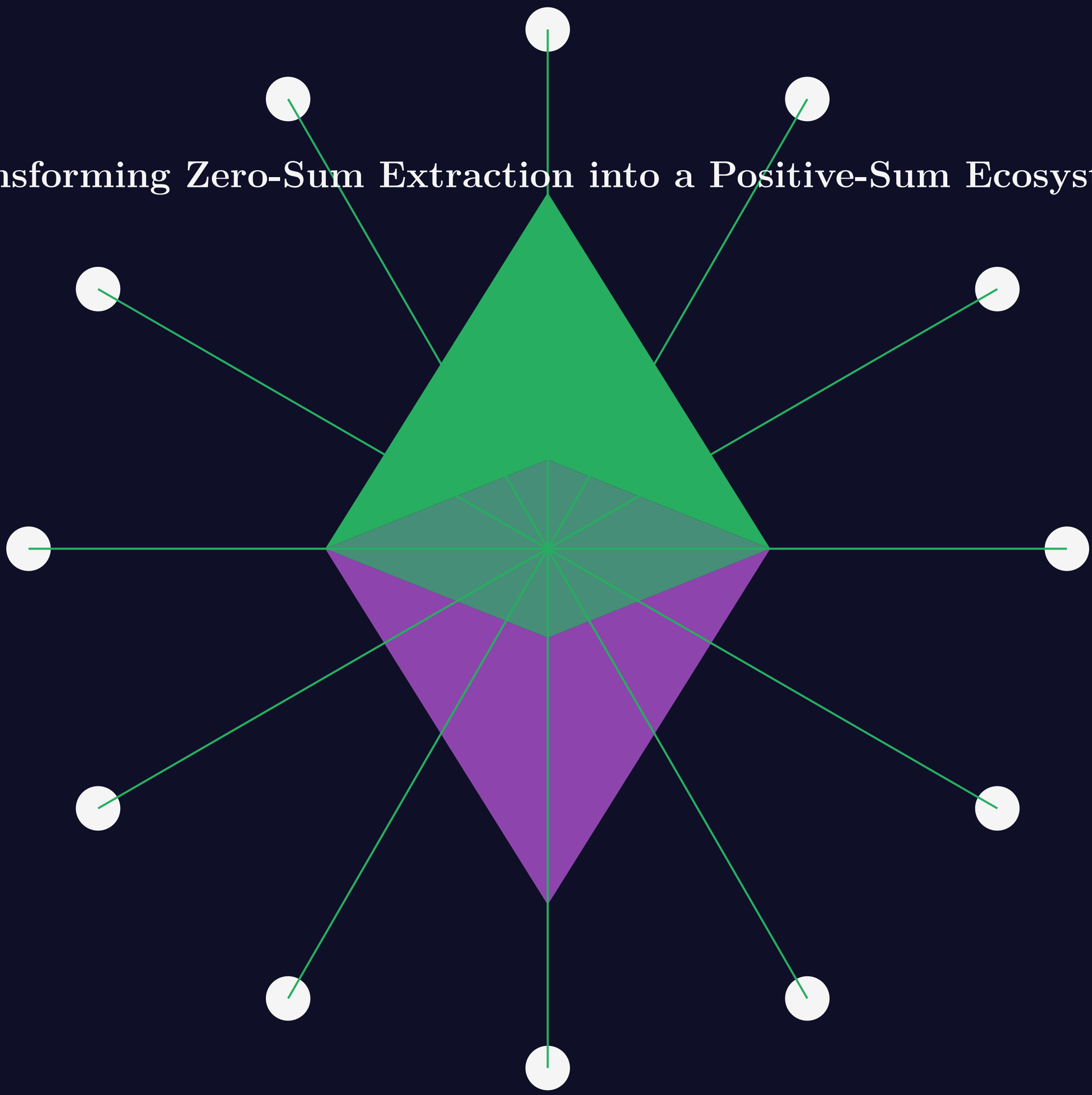
Optimizing EVMs

via a Decentralized MEV Bot Layer

Transforming Zero-Sum Extraction into a Positive-Sum Ecosystem



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Optimizing the Ethereum Virtual Machine via a Decentralized MEV Bot Layer: Transforming Zero-Sum Extraction into a Positive-Sum Ecosystem

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Abstract

This proposal explores a transformative framework to integrate decentralized Maximal Extractable Value (MEV) bots into the Ethereum Virtual Machine (EVM). Traditionally, MEV extraction has been exploitative, benefiting MEV bots while disadvantaging users through tactics like sandwich attacks. By reconfiguring MEV bots to protect users, share profits, and align incentives with network health, we envision a system where MEV extraction becomes a positive-sum ecosystem. This framework introduces adaptive profit-sharing mechanisms, flexible governance via staking and slashing, fraud detection tools, and network-wide collaboration. With user security and ecosystem sustainability at its core, this proposal redefines the MEV landscape to create a collaborative, fair, and self-sustaining blockchain environment.

1 Introduction

Maximal Extractable Value (MEV) refers to the potential profits that can be extracted from the blockchain's transaction ordering, including the reordering, inclusion, or exclusion of transactions in a block. MEV bots, designed to exploit these opportunities, have often contributed to predatory tactics such as front-running and sandwich attacks, where users are manipulated to provide profits for bots.

This proposal presents a novel approach by shifting MEV bots from being adversarial agents to cooperative participants in the blockchain ecosystem. By transforming the relationship between bots, users, and the network, the decentralized MEV bot layer can convert the zero-sum nature of MEV extraction into a positive-sum system. This approach leverages profit-sharing, adaptable governance, and bot coordination to enhance network performance, safeguard users, and reduce fraud. Ultimately, it offers a path to a more balanced, user-friendly blockchain ecosystem where incentives align for all participants.

2 Enhancing Network Performance

2.1 Transaction Sequencing for Optimal Block Space Usage

Mechanism: MEV bots can optimize transaction ordering to maximize the efficiency of block space usage. Rather than rigidly following the highest fees, bots can reorder transactions based on dynamic criteria such as gas cost optimization, transaction size, and priority.

- **Dynamic Transaction Reordering:** Bots could reorder transactions to avoid congestion, reducing gas spikes by clustering low-cost transactions during peak times.
- **Gas Price Smoothing:** By predicting demand, MEV bots could help minimize gas price fluctuations, offering users smoother execution of transactions with less volatility.
- **Load Balancing:** Bots distribute transaction load evenly across the network, helping to ensure that no single node becomes overburdened, reducing latency and increasing throughput.

Benefits:

- **Lower Gas Costs:** By optimizing transaction inclusion, users benefit from lower fees, especially during high-demand periods.
- **Reduced Congestion:** Better load management leads to smoother operation during periods of heavy traffic, decreasing wait times and transaction failures.
- **Optimized Block Utilization:** Bots ensure that blocks are filled efficiently, maximizing the use of available block space.

2.2 Automated Market Making and Liquidity Provision

Mechanism: MEV bots can act as automated market makers (AMMs), providing liquidity across decentralized exchanges (DEXs) and stabilizing prices. In this role, bots maintain continuous trading pairs, reduce slippage, and take advantage of arbitrage opportunities to keep the markets balanced.

- **Liquidity Management:** Bots can ensure adequate liquidity in key asset pairs, reducing slippage for larger trades and maintaining market stability.
- **Price Stabilization:** By correcting price disparities across exchanges, MEV bots can balance asset prices and reduce short-term volatility.

Benefits:

- **Trader Benefit:** Lower slippage and improved liquidity directly benefit traders, particularly during periods of high volatility.
- **Market Efficiency:** Enhanced liquidity provision leads to tighter spreads, improving overall market efficiency.
- **Smoother Price Action:** Bots' ability to execute cross-platform trades ensures that prices remain consistent across different DEXs.

2.3 Cross-Chain Arbitrage and Market Efficiency

Mechanism: MEV bots can execute cross-chain arbitrage opportunities, buying assets on one blockchain where prices are lower and selling them on another where prices are higher. This interoperability between blockchains provides efficient markets that reflect real-world asset values.

- **Arbitrage Execution:** Bots track price differences across chains and exploit these discrepancies by executing trades that align prices.
- **Cross-Chain Liquidity:** Arbitrage between blockchains adds liquidity to multiple networks simultaneously, benefiting the broader decentralized ecosystem.

Benefits:

- **Price Consistency:** Bots help to equalize prices across networks, reducing the discrepancies that arise due to the fragmentation of liquidity across different blockchains.
- **Increased Efficiency:** Arbitrage reduces inefficiencies and ensures that asset prices better reflect global supply and demand.
- **Enhanced Interoperability:** Cross-chain arbitrage promotes stronger connections between blockchain ecosystems, facilitating growth and integration.

3 Enhancing Security and Privacy

3.1 Mitigating Malicious Activities (Sandwich Attack Prevention)

Mechanism: Traditionally, sandwich attacks manipulate transaction ordering, allowing bots to profit by executing trades before and after a user's transaction to manipulate the price. In this new system, MEV bots can detect such malicious attempts and intervene to protect the user, profiting slightly while safeguarding user funds.

- **Sandwich Attack Detection:** MEV bots can recognize when a user transaction is vulnerable to a sandwich attack, flagging the suspicious activity.
- **Preventative Execution:** Bots can then execute trades to prevent the malicious actor from completing the attack, adjusting prices slightly in the user's favor while collecting a small profit for the network.

Benefits:

- **User Protection:** Users are shielded from price manipulation and unfair losses caused by malicious actors.
- **Bot Profitability:** Bots can still collect minor profits by using price manipulation in a protective rather than exploitative manner.
- **Network Security:** Reducing successful sandwich attacks enhances the overall security and trust in the network.

3.2 Privacy Enhancement through Obfuscation

Mechanism: MEV bots can employ cryptographic techniques such as zero-knowledge proofs and transaction aggregation to enhance user privacy. These methods ensure that while transactions remain valid and compliant, their details are hidden from potential adversaries.

- **Obfuscation of Transaction Details:** By using cryptographic techniques, bots can protect the privacy of user transactions without compromising the validity of the transaction on-chain.
- **Zero-Knowledge Proofs (ZKP):** ZKP techniques can validate transactions without revealing the full details of the transaction to external parties.

Benefits:

- **Increased Privacy:** Users benefit from enhanced privacy protections, safeguarding their transaction data from prying eyes.
- **Maintained Transparency:** Critical transaction information remains visible for compliance and auditability while protecting sensitive user details.

4 Economic and Game-Theoretic Implications

4.1 Profit Redistribution via Smart Contracts

Mechanism: MEV bots can be designed to share the profits they generate from arbitrage and transaction optimization with the users who initiate the transactions. Smart contracts automatically split profits between the user, the bot, and validators, creating a more equitable distribution of MEV extraction.

Flexible Profit-Sharing Formula:

$$\text{User Share} = \text{Total Profit} \times \alpha$$

$$\text{Bot Share} = \text{Total Profit} \times (1 - \alpha)$$

Where α could range between 1% and 5%, depending on the transaction size, market conditions, and user-defined criteria.

Benefits:

- **Fairer Ecosystem:** Users no longer bear the entire cost of MEV extraction. Instead, they share in the benefits.
- **Incentive Alignment:** Both bots and users are incentivized to act in ways that benefit the network, reducing exploitative behavior.
- **Market Flexibility:** The dynamic formula can adjust to changing market conditions, ensuring continued profitability for bots while protecting user interests.

4.2 Transforming MEV into a Positive-Sum Game

Mechanism: By changing the competitive, zero-sum nature of MEV into a collaborative, positive-sum framework, the entire ecosystem benefits. Bots work alongside users, not against them, and profits are shared to incentivize better behaviors.

Benefits:

- **Sustainable Growth:** The cooperative framework promotes long-term sustainability, reducing harmful practices such as gas wars and front-running.
- **Lower Market Volatility:** Collaborative MEV extraction results in fewer price spikes, reducing overall market volatility.
- **User Empowerment:** Users feel empowered to participate in the ecosystem, knowing that bots are acting in their best interest.

5 Staking and Slashing Mechanisms for Governance

5.1 Flexible Staking Requirements for MEV Bots

Mechanism: MEV bots can be required to stake tokens proportional to their expected profits. The staking system should remain flexible, with options for varying staking levels based on the bot's activity and market conditions.

Options for Staking:

- **Dynamic Staking Levels:** Bots that engage in more frequent or riskier behavior might be required to stake more tokens than conservative bots.
- **Staking Adjustments:** The staked amounts can change depending on market volatility, network activity, or community governance decisions.

Benefits:

- **Increased Network Security:** The more bots stake, the higher the collateral they place on their own good behavior.
- **Encouraged Compliance:** Flexible staking allows for bots to adapt to network conditions while remaining compliant with the rules.

5.2 Exploring Slashing Conditions

Mechanism: Slashing penalties can vary depending on the severity of the misbehavior. Rather than rigid rules, this system allows for partial or full slashing, depending on the context, governed by a decentralized decision-making process.

Options for Slashing:

- **Partial Slashing:** Minor misbehaviors or accidental protocol violations may result in only a portion of the staked tokens being slashed.
- **Full Slashing:** Severe violations, such as malicious attempts to exploit the network, can result in full slashing and expulsion from the bot network.

Benefits:

- **Tailored Punishments:** Flexibility in slashing allows the network to penalize bots proportionally, ensuring fairness while maintaining security.
- **Decentralized Governance:** The community can decide on slashing rules, adapting them to the evolving needs of the network.

6 Coordinated Network of Compliant Bots

6.1 Methods of Coordination

Mechanism: Bots coordinate through decentralized communication protocols, maintaining an interconnected network of compliant participants. This coordination allows for the network to crowd out rogue actors while promoting the long-term health of the ecosystem.

Options for Coordination:

- **Bot-to-Bot Communication Protocols:** Bots can share information about transaction sequencing, vulnerabilities, and network conditions to create a more resilient system.
- **Reputation Systems:** Bots can be assigned reputation scores based on their compliance with network rules. Bots with higher reputations gain access to more profitable transactions.

Benefits:

- **Rogue Bot Isolation:** A well-coordinated network of compliant bots reduces the chances of a rogue bot causing significant damage.
- **Collaborative Efficiency:** A network of bots working together results in a more efficient system, with fewer opportunities for exploitation.

7 Reducing Fraud and Scams Through MEV Bot Monitoring

7.1 Fraud and Scam Detection

Mechanism: Instead of focusing on regulatory compliance, the decentralized MEV bot network can be tuned to actively reduce fraud and scams by detecting and flagging suspicious transactions. Bots can use machine learning algorithms and predefined rules to identify potential fraud and act preemptively.

- **Suspicious Transaction Monitoring:** Bots scan transactions in real-time, looking for anomalies that suggest fraudulent or malicious activity.
- **Fraud Prevention:** Once flagged, these suspicious transactions can be rerouted, delayed, or blocked to protect users and prevent potential losses.

Benefits:

- **User Fund Protection:** Fraudulent transactions are detected and prevented before they can be executed, safeguarding users' assets.
- **Improved Network Trust:** With active fraud detection, the network becomes a safer place for users to transact, increasing confidence in the system.

8 Integration with the EVM for Governance and Enforcement

8.1 Direct EVM Connection

Mechanism: MEV bots can be integrated directly into the Ethereum Virtual Machine (EVM) for real-time monitoring, governance, and enforcement of compliance. The EVM can issue protocol updates to bots, enforce penalties, and monitor bot behavior without needing human intervention.

Benefits:

- **Immediate Response to Threats:** By being connected directly to the EVM, MEV bots can receive immediate updates and take action to neutralize threats.
- **Automated Governance:** The EVM ensures that bots stay compliant with network rules, eliminating the need for constant oversight by human actors.

9 Conclusion

The introduction of a decentralized MEV bot layer within the EVM marks a fundamental shift in how we understand and manage MEV extraction. By focusing on user security, flexible governance, and decentralized coordination, this proposal creates a sustainable, positive-sum ecosystem. MEV bots are transformed from adversarial entities into collaborative agents, aligning their interests with those of the users and the network. Through profit-sharing, fraud detection, privacy enhancements, and flexible staking, this system establishes a blueprint for a more equitable, resilient, and trustworthy blockchain ecosystem.

10 Visualizing the Decentralized MEV Bot System

To comprehensively understand the operations and interactions within the proposed decentralized MEV bot layer, we present an enhanced flowchart that illustrates the end-to-end process of the system. This visualization delves into how MEV bots optimize transactions, protect users, redistribute profits, and integrate with governance mechanisms.

10.1 Comprehensive System Flowchart

The flowchart in Figure 1 depicts the complete workflow of the decentralized MEV bot system, highlighting key components such as user transactions, MEV bot actions, profit redistribution, staking and slashing mechanisms, network coordination, and integration with the EVM.

10.2 Flowchart Explanation

In Figure 1, the process initiates when a **user submits a transaction** to the network. The **MEV bot scans the transaction** to assess its contents and potential implications.

The bot then reaches a **decision point** where it determines if any **malicious activity is detected**, such as potential sandwich attacks or front-running opportunities that could harm the user.

- **If malicious activity is detected** (*Yes* path):
  - The bot **intervenes to protect the transaction**, implementing measures to prevent exploitation.
  - Proceeds to **profit redistribution** via smart contracts, ensuring fair sharing of any profits from protective actions.
- **If no malicious activity is detected** (*No* path):
  - The bot **optimizes transaction sequencing** to enhance network performance, such as reducing gas fees or improving block utilization.
  - Proceeds to **profit redistribution** via smart contracts, sharing optimization benefits.

After profit redistribution, the bot **stakes tokens** as part of the governance mechanism, aligning its interests with network health. The bot's **behavior is monitored** continuously.

Another **decision point** assesses if any **misbehavior is detected**:

- **If misbehavior is detected** (*Yes* path):
  - The network **applies slashing mechanisms**, penalizing the bot by reducing its staked tokens.

  - The process leads to the **end state**, emphasizing enhanced network security through enforcement.

- **If no misbehavior is detected** (*No* path):
  - The bot **continues operations**, maintaining its role in the network.
  - It **coordinates with other MEV bots** to improve efficiency and security.
  - **Integrates with the EVM** for ongoing governance and compliance.
  - The process culminates in the **end state** of enhanced network performance and security.

10.3 Key Components Highlighted

The flowchart emphasizes several critical components:

- **User Protection:** MEV bots actively detect and prevent malicious activities to safeguard users.
- **Transaction Optimization:** Bots enhance network performance by optimizing transaction sequencing.
- **Profit Redistribution:** Profits from bot activities are fairly redistributed among participants via smart contracts.
- **Staking and Governance:** Bots stake tokens and are subject to slashing mechanisms, promoting compliant behavior.
- **Network Coordination:** Bots collaborate with each other, sharing information and strategies to strengthen the network.
- **EVM Integration:** Bots integrate with the EVM for real-time governance, enforcement, and protocol updates.

10.4 Enhanced Visual Representation

This comprehensive flowchart provides a detailed visual representation of the decentralized MEV bot system. It illustrates the interplay between various components and processes, offering a deeper understanding of how MEV bots transform from adversarial entities into collaborative agents that enhance the overall blockchain ecosystem.

The visualization highlights the system's complexity and the collaborative efforts to align incentives, promote security, and ensure efficient network operations.

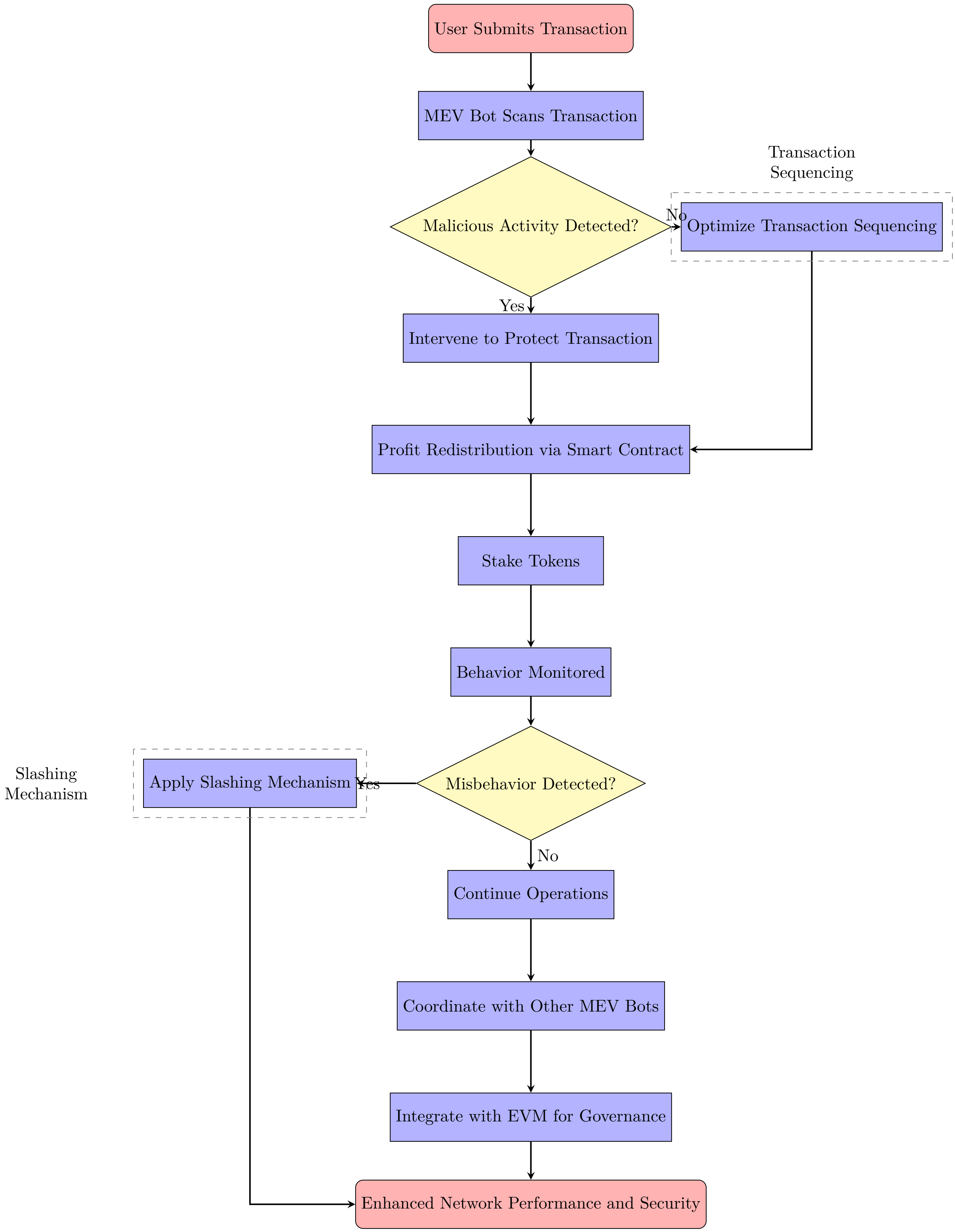

Figure 1: Comprehensive flowchart of the decentralized MEV bot system operation.