Governance proposal: deciding Nym reward distribution per network layer

Context, objective, idea

The current reward algorithm only rewards mix nodes but not entry or exit gateways. This is going to be changed so that ALL participants in the active set, whether acting as mix node, entry or exit gateway, are rewarded for their work.

The change is rather simple. The reward formulas stay the same, with the only difference being how the “share of work” variable (denoted as ω_i for node i) is computed for each node.

Until now, all nodes were assigned the same amount of work and thus ω_i was a constant for all nodes (with value 1/240, where 240 is the size of the active set, meaning that each node contributes equally to the total work, summing up to one). This made sense because routing in Nym is uniform, meaning that all mix nodes in a layer receive on average the same amount of packets. If some nodes are losing packets due to being faulty, congested, or offline, then that is captured by the performance parameter, which is also determines rewards.

Gateways, however, whether entry or exit, do not all contribute the same amount of work. Gateways are chosen by clients based on their own criteria, such as country location, network propagation latency, and prior experience (ie, was this gateway reliable when used in the past?). Even if all gateways were serving the same number of clients, some clients may send much more traffic than others, resulting in variable “work” per gateway. Note that mix nodes are still chosen uniformly at random per mixnet hop (layer), per packet, and thus unlike gateways, all the nodes in a layer are given the same amount of work.

An additional consideration is the special position of gateways: entry gateways interact with clients and thus need to perform additional work such as verifying client credentials; while exit gateways in addition act as proxies of the client traffic towards external services, and thus bear increased risks of, e.g, receiving complaints from recipients of the client traffic. Since setting flags to act as exit is voluntary for nodes, it is also crucial to incentivize a sufficient number of nodes to act as exits. This is reflected in an increased contribution to the “work share” assigned to the exit gateway compared to the other nodes in the path. The exact value of the exit premium is to be determined by a community vote.

In more detail, the following elements need to be considered to determine the “work share”:

1. The **share of work** done to **relay 5-hop or 2-hop** traffic: traffic that goes via 5 hops generates more “work” than traffic that only has to be relayed twice. We thus need to

take into account which share of total work corresponded to 5-hop “mixnet” traffic (s_m) and which to 2-hop “vpn” (or “fast”) traffic (s_v). This split is fully determined by the number of mixnet and vpn credentials spent by all clients in a time period, the amount of data allowed by each credential type (if they are not all the same size), and the fact that traffic travels 2 or 5 hops. The split variable is **not configurable**. Also note that $s_m + s_v = 1$

2. The **share of work** done by **each layer** (“hop”) relaying traffic:
    a. For 2-hop (“fast”) traffic, the split of work between the first (l_{ve}) and second (l_{vx}) hops is **configurable**, e.g., 40-60 or 33-67. Note that $l_{ve} + l_{vx} = 1$
    b. For 5-hop (“mixnet”) traffic, the split of work between the layers (l_{me}, l_{mx}, l_{mm}) is **configurable**, e.g., 20-15-15-15-35 or 17-17-17-17-32. Note that $l_{me} + l_{mx} + 3 * l_{mm} = 1$

3. The **share of work** done by the node **within a layer** is determined by the contribution (fraction) of relayed traffic and thus **not configurable**:
    a. For 2-hop (“fast”) traffic, the split of work between all nodes who have collected entry (resp. exit) credentials is proportional to the number of entry (resp. exit) credentials collected by the node, relative to the aggregate amount of entry (resp. exit) credentials collected by all nodes. We denote by f_{ve} and f_{vx} the fraction of entry and exit vpn tickets collected by a node.
    b. For 5-hop (“mixnet”) traffic, the split of work between all entry (resp. exit) gateways who have collected entry (resp. exit) mixnet credentials is proportional to the number of entry (resp. exit) credentials collected by the gateway, relative to the aggregate amount of entry (resp. exit) credentials collected by all entry (resp. exit) gateways. We denote by f_{me} and f_{mx} the fraction of entry and exit mixnet tickets collected by an entry/exit gateway.
    c. For 5-hop (“mixnet”) traffic, the split of work between all mix nodes of a layer is uniform, i.e., if there are W nodes in the layer, then each mix node in that layer performs a share equal to 1/W of the work of the layer.

$$R_i = R \cdot \rho_i \cdot \frac{\sigma_i'}{\beta} \cdot (\omega_i + \alpha \cdot \lambda_i') \cdot \frac{1}{1+\alpha}$$

$$s_m = \frac{5 * (T_{me} + T_{mx})}{T_{ve} + T_{vx} + 5 * (T_{me} + T_{mx})}$$

$$s_v = 1 - s_m$$

$$l_{me} + l_{mx} + 3 * l_{mm} = 1$$

$$l_{ve} + l_{vx} = 1$$

f_ve	fraction of **vpn entry** tickets presented by node in epoch (wrt total vpn entry tickets **T_ve** presented by all nodes)
f_vx	fraction of **vpn exit** tickets presented by node in epoch (wrt total vpn entry tickets **T_vx** presented by all nodes)
f_me	fraction of **mixnet entry** tickets presented by node in epoch (wrt total vpn entry tickets **T_me** presented by all nodes)
f_mx	fraction of **mixnet exit** tickets presented by node in epoch (wrt total vpn entry tickets **T_mx** presented by all nodes)

mixnet entry node (gateway)

$$\omega_i = s_m * l_{me} * f_{me} + s_v * (l_{ve} * f_{ve} + l_{vx} * f_{vx})$$

mixnet exit node (exit gateway)

$$\omega_i = s_m * l_{mx} * f_{mx} + s_v * (l_{ve} * f_{ve} + l_{vx} * f_{vx})$$

mixnet node (inner mixnet layer)

$$\omega_i = s_m * l_{mm} \div W + s_v * (l_{ve} * f_{ve} + l_{vx} * f_{vx})$$

Proposals

The variables that can be configured are thus:

- For 2-hop traffic, the split of work between entry and exit layers: l_{ve} and l_{vx} subject to the constraint that: $l_{ve} + l_{vx} = 1$
- For 5-hop traffic, the split of work among the five layers: l_{me}, l_{mm}, and l_{mx} subject to the constraint that: $l_{me} + l_{mx} + 3 * l_{mm} = 1$

Proposals for 2-hop traffic:

A) $l_{ve} = 0.40\,;\ l_{vx} = 0.60$, i.e, split **40-60**

B) $l_{ve} = 0.33\,;\ l_{vx} = 0.67$, i.e, split **33-67**

Proposals for 5-hop traffic:

C) $l_{me} = 0.20\,;\ l_{mm} = 0.16\,;\ l_{mx} = 0.32$, i.e., split **20-16-16-16-32**

D) $l_{me} = 0.20\,;\ l_{mm} = 0.15\,;\ l_{mx} = 0.35$, i.e., split **20-15-15-15-35**

E) $l_{me} = l_{mm} = 0.17\,;\ l_{mx} = 0.32$, i.e., split **17-17-17-17-32**

F) $l_{me} = l_{mm} = 0.16\,;\ l_{mx} = 0.36$, i.e., split **16-16-16-16-36**

Rationale:

- For **2-hop**, the split simply determines the premium for the exit vs the entry

- For **5-hop**, the first two options (C and D) assign to entry gateways a higher work factor to recognize that they do additional work compared to mix nodes (checking credentials and maintaining client connection state), while exit gateways receive a premium for the additional risk they might face legally as they interface with the clearnet. The two other options (E and F) treat entry gateways the same as mix nodes and only provide a premium to exits.