Loki Cryptoeconomics

Alterations to the staking requirement and emission curve.

Johnathan Ross, Simon Harman, Kee Jefferys

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Executive Summary

The initial Loki emission curve did not suit a Sybil attack resistant Service Node Network. We developed multiple case scenarios which altered the Loki emission curve to find a model which naturally promotes a reasonable percentage of the circulating supply being locked up in Service Nodes to retain the Sybil attack resistant properties of the network over the long term. We also altered the staking requirement equation to match the conditions of the new emission curve.

Important notice

This paper contains tables and charts which include examples of a price for the Loki cryptographic coin. Those prices are examples only and are not a prediction, forecast, or representation as to any actual likelihood of price movement of the Loki cryptographic coin. The payments shown in the examples below are general in nature and will only take effect if the planned hard fork occurs. Factors outside the control of Loki could impact what actual payments are made to service nodes, for example in the event of an attack on the Loki blockchain or there being bugs or errors in code.

Any references to the price of Loki in this paper are to the market price of the Loki cryptographic coin available on public cryptocurrency exchanges which choose to list the Loki token, noting that the Loki Foundation does not operate a cryptocurrency exchange.

Those parties not operating a service node should not rely on the examples when deciding whether or not to participate in the Loki project. This document should be read together with the Loki whitepaper published and other publications by Loki.

Acronyms

- LSR - Loki Staking Requirement - Staking requirement expressed in units of Loki.
- \$SR - Effective Dollar Staking Requirement - Expressed in terms of fiat currency.
- \$OE - Operating Expenses - Real dollar annual cost of running a server for a Service Node.
- LR - Lockup Ratio - Proportion of ‘staked’ Loki in Service Nodes compared to circulating supply.
- LROI - Loki Return on Capital Input - Return on Loki compared to Loki input.
- \$ROI - Effective Dollar Return on Capital Input - LROI converted to fiat value, minus \$OE.
- #N - Active Service Node count at any given block height.

1 Introduction

A paper was commissioned by the Loki team to assess the viability of the Loki Project’s initial cryptoeconomics. This paper[1], written by Dr Brendan Markey-Towler, an economist at the University of Queensland, laid out the complex optimisation problem of setting the staking requirement using strategic game theory. Using *Towler’s* paper we were able to create a model which allowed us to assess the viability of various case studies.

Through this modelling, we have formed the following views:

1. Setting an optimal staking requirement is largely dependant on the emission curve and the price of Loki.
2. The initial emission curve presented at Loki’s inception caused some economic problems for all models.

In this report, we aim to demonstrate our vision of what a successful economic structure should look like for Loki. We discuss what is required to enable such economics, and make an assessment of the current scheme Loki uses. We then propose a new economic scheme based on our findings, with a new emission curve, reward split, and definition of the staking requirement.

2 Desirable Economic Properties of Loki

One of the most important features of the Loki network is its built-in market-based Sybil resistance. We defined a successful Sybil attack as one where a single actor controls over 30% of the network’s nodes. At this level of dominance, an actor could conduct effective network wide temporal analysis. Forcing nodes to have a stake in the network greatly increases the cost of performing a Sybil attack. *Towler* proved the effectiveness of this protection in his game theory model[1].

However, this protection is not guaranteed. Using game theory, we were able to model the behaviour of rational economic actors, and built a picture of what the net state of all Service Nodes at any given time should be, given a set of economic conditions. Using this, we were able to assess the potential difficulty and cost of executing a successful Sybil attack on the network under varying conditions.

In an economic scenario where only 5% of the circulating supply is locked up in Service Nodes, an attacker would only have to purchase 2.15% of the circulating supply in order to begin conducting effective temporal analysis on the network. Although this attack would be costly, the attacker would be unlikely to experience any compounding effect of the attack cost as a result of their attack.

True market-based Sybil resistance only starts to materialise when a greater percentage of the circulating supply is locked up in Service Nodes. In a scenario where 90% of the circulating supply is locked, actors would struggle to purchase enough Loki to perform an effective temporal analysis. However, a 90% lockup is unlikely to occur as Loki aimed to set its equilibrium Service Node lock up to 50% of the circulating supply. In this scenario, an attacker would have to purchase $\tilde{2}1.5\%$ of the circulating supply to begin performing serious network wide temporal analysis. Purchasing $\tilde{2}1.5\%$ of the circulating supply to accomplish this level of saturation will cause liquidity to rapidly decline in the markets, driving up the price of each coin as the accumulation continues. Thus, we would see a compounding effect on the cost of such an attack.

Of course, this accumulation can happen over time; depending on the patience of the attacker. Assuming they stake the Loki as they accumulate it, this would dilute the rewards that all Service Nodes receive, including the attacker's. *Towler's* game theoretic model showed that this would start to cause other Service Nodes to drop off the network, but it would also come at an enormous opportunity cost to the attacker. They would suffer a negative ROI in dollar terms for all of their nodes as long as the node count remains above the natural equilibrium point derived from a positive $ROI[1].

The cost of this Sybil attack is based on the market price and liquidity of Loki over the course of the attack, but assuming low estimates of Loki's price, this attack would easily run into the tens or hundreds of millions of dollars. If an attacker could sustain these costs, they would eventually achieve dominance over the Service Node network and hold at least 30% of the nodes on the network. Other actors would be forced out, depending on their profitability tolerance, and the attacker could potentially start to return a net positive income from this attack. What happens next would then depend on the intentions of the attacker.

If the attacker chose to use their dominance to passively perform analysis on the network, the users of Loki may have not noticed that an attack is occurring until follow-on effects of that analysis arise, at which point the value of the network is likely to decline, further hurting the attacker financially.

If the attacker where to start using their dominance to undermine the network entirely by manipulating swarm tests, they could initiate the complete collapse of the Service Node network. This would likely have a catastrophic effect on the value of Loki as Service Nodes leave the network and operators attempt to sell their coins. While the network would have been destroyed, the attacker would now own a very large amount of worthless assets - a cost they cannot recover.

Through this analysis we can see that the level of Sybil resistance is derived from the attack cost, which is not only affected by the price of Loki, but also by the fact that a higher lockup ratio of the circulating supply has a compounding effect on the cost. Thus, we surmised that having an economic condition where a large percentage of the circulating supply becomes locked is desirable for the Loki Network's Sybil resistance to remain effective. Although the lockup selection is somewhat arbitrary, for the purposes of modelling, we placed this percentage target at 50%.

3 Required Conditions for High Lockup Ratio (LR)

A high lockup ratio (LR), according to our modelling, is achieved when the dollar term return on capital input ($ROI) had attracted enough Service Nodes to operate in favour of other forms of investment.

The LR was taken to be the midpoint in an equilibrium, where the number of nodes joining the network drove the rate of return down to the lowest tolerable $ROI compared to other forms of investment, and conversely, nodes leaving the network increased the $ROI for the remaining nodes up to the lowest tolerable $ROI.

$ROI is calculated by a combination of the following:

1. the dollar value of the Loki required to purchase the staking requirement (LSR);
2. the expected return on that in terms of Loki (LROI) (as the block reward grants the operator Loki, not dollars);
3. the real-world operating cost of running the Service Node (Operating Expenses, $OE);
4. and, the dollar value of the LROI. From these variables we deduced the actual $ROI.

The exact mathematics are discussed extensively in *Towler's* Paper: "Cryptoeconomics of The Loki Network"[1].

The LROI is directly proportional to the number of Service Nodes operating on the network, and the emission curve (the defined Loki inflation rate) embedded into the software. With the emission curve being the one variable we could hard-code, we ensured that it suited the remaining economic conditions we considered desirable.

The introduction of the $OE presented a new problem. The cost of operation can only be reflected in dollar terms, the dollar return rate of a Service Node directly affected the viability of the investment. The $SR must be set high enough so that the $OE are reasonably negligible compared to the $ROI. That being said, it is also important for the scalability of the network that as many Service Nodes as possible are incentivised to operate within this model, which means the LSR had to be set at an amount that balances $ROI and the node count (#N). We would also like to note that the relationship between LSR and the circulating supply causes a hard limit on #N. If the circulating supply is 50,000,000 and the staking requirement is 50,000, only 1000 nodes can possibly operate. In reality, #N will be the circulating supply divided by the LSR, which if we assume our target of 50%, would mean 500 nodes should operate in the right economic conditions.

To design the economic conditions to target a high LR, the $ROI needed to be consistently attractive overtime to raise the LR to our target of 50% or higher. Considering opportunity cost, rational actors would only deploy a Service Node if the $ROI exceeds that of other forms of investment. Using the long running average of stock market performance, we assumed that an 8% per annum $ROI would be near to the lowest tolerable $ROI for rational actors. Of course, this is difficult to define accurately, as the price of Loki is likely to fluctuate, making any long-term assessment of this profitability near impossible without speculating.

However, something we could redefine was the emission curve, which directly influences LROI through time. LROI will be proportional to the LR, but as the same amount of Loki will be rewarded each block regardless of the LR, it is one variable we could analyse closely.

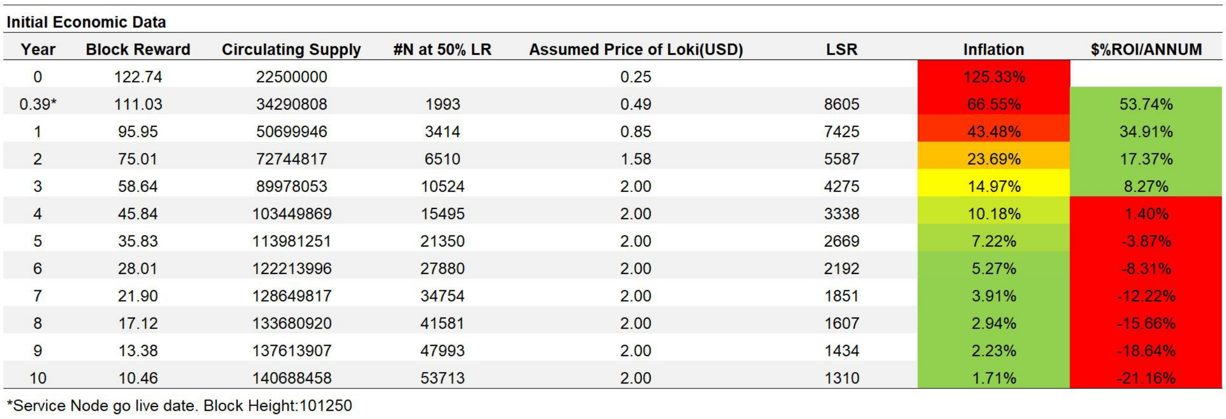
In summary, we aimed to design the emission curve so that at a target LR of 50%, the rate of return did not fall below 8% $ROI for as long as possible.

4 Initial Economics Scheme

This was the original economics scheme that was implemented during the inception of the Loki project. In this model, we defined:

- The reward ratio as 45% Service Nodes, 50% Miners, and 5% to Governance.
- The Staking requirement at 10,000 Loki which decreases over time.
- A speculative guess at the potential price of Loki through time (to help calculate $ROI).
- A steep emission curve based on an emission speed factor of 20.
- A conservative $OE was taken at $600 USD/year accounting for a high bandwidth/storage VPS.

In the chart below, the most important data to note is the "$ROI/ANNUM" column. The percentage of $ROI is calculated as if at that exact moment in time, the LR is exactly 50%, with the operating costs factored in. The resulting figure is therefore not an actual representation of the true $ROI, but the *pressure that exists* on the LR in either direction. A positive ROI above 8% suggests that the LR is likely to be above the 50% target. Anything below that makes it increasingly likely that the LR will fall below 50%.



Initial Economic Data

Year	Block Reward	Circulating Supply	#N at 50% LR	Assumed Price of Loki(USD)	LSR	Inflation	$%ROI/ANNUM
0	122.74	22500000		0.25		125.33%	
0.39*	111.03	34290808	1993	0.49	8605	66.55%	53.74%
1	95.95	50699946	3414	0.85	7425	43.48%	34.91%
2	75.01	72744817	6510	1.58	5587	23.69%	17.37%
3	58.64	89978053	10524	2.00	4275	14.97%	8.27%
4	45.84	103449869	15495	2.00	3338	10.18%	1.40%
5	35.83	113981251	21350	2.00	2669	7.22%	-3.87%
6	28.01	122213996	27880	2.00	2192	5.27%	-8.31%
7	21.90	128649817	34754	2.00	1851	3.91%	-12.22%
8	17.12	133680920	41581	2.00	1607	2.94%	-15.66%
9	13.38	137613907	47993	2.00	1434	2.23%	-18.64%
10	10.46	140688458	53713	2.00	1310	1.71%	-21.16%

*Service Node go live date. Block Height:101250

The Initial Economic Data shows that an emission curve that reduces over time results in each node receiving a diminishing reward through time. If inflation always decreases, so too will the LROI, and depending on the price, a lower $ROI, thus causing a diminishing LR through time.

At the most extreme end of this study, assuming the price of Loki will be $2, and with each Block Reward (BR) at year 10 equalling approximately 10 Loki, and assuming the average cost to run a Service Node for the year is $600 USD, each node will net a loss of $554 USD per annum. As this is obviously an untenable position, the LR is likely to drop well below

50%, undermining the Sybil resistance of the network. This current model gives the Loki Network less than 4 years of market-based Sybil resistance.

5 Solutions

The tempting solution to this problem was to change the emission curve to continue to generate high block rewards through time. However, this would increase inflation and create ongoing sell-side pressure of Loki. Many ‘Masternode’ type coins have failed because of unsustainable inflation rates. Most worryingly, this sort of perpetual hyperinflation could result in a positive feedback loop that would force the Loki Foundation to manually increase the LSR to account for constant reductions in the price of Loki, consequently dropping the #N to levels which would degrade the privacy of Lokinet. Therefore, drastically reducing the emission curve could allow rewards to be more evenly distributed through time, extending the lifetime of this economic model without drastically affecting the circulating supply over a 10-year period.

Once the emission curve was refined, we developed the LSR to avoid reaching the minimum $ROI threshold at a 50% LR. We aimed to design the LSR to be high enough at any point in time to mitigate the effect the $OE has on the overall $ROI, but also small enough that the #N is as high as possible. Because the LSR is not expressed in dollar terms and the $OE is, we accounted for a margin of variability in the Loki price when setting the LSR.

With these two parameters in mind, we analysed a range of possible options, only showing 3 of the case studies in this report to illustrate the outcome, and the resulting economic conditions. In each of these models, we defined:

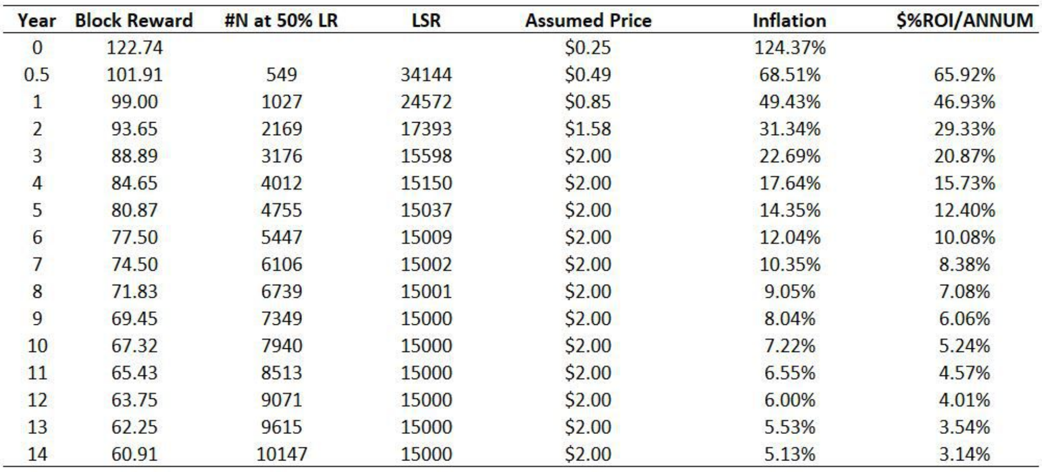
- The reward ratio as 50% Service Nodes, 45% Miners, and 5% to Governance, giving a slight increase in rewards to Service Nodes.
- The LSR is derived from the block height(h), starts at 45,000 Loki when Service Nodes go live, and was changed at block height 230704 to decrease over time to 15000 Loki using the below formula.

$$LSR = 15000 + \frac{25007}{2^{\left(\frac{h - 101250}{129600}\right)}}$$

- An assumption of the price of Loki over time (which is not a forecast or representation of the Loki price but is used to calculate a hypothetical $ROI for Service Node operators).
- A steep, immediate drop-off in emission which reaches for a specific asymptote.
- A conservative $OE was also defined as $600 USD/year.

5.1 Case Study 1

$$Reward = 50 + \left(\frac{55}{2^{\left(\frac{h}{1555200} \right)}} \right)$$

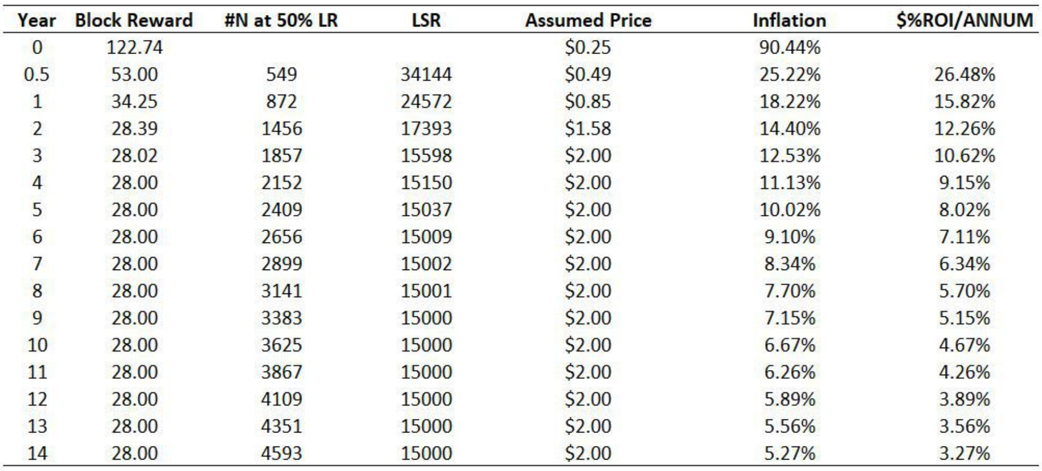


Year	Block Reward	#N at 50% LR	LSR	Assumed Price	Inflation	$%ROI/ANNUM
0	122.74			$0.25	124.37%	
0.5	101.91	549	34144	$0.49	68.51%	65.92%
1	99.00	1027	24572	$0.85	49.43%	46.93%
2	93.65	2169	17393	$1.58	31.34%	29.33%
3	88.89	3176	15598	$2.00	22.69%	20.87%
4	84.65	4012	15150	$2.00	17.64%	15.73%
5	80.87	4755	15037	$2.00	14.35%	12.40%
6	77.50	5447	15009	$2.00	12.04%	10.08%
7	74.50	6106	15002	$2.00	10.35%	8.38%
8	71.83	6739	15001	$2.00	9.05%	7.08%
9	69.45	7349	15000	$2.00	8.04%	6.06%
10	67.32	7940	15000	$2.00	7.22%	5.24%
11	65.43	8513	15000	$2.00	6.55%	4.57%
12	63.75	9071	15000	$2.00	6.00%	4.01%
13	62.25	9615	15000	$2.00	5.53%	3.54%
14	60.91	10147	15000	$2.00	5.13%	3.14%

Case Study 1 presented a $ROI above the threshold for the longest time of the three options. However, the inflation present in this model was quite high for the first few years. As discussed, inflation may ‘solve’ the LROI problem, but could have significant negative consequences for the price, and thus the $ROI, driving the LR down.

5.2 Case Study 2

$$Reward = 28 + \left(\frac{100}{2^{\left(\frac{h}{64800}\right)}} \right)$$



Year	Block Reward	#N at 50% LR	LSR	Assumed Price	Inflation	$%ROI/ANNUM
0	122.74			$0.25	90.44%	
0.5	53.00	549	34144	$0.49	25.22%	26.48%
1	34.25	872	24572	$0.85	18.22%	15.82%
2	28.39	1456	17393	$1.58	14.40%	12.26%
3	28.02	1857	15598	$2.00	12.53%	10.62%
4	28.00	2152	15150	$2.00	11.13%	9.15%
5	28.00	2409	15037	$2.00	10.02%	8.02%
6	28.00	2656	15009	$2.00	9.10%	7.11%
7	28.00	2899	15002	$2.00	8.34%	6.34%
8	28.00	3141	15001	$2.00	7.70%	5.70%
9	28.00	3383	15000	$2.00	7.15%	5.15%
10	28.00	3625	15000	$2.00	6.67%	4.67%
11	28.00	3867	15000	$2.00	6.26%	4.26%
12	28.00	4109	15000	$2.00	5.89%	3.89%
13	28.00	4351	15000	$2.00	5.56%	3.56%
14	28.00	4593	15000	$2.00	5.27%	3.27%

Case Study 2 incorporated a dramatic cut or ‘halvening’ of the block reward to stem inflation, and then implements a softer curve down to an asymptote of 28 Loki per block reward. At the 10-year mark, the circulating supply is at about 110 million Loki, as opposed to the original scheme which produced 140 million Loki after 10 years. The $ROI decreases far less dramatically, and while still only 3 years of $ROI above the threshold of 8% is expected, the following years are far less problematic.

5.3 Case Study 3

$$Reward = 14 + \left(\frac{2^7}{2^{\left(\frac{h}{64800}\right)}} \right)$$

Year	Block Reward	#N at 50% LR	LSR	Assumed Price of Loki	Inflation	$%ROI/ANNUM
0	122.74			$0.25	84.56%	
0.5	46.00	549	34144	$0.49	17.17%	19.21%
1	22.00	845	24572	$0.85	10.43%	8.14%
2	14.50	1318	17393	$1.58	8.01%	5.88%
3	14.03	1588	15598	$2.00	7.33%	5.42%
4	14.00	1754	15150	$2.00	6.83%	4.85%
5	14.00	1888	15037	$2.00	6.39%	4.40%
6	14.00	2013	15009	$2.00	6.01%	4.01%
7	14.00	2135	15002	$2.00	5.67%	3.67%
8	14.00	2256	15001	$2.00	5.36%	3.36%
9	14.00	2377	15000	$2.00	5.09%	3.09%
10	14.00	2498	15000	$2.00	4.84%	2.84%
11	14.00	2619	15000	$2.00	4.62%	2.62%
12	14.00	2740	15000	$2.00	4.42%	2.42%
13	14.00	2861	15000	$2.00	4.23%	2.23%
14	14.00	2982	15000	$2.00	4.06%	2.06%

Case Study 3 followed a similar path to case study 2, with even more restricted inflation, resulting in a static block reward of 14 after 4 years. While this did help spread the inflation out over a much greater period of time, it only guaranteed 2 years of $ROI above the threshold, and would likely lead to an equilibrium of around 30% LR forming, which is potentially not strong enough to maintain a high-level Sybil resistance.

5.4 Analysis

The three case studies illustrated a range of possible solutions, with case study 1 representing the least difference from the initial scheme, and Option 3 the furthest. The analysis we have performed here demonstrated that some midpoint between the two is most likely the best option. In light of this, we chose case study 2 to be our emission curve.

It should also be noted that this emission model will not remain viable forever. This rewards scheme should remain partially effective in maintaining a higher LR for over a decade. Beyond that, one could increase the emission, but extended periods of high inflation will only lead to a continual devaluation and therefore a stagnant or declining #N. A medium-term solution would be to eventually convert Loki to 100% proof-of-stake, where Service Nodes deterministically create blocks and risk losing their capital upon the creation of invalid blocks. In the long term, the only way we can foresee a high LR maintained is to work towards creating an internal economy within Loki, so that Service Nodes receive income from sources other than just the block reward - transaction fees accrued in proof-of-stake, for example.

Our assessment had also led us to believe it is in the best interests of the long-term viability of this project to implement this change to the emission curve as soon as the research was conducted, which lead us to proceed with the emission change at Loki Block height 64342. Doing so deferred the emission of Loki into the lifetime of the Service Nodes, giving extended runway to the viability of the economic model.

6 Setting a Staking Requirement (LSR)

In our model, we assessed the viability of a staking requirement set to 45,000 when Service Nodes go live, non-linearly reducing to nearly 10,000 Loki and linearly increasing to 15,000. We needed to re-asses the LSR formula with the implementation of infinite staking at block height 234767, we didn't want to end up with a situation where individuals lock in at a low LSR and thus earn a higher ROI than newcomers to the network who have to pay a higher amount for a SN stake. Because of this situation we decided to remove the part of the formula where the LSR reduces to 10,000 and increases the 15,000 with a formula that slowly decreases to 15,000. This was based on an approximation of our target #N whilst remaining considerate of the $ROI provided to each node.

As we have discussed, the optimal LSR needs to balance providing high $ROI (higher LSR) and a high #N (maximised by a low LSR).

The game theory that we analysed on this problem makes it clear that the optimal staking requirement is largely dependent on the price of Loki. The best possible way to limit the network to price exposure is to make the staking requirement directly correlate to Loki's price performance, as *Towler* suggested in his paper[1]. However, we believed that this exposesd the network to new risks, that in our opinion outweighed the benefit of adding this functionality to the design. Namely, this would:

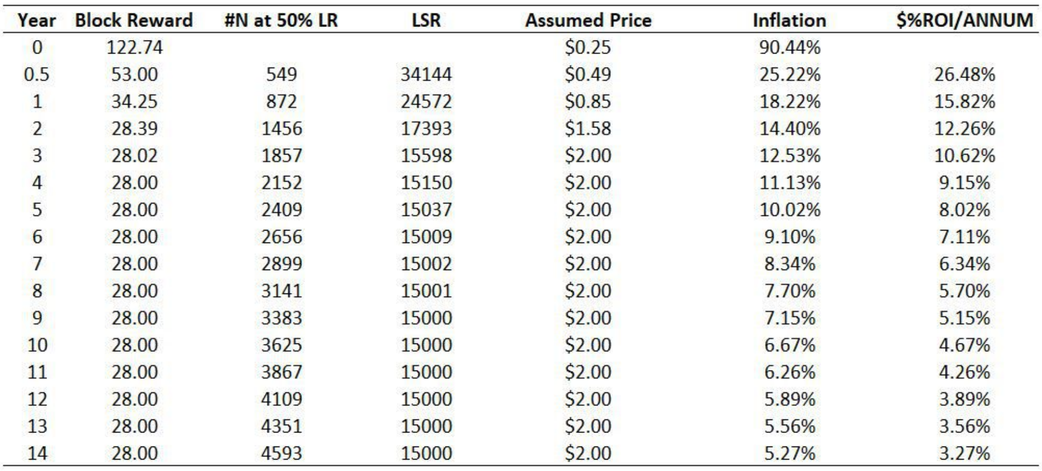
- Require the addition of a price oracle, which is difficult to implement while maintaining decentralisation.
- Be vulnerable to potential price manipulations that can be used to game this system in unforeseen ways.
- Overvalue the LR in favour of #N during periods of severe price declines.

Thus, we had to make as best an approximation of a reasonable LSR as possible. In consideration of this, Loki became particularly vulnerable if the LSR is set too low and the dollar value of Loki fails to increase. In this scenario, the $OE of each node will quickly drive the $ROI down, causing nodes to drop off the network. The drop-off of nodes could cause a precipitating price crash that exacerbates this problem.

Based on our modelling, we determined that a LSR at the initial Service Node launch to be 45,000 would reduce any effect the $OE has on the $ROI. At this rate, with Case Study 2 emission curve in place, the circulating supply will be about 34,290,808 when Service Nodes are live (this includes locked coins from the pre-mine). This would allow for a #N of 764 at a LR of 100%. However, the 100% LR is very unlikely to happen, so we can more reasonably predict that the LR will be closer to a 60% target due to the very high initial LROI and $ROI. At a LR of 60%, we should expect to see a #N of 4̃60.

This #N is of course very low. The Tor network, for example, runs at least 2000 'high' performance nodes on its network at the time of writing this report (out of a rough total of 6500). Such a #N is required of the Loki network to match and exceed this performance without increasing minimum standards of node performance and therefore $OE. However, this initial LSR is required to account for the $OE, given the price of Loki. We could lower the LSR to maximise #N, but doing so exposes the network's LR to price stagnation. If the price does not rise as it does in our model, a higher LSR provides the LR with a greater tolerance to the $OE.

We addressed the low #N by lowering the LSR over time. We concluded that the initial implementation of the LSR should progressively decrease to 15,000, after which it will remain fixed. This will improve the long-term price risk tolerance, without negatively impacting positive #N growth over time.



Year	Block Reward	#N at 50% LR	LSR	Assumed Price	Inflation	$%ROI/ANNUM
0	122.74			$0.25	90.44%	
0.5	53.00	549	34144	$0.49	25.22%	26.48%
1	34.25	872	24572	$0.85	18.22%	15.82%
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6	28.00	2656	15009	$2.00	9.10%	7.11%
7	28.00	2899	15002	$2.00	8.34%	6.34%
8	28.00	3141	15001	$2.00	7.70%	5.70%
9	28.00	3383	15000	$2.00	7.15%	5.15%
10	28.00	3625	15000	$2.00	6.67%	4.67%
11	28.00	3867	15000	$2.00	6.26%	4.26%
12	28.00	4109	15000	$2.00	5.89%	3.89%
13	28.00	4351	15000	$2.00	5.56%	3.56%
14	28.00	4593	15000	$2.00	5.27%	3.27%

After many attempts to model a potential staking requirement and emission curve, Case study 2 presented a reasonably low risk tolerance towards the price, whilst still accommodating a gradual increase in #N. The #N is sufficiently high after a few months, due to the circulating supply increasing and the staking requirement decreasing, without impacting LR to run a sufficiently large network for a brand new mix network. As adoption picks up, so too does the #N over the course of time in this model.

Although there were many members of the community that were quite vocal about their desire to keep the $SR low, our assessment lead us to believe that this was the lowest we can set it within our desired risk tolerance.

Furthermore, we recommended that the Loki community should be open to annually reviewing this staking requirement. If the price performance is proven to be consistently much lower or higher than our model has predicted, it may make sense to alter the staking requirement. Such changes can be conducted through gradual soft forks if required.

7 Conclusion

A hardfork was conducted at block 64324, approximately the 30th of July, 2018. This harfork changed one parameter in the Loki core code, which is the emission curve.

At block height 64324, the Loki block reward went from being calculated in terms of the circulating supply with an emission speed factor of 20, to be derived from the block height. Defining the base block reward based on height meant that the typical block size penalty will simply under-emit if miners attempt to create abnormally large blocks. However, this would not negatively impact Service Nodes as we intend to apply this penalty on the miner's reward output only.

The formula used to calculate the block reward (*Reward*) where h is the block height:

$$Reward = 28 + \left(\frac{100}{2^{\left(\frac{h}{64800}\right)}} \right)$$

At block height 101250, the Loki network hardforked to assign 50% of the block reward to Service Nodes, 45% to miners, and 5% to the two governance initiatives. The Hardfork also implemented a staking requirement which began at 45,000, descended non-linearly to 10,000 and was to increase linearly to 150,000, according to the equation:

$$LSR = max\left(\left(10000 + \frac{35000}{2^{\left(\frac{h - 101250}{129600}\right)}} \right), min\left(\left(\frac{5}{2592} h + 8000 \right), 15000 \right) \right)$$

At block height 230704, the LSR was re-assessed and a new formula was used where the LSR dropped non-linearly to 15,000, removing the need to have the linear increase to 15,000. This formula is as following:

$$LSR = 15000 + \frac{25007}{2^{\left(\frac{h - 101250}{129600}\right)}}$$

We believed that these changes amount to a more sustainable, more resistant, and greater capacity network over the next decade.

References

[1] Brendan Markey-Towler, *Cryptoeconomics of the Loki network* (2018), `https://loki.network/wp-content/uploads/2018/07/CryptoeconomicsOfTheLokiNetworkV1.pdf`.