mining, so before introducing this proposal, let's briefly introduce the Bitcoin mining mechanism.

The difficulty mechanism of Bitcoin mining is a core component of the Bitcoin network. It ensures that the minting progress is maintained at a stable rate of approximately one block every 10 minutes on a decentralized network. This mechanism is designed to adapt to changes in the network hash power at different times, with the aim of keeping the generation speed of new blocks relatively stable regardless of how the nodes joining the network.

The adjustment of Bitcoin mining difficulty is achieved through an automatic algorithm that adjusts the difficulty approximately every two weeks (2016 blocks). This cycle is designed based on the target block generation time of the Bitcoin network, which is one block every 10 minutes. If the average generation time of new blocks in the past 2016 blocks is less than 10 minutes, the difficulty will increase to ensure that the future block generation time returns back to 10 minutes. Conversely, if the block generation time is more than 10 minutes on average, the difficulty will decrease.

The specific calculation of the difficulty is based on the comparison between the generation time of the previous 2016 blocks and the target time (20160 minutes, i.e., two weeks). The difficulty adjustment formula increases or decreases the difficulty based on the ratio of actual time to target time. This adjustment is continuous to ensure that the Bitcoin network can adapt to the constantly changing hash power, whether miners joining or leaving, or high hash power mining hardware involving.

Furthermore, the adjustment of difficulty is also subject to a maximum change limit, that is, the difficulty cannot exceed 4 times the previous difficulty in any single adjustment. This is to prevent sudden large fluctuations in difficulty from impacting the network.

As the Bitcoin network develops, the mining difficulty continues to increase, mainly due to the growing hash power participating in mining. As more and more miners join the network and mining hardware technology improves, the total computing power for mining continues to rise, which increases the difficulty for individual miners or mining pools to discover new blocks. Therefore, the increase in mining difficulty reflects the growth of hash power in the Bitcoin network and also ensures that the issuance rate of Bitcoin remains stable.

The Bitcoin mining difficulty mechanism is key to the adaptability and stability of the Bitcoin network. It ensures that the generation rate of Bitcoin blocks remains at the designed target level by dynamically adjusting the difficulty value, while adapting to changes in network hash power.

```
/* Calculate the difficulty for a given block index.
 */
```

```cpp
double GetDifficulty(const CBlockIndex& blockindex)
{
    int nShift = (blockindex.nBits >> 24) & 0xff;
    double dDiff =
        (double)0x0000ffff / (double)(blockindex.nBits & 0x00ffffff);

    while (nShift < 29)
    {
        dDiff *= 256.0;
        nShift++;
    }
    while (nShift > 29)
    {
        dDiff /= 256.0;
        nShift--;
    }

    return dDiff;
}
```

Key code of aboved difficulty rules in bitcoin code(c++ version). Bitcoin github repo: https://github.com/bitcoin/bitcoin/blob/1dda1892b6bcc3d4f9678960cc9e9920f491e87e/src/rpc/blockchain.cpp#L87C1-L107C2

```cpp
unsigned int GetNextWorkRequired(const CBlockIndex* pindexLast, const CBlockHeader *pblock,
  const Consensus::Params& params)
{
    assert(pindexLast != nullptr);
    unsigned int nProofOfWorkLimit = UintToArith256(params.powLimit).GetCompact();

    // Only change once per difficulty adjustment interval
    if ((pindexLast->nHeight+1) % params.DifficultyAdjustmentInterval() != 0)
    {
        if (params.fPowAllowMinDifficultyBlocks)
        {
            // Special difficulty rule for testnet:
            // If the new block's timestamp is more than 2* 10 minutes
            // then allow mining of a min-difficulty block.
            if (pblock->GetBlockTime() > pindexLast->GetBlockTime() + params.nPowTargetSpacing*2)
                return nProofOfWorkLimit;
            else
            {
                // Return the last non-special-min-difficulty-rules-block
                const CBlockIndex* pindex = pindexLast;
                while (pindex->pprev && pindex->nHeight % params.DifficultyAdjustmentInterval()
                  != 0 && pindex->nBits == nProofOfWorkLimit)
                    pindex = pindex->pprev;
                return pindex->nBits;
            }
        }
        return pindexLast->nBits;
    }

    // Go back by what we want to be 14 days worth of blocks
    int nHeightFirst = pindexLast->nHeight - (params.DifficultyAdjustmentInterval()-1);
    assert(nHeightFirst >= 0);
    const CBlockIndex* pindexFirst = pindexLast->GetAncestor(nHeightFirst);
    assert(pindexFirst);

    return CalculateNextWorkRequired(pindexLast, pindexFirst->GetBlockTime(), params);
}
```

Bitcoin github repo: https://github.com/bitcoin/bitcoin/blob/1dda1892b6bcc3d4f9678960cc9e9920f491e87e/src/pow.cpp#L14

2.2- Proof of Mint(PoM)

If we replace Bitcoin's hash calculations with the act of minting, effectively transforming hash power into the level of participation in minting, we arrive at our proposed solution, known as **Proof of Mint**, or **PoM** for short.

Assuming we deploy **PoM** on Ethereum, which has updated to a **Proof of Stake (PoS)** consensus with an average block time of approximately **12 seconds**. To achieve stability in the minting process, we have designed the following plan:

- The entire minting progress is divided into several **Eras**, each **Era** containing several **Epochs**.
- Each **Epoch** has a difficulty-coefficient (the initial **Epoch**'s difficulty-coefficient is **1**), which is determined by the actual running time of the previous **Epoch** and determines the current block's mint-size.
- Each epch has several minting instances, the **mint size** of each minting instance of the same epoch are same.
- The **target mint size of epoch** and **base mint size of epoch** in each **Epoch** within an **Era** decrease according to a fixed **reduction factor**.
- Each minting requires a fixed fee, which does not change with the decreasing mint-size of **Era** and **Epoch**.

2.3- Example:

2.3.1- Quick minting In the 1st **Era**, the **target mint size of epoch** is **100,000 tokens**, the **base mint size of epoch** is **100 tokens**, the **target mint time per epoch** is **10 minutes**, and the minting fee is **0.1 ETH**.

Let's see that in the 9th **Epoch**, if **100,000 tokens** were minted in 400 seconds with a **difficulty coefficient** of **1.015086348**, the 10th **Epoch** eclapsed 200 seconds, then the 10th **Epoch**'s **difficulty coefficient** will automatically increase to **1.028665947**, and the **mint size per minting** will automatically decrease to **100 / 1.028665947 = 97.86137759 tokens**, with the cost per token to **0.1ETH / 97.86137759 tokens = 0.001021854 ETH**.

Then the 11th **Epoch** takes **1000 minutes** (more than target time 600 seconds), so the **difficulty coefficient** will keep same as the 10th **Epoch**'s **difficulty coefficient**, and the **mint size per minting** and the cost per token are same as the 10th **Epoch**.

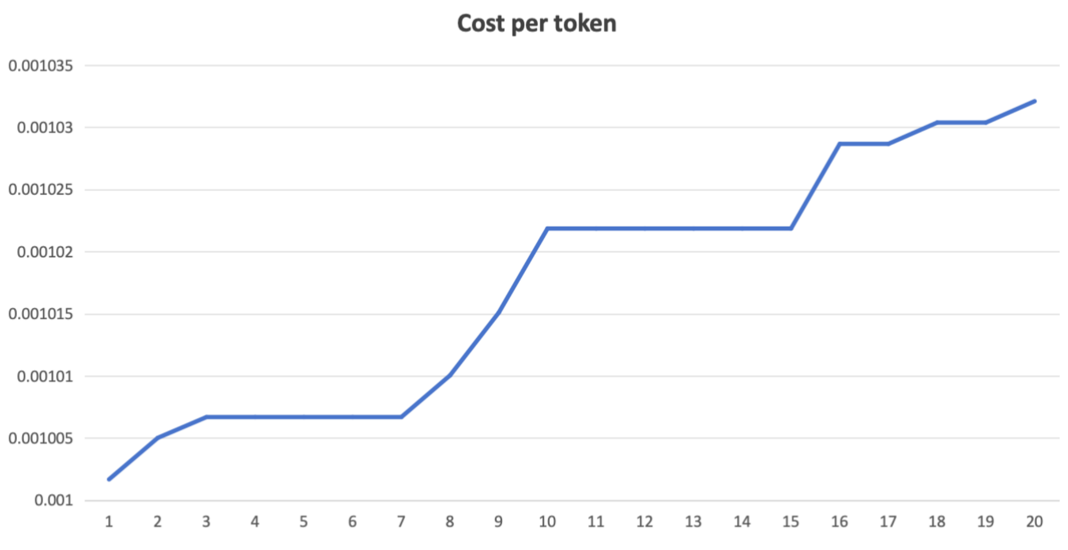
Then, the 16th **Epoch**'s minting time change to be **200 seconds**, and the **difficulty coefficient** will automatically increase to **1.028665947**, and the **mint size per minting** will decrease to **100 / 1.028665947**

= **97.213289 tokens**, with the cost per token to **0.1ETH / 97.213289 tokens = 0.001028666 ETH**, which is higher than the previous **Epochs**.

Here is a sheet to explain the above example:

Epoch	Epoch mint time	Change of Difficult Coefficient	Difficulty Coefficient	Mint Size per Minting	Cost per Token
1	500	0.001666667	1.001666667	99.83361065	0.001001667
2	400	0.003333333	1.005005556	99.50193752	0.001005006
3	500	0.001666667	1.006680565	99.3363769	0.001006681
4	600	0	1.006680565	99.3363769	0.001006681
5	700	0	1.006680565	99.3363769	0.001006681
6	800	0	1.006680565	99.3363769	0.001006681
7	600	0	1.006680565	99.3363769	0.001006681
8	400	0.003333333	1.010036167	99.00635571	0.001010036
9	300	0.005	1.015086348	98.51378678	0.001015086
10	200	0.006666667	1.02185359	97.86137759	0.001021854
11	1000	0	1.02185359	97.86137759	0.001021854
12	800	0	1.02185359	97.86137759	0.001021854
13	1200	0	1.02185359	97.86137759	0.001021854
14	1500	0	1.02185359	97.86137759	0.001021854
15	1000	0	1.02185359	97.86137759	0.001021854
16	200	0.006666667	1.028665947	97.213289	0.001028666
17	800	0	1.028665947	97.213289	0.001028666
18	500	0.001666667	1.03038039	97.05153644	0.00103038
19	600	0	1.03038039	97.05153644	0.00103038
20	500	0.001666667	1.032097691	96.89005302	0.001032098

The chart of token cost of above sheet as following:

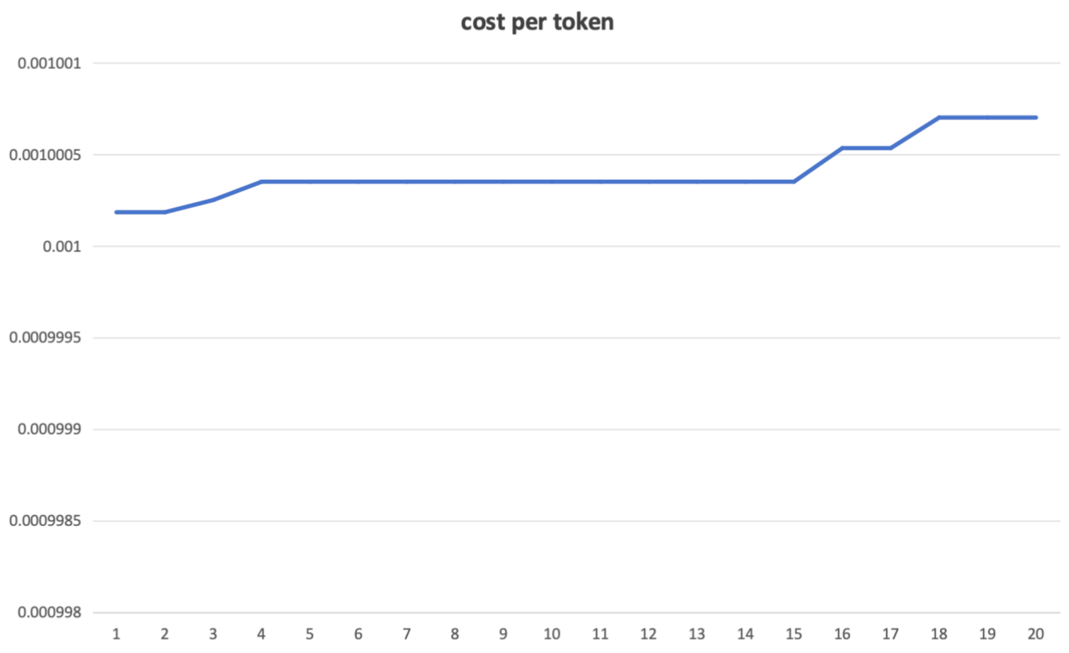


2.3.1- Minting as target time If the minting is too fast, the cost of minting will increse quickly. But if the minting is according to the target time, everyone will get the some cost of tokens.

Here is the sheet to explain:

Epoch	Epoch mint time	Change of Difficult Coefficient	Difficulty Coefficient	Mint Size per Minting	Cost per Token
1	589	0.000183333	1.000183333	99.98167003	0.001000183
2	609	0	1.000183333	99.98167003	0.001000183
3	596	6.66667E-05	1.000250012	99.97500503	0.00100025
4	594	0.0001	1.000350037	99.96500853	0.00100035
5	607	0	1.000350037	99.96500853	0.00100035
6	609	0	1.000350037	99.96500853	0.00100035
7	609	0	1.000350037	99.96500853	0.00100035
8	608	0	1.000350037	99.96500853	0.00100035
9	604	0	1.000350037	99.96500853	0.00100035
10	608	0	1.000350037	99.96500853	0.00100035
11	608	0	1.000350037	99.96500853	0.00100035
12	607	0	1.000350037	99.96500853	0.00100035
13	607	0	1.000350037	99.96500853	0.00100035
14	605	0	1.000350037	99.96500853	0.00100035
15	603	0	1.000350037	99.96500853	0.00100035
16	589	0.000183333	1.000533435	99.94668497	0.001000533
17	608	0	1.000533435	99.94668497	0.001000533
18	590	0.000166667	1.00070019	99.93002996	0.0010007
19	603	0	1.00070019	99.93002996	0.0010007
20	611	0	1.00070019	99.93002996	0.0010007

The chart of token cost of above sheet as following:



2.3.2- About the base mint size of epoch Additionally, the **base mint size of epoch** decreases progressively. Assuming a **reduction factor** of **3/4**:

- 1st **Era**, the **target mint size of epoch** is **100,000 tokens**, and the **base mint size of epoch** is **100 tokens**.

- 2nd **Era**, the **target mint size of epoch** is **100,000 * 3/4 = 75,000 tokens**, and the **base mint size of epoch** is **75 tokens**.
- 3rd **Era**, the **target mint size of epoch** is **75,000 * 3/4 = 56,250 tokens**, and the **base mint size of epoch** is **56.25 tokens**.
- ...

2.4- Benefits

2.4.1- Benefit 1 If **Bots** participate in the minting, they will find that the faster the minting speed, the fewer tokens they receive, and the higher the cost. Contrary to many methods that try to prevent **Bots** from participating minting, this proposal does not prevent Bots from batch minting. However, the high cost and low yield will stop Bots.

2.4.2- Benefit 2 If **Bots** monitor the minting time of the previous **Epoch** to calculate the difficulty of the next **Epoch** and valuate whether to participate or not, then all Bots must have their own strategies. Otherwise, convergent strategies will lead to all Bots crowding and causing a significant decrease in yield and a substantial increase in costs. Because the yield of Bots do not depend on the “speed” of minting, but more on the “guesswork” of the behavior of other Bots, greatly increasing the strategic difficulty for Bots.

2.4.3- Benefit 3 Adopting a mechanism where difficulty only increases and never decreases ensures that the expected mining cost is always on the rise. When the difficulty increases rapidly, users will not anticipate a decrease in difficulty, either continuing to mint or stopping minting. This avoids the halt in minting that can occur when waiting for the difficulty to drop.

2.4.4- Benefit 4 As the difficulty and mining cost increases, until the market deems the cost to have reached a reasonable level, at which point minting will slow down or stop. The mining cost at this time will be an Anchor of the market price of tokens.

2.4.5- Benefit 5 The funds collected from mining are used for the liquidity pool of decentralized exchange. This proposal avoids the issue of some platforms in the past charging a fixed minting fee that was far from sufficient for the market’s liquidity needs. As the difficulty increases, the output per minting will decrease, and the number of minting to complete the target mint size of epoch will increase, thereby raising the minting fee. The increased minting fees are directed into the liquidity pool, providing ample liquidity support for Market Value Management.

2.4.6- Benefit 6 When market prices fall, people will find that minting is no longer cost-effective, leading to a slowdown or cessation of minting activities. The addition of low-cost supply will decrease or stop, avoiding the “death spiral” trap of falling prices coupled with a continuous increase in tokens supply. If new miners come in, the difficulty and the cost will rise again.

2.4.7- Benefit 7 The cost of minting and the level of difficulty are entirely dependent on market participation, with no centralized control, achieving a dynamic balance in a decentralized environment.

This mechanism effectively incentivizes early participants and is very friendly to community members who keep attention, while being unfriendly to speculators and those who cheat through technical tricks.

> We have coded **PoM** mining algorithm on the Ethereum testnet **sepolia**(**solidity**) and the **Solana**(**rust/anchor**) Devnet, and will provide front-end **Typescript** scripts for community testing, while also open-sourcing **python** language simulation code.

3. Calculations

3.1 - Formulas

3.1.1 - Difficulty Coefficient of Current Epoch

- d: Difficulty coefficient
- d': Difficulty coefficient of previous epoch
- δd: Change of difficulty coefficient
- N_e: Elapsed Blocks numbers Of passed Epoch
- N_t: Target Number Of Blocks Per Epoch

The change of difficulty coefficient is calculated based on the ratio of actual time to target time. We only consider the elapsed blocks are higher than tthe target number of blocks per epoch. The formula is as follows:

$$\delta d = \frac{1 - \frac{N_e}{N_t}}{100}, (N_e < N_t) \tag{1}$$

$$\delta d = 0, (N_e \geq N_t) \tag{2}$$

Note: In the above formular, 100 is a factor used to control the proportion of difficulty increase within a certain threshold range. Setting this value to 100 means that the maximum rate of difficulty increase is 1%. If this value is set to 50, then the maximum rate of difficulty increase is 2%.

After we get the change of difficulty coefficient, the difficulty coefficient of current epoch will be:

$$d = d' * (1 + \delta d) \tag{3}$$

For blockchains that can accurately obtain block timestamps, the above **number of blocks** can be replaced with **timestamp**.

Example:

In the example of 2.3.1, the target minting time of each **Epoch** is 600 seconds. On the **10th Epoch**, minting took 200 seconds, and the **difficulty-coefficient** of **9th Epoch** is **1.015086348**, so the new **difficulty-coefficient** for the **10th Epoch** will be adjusted to: **1.015086348 * ((1 - 200 / 600) / 100 + 1) = 1.02185359**.

And On the **11th Epoch**, minting took 1000 seconds which is longer than the target minting time of 600 seconds, then keep the same **difficulty-coefficient** of **1.02185359** as the **10th Epoch**.

3.1.2 - Base Mint size per Minting of the Current Era(Mb)

- M_b: Base mint size per minting of current Era
- M_0: Base mint size per minting of the Genesis Era
- f: Reduction factor
- e: Current era

$$M_b = M_0 * f^{e-1} \tag{4}$$

Reduction factor

- f=0.5 means a **50%** reduction (halving) each Era
- f=2/3 means a **33.33%** reduction each Era
- f=3/4 means a **25%** reduction each Era
- f=4/5 means a **20%** reduction each Era
- f=5/6 means a **1/6** reduction each Era. etc.

3.1.3 - Target Mint Size per Epoch of current Era

- T: Target mint size per Epoch of the current Era
- T_0: Target mint size per Epoch of the Genesis Era
- f: Reduction factor
- e: Current era

$$T = T_0 * f^{e-1} \tag{5}$$

3.1.4 - Mint Size per Minting of current Epoch

- M: Mint size per Minting of current Epoch
- M_b: Base mint size per minting of current era
- d: Difficulty coefficient

$$M = \frac{M_b}{d} \tag{6}$$

Example:

In the example of 2.3.1, the **base mint size per minting** of the current Era is **100 tokens**, and the **difficulty coefficient** of the **16th Epoch** is **1.028665947**, then the minting size will be: **100 / 1.028665947 = 97.213289 tokens**.

3.1.5 If the T is not an integer multiple of M, adjustments need to be made to the M, that is:

$$M_a = \frac{T}{\lfloor \frac{T}{M} \rfloor + 1}, (T \nmid M) \tag{7}$$

If the T is an integer multiple of the M, no adjustments are needed as described above.

$$M_a = M, (T \mid M) \tag{8}$$

3.1.6 - Token cost Although the cost per minting remains unchanged, as the difficulty increases, the number of Tokens obtained per minting will decrease, so the cost of the Tokens will increase.

Here is how to calculate the cost of token.

- P_0: Minting fee
- p: Token cost

$$p = \frac{P_0}{M_a} \tag{9}$$

If the **T** is not an integer multiple of **M**, price will be:

$$p = \frac{P_0 * (\lfloor \frac{T_0}{M_0} * d \rfloor + 1)}{T_0 * f^{e-1}}, (T \nmid M) \tag{10}$$

$$p = \frac{P_0}{M_0 * f^{e-1}} * d, (T \mid M) \tag{11}$$

As P_0, T_0, M_0, f and e are constant in an era, we know that: $p \propto d$.

3.1.7 T and M are decreasing exponentially with each **Era**, but the ratio between the two remains constant, regardless of the **Era**.

$$T = T_0 * f^{e-1} \tag{12}$$

$$M = \frac{M_b}{d} = \frac{M_0 * f^{e-1}}{d} \tag{13}$$

$$\frac{T}{M} = \frac{T_0}{M_0} * d \tag{14}$$

3.1.8 If the N_t is set to 10 minutes, then the theoretical target interval time for each minting is: 600 seconds / 33 = 18.18 seconds per instance.

If the interval time is longer, it means that completing all mints in an **Epoch** takes longer than planned (10 minutes), which implies fewer miners, and in this case, the difficulty decreases, and the reward per minting increases.

Conversely, if the interval time is shorter, it indicates that completing an **Epoch** of mining takes less time than planned (10 minutes), which implies more miners, and in this case, the difficulty increases, and the reward per minting decreases.

3.2- Key code for calculating mint size of epoch (rust)

```rust
pub fn get_mint_size(
  config_data: &TokenConfigData,
) -> Result<(u64, f64, u64)> {
  let delta_difficulty_coefficient = if config_data.mint_state_data.elapsed_seconds_epoch
    < config_data.target_seconds_per_epoch {
    (1.0 - config_data.mint_state_data.elapsed_seconds_epoch.safe_as_f64()? /
      config_data.target_seconds_per_epoch.safe_as_f64()?) / 100.0
  } else {
    0.0
  };
  let difficulty_coefficient = config_data.mint_state_data.difficulty_coefficient_epoch
    * (1.0 + delta_difficulty_coefficient);
  let base_mint_size = config_data.initial_mint_size.safe_as_f64()?
    * config_data.reduce_ratio.powf((config_data.mint_state_data.current_era - 1).safe_as_f64()?);
  let base_target_mint_size_per_epoch = config_data.initial_target_mint_size_per_epoch.safe_as_f64()?
    * config_data.reduce_ratio.powf((config_data.mint_state_data.current_era - 1).safe_as_f64()?);
  let mint_size =  base_mint_size / difficulty_coefficient;
  let target_mint_size_epoch = (base_target_mint_size_per_epoch / mint_size).trunc()
  * mint_size;
  Ok((mint_size.safe_as_u64()?, difficulty_coefficient, target_mint_size_epoch.safe_as_u64()?))
}
```

4. Deployment Parameter

4.1 Total Supply

Different with normal token launch schema, the **total supply** of **PoM** is calculated based on **Era**, **Epoch**, and the **Reduction factor**.

There are four parameters that determine the total supply:

- E: Total Eras
- C: Initial epoches per Era
- T_0: Initial target mint size per epoch
- f: Reduce factory by era, $f \in (0, 1)$

Calculation

$$TotalSupply = \sum_{i=1}^{E} (C \cdot T_0 \cdot f^{i-1}) = C \cdot T_0 \cdot \frac{1 - f^E}{1 - f} \tag{15}$$

Example:

E=15, C=10, T_0=100,000 tokens, f=0.75

The total supply is: 3,946,546.156 tokens

Click here to open Wolfram calculation, you can use **wolfram** to calculate the total supply easily.

4.1.1 - Max Total Supply As E approaches infinity, meaning that mining can continue indefinitely, **TotalSupply** will converge to a value, which is:

Calculation

$$lim_{Eß\infty}(\cdot C \cdot T_0 \cdot \frac{1 - f^E}{1 - f}) = C \cdot T_0 \cdot \frac{1 - f^\infty}{1 - f} = \frac{C \cdot T_0}{1 - f} \tag{16}$$

Example:

C=10, T_0=100,000 tokens, f=0.75

The total supply is: 4,000,000 tokens

4.2 Estimated Total Minting Time:

Note: The actual total minting time will differ from the estimated total minting time.

The following formula is for calculating the estimated total minting time.

- E: Eras
- C: Epoches per Era
- N_t: Target Number Of Blocks Per Epoch
- t: Seconds per block

Calculation

$$TotalEstimatedTime = E \cdot C \cdot N_t \cdot t \tag{17}$$

Example: E=15, C=10, N_t=50, t=12 seconds

The estimated total minting time: 15 * 10 * 50 * 12 = 90,000 seconds = 25 hours

4.3 Total Eras

Combining the two formulas above, we can calculate the value of E_r(Total Eras) when 80% of the total supply (r) of tokens has been minted.

$$C \cdot T_0 \cdot \frac{1 - f^{E_r}}{1 - f} = \frac{C \cdot T_0}{1 - f} * r \tag{18}$$

From this equation, we get:

$$E_r = \log_f(1 - r) \tag{19}$$

Example:

r=80%, f=0.75, then E_r=$\log_{0.75}(1 - 0.8) = \frac{\ln 0.2}{\ln 0.75} = 5.59$.

That means in the middle of the 6th Era, 80% of the total supply will be minted.

If $C = 10$, on the 56th epoch(5.59*10), 80% of the total supply will be minted.

4.4 Total Minting Fee

Each minting requires a fixed fee, however, due to the increase in difficulty, the minting times within the same epoch will increase, and the number of tokens obtained per minting will decrease, thus the total fee will increase accordingly.

> **Note:** These minting fees are added to Liquidity pool automatically.

- Fee: Total Fee
- P_0: Minting fee per minting
- d: Difficulty coefficient
- Q: Mint times in an epoch
- T_0: Target mint size per epoch of the Genesis Era
- M_0: Base mint size per minting of the Genesis Era
- C_e: Elapsed epoches, $C_e = E * C$

Mint times in an epoch:

$$Q = \lfloor \frac{T_0}{M_0} * d \rfloor + 1, (T_0 \nmid M_0) \tag{20}$$

$$Q = \frac{T_0}{M_0} * d, (T_0 \mid M_0) \tag{21}$$

For simplicity, let's assume $T_0 \mid M_0$, the total fee:

$$TotalFee = \sum_{i=0}^{C_e} (P_0 \cdot Q_i) = \sum_{i=0}^{C_e} (\frac{P_0 \cdot T_0}{M_0} * d_i) \tag{22}$$

As $d_i = d_{i-1} \cdot (1 + \delta d_i)$, $\delta d \in [0, 0.01]$ (see. 3.1.1), and $d_0 = 1$, the total fee range will be:

$$TotalFee \in [\frac{P_0 \cdot T_0}{M_0} \cdot \sum_{i=0}^{C_e} 1^i, \frac{P_0 \cdot T_0}{M_0} \cdot \sum_{i=0}^{C_e} 1.01^i] \tag{23}$$

Simplified:

$$TotalFee \in [\frac{P_0 \cdot T_0}{M_0} \cdot (C_e + 1), \frac{P_0 \cdot T_0}{M_0} \cdot 100 \cdot (1.01^{C_e+1} - 1)] \tag{24}$$

Example

$P_0 = 1$ USD, $T_0 = 9000$, $M_0 = 100$, $d = 1.5$, $C_e = 300$, Minimum total fee is \$27,090, and max is \$170,877.

This indicates that if minting is done quickly, the actual minting time in epoch (N_e) is less than the target time(N_t), it will lead to a continuous increase in difficulty and mint cost. Consequently, the total fees collected will be **6.3** times higher than if the difficulty remained constant, and the difference becomes more significant as the epoch number increases.

4.5 Use cases

4.5.1 If the target total supply is 21 million(around), there can be (but not limited to) the following parameter combinations:

C	T_0	M_0	f	N_t	t	Total Supply	Eras	Epoches	Days	Total Fee(min)	Total Fee(max)
600	9000	1000	0.75	2000	12	21.6 million	10.413	6248	1735.56	56,241	9.088e29
500	11000	1000	0.75	500	12	22 million	10.413	5206	361.57	57,277	3.49e25
2500	1000	100	0.75	1000	0.4	10 million	10.413	26032	120.5	260,320	3.15e115

Note:

- $Eras = \log_f(1 - 0.95)$, mint rate is 95%
- $Epoches = Eras * C$
- $days = Epoches * N_t * t/3600/24 = log_f(1 - 0.95) * C * N_t * t/86400$
- As the f, t are fixed, the total days is depent on C and N_t

4.5.2 How to calculate all parameters We will try to calculate all parameters according to the following conditions:

- Total Supply
- Target minting days
- Minimum total fee collected

The constants are:

- Total Supply: 10,000,000
- Total minting days: 180 days, 95% of the total supply will be minted
- Taget minting fee: 30,000 USD
- f = 0.75
- T_0 = 10,000
- M_0 = 1,000
- t=0.4 seconds(for Solana blockchain)

Calculation

1- $\because TotalSupply = C \cdot T_0/(1-f)$, so Initial epoches per era(C) will be:

$C = TotalSupply \cdot (1-f)/T_0$ = 10,000,000*(1-0.75)/10000=250

2- From the following formula, we can get $N_t = 14935$

$$C * N_t * t * \log_f(1-0.95) = 180days * 86400seconds/day \tag{25}$$

3- From the Following formula, we can get $C_e = 2603$

$$C_e = Eras * C = log_f(1-0.95) * C = 10.413 * 250 = 2603 \tag{26}$$

4- We already know: $T_0 = 10,000$, $C_e = 2603$, $M_0 = 1000$, the minimum total fee formula:

$$\frac{P_0 * T_0 * (C_e + 1)}{M_0} = P_0 * 10,000 * 2604/1000 = 300,000 \tag{27}$$

According the minimum total fee formula, we can get $P_0 = 11.52$ USD, which means the lowest price of each token is $P_0/M_0 = 11.52/1000 = 0.01152$ USD

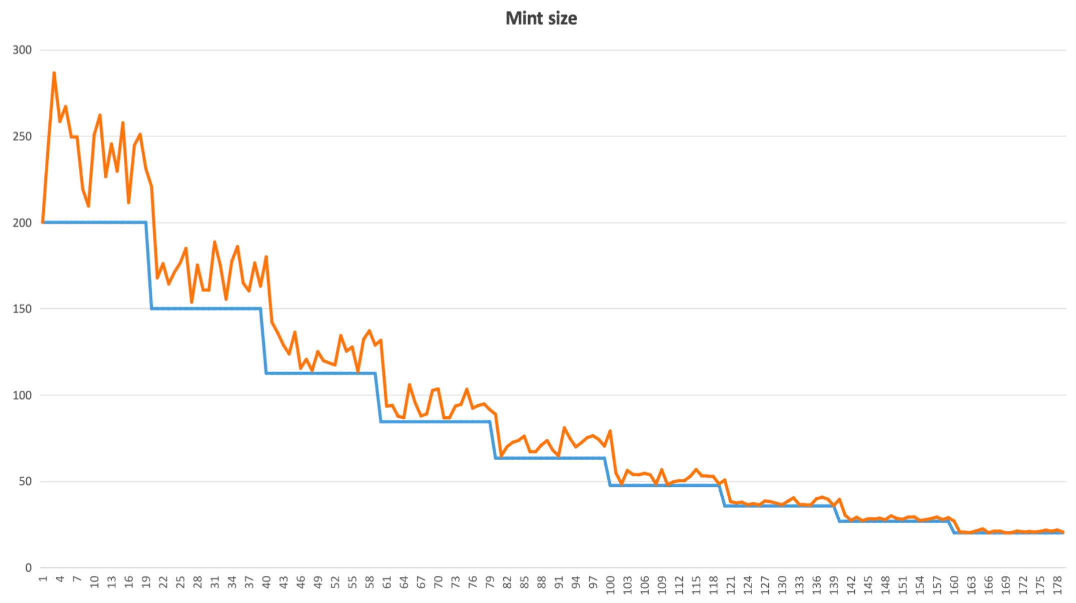
Click here to open online calculator

5. Testing and Evaluation

Below are the parameters for the simulation test:

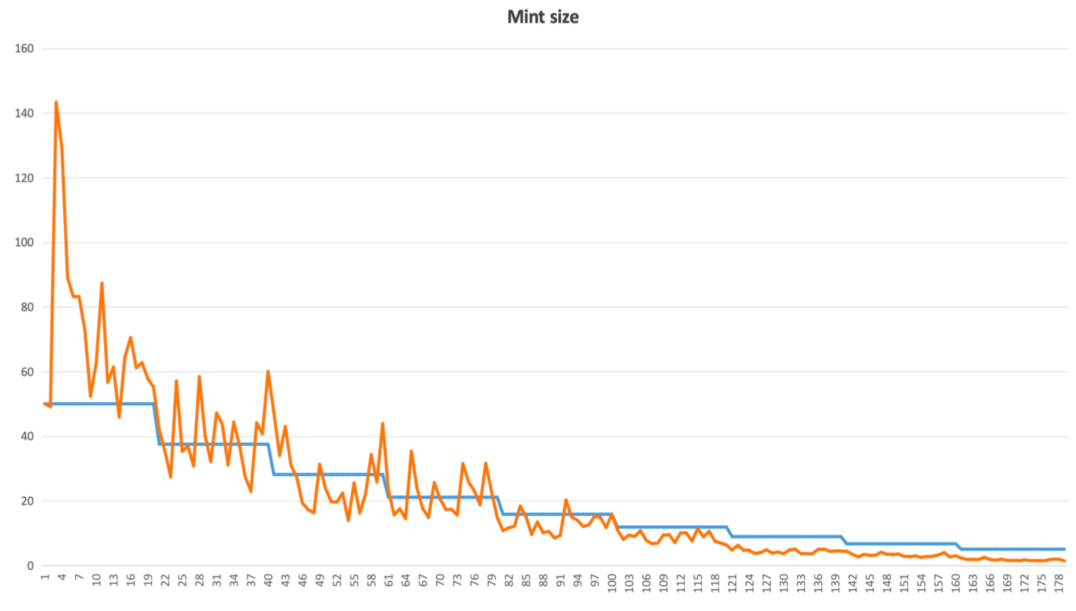
- Minting interval time range: Randomly between 0-30 seconds
- Total number of Eras: 10
- Number of Epochs per Era: 20
- Minimum difficulty coefficient: 0.2
- Reduction coefficient: 3/4
- Base mint size per minting in the Genesis Era: 50
- Target mint size per Epoch in the Genesis Era: 200

Minting Rewards



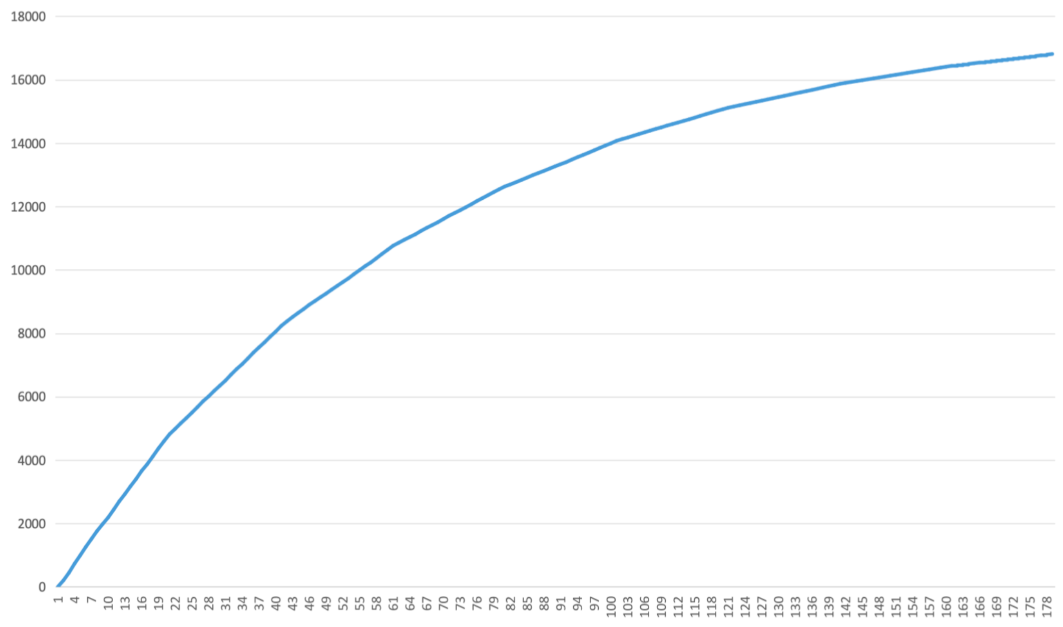
Epoch Actual Minting Yield vs. Target Minting Yield

The orange line is the **actual mint size of the current Epoch**, and the blue line represents the **target mint size per minting**, showing a trend of a 25% reduction per Era.

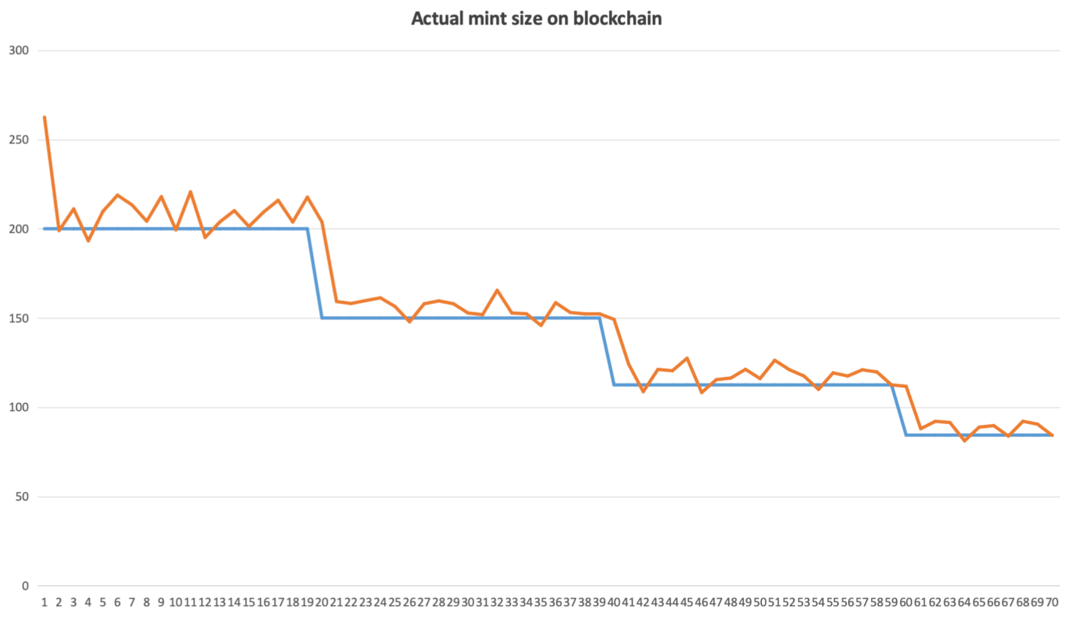


Actual Minting Reward vs. Target Minting Reward

The orange line is the **actual mint size**, and the blue line is the **target mint size**.



Total Minting Curve



Simulation Results on Ethereum Chain

The above are simulation results on the Ethereum chain.

6. Affiliate minting program

6.1 - Description

The **Affiliate Minting Program** (**AMP**) allows each user to generate an **Unique Referral Code** (**URC**) and share it with others. When others use this **URC** to mint, they can get a discount on the minting fees, and the referrer can get some rewards. **AMP** is designed to be decentralized and community-driven, incentive for building bettercommunity.

1. Decentralization and Community Driven
    - All minting must use an **URC**, that every minting is associated with a member of the community.
    - The progress and speed of minting are influenced by the community members in sharing **URC**, not by the core team or some whales.
    - Through **AMP**, the community can form a consensus more easily and attract more members to participate in the community.
2. Incentivizing Community
    - Dual incentives: Both the Code Sharers (referrer) and the users who uses the **URC** (minter) can benefit, and this dual incentive mechanism helps the growth and activity of the community.
3. Mint discount and Rewards for referr
    - The mint fee discount is linked to the token balance of the account providing the **URC**. The more referrer's balance, the more discount of minting, the less mint fee. That will encouraging participants to hold more tokens rather than selling them all.
    - **URC** sharers can get stable rewards, this rewards are automatically distributed to the referrer's account by the chain coins(ETH for Ethereum, or SOL for Solana) when the minting is happened.
4. Minting Fees and Difficulty Adjustment
    - Dynamic difficulty: The total cost and difficulty of minting will be dynamically adjusted based on the community; the more people mint, the faster the minting speed, the higher the total minting cost, and the higher the extra minting fee.
    - Part of the minting fees is redistributed as discounts to minters and as rewards to **URC** sharers.

$$ExtraMintFee = \frac{P_0 \cdot T_0}{M_0} \cdot (\sum_{i=0}^{C_e} d_i - C_e - 1) \tag{28}$$

The formula indicates that the higher d_i is(approximately above 1), the higher the extra minting fee.

Since the minting fee goes into the Liquidity Pool to support exchanging in the marketplace, therefore, **AMP** will have a positive impact on community development and token exchanging.

6.2 - Calculations

6.2.1 - Mint discount Discount is decided by the ratio of the balance of code sharers to the total supply of tokens.

- r: The ratio of the balance of code sharers to the **current** total supply of tokens.
- k: The discount rate.

r	k
$< 0.2\%$	0
0.2-0.4%	5%
0.4-0.6%	10%
0.6-0.8%	15%
0.8-1%	20%
$> 1\%$	25%

6.2.2 - Minting Fee after discount

- Fee: Minting fee after discount
- P_0: Original minting fee
- p_0: Price of minted token for the first Epoch
- p: Price of minted token before discount
- d: Difficulty coefficient
- k: The discount rate

$$\frac{Fee}{M_b} \cdot d = p_0 + (p - p_0) \cdot (1 - k) = p \cdot (1 - k) + p_0 \cdot k \tag{29}$$

$$p = \frac{P_0}{M_b} \cdot d, p_0 = \frac{P_0}{M_b} \tag{30}$$

From aboved equivalent formula, we can get the minting fee after discount:

$$Fee = P_0 \cdot (1 + \frac{k}{d} - k), (d \geq 1, k \leq 0.25) \tag{31}$$

The balance between Fee and original P_0 is:

$$P_0 - Fee = P_0 - P_0 \cdot (1 + \frac{k}{d} - k) = P_0 \cdot k \cdot (1 - \frac{1}{d}) \tag{32}$$

The discount rate is:

$$\frac{P_0 - Fee}{P_0} = k \cdot (1 - \frac{1}{d}) \tag{33}$$

Example:

P_0 = 8 USD, d = 12.3, $TokenBalance$=26,000, $TotalSupply$ = 5,000,000 USD

Token ratio to total supply(r) = 26,000 / 5,000,000 = 0.52%,

so the discount(k) is 10%.

The actural minting fee will be: $8 * (1 + 0.1/12.3 - 0.1) = 7.265$ USD

Comparing with the original minting fee, the discount is: $1 - 7.265/8 = 9.19\%$

6.2.3 - Unique Referral Code(URC) Unique Referral Code(URC) is a unique code that is generated by the sharer's account and timestamp.

6.2.4 - limitations of mint code

- The number of times that the code can be used is not unlimited, with a default of 50. That means after **50** mints by this code, the code will be invalid and need the sharer re-activate it.
- Code sharers can not re-activate the code at anytime, there's an interval between each activation. Default interval is **24 hours**.

6.2.5 - Benefits of code sharers The code sharer can got 20% of the balance fee the miner saved.

$$CodeSharerReward = 0.2 \cdot (P_0 - Fee) = 0.2 \cdot P_0 \cdot k \cdot (1 - \frac{1}{d}) \tag{34}$$

The higher the difficulty, the larger the k, the greater the benefits for the Code Sharer.

Example:

From the previous example, the reward for code sharer is:

$0.2 * 8 * 0.10 * (1 - 1/12.3) = 0.147$ USD

6.3 - Evaluation

Let's make some change on the formula of minting fee, and see how it affects fee.

$$\frac{MintFee}{P_0} = 1 + \frac{k}{d} - k, (d \geq 1, k \leq 0.25) \tag{35}$$

6.3.1 - Difficulty(d) Effects on Minting Fee As the formula of minting fee, the higher the difficulty is, the lower minting fee and the more discount.

6.3.2 - k Effects on Minting Fee As the formula of minting fee, the higher the k is, the lower minting fee and the more discount.

6.3.3 - Risk We have to consider one situation that **AMP** probably lead to self-minting(using self **URC** to mint), but we believe that: once a person has a certain number of Tokens, they will prefer to build community and share the Code to others.

Additionally, even if everyone use the maximum discount to mint(which is impossible), the minimum total minting fee would be as follows:

$$CodeSharerReward = 0.2 \cdot (P_0 - Fee) = 0.2 \cdot P_0 \cdot k \cdot (1 - \frac{1}{d}) \tag{36}$$

Because $max(k) = 25\%$, when $d = \infty$, Code Sharer receives 5% of P_0.

So, the minimum total minting fee is 95% of the plan. Considering the community activity that **AMP** may bring, and the increase of difficulty will bump the minting fee, this reduction is worthwhile.

6.4 - Initialization

6.4.1 - System Referrer Why need for a system/default referrer?

All minting requires **URC**, if someone can not obtain an **URC** from community members, he/she can use the default **URC** provided by the system.

When using the default **URC**, there is no discount (cause the default referrer's account balance is 0).

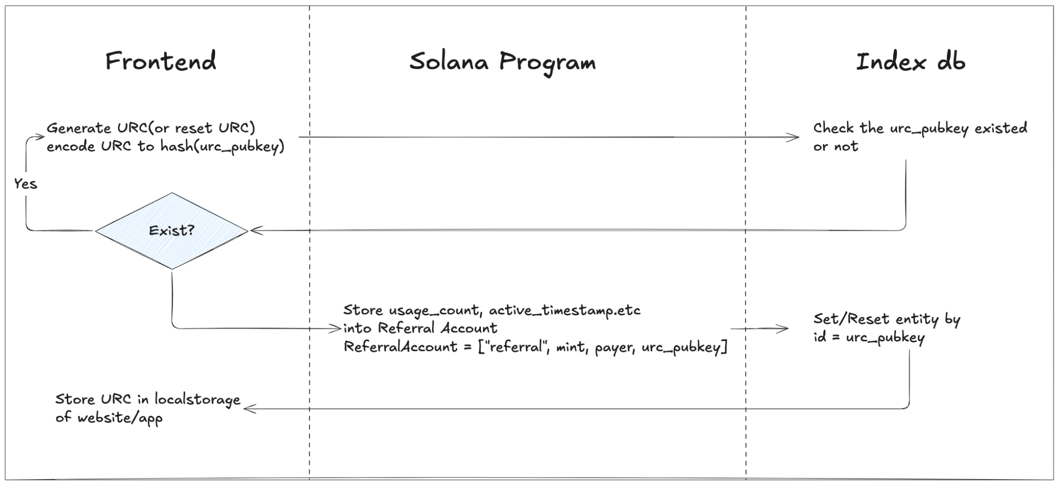
6.5 - Program Implementation

```rust
// Calculate the fee value and the referrer reward
pub fn get_fee_value(fee_rate: u64, difficulty_coefficient: f64, referrer_ata_balance:
  u64, total_supply: f64) -> (f64, f64) {
  let balance_ratio = referrer_ata_balance as f64 / total_supply;
  let discount_rate = if balance_ratio < 0.002 {0.0}
  else if balance_ratio < 0.004 {0.05}
  else if balance_ratio < 0.006 {0.1}
  else if balance_ratio < 0.008 {0.15}
  else if balance_ratio < 0.01 {0.2}
  else {0.25};
  let fee = fee_rate as f64 * (1.0 + discount_rate / difficulty_coefficient -
    discount_rate);
  let code_sharer_reward = 0.2 * fee_rate as f64 * discount_rate * (1.0 - 1.0 /
    difficulty_coefficient);
  (fee as f64, code_sharer_reward)
}
```

6.6 - The URC generation and verification workflow

To Avoid the events Bot to monitor the generation and updating of URC code for front running, only the **URC_Pubkey** is exchanged between frontend and blockchain.

Here is the workflow of URC generation and verification on Solana Blockchain.


Frontend
Solana Program
Index db
Generate URC(or reset URC)
encode URC to hash(urc_pubkey)
Check the urc_pubkey existed
or not
Yes
Exist?
Store usage_count, active_timestamp.etc
into Referral Account
ReferralAccount = ["referral", mint, payer, urc_pubkey]
Set/Reset entity by
id = urc_pubkey
Store URC in localstorage
of website/app

7 - Liquidity

The minting fee will ultimately be injected into the liquidity pool of the Decentralized Exchange, where transaction fees can be earned.

7.1 - Tokens for the Liquidity Pool

A portion of the total Token supply will be allocated to the liquidity pool as SOL/Token pair. This allocation is distributed into a dedicated liquidity account during minting. Once certain conditions are met(Ex. Era#1 is done), these Tokens, along with transaction fees(SOL), are added into the liquidity pool automatically.

- M_a: The number of Tokens minted per instance (see 3.1.4, 3.1.4)
- r_l: The proportion of the initial liquidity pool relative to the total issuance, where $r_l < 1$
- L: The number of Tokens entering the liquidity-specific account per minting event

$$L = \frac{M_a \cdot r_l}{1 - r_l} \tag{37}$$

Cause the total supply of tokens:

$$TotalSupply = \sum_{i=1}^{E}(C \cdot T_0 \cdot \frac{1 - f^E}{1 - f}) = C \cdot T_0 \cdot \frac{1 - f^E}{1 - f} \tag{38}$$

The tokens for initializing Liquidity pool:

$$InitLiquidity = TotalSupply * \frac{r_l}{1 - r_l} = C \cdot T_0 \cdot r_l \cdot \frac{1 - f^E}{(1 - f) \cdot (1 - r_l)} \tag{39}$$

7.2 - Minting Fees

The minting fee is described in section 6.2.2. The distribution of the minting fee is as follows:

- URC supplier : 0-5%
- Protocal fee: 5%
- Liquidity Pool : 90-95%

7.3 - Estimated Price at Liquidity Pool Initialization

According to the **AMM** of Decentralized Exchanger, the token price at the time of initializing the liquidity pool is:

$$Price = \frac{0.90 \cdot TotalFee}{InitLiquidity} \tag{40}$$

As the total mint fee is a range:

$$TotalFee \in [\frac{P_0 \cdot T_0}{M_0} \cdot (C_e + 1), \frac{P_0 \cdot T_0}{M_0} \cdot 100 \cdot (1.01^{C_e+1} - 1)] \tag{41}$$

So, the lowest price when initializing the Liquidity Pool will be:

$$P_{low} = \frac{P_0 \cdot (C_e + 1)(1 - r_l)(1 - f)}{M_0 \cdot C \cdot r_l \cdot (1 - f^E)} * 0.90 \tag{42}$$

And the highest price will be:

$$P_{high} = \frac{100 \cdot P_0 \cdot (1.01^{C_e+1} - 1)(1 - r_l)(1 - f)}{M_0 \cdot C \cdot r_l \cdot (1 - f^E)} * 0.90 = \frac{100 \cdot (1.01^{C_e+1} - 1)}{C_e + 1} \cdot P_{low} \tag{43}$$

In the aboved formula, $C_e = E \cdot C$ (C is Epoches per Era, E is Eras)

8 Refund

Proof of Mint (PoM) is an new token launch model that dynamically adjusts minting size based on time. Its key logic is as follows:

- **Dynamic Cost Adjustment**:
  - When the actual minting time is **shorter than the target minting time**, the mint size decreases, and the token cost increases.
  - When the actual minting time is **equal to or longer than the target minting time**, the minting quantity and token cost remain unchanged.
- **Incentive Mechanism**:
  - The mechanism incentivizes early participants through cost increases, driving minting activity.
  - However, it may also lead to excessively high costs for later participants, affecting fairness.

8.1 Introduction and Design of the Refund Mechanism

To address the above issues, PoM introduces **Refund** as an auxiliary constraint to ensure fairness and protect participant. Its key points are as follows:

8.1.1 Target Era Lock: During the Target Era, all raised minting fees are locked in a special Vault, and participants can initiate a Refund at any time.

8.1.2 Token Quantity Verification: When refunding, the system verifies whether the total amount of tokens in the user's wallet equals the quantity at the time of minting.

If the user has transferred or traded part of the tokens, the Refund will fail unless the corresponding amount of tokens is replenished in the wallet.

8.1.3 Fee Deduction Rules: When refunding, some coins (e.g., ETH/SOL) will be deducted as refunding fee to prevent abuse.

If a URC was used during minting and a discount was obtained, the rewards already paid to the URC Provider will be deducted during the Refund.

8.1.4 Advantages and Effects of Refunding

- **Fairness Guarantee**:
  - Through refunding, later participants do not need to bear excessively high minting costs, ensuring fair participation.
  - The dynamic adjustment of minting fees and the refunding work together to avoid cost surges caused by the "hot minting"
- **Anti-Sybil Attack**:
  - Sybil attackers are discouraged from early intervention due to the risk of later participants initiating Refunds.
  - This mechanism effectively reduces the probability of malicious behavior through economic incentives and constraints.

- **Community Simulation Verification**:
  - Simulation tests conducted within the community show that Refunding significantly improves the fairness of the minting process and participant satisfaction.
  - The most direct result is that Sybil attackers reduce their malicious activities due to Refund risks, further optimizing ecosystem health.

8.2 Refund is not always available

Please note that the refunding is only available during the Target Era. After the Target Era, the minting fees will be used to initialize the liquidity pool, and the refunding function will be disabled.

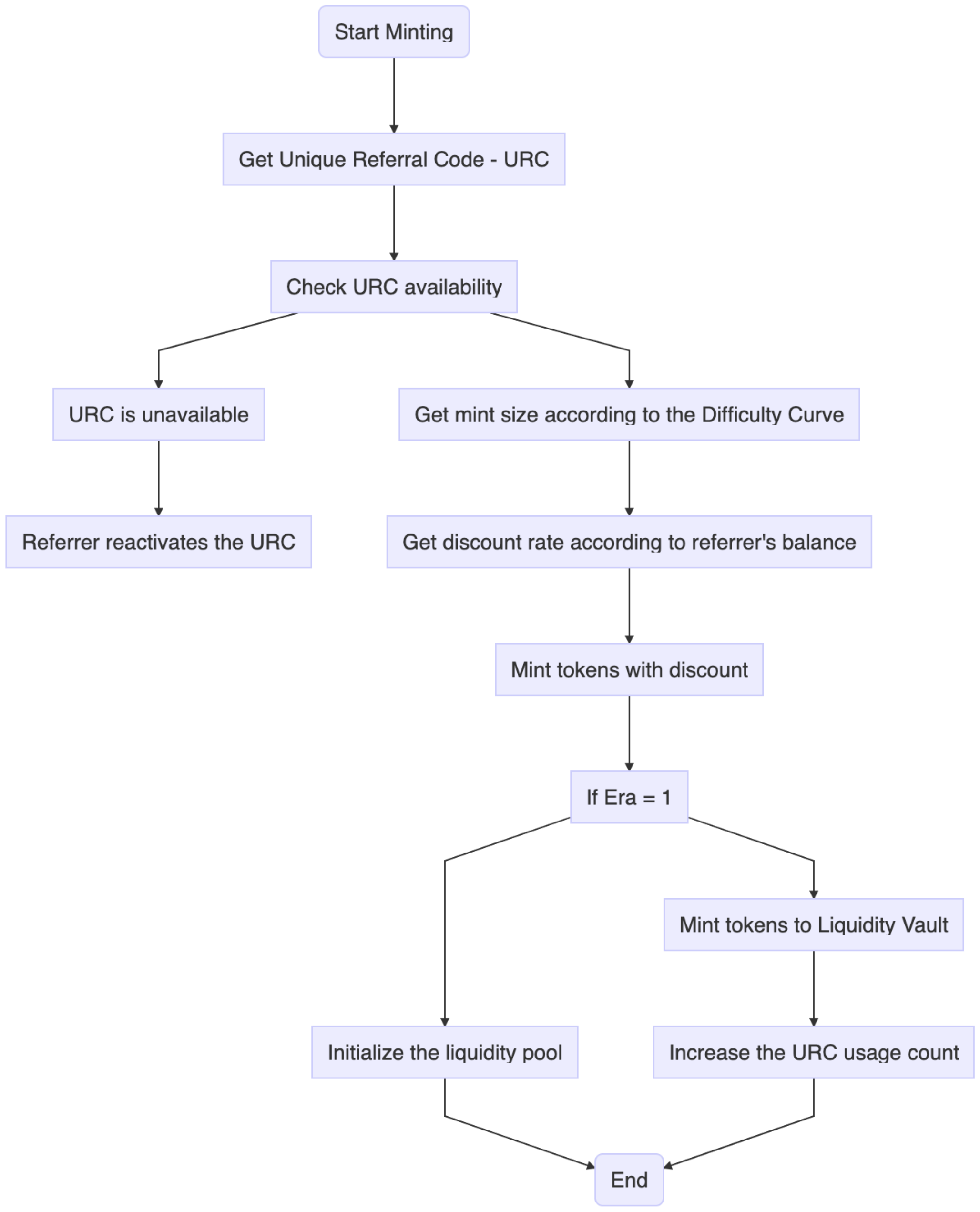
9 - Complete Case Study

The following is a comprehensive case study demonstrating the deployment of the Proof of Mint(PoM) mechanism on **Solana** blockchain

9.1 - Parameters

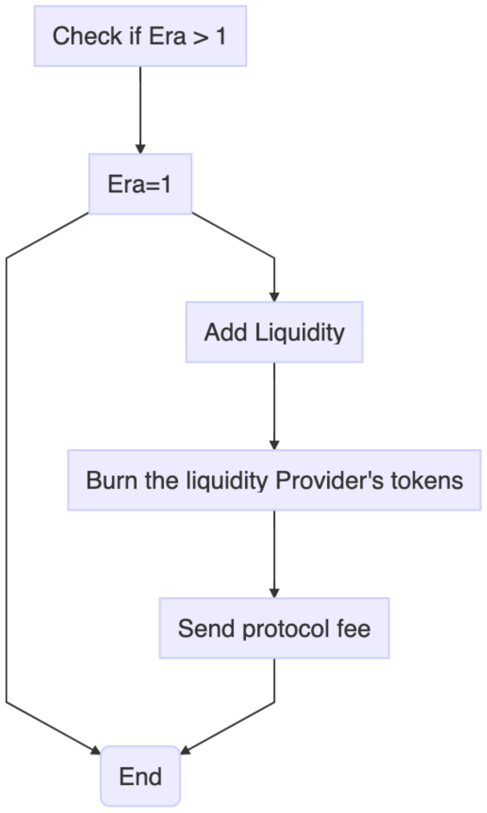
- Total supply: 1,000,000,000 tokens
- Target mint size per minting for 1st Era(M_0): 10,000 tokens
- Target mint size per epoch for 1st Era(T_0): 1,000,000 tokens
- Minimum minting instances per Epoch: 100
- Target Era(E): 1, after the first Era is completed, holders can transfer tokens and the liquidity pool is initialized.
- Epoches per ear(C): 250
- Target minting days: 30 days
- Reduction factor(f): 0.75
- Tokens percentage for Liquidity(r_l): 10%
- Fee per minting(P_0): 2 USD per minting (0.0002USD/token)
- Target minting time per Epoch: 173 minutes (around 3 hours)
- How to handle of LP tokens generated when initializing the liquidity pool: **All destroyed**
- Upon reaching Target Era#1:
  - Total Supply: 250,000,000 tokens (25% of max supply)
  - Total number of Epochs: 250
  - Number of minting: >= 25,000
  - Total minting fee: 50,200 USD to 223,050 USD
  - Price at the time of initializing the liquidity pool: 0.001807 USD to 0.008030 USD

9.2 - Mint workflow(Technically)


Start Minting
Get Unique Referral Code - URC
Check URC availability
URC is unavailable
Get mint size according to the Difficulty Curve
Referrer reactivates the URC
Get discount rate according to referrer's balance
Mint tokens with discount
If Era = 1
Mint tokens to Liquidity Vault
Initialize the liquidity pool
Increase the URC usage count
End

9.3 - Initialize the liquidity pool workflow (Technically)

Anyone can initialize the liquidity, the only condition is Era > 1.


Check if Era > 1
Era=1
Add Liquidity
Burn the liquidity Provider's tokens
Send protocol fee
End