Levery: A Compliant Infrastructure for Institutional DeFi via Uniswap v4 Hooks

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Abstract

Levery represents an innovative approach to bridging traditional finance and decentralized finance (DeFi) through a permissioned Automated Market Maker (AMM) model integrated with Uniswap v4 hooks. Leveraging features such as flash accounting, a singleton pool design, and customizable hook callbacks, Levery enforces dynamic fee adjustments and rigorous compliance checks (including AML, KYC, and KYB measures).

This paper details the technical framework of Levery, including its dynamic fee calculation methodology, real-time oracle integration, security protocols, and compliance mechanisms. Empirical simulations further demonstrate that liquidity providers achieve over six times the gains compared to Uniswap V3, while swap prices remain competitive.

1 Introduction

Decentralized Finance (DeFi) has fundamentally transformed financial markets by enabling permissionless, non-custodial trading and liquidity provision. However, many existing protocols lack the robust compliance measures required by traditional financial institutions. Levery addresses this challenge by integrating with Uniswap v4 through hooks, thereby implementing a permissioned Automated Market Maker (AMM) that incorporates identity verification, regulatory compliance, and dynamic market adjustments.

1.1 Background and Related Work

The evolution of AMM protocols—from Uniswap v1 and v2 to the concentrated liquidity of Uniswap v3—has significantly improved capital efficiency. Uniswap v4 Core [1] further advanced the field by introducing hook mechanisms that allow for flexible integration of custom logic. Although protocols such as Balancer and Curve have explored various liquidity models, they often do not meet the stringent compliance requirements necessary for institutional adoption. Levery builds on these advancements by focusing on regulatory compliance and enhancing liquidity provider (LP) efficiency.

1.2 Contributions and Limitations

This paper makes the following contributions:

1. **Compliance-Integrated AMM:** Extension of Uniswap v4's hook architecture to incorporate rigorous compliance checks.
2. **Dynamic Fee Mechanism:** A novel method to adjust fees in real time based on market data, effectively mitigating toxic arbitrage.
3. **Enhanced LP Efficiency:** Implementation of dynamic fee adjustments during swap operations to protect LPs from trades executed at prices far from market value.
4. **Empirical Evaluation:** Simulation results demonstrate over six times greater gains for LPs using Levery compared to Uniswap V3.

Limitations include assumptions regarding oracle data reliability and potential latency in compliance verification—areas identified for future research.

2 Institutional Market Need

The institutional financial market demands platforms that combine the cost efficiencies of DeFi with robust compliance and transparency. With blockchain technology poised to transform markets valued at over $867 trillion [2], institutions require systems that facilitate secure trading of both digital and tokenized real-world assets. Levery is designed to meet these needs by enforcing strict regulatory protocols while reducing transaction costs and counterparty risks.

3 Technical Framework

3.1 Leveraging Uniswap v4 Hooks

Uniswap v4 Core [1] introduced a flexible hook architecture that permits the injection of custom logic at critical stages of a pool's lifecycle. Levery adapts this architecture to:

- Execute pre-swap compliance checks (AML, KYC, KYB).
- Dynamically adjust fees based on real-time market data.
- Implement custom accounting routines for enhanced regulatory reporting.

3.2 Dynamic Fee Calculation

Dynamic fee calculation in Levery mitigates risks such as impermanent loss and toxic arbitrage. Define:

- P_0 and P_1: current asset prices in the pool.
- M: real-time market price retrieved from decentralized price oracles.
- α: liquidity provider fee multiplier.
- F_{base}: base swap fee.
- F_{pool}: pool-specific fee, if applicable.

The initial swap fee is given by:

$$F_{\text{swap}} = \begin{cases} F_{\text{pool}}, & \text{if } F_{\text{pool}} \neq 0, \\ F_{\text{base}}, & \text{otherwise.} \end{cases} \tag{1}$$

Subsequent adjustments are computed as:

$$F_{\text{swap}} = \begin{cases} F_{\text{swap}} + \left(\dfrac{P_0 - M}{M} \times \alpha\right), & \text{if } P_0 > M \text{ and swap from asset 0 to 1,} \\ F_{\text{swap}} + \left(\dfrac{M - P_0}{M} \times \alpha\right), & \text{if } P_0 < M \text{ and swap from asset 1 to 0,} \\ F_{\text{swap}}, & \text{otherwise.} \end{cases} \tag{2}$$

This mechanism ensures that fees are dynamically adjusted in real time to reflect current market conditions, thereby protecting LPs from adverse price movements and toxic arbitrage.

3.3 Oracle Integration

Levery integrates with multiple decentralized price oracles via offchain reporting (OCR) protocols to obtain accurate, real-time market data. This data continuously informs dynamic fee adjustments, ensuring that transaction prices remain aligned with global market conditions.

3.4 Architecture and Security

3.4.1 Permissioned AMM and Compliance Hooks

Levery incorporates identity verification and compliance checks within each hook callback. This ensures that only authorized and compliant participants can execute swaps or liquidity operations, in accordance with institutional regulatory standards.

3.4.2 Singleton Model and Flash Accounting

By leveraging Uniswap v4's singleton model, Levery consolidates the state of all pools into a single contract, reducing deployment costs and enhancing efficiency. Flash accounting mechanisms maintain balanced internal token states during complex multi-hop transactions, significantly lowering gas costs.

3.4.3 Multisig Security via the Safe Ecosystem

Integration with the Safe (formerly Gnosis Safe) ecosystem enables multisignature approvals for critical transactions, thereby minimizing counterparty risk and preventing unauthorized operations.

4 Operational Flows

This section outlines the business logic and flow diagrams for Levery's core operations. Each subsection succinctly explains the underlying process—detailing the pre-execution hooks, on-chain compliance verifications, and final execution steps—accompanied by a corresponding flow diagram. These diagrams capture the sequential decision points and actions, reflecting Levery's layered approach to risk management and regulatory compliance.

4.1 Swap Operation Flow

Business Logic:

- **Compliance Check:** Validate that the wallet meets all AML, KYC, and KYB requirements.
- **BeforeSwap Hook:** Execute additional verification and logging.
- **Oracle Retrieval:** Retrieve the current market price in real time.
- **Dynamic Fee Adjustment:** Adjust the swap fee based on the deviation between the pool price and the market price (mitigating toxic arbitrage).
- **Execution:** Proceed with the swap only if the compliance check is successful.

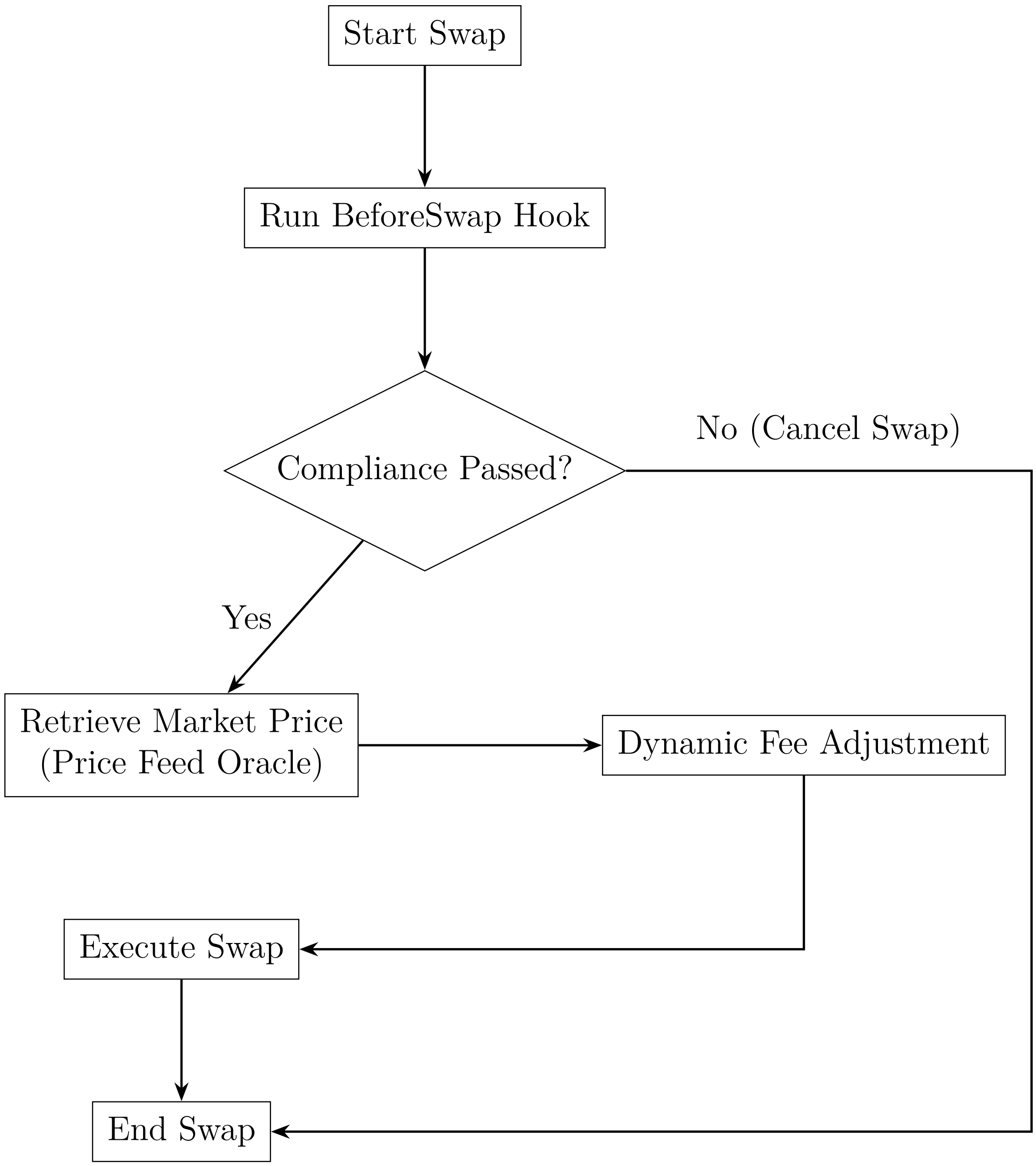

Figure 1: Swap Operation Flow: BeforeSwap Hook, Compliance Check, Oracle Integration, and Dynamic Fee Adjustment

4.2 Add Liquidity Operation Flow

Business Logic:

- **BeforeAddLiquidity Hook:** Execute risk analysis, logging, and additional verifications.
- **Onchain Compliance Check:** Verify on-chain that the user is compliant.
- **Operation:** Proceed with adding liquidity to the pool.

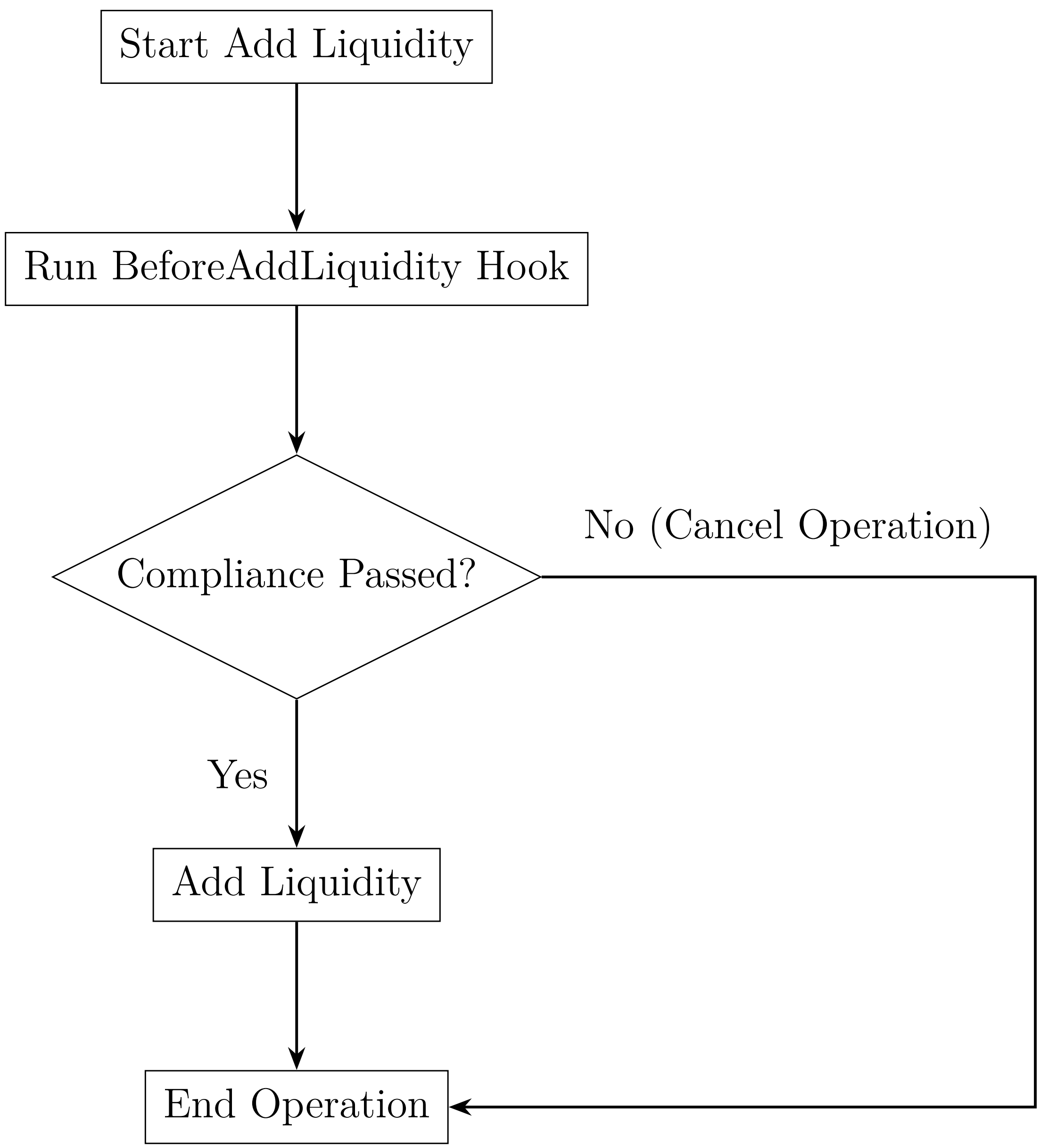

Figure 2: Add Liquidity Operation Flow: Hook Execution followed by Onchain Compliance Verification

4.3 Remove Liquidity Operation Flow

Business Logic:

- **BeforeRemoveLiquidity Hook:** Execute additional verification and logging.
- **Onchain Compliance Check:** Verify on-chain that the user remains compliant.
- **Operation:** Proceed with the removal of liquidity from the pool.

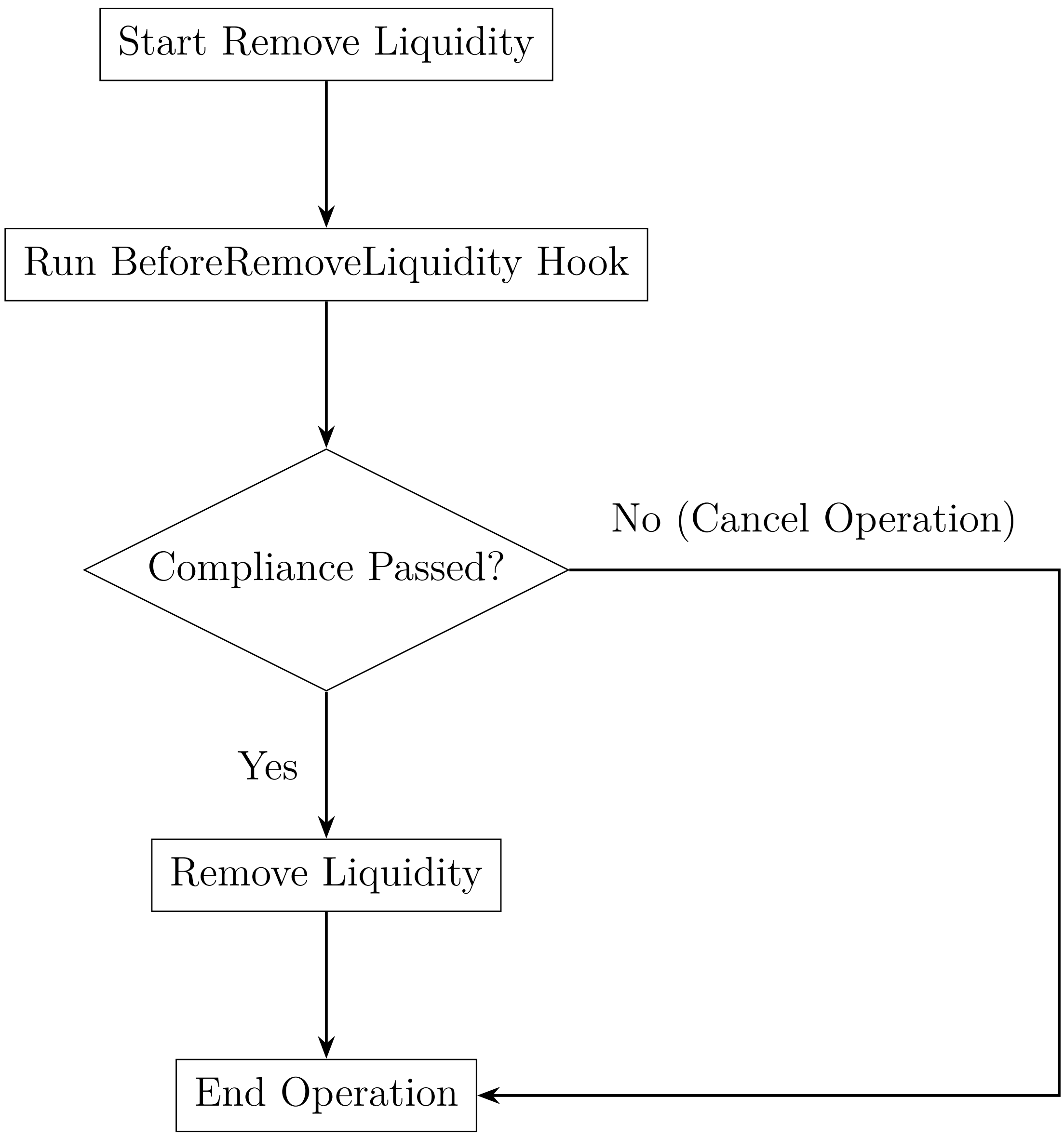

Figure 3: Remove Liquidity Operation Flow: Hook Execution followed by Onchain Compliance Verification

5 Efficiency for Liquidity Providers

One of the major challenges in current AMM platforms is toxic arbitrage, where swaps are executed at prices that deviate significantly from the true market value. Such discrepancies often lead to adverse price execution and increased impermanent loss for liquidity providers (LPs). Levery addresses this issue by employing a dynamic fee mechanism during swap operations. By continuously retrieving real-time market prices from decentralized price oracles and adjusting swap fees accordingly, Levery narrows the gap between the pool's internal price and the global market price. This adjustment not only deters arbitrageurs but also ensures that LPs receive a fair share of fees, thereby enhancing their overall efficiency and profitability.

5.1 Empirical Evaluation

We conducted simulations comparing historical swaps on Uniswap V3 with simulated results using the Levery Hook on Ethereum Mainnet, covering the period from March 10, 2024, to June 8, 2024. The simulation focused on a Uniswap V3 pool for USDC/ETH with a 0.05% fee (pool address: 0x88e6A0c2dDD26FEEb64F039a2c41296FcB3f5640), with a total pool volume of approximately $440M USD. A Chainlink Oracle for ETH/USDC (address: 0x5f4eC3Df9cbd43714FE2740f5E3616155c5b8419) provided pricing data.

Key simulation results include:

- **Swaps Analyzed:** 5,739 historical swaps.
- **Fee Comparison:** Uniswap V3 operated at a fee of 0.05%, whereas Levery's average fee was 0.31%.
- **LP Fee Gains:** Total liquidity provider fees accrued were approximately $1.39M USD for Levery, compared to $220K USD for Uniswap V3—yielding gains of over six times.
- **Market Competitiveness:** Despite higher fees, Levery pools remain competitive for swappers due to dynamic fee adjustments that maintain alignment with market prices. Importantly, the fee multiplier is constrained to be less than 100% of the difference between the market price and the pool price. This ensures that the dynamic fee mechanism never amplifies the fee adjustment beyond the actual price differential, thereby preventing the pool from quoting prices that are excessively favorable to liquidity providers.

The complete simulation source code is available at `https://github.com/levery-org/levery-market-simulation`.

6 Conclusion and Future Work

Levery represents a significant advancement in bridging traditional financial systems with decentralized finance. By integrating with Uniswap v4 and extending its hook architecture for compliance enforcement, Levery enhances security, operational efficiency, and regulatory adherence. The dynamic fee mechanisms—driven by real-time oracle integration—ensure that swap transactions occur near prevailing market prices, thereby protecting liquidity providers and reducing exposure to toxic arbitrage.

Future work will focus on expanding asset support, further optimizing dynamic fee mechanisms through comprehensive simulation studies, and enhancing regulatory reporting features to meet evolving institutional requirements.

7 Glossary

AMM **Automated Market Maker:** A type of decentralized exchange protocol that uses mathematical formulas to price assets, eliminating the need for traditional order books.

KYC **Know Your Customer:** A process used to verify the identity of clients, ensuring compliance with legal regulations.

KYB **Know Your Business:** Similar to KYC, this process verifies the legitimacy and compliance of a business entity.

AML **Anti-Money Laundering:** Regulations and procedures aimed at preventing the laundering of money obtained through illicit activities.

DeFi **Decentralized Finance:** Financial services built on blockchain technology that operate without central intermediaries.

Oracle **Decentralized Oracle:** A service that provides external data (such as market prices) to blockchain-based smart contracts.

References

[1] Hayden Adams, Moody Salem, Noah Zinsmeister, Sara Reynolds, Austin Adams, Will Pote, Mark Toda, Alice Henshaw, Emily Williams, and Dan Robinson. Uniswap v4 core, 2024. August 2024.

[2] World Economic Forum. Digital assets, distributed ledger technology and the future of capital markets, May 2021.

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