PUP-21 Effects on Node Rewards

Simulation of a plausible post-PIP-22 network landscape and the effects of the PUP-21 values on the node rewards.

Public report by:

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Disclaimer

This work was founded by Pocket Scan Technologies LLC, a company operating on the Pocket Network.

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Changelog

v1.0	2022-07-27	First version.
v1.1	2022-07-28	Added note on values and released code link.

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1 Abstract

This report summarizes the effects of the PIP-22 using the proposed parameters of PUP-21, a plausible set of assumptions and a Monte Carlo simulation of the Cherry Picker behavior. The results of this simulation suggest that in order to maintain the minted POKT levels constant after the implementation of the PIP-22, the expected rewards of a non-compounding node will be reduced by a 14% even in the higher performing nodes. The PUP-21 appears to have a harsher impact on the small node runners, punishing them if they are not able to compound their stake and reducing the rate of return for lower compound tiers in favor of higher rates of return for high compound tiers. A parameter change is needed in order to reduce the impact on the small nodes. We propose to enable the DAO to implement a non-linear weight staking. The proposed solution can be easily applied with minor changes on the PUP-21 and no code changes on the PIP-22.

2 Current and Proposed Landscape of the Pocket Network

In this section the current state of the network is described using the available information and a post-PIP-22 landscape is proposed using a series of assumptions.

The data used to describe the Pocket Network is obtained from public sources such as the Pocket Network Blockchain (PNB) data and the Cherry Picker Snapshot (CPS) database provided by Pocket Core.

2.1 Current Pocket Network Landscape

The Pocket Network as of writing of this report have $\sim 35 \times 10^3$ *servicing* nodes. Among them 1000 are also *validator* nodes. The Pocket Network has currently 31 chains producing relays, however the top 8 chains conform the $xx\%$ of the network traffic. Also, by considering only this sub-group of chains a good approximation of the whole network behavior can be achieved.

Table 1: Top Network Chains.

Chain.	Share.
0040	25.04%
0021	23.47%
0009	19.89%
0027	11.43%
0004	4.88%
0005	3.75%
0049	2.70%
03DF	2.61%
Total	93.77%

An other fact of the Pocket Network is that the number of relays is not evenly distributed among the staked nodes, there is a Quality Of Service (QoS) mechanism enforced by the Cherry Picker (CP) which rewards faster and stable nodes by assigning them more traffic when compared to other nodes with lower performance [1]. The CP is part of the Pocket Portal (PP) which is the main way for accessing the Pocket Network. Then,

[1] For more information on the CP behavior please refer to the article "Demystifying the Cherry Picker"

in order to describe the Pocket Network, the CP and the PP must be taken into account. The data of the CP and the PP is available in the CPS (Cherry Picker Snapshot) database. The CPS produces a series of metrics regarding all the nodes that interacted with an application in the last sessions, it includes very useful information about the nodes QoS, including:

- Median Success Latency (MSL) : The median response time of a node's successful relay.
- Percentile 90 Success Latency (p90) : The p(90) response time of a node's successful relay.
- Weighted Success Latency (WSL) : The weighted response time of a node's successful relay.
- Success Rate (SR) : The success rate of the node relays.
- Failure State (FS) : A flag indicating if the node entered a failure state.

In addition to the QoS data the CPS provides information about the used Portal. The PP works in 15 different Amazon Web Services (AWS) Availability Zones (AZs). Most of the Pocket Network traffic is focused in 5 regions, as shown in table 2, but they fluctuate often.

Under the described conditions a relatively fair way to describe the network is by means of the average MSL (Avg. MSL) on the top 8 chains and the top 5 portal locations. . The resulting Pocket Network node quality distribution can be seen in figure 1. The figure represents the Pocket Network distribution using the node's Avg. MSL. The different tiers, A through D, represent QoS groups. The nodes in the tier A are expected to have a better QoS (and thus higher rewards) than those in the tier B. The segmentation of the tiers is done to obtain a clear reward difference between the different tiers, the values are obtained empirically and they can be observed in table 3.

Table 2: Top Gateways.

AWS Region	Share.
eu-central-1	$\sim 25\%$
us-east-1	$\sim 20\%$
ap-southeast-1	$\sim 15\%$
us-east-2	$\sim 5\%$
ap-northeast-2	$\sim 5\%$
Total	$\sim 75\%$

Note on Avg. MSL value: This is not a perfect metric for a node's performance but choosing a single parameter to describe a complex behavior is cannot be done without loosing accuracy. Nevertheless this parameter is only used to perform a coarse division of the data and present a clearer graph, it is not used for simulating the node's behavior.

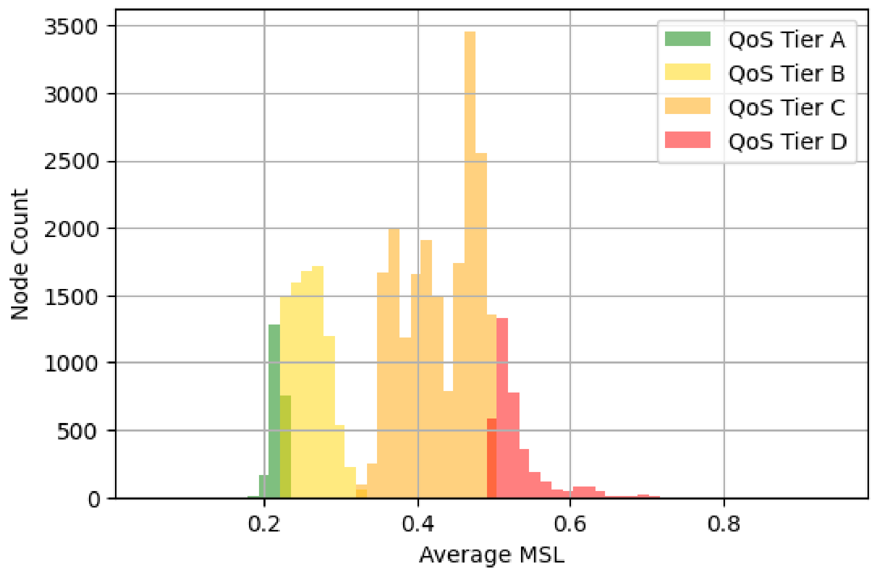

Figure 1: Histogram of nodes in the Pocket Network sorted by their Avg. MSL. The color represent the different QoS nodes in the network, the lower the Avg. MSL, the better is the node's QoS.

Table 3: Quality of Service Tiers and parameters.

QoS Tier	Avg. MSL.	Nodes.
A	<225 ms	2212
B	<325 ms	8480
C	<0.5 ms	20151
D	>0.5 ms	3719
Total	-	34562

It can be seen in figure 1 that the current network possess a large amount of non-performing nodes (approx. $\sim 24 \times 10^3$ nodes from QoS Tiers C and D). These nodes are not beneficial for the network since their QoS is below the expected levels [2]. These nodes are also the ones that are being more severely punished by the drop in the POKT price, since they service fewer relays and hence produce fewer tokens and they struggling to remain profitable.

2.2 Proposed Effects of the PIP-22

The PIP-22 was introduced as way to enable node runners to increase their node's staked amount and obtain an advantage in terms of POKT generation. One of the expected effects of this proposal is to reduce the number of nodes by *compounding* several node's stakes into a single compounded node with stake equal to the sum of all the compounded nodes original stakes. In this particular case a node runner will see their node running costs reduced to a fraction of their initial costs, i.e. if the node runner compounds three nodes, their running costs will be a third of the original cost but their rewards would be the same [3].

[2] As rule of thumb a good node should be under $150mS$ of MSL and a *useful* node below $350mS$. Nodes with lower performance are normally chosen as a last resort servicer when no other nodes are available. This is the observed behavior in the CP code.

[3] This is not true. We will discuss this point later

It is difficult to tell what will happen after the PIP-22 is applied and there is not a single way of explaining any of the possible scenarios. In this context we expect the network landscape after PIP-22 to be the following:

- Servicer nodes reduction to a total of $\sim 20 \times 10^3$ nodes.
- The compounding probability will be higher on nodes with lower QoS.
- The maximum compounding stage will be preferred if any compounding is done.
- The total stake will increase due to external POKT (not all staked POKT will come from unstaking other servicer nodes).

Compounding Probability

The compounding of nodes is expected to be uneven across different node tiers. A node from tier A is probably less encouraged to do compounding since their rewards are enough to cover their hardware costs, however a node from the lower tiers is probably running without much profit and requires some degree of compounding to keep up with costs in the current market [4]. In figure 2 the proposed compounding probability modulation as a function of the Avg. MSL is presented. It can be seen that the base compounding probability is 10% for tier A nodes and it starts to increase linearly to 70% for nodes with Avg. MSL above $500ms$.

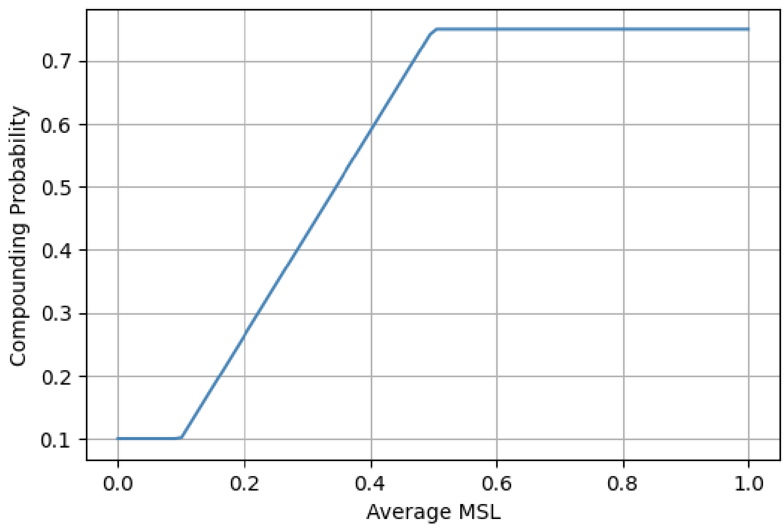

Figure 2: Compounding probability of a given node as a function of the Avg. MSL.

Given the distribution of nodes presented in figure 1, the node compounding probability cumulative distribution takes the shape presented in figure 3.

[4] We will not discuss the cost of running a node here, these assumptions are made on our experience as node runners and some community opinions in informal chats.

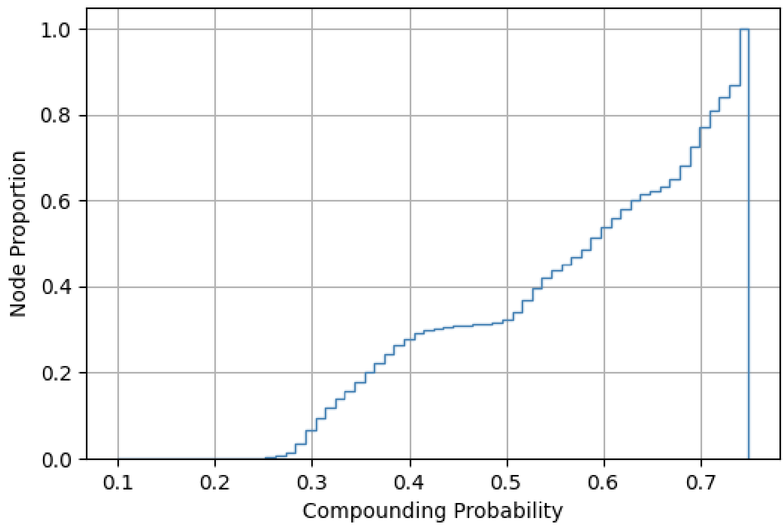

Figure 3: Compounding probability cumulative distribution for the current node population.

Compounding Distribution

The compounding distribution is chosen to be uneven. The proposed scenario expects that roughly half of the nodes in the network will be compounded and that the compounding will be skewed to the largest compounding level. This means that if a node runner chooses to compound their nodes she will try to compound to the highest possible level. Using the proposed compounding levels of PUP-21 the expected compounding distribution of the network is presented in figure 4. It can be seen that 60% of the nodes are expected to remain unchanged (15kPOKT stake) and that most of the compounded nodes will be in the highest level (60kPOKT stake).

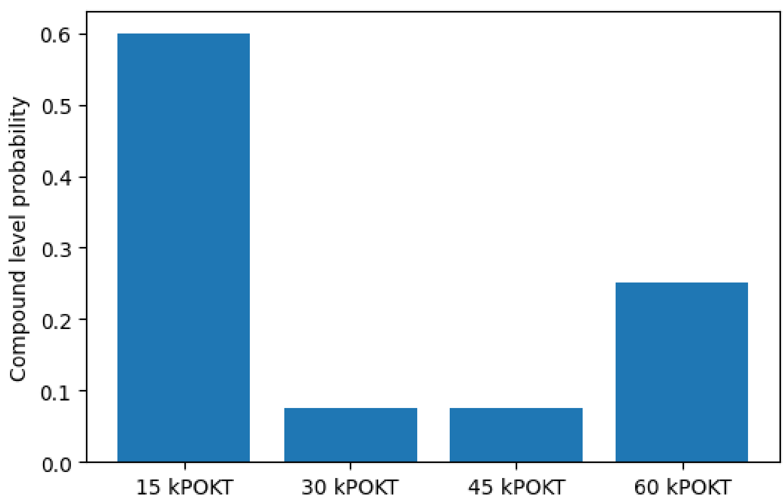

Figure 4: Compounding probability cumulative distribution for the current node distribution.

2.2.1 Resulting Network Landscape

Using a random sampling of the current nodes a new set of 20×10^3 nodes is chosen. The probability of keeping a node after the node reduction is $p_k = 1 - p_c$ where p_c is the compounding probability of the node. The resulting node distribution is presented in figure 5. The new node distribution shows a larger portion of the higher tiers when compared to the original distribution. The table 4 presents the expected number of nodes in each tier along the reduction percentage.

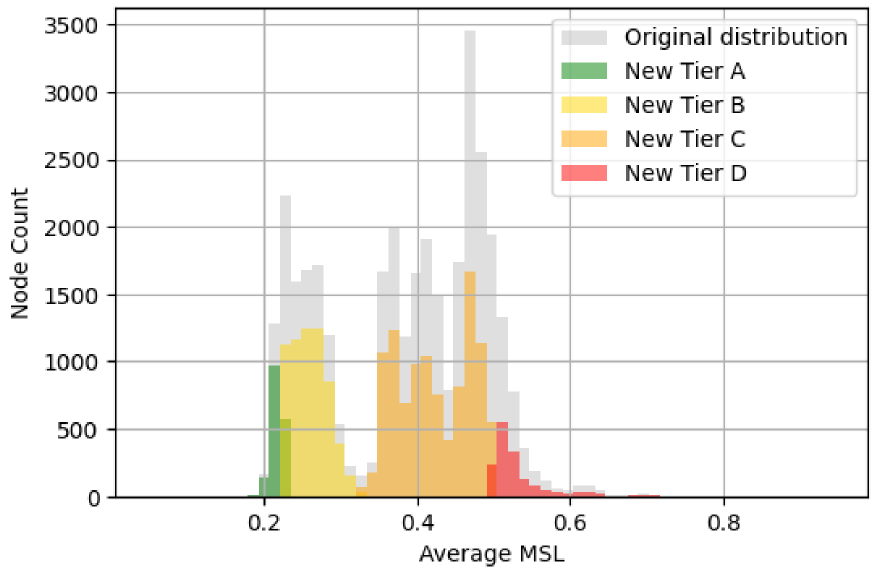

Figure 5: Histogram of nodes in the Pocket Network post the PIP-22 expected reduction, sorted by their Avg. MSL. The color represent the different QoS nodes in the network. The grey shade reflects the distribution prior the expected distribution.

Table 4: Nodes by tier in the network in the current network state and after the expected reduction associated with PIP-22.

Node Tier	Current Nodes	post PIP-22 Nodes	change
A	2212	1700	-23.15%
B	8480	6212	-26.75%
C	20151	10569	-47.55%
D	3719	1519	-59.16%

The compounding level of each node is chosen randomly following the probability distribution presented in figure 4. The resulting number of nodes in each compounding level is presented in figure 6. The resulting compounding levels require an increase in the total staked POKT in the network of $\sim 14\%$.

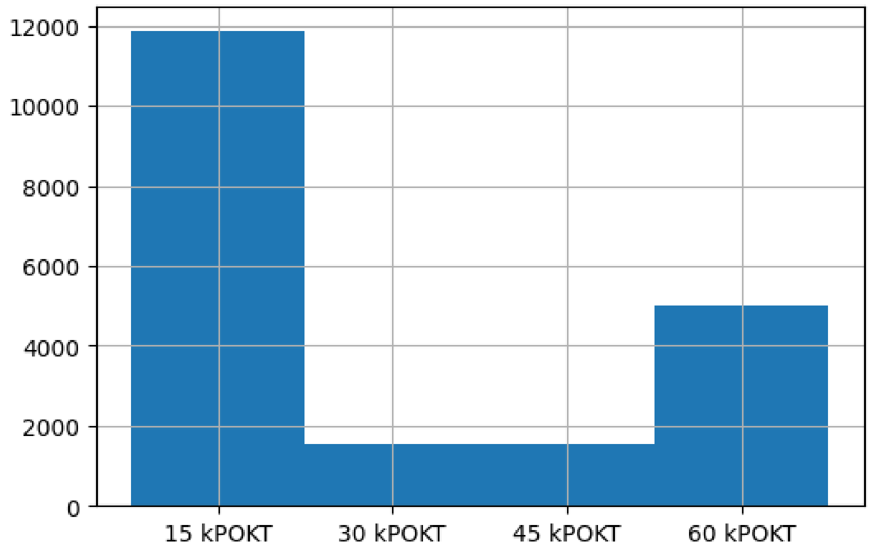

Figure 6: Compounding probability cumulative distribution for the current node distribution.

3 Simulation Results

The simulations presented in this report are based on a Monte Carlo sampling of a mathematical model of the Pocket Network. The model includes:

- The behavior of the CP.
- The QoS of each individual node in the network.
- The distribution of the relays along the different gateways of the PP.
- The application's relays number by session.
- The node selection probability.
- The use of multiple chains by node.

The simulation was limited to the top 8 chains and the top 5 gateways due to time constraints, resulting in $\sim 63\%$ of the total relays in the network being simulated.

In the following subsections the results of the simulations are presented. Each sub-section focus on presenting a different aspect of the PIP-22 and PUP-21 effect on the network. The proposed solution will be presented in section 3.3. Higher order conclusions and discussions will be done in section 4.

3.1 Reduced node network vs current state

The current Pocket Network posses $\sim 35 \times 10^3$ nodes and this number is expected to be reduced to $\sim 20 \times 10^3$. The first step for analyzing the effect of PIP-22 is to analyze how a network with with fewer nodes will impact the node earning average. In order to obtain this number we simulated a group of 1000 nodes of each QoS tier and calculated their income in 24Hs of work [5]. The Monte Carlo sampling was done using 10000 iteration, where a iteration is a whole day's work (24 sessions). This simulation was performed in each scenario: With the current number of nodes and with the expected reduction of the number of nodes. The sub-group of nodes used for the reduced nodes simulation is obtained following the assumptions presented in section 2.2.

The obtained probability distribution for the 24Hs income [6] in the current state and in an hypothetical reduction of the number of nodes is presented in figure 7. The mean values for each node tier prior and after the node reduction process is presented in table 5. It can be seen that the reduction of 42.71% in the number of nodes (from 34562 to 20000) resulted in an increment of $\sim 71\%$ in the node average gain.

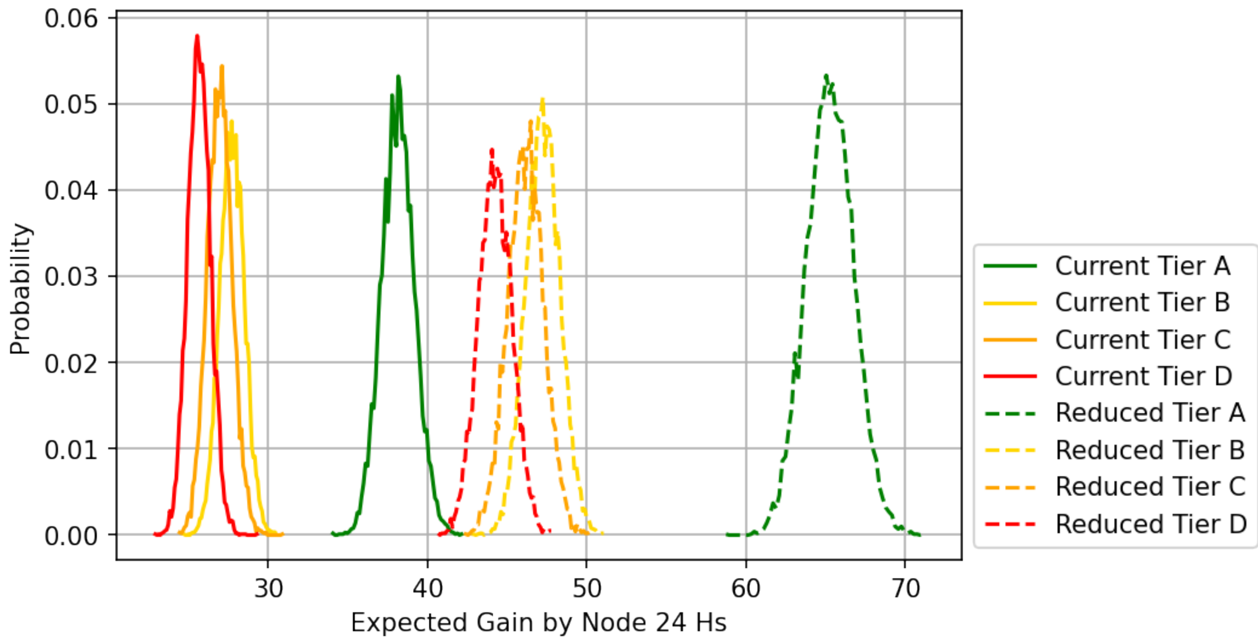

Figure 7: Probability distributions of the 24Hs income per node using a group of 1000 nodes. The solid lines represent the current distributions (using a $\sim 35 \times 10^3$ nodes population) and the dashed lines the expected distributions after the node reduction (using a $\sim 20 \times 10^3$ nodes population)

[5] We used a group of 1000 nodes since a single node might not enter a session at all in a 24Hs period, using a large group reduces the impact of the selection probability on the calculated means.

[6] The absolute values of POKT generated by node are approximately a 60% of the expected values in tier A nodes. This difference comes from the reduced portion of the network that was simulated and the coarse segmentation of nodes used to compose the tiers.

Table 5: Expected 24 Hs average gain by node with a $\sim 35 \times 10^3$ nodes population and with a $\sim 20 \times 10^3$ nodes population.

Node Tier	Full Population Mean	Reduced Population Mean	change
A	38.16	65.27	71.04%
B	27.74	47.24	70.29%
C	26.97	46.16	71.15%
D	25.67	44.25	72.38%

3.2 Impact of PUP-21 Proposal

The PUP-21 proposes the following values for the stake weighting:

- ValidatorStakeFloorMultiplier : 15×10^3 POKT
- ValidatorStakeWeightMultiplier : Variable. To be adjusted by the DAO to keep the minted POKT constant.
- ServicerStakeWeightCeiling : 60×10^3 POKT
- ValidatorStakeFloorMultiplierExponent : 1.0, Linear weighting.

In the current state of the network, the simulation produces a total of 6.38414×10^8 relays in average every 24Hs (9.6×10^5 POKT minted). This number is inline with the reduced portion of the network that was simulated. After the implementation of the PUP-22, in the reduced nodes scenario, this value remains constant as expected.

Now, if we set the ValidatorStakeWeightMultiplier $= 1.0$ will result in the following stake weighting levels shown in table 6

Table 6: Stake weighting multipliers with PUP-21 values and ValidatorStakeWeightMultiplier $= 1.0$

Stake	Multiplier
15 kPOKT	1.0
30 kPOKT	2.0
45 kPOKT	3.0
60 kPOKT	4.0

This results in a total daily POKT minting of 1.9×10^6, a 97% increase in the minted POKT.

As expected, the ValidatorStakeWeightMultiplier must be set to a higher value to keep the POKT minting constant.

A way of finding a suitable multiplier could be found by trying to keep the networks rate of return constant, as if no compounding was done. To achieve this the following can be done:

1. Take the total stake of the network and divide it by ValidatorStakeFloorMultiplier:

$$\text{baseNodes} = \frac{\text{total stake}}{\text{ValidatorStakeFloorMultiplier}}, \quad (1)$$

replacing the values with our simulation results in:

$$\text{baseNodes} = \frac{595800 POKT}{15000 POKT} = 39720. \quad (2)$$

Note that the new (simulated) stake produces more nodes due to the expected increment in the total stake in the network.

2. Take the ratio between this fake amount of nodes an the actual amount of nodes:

$$\text{ValidatorStakeWeightMultiplier} = \frac{\text{baseNodes}}{\text{stakedNodes}}, \quad (3)$$

again, using simulation values:

$$\text{ValidatorStakeWeightMultiplier} = \frac{39720}{20000} = 1.986 \quad (4)$$

Using the obtained value we compute the new multipliers shown in table 7:

This new value results in a total daily POKT minting of 9.6×10^5, The same as before the implementation of the PUP-22 and hence it does not interfere with the WAGMI proposal.

Using the correct values for the PUP-21 we can re-scale the simulated 24 HS POKT gain average by node. If a node runner does not perform any kind of compounding she will remain in the level 1 of the compounding table (see table 7) that means that their gain is going to be modulated by a ~ 0.5 factor. The resulting 24 Hs gain probability in each node tier is now shown in figure 8, and their means are presented in table 8. The implementation of PIP-22 using the PUP-21 values results in a loss of $\sim -13\%$ for any node runner that does not perform compounding.

Table 7: Stake weighting multipliers with PUP-21 values and ValidatorStakeWeightMultiplier $= 1.986$

Stake	Multiplier
15 kPOKT	0.50
30 kPOKT	1.01
45 kPOKT	1.51
60 kPOKT	2.01

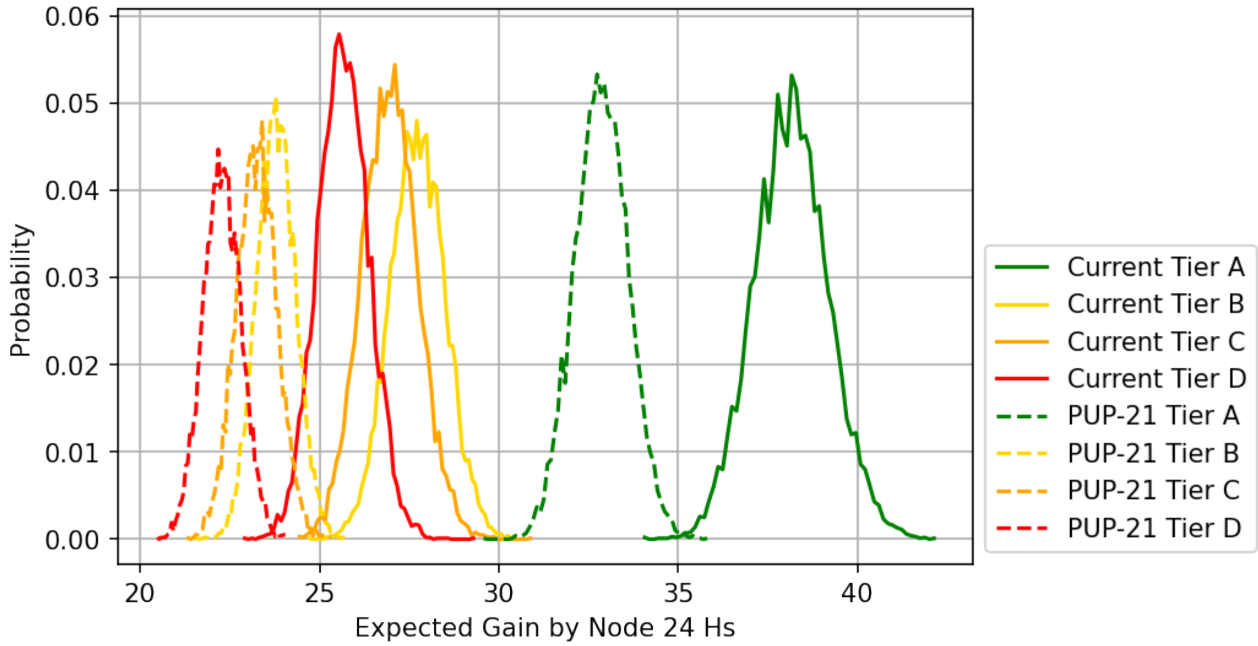

Figure 8: Probability distributions of the 24Hs income per node using a group of 1000 nodes. The solid lines represent the current distributions (using a $\sim 35 \times 10^3$ nodes population) and the dashed lines the expected distributions after the node reduction (using a $\sim 20 \times 10^3$ nodes population) and implementation of PUP-21 weighting.

Table 8: Expected 24 Hs average gain by node with a $\sim 35 \times 10^3$ nodes population and with a $\sim 20 \times 10^3$ nodes population and implementation of PUP-21 weighting.

Node Tier	Full Population Mean	Reduced Population Mean	change
A	38.16	32.86	-13.88%
B	27.74	23.79	-14.23%
C	26.97	23.24	-13.86%
D	25.67	22.28	-13.20%

3.3 Proposed Solution

As shown in the previous subsection the application of the PIP-22 using the PUP-21 parameters could result in a reduction of the node gains on those nodes that do not perform compounding. We propose to enable the DAO to control more than one parameter. Specifically we will show that by controlling the ValidatorStakeWeightMultiplier and the

ValidatorStakeFloorMultiplierExponent a solution can be found where the node runners who do not wish to compound wont see any reduction of their income.

Setting the value ValidatorStakeFloorMultiplierExponent < 1.0 enables the reduction of the minting on the higher levels of the stake compounding. This non linearity could be used to leverage the losses of the first level compounding multiplier, that means that it is possible take gains from the compounded nodes to keep the incomes in the base stake level constant. We propose to do the following to stabilize the POKT minting:

1. Take the total stake of the network and divide it by ValidatorStakeFloorMultiplier:

$$\text{baseNodes} = \frac{\text{total stake}}{\text{ValidatorStakeFloorMultiplier}}, \tag{5}$$

   replacing the values with our simulation results in:

$$\text{baseNodes} = \frac{595800POKT}{15000POKT} = 39720. \tag{6}$$

2. Take the ratio between this fake amount of nodes an the actual amount of nodes **and multiply by a constant K < 1.0**:

$$\text{ValidatorStakeWeightMultiplier} = \frac{\text{baseNodes}}{\text{stakedNodes}} \times K, \tag{7}$$

   using the simulation values and a empirically found value for $K = 0.86$:

$$\text{ValidatorStakeWeightMultiplier} = \frac{39720}{20000} \times 0.86 = 1.70796 \tag{8}$$

3. Using the fixed ValidatorStakeWeightMultiplier find a ValidatorStakeFloorMultiplierExponent such that keeps the minting constant:

$$\frac{\sum_{i=1}^{4} N_i \, M_i}{\sum_{i=1}^{4} N_i} = 1, \tag{9}$$

   where N_i is the number of nodes and M_i is the gain multiplier in the i^{th} compounding level. This can easily be found using a value search. For our simulation the resulting value is ValidatorStakeFloorMultiplierExponent $= 0.8228$

Using the obtained values we compute the multipliers shown in table 9.

By applying the proposed weighting to the simulated values we obtain a total daily POKT minting of 9.6×10^5, The same as before the implementation of the PUP-22 and hence it does not interfere with the WAGMI proposal. Moreover, the proposed parameters have no impact in node runners that do not wish to make any compounding. It can be seen in figure 9 and table 10 that the impact in non-compounded node runners is negligible.

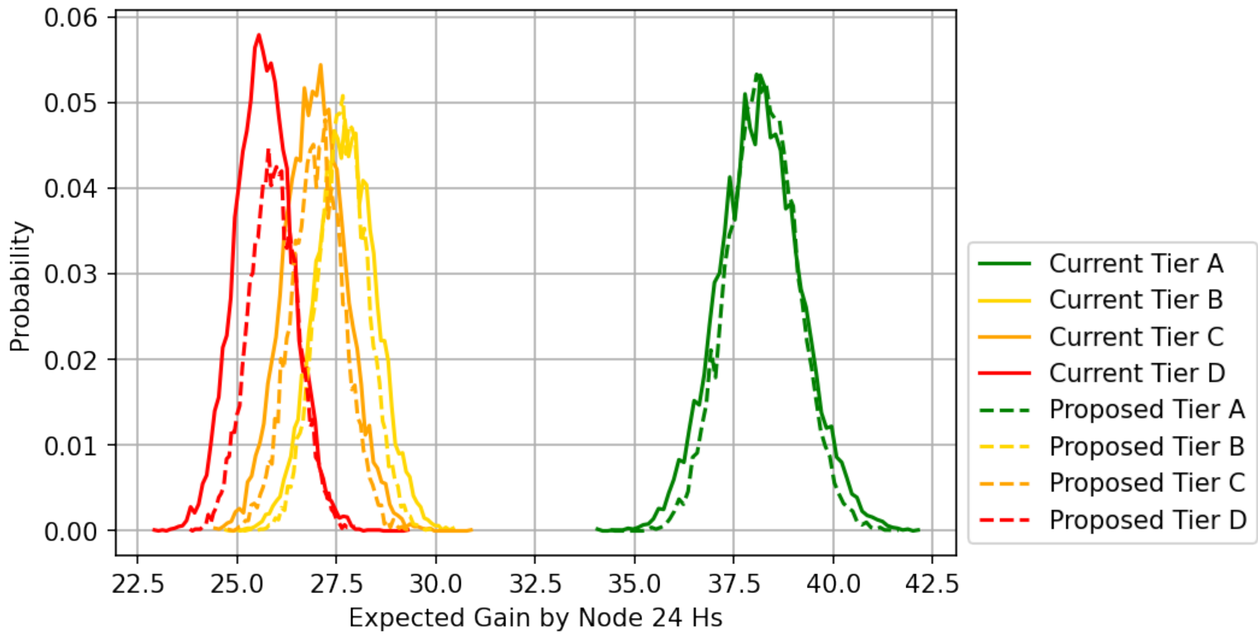

Figure 9: Probability distributions of the 24Hs income per node using a group of 1000 nodes. The solid lines represent the current distributions (using a $\sim 35 \times 10^3$ nodes population) and the dashed lines the expected distributions after the node reduction (using a $\sim 20 \times 10^3$ nodes population) and implementation of the proposed weighting.

Table 9: Stake weighting multipliers with the proposed values : ValidatorStakeWeightMultiplier $= 1.70796$ **and ValidatorStakeFloorMultiplierExponent** $= 0.8228$

Stake	Multiplier
15 kPOKT	0.59
30 kPOKT	1.04
45 kPOKT	1.45
60 kPOKT	1.83

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Table 10: Expected 24 Hs average gain by node with a $\sim 35 \times 10^3$ nodes population and with a $\sim 20 \times 10^3$ nodes population and implementation of the proposed weighting.

Node Tier	Full Population Mean	Reduced Population Mean	change
A	38.16	38.21	<0.1%
B	27.74	27.66	<0.1%
C	26.97	27.03	<0.1%
D	25.67	25.91	0.1%

4 Discussion and Conclusions

In this report we have shown the results of a simulation of a plausible Pocket Network landscape after the implementation of PIP-22. The observed results point out that if the assumptions are correct, the PUP-21 proposed values will result in a reduction of the income in nodes in the initial weighting level, the nodes with less than 30kPOKT stake.

We believe that this reduction in non-compounded node's income is undesirable since the need of compounding is more clear in nodes with lower QoS. A tier A node can still be profitable in the current market. Also the price of keeping low performance nodes alive will be paid by reduction of rewards from all the nodes that wont/cant perform compounding. We believe that this does not align with the goal of the Pocket Network which is to encourage better QoS. Moreover, if after the implementation of PUP-21 the market conditions worsen, it will push every single node runner to perform compounding which in turn will change once more the ValidatorStakeWeightMultiplier to a higher level. This behavior could lead to a race for staking that will only increase the base stake of node and will allow low tier nodes to stay alive only due to stake compounding, kicking out those node runners with good QoS but with no access to capital to compound their nodes (the little guy will pay to keep low QoS whales alive).

In order to fix this probable outcome we propose to enable the DAO to modify an other parameter, the ValidatorStakeFloorMultiplierExponent. We also provide guidance on how it should be adjusted. By means of tuning this value the DAO can find a set of parameters which keep the income of non-compounding nodes stable and regulates the minting of the network by reducing the gains of high-compounded nodes. Moreover, the proposed values only apply a -9% change to the highest compounding level multiplier (when compared to PUP-21 proposed values). We believe that this change is not over-sized in contrast to a loss of -14% on nodes without compounding.

Source Code

The source code of the simulation process is not public and will not be released. The code for reproducing the plots presented in this document and the results of the simulation are being released in "https://github.com/pokt-scan/poktscan-pip-22-simulations". The released code can be used to explore different PIP-22 scenarios. The node tiers cannot be modified since they are part of the simulation. The compounding levels of the nodes can be easily modified by re-assigning the *compoundLevel* column of the *nodeSelectionData* Pandas DataFrame on those nodes with the *useNode* colum value equal to 1.