

The Maha Protocol – ARTH Whitepaper

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Steven Enamakel

enamakel@mahadao.com

This whitepaper is meant to be treated as a draft and further revisions will be made to this document.

Abstract

In this paper we describe ARTH coin. A decentralized algorithmic cryptocurrency that aims to maintain its purchasing power over time, irrespective of which direction the market moves.

A brief about Inflation and Stablecoins

A tiny peek into the history of our civilization lays bare a simple fact – centralization has been an inevitable side effect of progress. While centralization has its merits, it has always, in one form or the other, come with one integral requirement – Trust. In whoever or whatever is at the center. A lack of trust in such centralized authorities gave rise to the concept of Decentralization.

The Loss of Purchasing Power

While there have been efforts to decentralize several aspects of our world, nothing has been as important as the Decentralizing of Money. For much of human history gold was the de-facto global reserve currency and the underlying asset that backed all paper money. The 1971 US government under President Richard Nixon “unpegged” the US Dollar from Gold effectively bringing the Gold Standard to an end. Various political and economic events before and after that historic decision made the US Dollar the new global reserve currency whilst being backed by nothing but trust.

The Federal Reserve, freed from the constraints of backing their “papers” with gold, has been on a printing spree since then under various banners. However, it is a recorded fact that most fiat currencies including the dollar have lost anywhere between 50-100% of their value over the last few decades making inflation and the loss of “purchasing power” a harsh reality of the modern economic system.



(Reduction of the purchasing power of the Dollar. [Know More](#))

Decentralizing Money and Beyond

Amongst the many efforts to decentralize money, nothing has been as successful as Bitcoin which made it possible to transfer value without a centralized authority through an intricately designed infrastructure. Ethereum, through its programmable and smart contract based blockchain set in motion an unprecedented movement that opened up doors to the decentralization of various things such as apps, platforms, and finally entire organizations.

It is this element of decentralization of organizations that Maker DAO picked up on. Maker DAO implemented this concept through a two-token infrastructure namely the Maker Token and Dai, and showed that it was possible to create decentralized stablecoins that are algorithmic and backed by crypto collaterals.

The Solution

With the reality of decrease in purchasing power and the need for decentralizing money as the backdrop, ARTH was built on top MakerDAO's concept of DAI to add in features that makes the coin not only value-sable but also as a raw measure of buying power of an asset.

We hereby introduce ARTH - A decentralized algorithmic value-stable coin that aims to maintain (and in some cases even appreciate) the buying power or value of the coin irrespective of which direction the market moves.

ARTH is able to do this by being backed by stable collaterals that are complete hedges of each other, so that if one asset depreciates in buying power, the other asset appreciates keeping the net buying power of the coin stable.

ARTH also uses a special method of measuring the buying power of an asset that is not tied to any of the fiat currencies which makes ARTH, inflation-proof as well.

Calculating the buying power of an asset

Most assets in the cryptocurrency space are denominated in US Dollars. However, as shown in the previous sections, the USD itself has lost most of its purchasing power over the past few decades which causes issues for anybody who holds USD or has assets that are backed by USD as they will also have to account for inflation.

To create an asset that is designed to protect the buying power of its holder, we need to come up with an absolute unit of measure to understand the buying power of an asset (which is not measured in US dollars). A possible suggestion could be to calculate buying power in terms of how many units of gold an asset can be traded for as gold was once the standard measure of wealth.

Understanding how to measure the buying power of an asset is important to make accurate decisions based on whether or not an asset has appreciated or depreciated in buying power.

The ARTH Vault

The vault was a concept first introduced in MakerDAO as a way of managing the underlying collaterals that have been locked to generate a token.

The ARTH Vault builds further on this, borrowing concepts like the DSR (Dai Savings Rate), Emergency Shutdown, Stability fees etc to create a system that behaves similar to what would be the equivalent of a decentralized reserve bank.

The ARTH vault creates ARTH tokens by locking in collaterals and minting new ARTH tokens against it in the form of debt; and releases collaterals when this debt is paid back and the ARTH tokens are burnt.

The vault also facilitates buying and selling of the underlying collaterals in various market scenarios to maintain the net buying power of the ARTH coin.

Essentially the main purpose of the ARTH vault is two-fold:

1. Ensure that the buying power of the ARTH tokens that are minted should never go below a certain point.
2. Employ strategies that help the vault increase the net buying power by locking in more and more collateral as the market fluctuates.

Creating ARTH tokens using the ARTH Vault

To create ARTH, a vault needs to be created and collateral needs to be deposited and locked inside of it. Against that value of the locked collaterals, ARTH tokens are minted and given to the vault owner as debt.

To release the collaterals locked in the vault, the vault owner pays back his debt along with a stability fee (which can be paid in ARTH or in MAHA tokens). When the debt is paid off, the ARTH tokens are burnt from the supply.

Debt-to-Collateral ratio

The Debt-to-collateral ratio will ensure that ARTH tokens will always be issued at a value lesser than the net value of the vault. This gives some room for price volatility for any of the collaterals before a vault stands a chance of being liquidated.

For example a collateral with a 150% debt-to-collateralization ratio will allow for 50% of the collateral's value to be issued in the form of ARTH tokens.

Vault Liquidation & Liquidation Ratio

A vault risks liquidation when the collaterals that have been locked in depreciate in value and the position held by the vault nears the liquidation ratio.

When a vault is marked as to be liquidated, the ARTH minting stops and the locked collaterals are sold to anyone who is willing to pay back the debt in ARTH tokens at a discount to the vault owner.

These liquidations will ensure that in periods of huge price swings, the ARTH market itself as a whole is never undercollateralized. This also ensures value stability for the ARTH coin.

Collateral Buying Power Ratio

The buying power ratio of each of the collaterals deposited in the vault is a predefined value that is used to define how much of each collateral should be in the vault.

For example, a vault designed with two assets A and B, and with a collateral buying power ratio of 1:1, should ensure that at all times the buying power of both assets is the same.

Any deviation from this ratio will force the vault to perform a rebalancing where it will sell one collateral for the other, bringing the balance back to the ratio.

Rebalancing the underlying collaterals

Since the ARTH vault is backed by collaterals, it will eventually be subject to market fluctuations. Hence the net buying power of the vault can either appreciate or depreciate because of the market effect from the underlying collaterals.

In cases where the net buying power of the vault depreciates, the vault does not do any rebalancing to counter this depreciation. The depreciation of the vault is a weighted average of the depreciation across all the collaterals.

In cases where the net buying power appreciates, the vault will perform a rebalance to try and maintain the buying power ratios.

Which means just like a reserve bank, the ARTH vault will systematically buy/sell the underlying collaterals for another collateral so that all of the collateral's buying power ratios are met.

Rules for Rebalancing

The strategy employed for rebalancing by the vault will follow the following rules.

1. Ensure that the buying power of all collaterals maintain the ratio defined at all times.
2. The collateral being sold is the asset which has appreciated in buying power and the amount to be sold is calculated based on the increase in buying power.
3. The collateral being bought is the asset which has depreciated in buying power and the amount to be bought is calculated based on the amount of other collaterals we can sell.
4. The collaterals are sold in such a way that we are not left with less than 50% of the quantity we started off with. This is called a stop-sell.

Understanding the Stop-sell

Because we are selling the appreciating asset for a depreciating one, we end up in a scenario where if one side continues to appreciate, the vault strategy will continue selling off the appreciating collateral to maintain the buying power ratio.

This causes a situation where the vault will end up having sold one side of the collateral fully and end up having a full exposure to the other collateral.

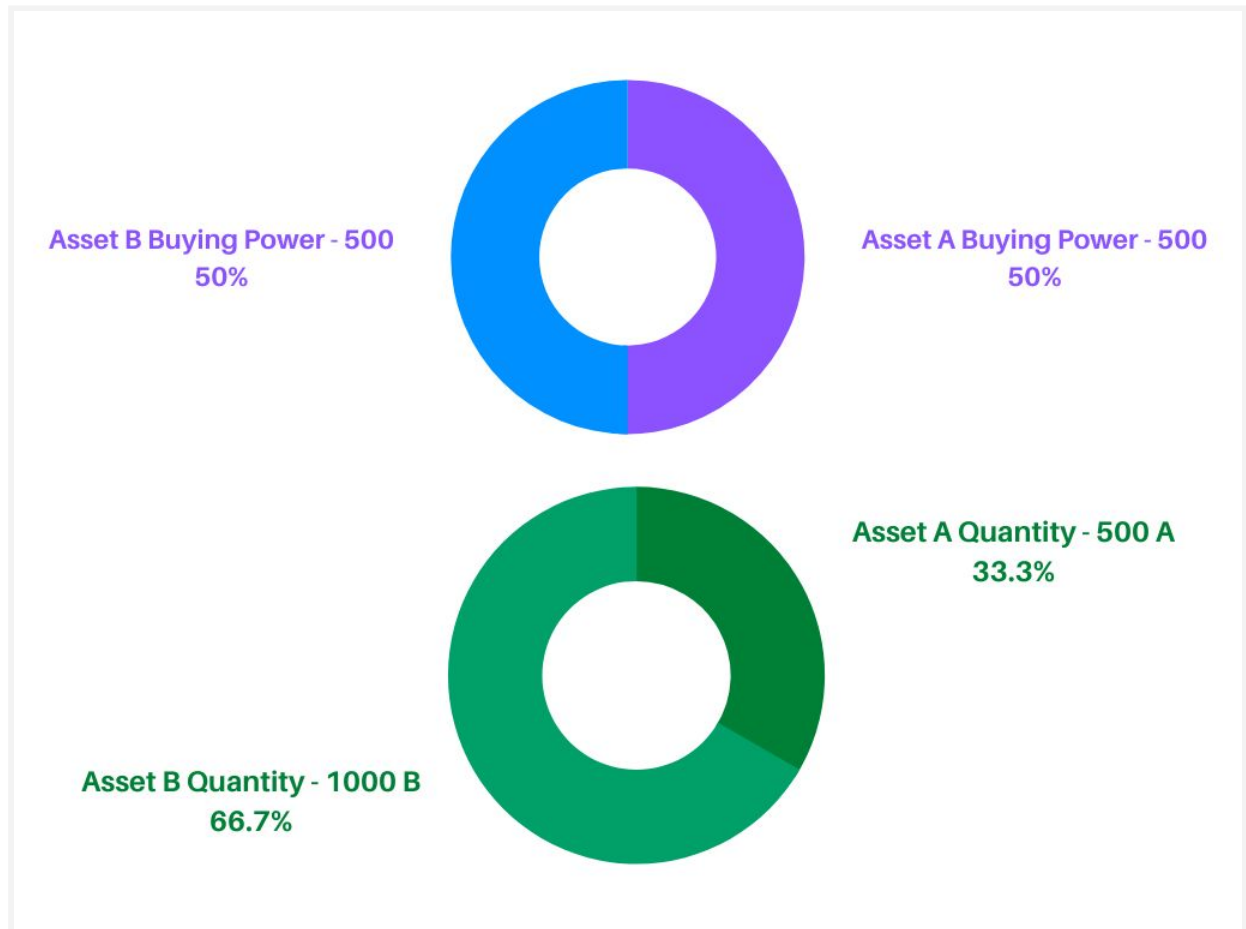
The stop-sell ensures that the vault will never sell collateral more than a percentage of what it had initially started with.

For example; If the vault had a stop sell of 10% and one of the collaterals, say, asset A appreciates by 50%. Then this will trigger the vault to trigger a rebalance and make a trade

selling 16% of asset A. But since selling 16% is more than our stop sell of 10%, this trade does not execute.

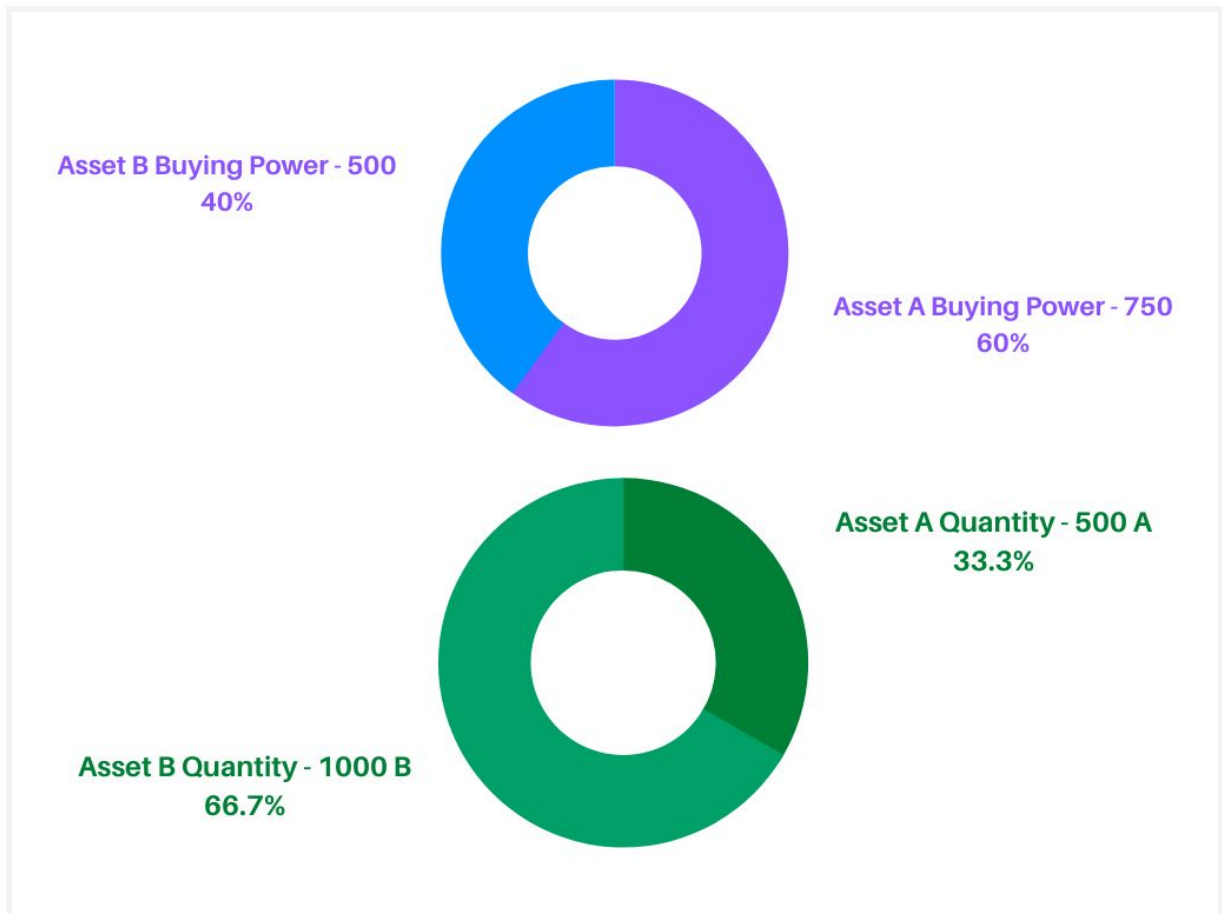
Rebalancing Strategy Example

To elaborate how the rebalancing strategy works in a scenario where one asset appreciates, we have the following visualisation where we have two assets A and B and a vault which maintains a 50-50 ratio with respect to the buying power of each asset. The diagram shows how the vault will behave in this scenario.



A vault with two assets holding a 50-50 ratio between them in buying power. Asset A is worth 1 unit of buying power and Asset B is worth 0.5 units of buying power. Creating a vault with a net buying power of 1000 units.

Now assuming that the buying power for Asset A appreciates by 50% and that for Asset B stays the same, we end up with the following composition in our vault.



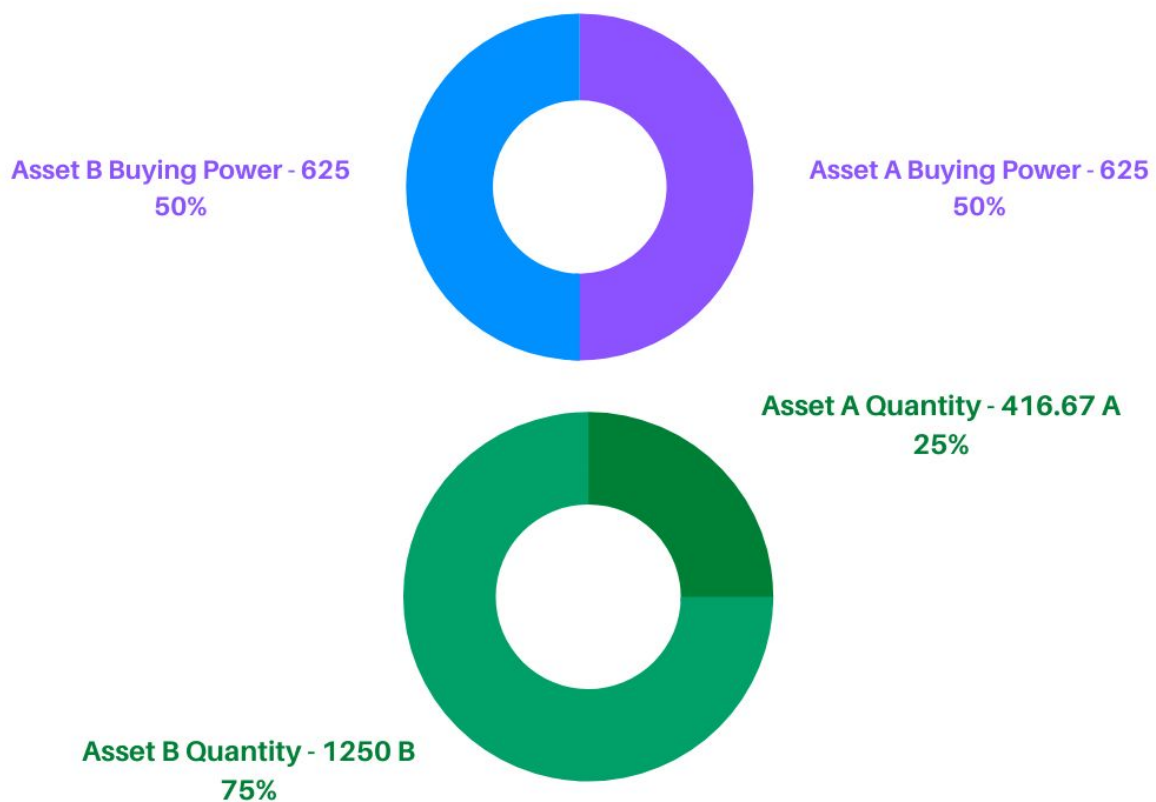
Status of the vault when asset A appreciates by 50%. Net buying power of the vault is 1250 units

When asset A appreciates by 50% in buying power, the quantities held by the vault of both assets remain the same however the net buying power of the vault has now become 1250 units which is an increase of over 25%.

When this happens, the vault triggers a rebalance selling the excess appreciated amount of asset A for asset B. Since asset A appreciated by 250 buying power units (500 - 750), the vault decides to sell off half of that (125 buying power units of A) for asset B; to come back to the 50-50 buying power ratio.

Which means a trade is published *selling 125 buying-power units of A for 125 buying-power units of B*.

After taking into account the price of A and B, we come up with the final trade which is *selling X units of A for Y units of B*.



The vault after it has rebalanced and sold asset A for asset B

After the rebalance the vault is back to a 50-50 ratio in buying power, but the quantities of both A and B have changed.

Moreover if asset A keeps on further appreciating, then the vault will continue to sell more of asset A to buy more of asset B; but the vault will stop selling asset A if it has already sold more than 50% of what it had initially started off with.

This is done to avoid selling off too much of asset A and to also allow the vault owner to realise the continuous upside of having an appreciating asset.

All parameters for the strategy can be changed upon vote by the governance token holders.

Holding auctions to buy/sell the underlying collateral

When the vault decides to buy/sell locked collaterals, it'll automatically open a trade/swap placing the collateral to be sold on one side and requesting the collateral to be bought on the other side.

The rate for which the collaterals are sold are determined by two variables.

- 1) A price feed (which is given by price oracles)
- 2) A market maker discount.

The market maker discount is a discount that is applied to the price of the trade to make the trade more attractive to market makers who'll fulfill the order to realise a profit through arbitrage in other markets.

Since the amount being sold is from the profits of vault, the vault can risk giving away a discount as the net buying power change still remains positive.

Initially a market maker discount can be set to promote more engagements with market makers.

The auction parameters are community governed and can be changed upon vote by MAHA token holders.

Choosing the right kind of collaterals for ARTH

An ARTH vault's value is derived from the value of the underlying assets inside of it. Which is why it is crucial to choose the right kind collaterals and their ratios when deciding the value of ARTH.

The ARTH vaults are designed to appreciate in value when one of the underlying assets appreciates in value and contributes to the net vault's value as a whole. In certain scenarios when all of the collaterals locked inside the ARTH vault depreciate, the ARTH vault would depreciate as well.

This makes it important to choose collaterals that are perfect hedges of each other to come up with a strategy that appreciates the value of ARTH irrespective of the direction of the market.

Therefore when choosing a collateral, the following points need to be considered:

- **High Market Capitalization:** Collaterals with large enough market capitalization should be preferred over smaller ones. Small market cap collaterals would not only limit the amount of value that can be captured by the vault, but would also be more prone to manipulation.

Choosing high market cap assets will ensure steady price-movements and avoid vaults getting liquidated during major price swings.

- **Uncorrelated to other assets/Negative Beta:** Ideally collaterals should be chosen such that they have a negative beta with other collaterals, i.e. they are perfect hedges of each other. Such that when one collateral goes down, the other collateral should go up and keep the value stable. Fiat collaterals are often heavily correlated with the US dollar. Crypto collaterals are often heavily correlated with Bitcoin. The collateral ratios decide how much of each collateral is stored within the vault and can

be governed by MAHA token holders. This will allow MAHA token holders to easily introduce or phase out collaterals as and when needed.

For example, A vault with three different collaterals with a buying power ratio of 1:1:1, will try to maintain a reserve with equal buying power for each collateral as per the strategy mentioned above.

In cases where one of the underlying collaterals becomes unstable or is deemed as “high” risk, it can slowly and gradually be removed from the ARTH vault by reducing its buying power ratio to 0. This can be a community governed decision made by MAHA coin token holders.

Simulating across various market scenarios

We use the following parameters:

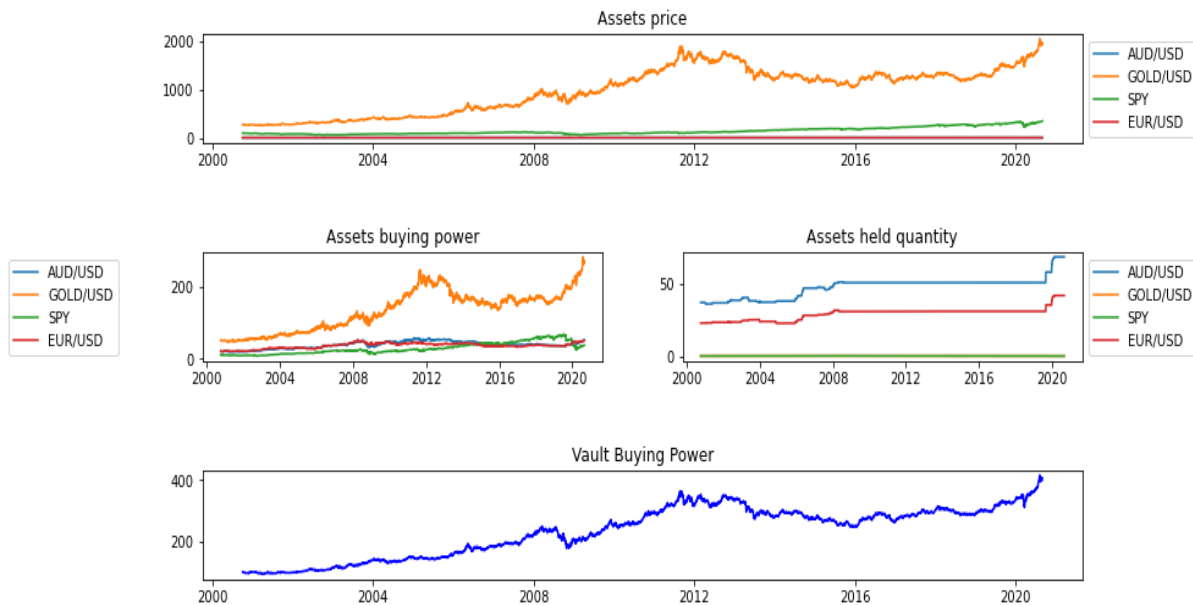
1. Stop sell of 30%
2. Stop loss of 30%
3. 5% slippage for every rebalance
4. Rebalance to happen once every 7 days
5. 50% of the appreciated value from the appreciating asset, is sold off during every rebalance
6. Starting with a buying power of 100 (so that it is easy to measure % increase)

Using a basket of Forex, Gold and US Equities

Here we try with data from 1990-2020 and keep 50% of the vault’s buying power in GOLD and the remaining in Australian Dollar, Euro and SPY500 ETF. AUS and EUR will represent the fiat markets and SPY500 ETF will represent the stock market. Since usually gold is often used as a hedge against the stock & forex markets, we keep a 50% ratio in gold.

Buying power for this simulation is calculated in USD. Assets chosen are distributed with the following ratios:

1. Australian Dollar (20% starting buying power)
2. Gold (50% starting buying power)
3. S&P 500 ETF (10% starting buying power)
4. Euro (20% starting buying power)



At the end of the simulation, the vault has rebalanced itself around 90 times over the course of 20 years and has appreciated itself by over 309%. (Full analysis and code can be found [here](#))

Using a basket of Stablecoins, Gold and Cryptocurrencies

The purpose of this simulation is to understand how ARTH would perform if in a real world scenario if it had launched around the year 2019. Here we choose a basket of stablecoins, gold and cryptocurrencies keeping stablecoins on one side of the hedge and fiat currencies on the other side.

Buying power for this simulation is calculated in USD. Assets chosen are distributed with the following ratios:

1. WBTC (20% starting buying power)
2. Gold (10% starting buying power)
3. ETH (20% starting buying power)
4. Euro (50% starting buying power)



At the end of the simulation, the vault has rebalanced itself around 6 times over the course of 1 year and has appreciated itself by over 80%. (Full analysis and code can be found [here](#))

How to calculate the price of one ARTH token

While we talk about ARTH in terms of it's buying power, to the end user, ARTH will most likely be represented in their native fiat currency (like USD, RNB, EUR etc..).

The value of ARTH in a particular currency can simply be thought of as the net value of all the underlying collaterals backing 1 ARTH token denominated in that currency.

This would mean that if we were to calculate the USD value of one ARTH token, then it'd look something like the following. (note that BTCUSD price at the time of writing is 10,500\$)

(assuming two collaterals used: ie BTC and USD)

$$\text{BTC}^{\text{value}} = (\text{supply of locked BTC}) * (\text{BTC/USD price} \sim 10,500\$)$$

$$\text{USD}^{\text{value}} = (\text{supply of locked USD}) * (\text{USD/USD price} \sim 1\$)$$

$$\text{ARTH}^{\text{circulation}} = \text{total circulation of ARTH}$$

$$\text{ARTH}^{\text{USD}} = (\text{BTC}^{\text{value}} + \text{USD}^{\text{value}}) / (\text{ARTH}^{\text{circulation}})$$

But this does not account for slippage or the various transaction fees that a user will have to account for when moving collaterals back and forth the various side-chains for example.

Moreover not every ARTH token is directly redeemable for the proportion of the underlying collateral. The collaterals are only redeemable in two scenarios, either when the vault is nearing its liquidation point or when the owner of the vault decides to sell the ARTH tokens and release the collaterals.

For example; if every vault is created with a minimum of 100 ARTH tokens, it'll be impossible to redeem 1 ARTH token for its underlying value. A minimum of 99 ARTH tokens would be needed to liquidate the vault and redeem it's collaterals.

Finally, this equation also does not account for any overcollateralization because of the 50% stop-sell which we have defined in the vault's strategy.

Taking all of the above into consideration, we introduce three new variables to come to the true market rate of an ARTH Token :-

1. Slippage
2. Overcollateralization
3. Fees

Any deviation from this market rate can easily be corrected by arbitrageurs and market makers.

$$\text{ARTH}^{\text{True USD value}} = \text{ARTH}^{\text{USD}} * \text{Slippage} - \text{Fees} + \text{OverCollateralization}$$

As we can see it's not very straightforward to calculate the value of one ARTH coin when you compare it with a fiat.

Huge fluctuations in ARTH's price will only happen when the market cap of ARTH is small and the markets are not liquid enough. Because ARTH is backed by its underlying assets, major price fluctuations will be less frequent as markets and ARTH become more and more liquid.

Stability Fees

To control the supply of ARTH tokens in the market, the ARTH vault will charge a fee in MAHA tokens to the vault liquidator whenever he/she wishes to release the locked collaterals in the vault.

A high fee will discourage creation and liquidation of ARTH vaults and a low fee will encourage creation and liquidation of ARTH vaults.

Fees collected will be burnt off, reducing the supply of MAHA tokens and hence appreciating it's value.

Emergency shutdown

To protect the ARTH holders against attacks on the infrastructure, an emergency shutdown module can be invoked as a last resort.

Upon activation, the Emergency Shutdown module will deploy a two-pronged safety mechanism i.e. new vaults will stop getting created and all existing vaults will be instructed to stop creating new ARTH tokens. This will ensure vault owners can reclaim their collaterals against the circulating ARTH and the overall rebalancing activities will come to a halt as well.

MAHA Minority can use this Emergency Shutdown Module to specifically thwart three types of attacks:

1. Malicious Governance
2. Critical bug in smart contract code
3. Long-term market irrationality

The MAHA voters will determine a quorum (initially 1,000,000 MAHA) that is required to be deposited to trigger the Emergency Shutdown. Irrespective of a quorum being reached, all MAHA Tokens deposited into this module will be immediately burnt off.

ARTH Savings Rate - ASR

SiAn ARTH Savings Rate system has been put into place to allow token holders to earn passive income whilst holding ARTH. The model incentivizes the balance of supply and demand of ARTH and allows for capital to be deployed more efficiently while still holding true to its core role of providing strong, decentralized stability.

The ASR is a basic interest system. Token holders can lock and unlock ARTH into a savings contract which would continuously accrue interest based on ASR - a global system variable. If the prevailing ASR is 3%, a holder who locks 100 ARTH tokens for a full year, will earn three additional ARTH when they unlock the same. The funds needed for the ASR come from the Stability Fees paid by CDP's. For example, average stability fees of 4% collected on CDP's could easily fund an ASR of 3%.

Beyond keeping the balance of demand and supply of ARTH, this system will prove to be a major monetary policy lever that the decentralized governance can control. This will be a global parameter that will be adjusted often to deal with short-term changes in the market conditions of the ARTH economy.

These two mechanisms in conjunction, provide a powerful array of tools to guard both short-term and long-term stability of the ARTH token.

Known Risks

The following risks have been identified as risks to the stability of ARTH.

- **New economic model** - Any uncertainties with any new economic model
- **Smart contract bugs** - Possibility of any bug in the smart contract can bring the entire system down irrespective how much code-review has been done on the smart contracts. To address this each smart contract needs to be audited.
- **Low liquidity** - If there isn't enough liquidity to support the various rebalances or generate enough ARTH, then ARTH can see itself depreciate in value. To address this
- **Collapse of one of the underlying collaterals** - An unstable collateral which collapses can cause ARTH to lose its value proportionate to how much value exposure was there to the collateral.
- **Collapse of the price feeds** - The price feeds are a crucial piece for the ARTH vaults to determine the situation of the market. Any collapse in these price feeds would cause the ARTH vaults to make decisions based on incorrect data.
- **Centralization of MAHA tokens** - Majority of the decisions made for ARTH are decided upon MAHA token holders. Therefore a centralisation of MAHA tokens will cause the decisions to be one-sided which might not possibly result in the best outcome.

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