PHOTREK

Reputation & Voting Weight System
DFR4-RFPD2
Milestone 4 Report

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Date: February 04, 2025

Executive Summary

The reputation and voting weight system project, initiated by SingularityNet's Deep Funding program, is an effort to design a community decision system that enhances the quality of the investments made by the SingularityNET ecosystem. The goal is to reinforce the integrity of the ecosystem while ensuring that community-driven contributions and decision-making align with strategic goals. The Photrek team was initially focused on refining system architecture, defining high-level requirements for microservices to collect and export important data, and outlining functionality desired in the user interface for this system. Current work focuses on developing an RFP for research on decentralized identity (DID) methods and a DID hub for the SNET community. Additional work will focus on creating detailed product requirements documents, outlining a roadmap for future enhancements, and outlining research and suggestions for potential updates to the existing Knowledge Graph based on evolving system needs. This effort represents steps toward designing and implementing a system that will allow voting systems in SingularityNET to account for a variety of contributions and forms of participation from SingularityNET community members that can be taken into account as weighting mechanisms in community decision-making.

Introduction

The Reputation and Voting Weight System is a core initiative under SingularityNET's Deep Funding program, designed to improve community-driven governance by ensuring fair, transparent, and strategically aligned decision-making. The system aims to reduce reliance on monetary investments alone by incorporating diverse contributions and participation metrics into voting weight calculations.

This document outlines the product requirements, roadmap for future enhancements, and knowledge graph updates, ensuring a scalable, modular, and privacy-preserving architecture that can evolve with the ecosystem's needs. The platform will integrate decentralized identity (DID), privacy-preserving reputation scoring, and modular microservices while aligning with best practices for security, compliance, and long-term governance.

Milestone Objectives

This milestone is being updated to focus on the creation of a detailed product requirements document and a roadmap for future enhancements to the system. Additionally, it will include research and suggestions for potential updates to the existing Knowledge Graph (KG) based on the evolving system needs and potential new integrations.

Deliverables:

- A Product Requirements Document that outlines the detailed requirements for the system, including the current scope and potential future functionalities.
- A Roadmap for Future Enhancements.
- Knowledge Graph (KG) Updates

Milestone Accomplishments

Product Requirements

Reputation & Voting Weight System: Product Requirements

1. Executive Summary

The Reputation & Voting Weight System aims to improve the decision-making process in SingularityNET's Deep Funding (DF) governance model by incorporating non-monetary contributions into voting weights. The system introduces a modular microservices-based architecture, allowing flexible reputation score calculations based on diverse forms of participation. It ensures privacy-preserving identity verification, pseudonymous reputation scoring, and expandability for future decentralized identity (DID) and Zero-Knowledge Proof (ZKP) integrations.

This document defines the detailed requirements of the system, covering architecture, microservices, user interface, integration, security, and compliance needs.

2. System Objectives

2.1 Primary Goals

- Enable fairer governance by incorporating contributions (beyond token holdings) into voting weight calculations.
- Support multiple reputation sources through a modular microservices architecture.
- Ensure privacy and security through pseudo-identity mapping and ZKP-ready architecture.
- Integrate with WaLT for decentralized identity (DID) compatibility while maintaining privacy-first principles.
- Allow configurability for different voting scenarios, allowing communities to define reputation models.

2.2 Future Expansion Goals

- Full ZKP integration to enable privacy-preserving on-chain reputation scoring.
- Decentralized Governance Mechanisms (e.g., DAO-driven management).
- AI-powered reputation enhancements, such as fraud detection models.
- Interoperability with broader Web3 ecosystems, enabling cross-platform reputation portability.

3. System Architecture & Design

3.1 High-Level Architecture

The system consists of three core layers:

1. Identity & Authentication Layer

- Wallet Address & DF Profile Mapping: Connect multiple wallets and DF profiles to a single pseudo-identity (pseudo-ID).
- WaLT Integration: Enable compatibility with SingularityNET's Wallet Linking Tool (WaLT).
- Future ZKP Integration: Architect the system for Zero-Knowledge Proof-based identity verification.

2. Reputation Computation Layer

- Microservices-Driven Design: Reputation is computed by independent, configurable microservices.
- Scoring Aggregation Engine: Combines multiple microservice outputs into a final reputation score.
- Role-Based Access Controls:
    - Users: Can view their own reputation data.
    - Admins/Developers: Can oversee scoring models and monitor system behavior.

3. Application & User Interface Layer

- Configurable UI: Users can select microservices, adjust weights, and run calculations.
- Reporting & Analytics: Visualization of historical reputation trends and contributions.
- Export & API Access: Support CSV, JSON, PDF exports and API-based access for external integrations.

4. Functional Requirements

4.1 Must-Have Features

A. Identity & Reputation Mapping

- Wallet & DF Profile Linking:
  - Map wallets + DF profiles to a single pseudo-ID.
  - Ensure one pseudo-ID per human to prevent Sybil attacks.
- Privacy-Preserving ID Handling:
  - Pseudo-ID mappings are hidden from normal users but accessible to admins/developers.
  - Reputation scores are calculated without exposing real identities.

B. Reputation Computation & Weighting

- Configurable Microservices:
  - Allow users to select scoring microservices based on contributions (e.g., engagement, voting history, AGIX holdings, proposal participation, etc.).
  - Enable assigning weights to each microservice's output.
- Standardized APIs for Data Flow:
  - APIs must support secure data exchange between microservices, reputation system, and external tools.
- Error Handling & Fault Isolation:
  - Ensure microservices operate independently, preventing system-wide failures.

C. User Interface & Governance

- User-Friendly UI:
  - Provide dashboard-style interactions for reputation configuration and monitoring.
- Role-Based Permissions:
  - Users: View own scores.
  - Admins: Configure weighting models, microservices, and integrations.
- Reporting & Analytics:
  - Allow users to export reputation data and view trends.

D. Security & Compliance

- Pseudonymization & Anonymization Mechanisms to protect user identity.
- Integration Readiness for Zero-Knowledge Proofs (ZKP) to improve privacy in reputation calculations.
- Compliance with GDPR & CCPA by ensuring data transparency and revocation rights.

5. Roadmap for Future Enhancements

Phase	Milestone	Description
1	**MVP System**	Core **reputation microservices, UI, APIs**
2	**WaLT Integration**	Connect **Wallet Linking Tool** for decentralized identity
3	**ZKP Research**	Define requirements for **Zero-Knowledge Proof privacy**
4	**ZKP Integration**	Implement **ZKP-based identity verification**

6. Knowledge Graph (KG) Enhancements

6.1 Existing KG framework

- The existing KG framework supports data injection, querying, and modification.
- KG is flexible in structure, allowing future integrations with reputation scoring.
- Reference: https://deepfunding.ai/proposal/scalable-metta-knowledge-graphs/

6.2 Potential Enhancements

- Microservice Integration with KG
  - Allow KG to store & process decentralized reputation data.
- Hybrid Reputation Model: KG + Bayesian Networks
  - KG provides structured relationships.
  - Bayesian models offer probabilistic trust scores.
- ZKP-Enhanced Queries
  - Implement privacy-focused query systems for KG reputation insights.

6.3 Research & Next Steps

- Evaluate the feasibility of integrating KG with ZKP privacy models.
- Assess community-driven governance for KG structure modifications.

7. Conclusion

The Reputation & Voting Weight System represents a significant shift in how governance is conducted within SingularityNET's Deep Funding program. The combination of microservices, privacy-first identity handling, and knowledge graph integrations lays the groundwork for a decentralized, trust-driven governance model.

By designing the system to be ZKP-ready from the start, we ensure that future enhancements such as decentralized identity verification, scalable privacy measures, and AI-assisted reputation modeling can be smoothly integrated as the ecosystem evolves.

Future Enhancements

The reputation system and voting weight platform will be continuously refined and expanded to enhance its usability, scalability, and governance mechanisms. Several key areas for future development include:

1. Incentivizing Microservice Integration

To encourage the further development of the platform, an incentive system could be created for developers who develop and maintain microservices.

Possible measures in this area are:

- Rewards for developers: The introduction of an incentive program could motivate developers to create and maintain high-quality microservices in the long term.
- Standardized API framework: Developing a standardized and well-documented API framework could simplify integration and reduce barriers to entry for developers.
- Ecosystem funding program: A funding program for microservices could be created to provide financial support for the development of highly effective and innovative solutions.

2. Decentralized Governance & DAO Framework

Decentralized governance mechanisms could be further developed to strengthen sustainability, transparency and community-driven decision-making in the long term. A possible future option would be the gradual introduction of a Decentralized Autonomous Organization (DAO) framework.

Possible approaches for such a development:

- On-chain governance: Introduction of smart contract-based governance mechanisms that enable token holders, contributors and other relevant stakeholders to vote on system updates, feature enhancements and resource allocations.
- Gradual decentralization: A gradual handover of governance responsibilities from a central team to the community could be considered. This could be done through a scaled model that allows for different levels of participation and ensures that decisions continue to be made efficiently.
- Stakeholder engagement: Develop governance models that allow different user groups (e.g., proposers, reviewers, developers, contributors) to participate in decision-making processes according to their reputation, expertise, or activity within the ecosystem.

3. AI, ZKP & Blockchain Integration

In the future, the integration of more AI and blockchain features could further improve the accuracy, fairness and security of the reputation and voting weight system.

Possible future developments in this area include:

- AI-supported evaluation & fraud detection: The use of AI-powered analytics could help evaluate contributions from reviewers and proposers, detect suspicious voting patterns early on, and optimize weighting calculations for governance decisions.
- On-chain reputation verification: Storing and verifying reputation scores on the blockchain could be considered to ensure data integrity, transparency, and immutability.
- Integration of zero-knowledge proofs (ZKPs): The use of privacy-preserving ZKP protocols could enable anonymous identity verification without disclosing personal data. This could reconcile decentralized transparency and privacy requirements.

4. Integration of TrustLevel's proposal review system as a microservice

To further improve the integrity and quality of governance decisions (esp. funding decisions), the proposal review tool developed by TrustLevel, with support from Photrek, could be integrated into the platform as a microservice.

This would open up the following new possibilities:

- Quality assessment of reviewers and proposers: The reputation system could be made more accurate by collecting relevant data on the quality of proposal reviews, the commitment of proposers, and their overall contribution to the ecosystem.
- Dynamically adjusting reputation weights: Insights from the review system could be used to enable a dynamic adjustment of reputation weights, ensuring that expertise, performance, and historical participation are accurately reflected in governance decisions. Instead of a static reputation model, reputation scores could be continuously refined based on verified contributions and engagement levels.
- Incentives for high-quality contributions: To further encourage high-quality reviews and active participation, an incentive system could be introduced, leveraging the review tool's advanced reputation and proposal rating calculations. This could be done by granting reputation points, governance privileges or even economic incentives.
- More trust and transparency: The introduction of a standardized evaluation framework would ensure that governance decisions are based on sound and credible assessments. This could further strengthen trust in the system.

5. Enhance the voting system by integrating Plural Voting

Create an RFP to enhance the voting system by integrating Plural Voting mechanisms with homomorphic encryption to ensure vote privacy. Based on simulation results from Photrek's previous proposals and ongoing experiments conducted by the team, Plural Voting has demonstrated the most decentralized voting mechanism that optimally balances community welfare and influence distribution.

Goals of Plural Voting

The primary goal of Plural Voting is to incentivize meaningful participation in governance while ensuring a fair and transparent allocation of influence. This can be done with two approaches, a) adding preferential weighting of choices using the current equity style credits, or b) exploring the dynamics of a pay-for-vote system.

Equity-style Plural Voting properties:

- Participants would still receive voting credits equal to the square root of the AGIX holdings

- Rather than an independent ranking from 1 to 10; participants would allocate their AGIX coins to proposals based on the strength of their opinion. The votes per proposal would be equal to the square root of the allocation.
- The square root of the wallet provides a decentralized balance between the participants.

The square of the proposal allocation establishes fair pricing of influence so that extreme opinions are discouraged.

Payment-Style Plural Voting properties

1. Pay to Vote: Participants allocate funds to express their voting preference. The amount assigned to each choice is evaluated using a quadratic scale, ensuring that marginal influence decreases as more is allocated to a single option (i.e., the square root of the allocated amount is taken).
2. Receive a Return: Participants receive a return based on the average payments of all voters, minus a potential fee if applicable. This ensures a more equitable distribution of voting incentives.
3. Payment-style Plural Voting can be viewed as a marketplace for public decisions. In this market, everyone starts as a seller of influence for the public decisions. For decisions, which a participant has a strong opinion, they have the freedom to spend more transitioning into a buyer of influence.
4. Buyers of influence, those who spend more, receive a reward by having a higher probability of achieving their desired outcome on the community decision. Sellers of influence, those who spend less, receive a reward by being compensated for being less influential. This creates a win-win atmosphere for all participants.

To protect voter privacy, homomorphic encryption will be utilized to ensure that votes remain confidential while still enabling transparent result verification.

These future enhancements will ensure that the system remains adaptive, privacy-preserving, and community-driven, supporting scalable governance and improved decision-making within the SingularityNET ecosystem.

Knowledge Graph Updates:

Integration of the platform with the existing Knowledge Graph project:

As part of Deep Funding Round 4, a project was awarded to create the following Knowledge Graph framework for the ecosystem. The ultimate goal is to improve the AI infrastructure within SingularityNET, making it more powerful, scalable, and accessible, while ensuring that it remains decentralized, open, and compatible with multiple AI tools and services.

What the team is planning:

Adam and his team are working on integrating the Hyperon backend with the MeTTa Optimal Reduction Kernel (MORK) to improve the storage, retrieval and processing of knowledge graphs within the SNET ecosystem. This project aims to make AI reasoning and knowledge representation faster, more scalable and more interoperable with other AI systems and services. Their plan includes several important steps:

1. Use Hyperon to manage large knowledge graphs
    - Hyperon will serve as the core module for efficiently and scalably storing and managing structured knowledge.
    - It will enable AI agents to retrieve and use knowledge more effectively.
    - The goal is to store large amounts of information in a compressed but accessible form to improve AI reasoning.
    - Import and process data from various external sources and formats.
    - Store and query large knowledge graphs efficiently.
    - Interact smoothly with other AI and blockchain services.
2. Supporting Multiple Query Languages (SPARQL & MeTTa)
    - SPARQL – a standard knowledge graph query language used in many AI and database systems.
    - MeTTa – a more flexible and AI-optimized language designed for advanced reasoning and inferences.
    - Supporting both languages will make the system compatible with existing AI infrastructure while introducing new, more advanced features.
3. Unifying code, documentation, and knowledge graph data with Metagraphs
    - The team is storing not only data but also AI logic, version control and documentation in Metagraphs (a more advanced and structured way of representing information).
    - This improves transparency, reproducibility and collaboration in AI development.
    - The end goal is to create an ecosystem in which data, code and AI models are seamlessly integrated. Knowledge Graph (KG) framework will allow users to load data, modify specific parts, and share edited versions with others.
    - Scalability: The KG framework is intentionally size-agnostic, meaning it can accommodate vast amounts of structured data without constraints.
4. Creating a comprehensive online editor for AI development
    - They plan to create a web-based MeTTa editor that allows users to:
        - directly interact with knowledge graphs.
        - run AI argumentation processes and test different AI models.

- develop and deploy AI logic in a user-friendly online environment.

Based on our conversations with the team, these are the next steps:

- Current Status: The team is currently working on Milestone 2 of 5 of the project.
- Next Steps:
    1. Develop a framework for KG Interaction:
        - Define how users inject new data, query insights, and retrieve structured outputs through Hyperon's Metagraph framework.
        - Establish standardized APIs for integrating the knowledge graph with reputation microservices and other decentralized AI components.
    2. Introduce 'KG Applications' RFPs (Next DF Round):
        - Create request-for-proposals (RFPs) for applications that leverage KG for decision-making, governance, and analytics.
        - Encourage solutions that enhance knowledge representation and trust-based governance.
    3. Potential Path: Build KG with Adam's Team's Framework
        - Explore integrating Adam's team's Metta-based KG architecture to enhance scalability, flexibility, and AI-assisted reasoning.
        - Assess compatibility with Zero-Knowledge Proof mechanisms for privacy-preserving knowledge queries.

Knowledge Graphs vs. Bayesian Models:

Dominik recently wrote an article about whether knowledge graphs or bayesian models are better suited for reputation systems, or a combination of both. Below is a summary of the article:

The article explores the design of reputation systems for decentralized communities, emphasizing the importance of balancing transparency, accuracy, and privacy. It compares two tools—Knowledge Graphs and Bayesian Networks—highlighting their strengths and limitations in addressing challenges like pseudonymity, fraud, and interoperability.

- Knowledge Graphs excel in representing structured relationships and are ideal for transparency and interoperability, especially when integrated with decentralized identity systems. However, they struggle with handling uncertainty.
- Bayesian Networks specialize in managing uncertainty, enabling real-time updates, fraud detection, and predictive trust calculations. However, they lack the semantic richness and scalability of knowledge graphs.

The article advocates for a hybrid approach that combines these tools:

1. Knowledge Graphs map interactions and relationships.
2. Bayesian Networks evaluate uncertainties and provide probabilistic trust scores.
3. Integration with Decentralized Identity (DID) ensures privacy and portability.
4. Use of Zero-Knowledge Proofs preserves privacy while maintaining trust.

The hybrid model seems to be the most robust solution for fostering trust, detecting manipulation and improving collaboration in decentralized ecosystems in the future, especially in the areas of governance, DeFi and open source projects.

Link to the article:
https://medium.com/@dominik_36234/designing-reputation-systems-for-decentralized-communities-knowledge-graphs-bayesian-networks-or-83dedce94874

Budget & Schedule

Milestone	Description	Budget	Status
1	Project Kick-off / Community Workshop / Architecture Design	$4,450	Submitted - October 18th 2024
2	Microservices Architecture and Layer RFP	$6,300	Submitted - December 19th 2024
3	Decentralized Identity (DID) research RFP	$6,540	Submitted - January 02 2025
4	Product Requirements, Roadmap, and Knowledge Graph Enhancements	$7,710	Submitted - February 04 2025

Future Plans & Change Notifications

References

- RFP Design: DF Reputation Framework
- Reputaion & Voting Weight System Project Plan
- Reputation & Voting Weight System: Workshops
- https://miro.com/app/board/uXjVNtUtkzQ=/
- Community Workshop

- RFP1: SNET DF4-RFPD2 - M2
- RFP2: SNET DF4 - RFPD2 - M3 - DID Hub Research