

PROTOCOL FOR THE ROTATION OF VALIDATOR NODES

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LACCHAIN



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The open-source implementation of the Rotation Protocol for Validator Nodes presented in this paper, as well as tutorials and examples for its use, can be found at <https://github.com/LACNetNetworks/rotation-validator>. LACNet is the Underlying Orchestration Vehicle that orchestrates the LACChain Blockchain Networks developed by the LACChain Alliance.



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1. Scoring of Validator Nodes

In order to rotate nodes in a way that maximizes the performance and decentralization of the network, it is necessary to first understand the health and contribution of active validator nodes. This framework proposes doing this by calculating a Node Health Score, based in the following 5 metrics:

Table 1. KPIs evaluated in validator nodes.

Metric	Definition	Importance (1-5, 5 is most important)
Blocks generated	Node is proposing blocks as expected (compared to other nodes)	5
Block time	Node is proposing blocks within the expected time specified in the genesis file (2 seconds)	4
Online time percent	Node is online as expected	4
Decentralization	Node location is adding decentralization to the network (based on distance to other nodes and number of other nodes in the same location)	3
Block propagation time	Node is proposing blocks that are propagating to other nodes as expected compared to other median of nodes and to previous performance	2



The Node Health Score algorithm is as follows:

- **blocks_score:** $\text{blocks_generated} / \text{max of blocks_generated across all nodes}$.
- **block_time_score:** $1 / (\text{block_time} / 2)$.
- **decentralization_distance:** $\text{avg distance to every other node} / \text{number of nodes in same location}$.
- **decentralization_score:** $\text{decentralization_distance} / \text{max of decentralization_distance across all nodes}$.
- **online_score:** $\text{online_time_percent} / 100$.
- **propagation_avg_score:** $\text{propagation_avg_time} / \text{propagation_time}$. if the result is greater than 1, score is 1.
- **propagation_time_score:** $\text{propagation_time} / \text{median of propagation_time across all nodes}$. if the result is greater than 1, score is 1.

Table 2 shows an example of 3 nodes being scored according to the Node Health Score algorithm. Table 3 shows the overall score for the same set of nodes and performances.

Table 2. Example of scoring for three nodes.

node	node1	node2	node3
blocks_generated	90	90	90
block_score	1.00	1.00	1.00
block_time	2	2	4
block_time_score	1.00	1.00	0.50
online_time_percent	100%	80%	100%
online_score	1.00	0.80	1.00
decentralization_distance	454.90	206.78	78.13
decentralization_score	1.00	0.45	0.17
propagation_time	3.72	552.34	772.87
propagation_time_score	1.00	1.00	0.73
propagation_avg_time	3.72	510.21	773.20
propagation_avg_score	1.00	0.92	1.00



Table 3. Example of overall score.

node	node1	node2	node3
block_score	1.00	1.00	1.00
block_time_score	1.00	1.00	0.50
online_score	1.00	0.80	1.00
decentralization_score	1.00	0.45	0.17
propagation_time_score	1.00	1.00	0.73
propagation_avg_score	1.00	0.92	1.00
overall_score	1.00	0.86	0.74

2. Rotation of Validator Nodes

The validator node health scores are useful to monitor the health of the network, and they are used as inputs to determine the rotation of active and inactive validator nodes. Active validator nodes can be rotated out under two circumstances:

- Health check round
- General rotation round

2.1. Health Check Rounds

The health check rounds are periodical checks on the validators' performance. They are intended to identify validator nodes that are underperforming and rotate them before they lead to a malfunction of the network (e.g., delaying or interrupting block generation). The rules applied are the following:

- Every 30 minutes, the scoring methodology will run to 1) calculate an overall health score for each active node and 2) identify any nodes that are performing below thresholds. Thresholds are presented in Table 4.



- If a node is performing below threshold in the 30 minutes check, a report and an alert are sent to the Permissioning Committee which will decide if the node should be immediately rotated out.¹
- If the node continues to perform below thresholds for 24 hours, the node will be flagged for rotation out and rotation will be triggered automatically.

In the example scores presented in Tables 2 and 3, node #2 would be identified as not hitting the online time percent threshold and node #3 would be identified as not hitting the block time threshold.

Table 4. Thresholds of minimum performance accepted.

Metric	Rotation Threshold
Blocks generated	Node is proposing 85% or fewer blocks than expected
Block time	Node is proposing blocks with an average time greater than 4 seconds
Online time percent	Node is online 95% or less
Decentralization	N/A
Block propagation time	N/A

2.2. General Rotation Round

The general rotation round is the process established to organically rotate out active and rotate in inactive validator nodes. The purpose of this rotation is to allow any entity capable of maintaining a reliable validator node to participate in the block generation while keeping the number of validators set to the optimal number 11 (see Section 2.3). This allows for a high degree of decentralization. The rules applied are the following:

- Every 2 weeks, there will be a general rotation round where 2 active nodes are flagged for rotation out and 2 inactive nodes are proposed for rotation in.

¹ Monitoring tools shall allow to detect malfunctions or misbehaviors of validator nodes instantly. The 30-minute check allows to detect validator nodes that are performing according to the rules established but lacking reliability.



- The algorithm selects the 2 nodes to be rotated out based on rotation probabilities that are based on the Node Health Scores. The lower the score, the higher the rotation probability. The algorithm for the adjusted overall score is $1 / (1 + \text{EXP}(-20 * (\text{overall_score} - 0.9)))$ and for the rotation probability is $(1 - \text{Adjusted overall score}) / \text{Sum of adjusted overall scores}$.
- When an active node is rotated out during general rotation, they will keep their historical health scores and be put in a pool of inactive nodes ready for rotation back in. Active nodes that have been rotated out due to poor performance will not keep their historical health scores and instead be flagged for review by the Permissioning Committee; after review, the node will start from a clean slate and be put into the pool of inactive nodes ready for rotation in.
- The logic for inactive nodes chosen for rotation in are as follows depending on how many nodes need to be rotated in is:
 - 1st replacement node: If available, a node with historical health scores chosen based on the probabilities determined by their average health scores.
 - 2nd replacement node: If available, a node with no previous health scores (e.g., either a complete new node or a previously poorly performing node that was reviewed and cleared by the Permissioning Committee).
 - Continued, flipping between nodes with scores and nodes without scores as available.

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