Lanca Bridging Framework: Enabling Cross-chain Liquidity Through A Dual-Layer Liquidity Management System

Andy Bohutsky [1], Oleg Kron [1], Phuc Le [1]

[1] Concero & Lanca Labs

Abstract

Cross-chain solutions commonly face significant challenges, such as the need for substantial liquidity to be locked across multiple blockchains, resulting in inefficiencies, and a course to compromise security in favour of achieving faster transaction speeds. This problem encourages us to develop a better solution to address all of these disadvantages without trading off any aspect of the cross-chain bridge trilemma - the Lanca Bridging Framework.

Lanca is a fully decentralised cross-chain bridging framework enabling seamless value transfer across different blockchain networks. Its technology is based on an innovative parent-child pool architecture and dynamic IOU (I-owe-you) system. Lanca addresses these aforementioned challenges by introducing a Master Pool on a master chain that manages Child Pools across different blockchains, ensuring efficient liquidity distribution and rebalancing. The framework implements a novel IOU-based rebalancing mechanism where participants called Rebalancing Agents earn fees by maintaining liquidity equilibrium across Child Pools on multiple blockchains.

Lanca's technical design ensures high capital efficiency, reduces idle liquidity, and scales effortlessly to any chain in several hours thanks to the underlying Concero's messaging infrastructure. Additionally, security is the top priority in Lanca's architecture, so cross-chain messaging is powered by Concero Messaging V2, which is employed by both cryptographic and economic security. The parent-child pool models, coupled with dynamic rebalancing, provide a unified liquidity layer that enhances cross-chain unification while maintaining security through a robust validation system. Among the Lanca Bridging Framework built on top of Concero Messaging V2, Lanca also has a separate architecture built on top of Chainlink CCIP, which is called CCIP-centric Lanca Bridge.

This whitepaper presents Lanca's architecture, technical specifications, economic models, and security considerations. It demonstrates how Lanca can achieve efficient cross-chain liquidity management without compromising decentralisation or security

1. Introduction

The blockchain landscape has evolved significantly since Bitcoin's inception and Ethereum's smart contract revolution. These technologies lead to a diverse ecosystem of blockchain networks, each optimised for specific use cases. While this diversity promotes innovation, it has created a fragmented ecosystem where assets and liquidity are isolated across different chains. As of this writing, the blockchain landscape encompasses 277 Layer-1 [1] and 105 Layer-2 [2] public blockchains, according to Coingecko. However, these figures represent only a fraction of the broader landscape as they represent only public blockchains. The number of private and bank chains developed by financial institutions and banks is growing exponentially, as we can see in the adoption wave through the involvement of capital market players [3]. So, this trend further magnifies fragmentation. Smart contract technology has revolutionised financial markets through decentralised finance (DeFi), which creates a borderless ecosystem for global value transfer and trading across blockchain networks. This transformation has captured significant institutional interest, with The Economist's Q2 research report for OKX projecting digital asset market values to exceed $10 trillion by 2030 [4]. As the DeFi ecosystem expands, the need for efficient cross-chain liquidity solutions becomes increasingly critical for sustaining this growth.

Current blockchain interoperability solutions, particularly trusted bridges and atomic swaps, face significant limitations despite their basic functionality. The primary challenge lies in their requirement for substantial locked capital across multiple blockchains, resulting in inefficient use of resources. Consider a traditional bridge protocol: to enable $1 million in cross-chain transfers, it must lock $1 million on each connected blockchain. This one-to-one liquidity requirement not only demands extensive capital investment but also creates considerable security vulnerabilities. The severity of these security risks became evident during 2021-2022, when bridge exploits led to losses exceeding $2 billion.

Existing cross-chain solutions like Stargate and Across Protocol have introduced innovative approaches to blockchain interoperability, each with distinct advantages and limitations. Stargate's unified liquidity pools architecture, enhanced by its V2 AI Planning Module (AIPM), enables efficient cross-chain transfers without wrapped tokens and implements cost-effective transaction batching. While its integration with LayerZero provides message verification, Stargate's limited asset support and centralisation risks through its foundation-controlled structure present notable drawbacks. Similarly, Across Protocol's intent-based architecture, featuring competitive relayers and optimistic verification, achieves impressive transaction speeds through upfront execution and settlement via UMA's oracle. However, its reliance on a robust relayer marketplace and the capital efficiency challenges posed by the oracle's challenge period highlight the ongoing complexities in achieving optimal cross-chain solutions. These limitations in current protocols encourage the development of more comprehensive solutions that can better address the challenges of cross-chain bridging while maintaining security and efficiency.

We developed Lanca after extensive research and experimentation with different cross-chain minimum viable products (MVPs). Through in-depth analysis, we identified that users primarily require four attributes for cross-chain transactions: capital efficiency, security, ease of use and scalability. Existing infrastructure fails to meet these requirements simultaneously, which laid the foundation for the Lanca Bridging Framework (LBF).

Lanca introduces a novel parent-child pool architecture, where a Master Pool on a master blockchain manages Child Pools across different networks. This design is complemented by a dynamic IOU system that allows Rebalancing Agents to maintain liquidity equilibrium across pools, significantly improving capital efficiency. Unlike traditional approaches that require equal liquidity across all chains, Lanca's model enables more efficient liquidity utilisation.

Our vision is to create a unified liquidity layer that seamlessly connects all blockchain networks, enabling efficient capital flow while maintaining robust security. Lanca's architecture is designed to scale horizontally across any number of chains and vertically through different asset types, providing a foundation for the next generation of cross-chain applications.

2. Technical Overview

Lanca's evolution includes two distinct but complementary architectures designed to serve different market needs. The first iteration, Lanca Bridge, leverages Chainlink's robust infrastructure, specifically utilising Chainlink Functions for execution and Chainlink CCIP for settlement. This CCIP-centric design provides a secure foundation for facilitating cross-chain transactions, particularly suited for traditional finance (TradFi) integration with DeFi.

To expand Lanca's capabilities and achieve our vision of chain unification, we developed LBF, which integrates with Concero Messaging V2. This architectural advancement represents a significant shift from Concero Messaging V1, enabling rapid deployment across any blockchain network with minimal technical overhead. LBF's design prioritises flexibility and efficiency in cross-chain communication while maintaining security standards.

The decision to maintain both systems - the CCIP-centric Lanca Bridge and the more versatile LBF - is to support and connect both TradFi and DeFi ecosystems. Each architecture serves distinct use cases: Lanca CCIP-centric Bridge focuses on secure, regulated cross-chain transactions for traditional financial institutions, while LBF facilitates broader blockchain interoperability for the wider DeFi ecosystem. These systems will operate in parallel, providing complementary solutions to meet diverse market needs while maintaining Lanca's commitment to secure and efficient cross-chain communication.

2.1. LBF's Overall Architecture

Lanca Bridge built on Chainlink CCIP (CCIP-centric)

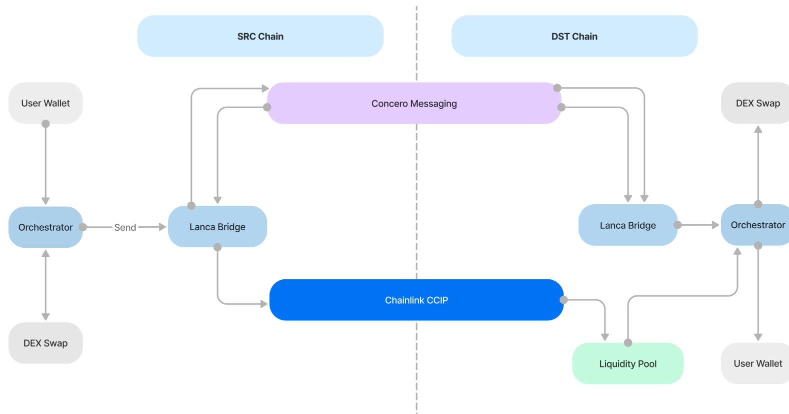

Figure 1. Lanca CCIP-centric Bridge architecture

Lanca's evolution includes two distinct but complementary architectures designed to serve different market needs. The first iteration, Lanca Bridge, leverages Chainlink's robust infrastructure, specifically utilising Chainlink Functions for execution and Chainlink CCIP for settlement. This CCIP-centric design provides a secure foundation for facilitating cross-chain transactions, particularly suited for traditional finance (TradFi) integration with DeFi and projects within the Chainlink ecosystem.

In terms of the technical process flow, the transaction process begins when a user sends assets to a contract on the source chain through a Transparent Proxy, which then forwards the message to an orchestrator responsible for managing the transaction flow. The orchestrator first performs a source-chain swap to obtain a bridgeable asset before calling the migration contract to initiate the transfer to the destination chain. These assets are then sent to the settlement layer (CCIP), triggering the Concero Messaging. This action initiates source chain functions that queue the transaction on the destination chain.

As Concero Messaging utilised Chainlink Functions as an execution layer, once queued, the destination chain's Chainlink Functions verify the transaction's existence on the source chain. After receiving transaction confirmation via Chainlink Functions, the destination migration contract allows the orchestrator to proceed with the transaction on the destination chain. The orchestrator then obtains a loan from the Pool to execute the transaction, optionally performing a swap to acquire the desired destination asset before sending it to the user.

Finally, the settlement layer (CCIP) delivers the original assets to the destination chain pool, completing the cross-chain transfer process.

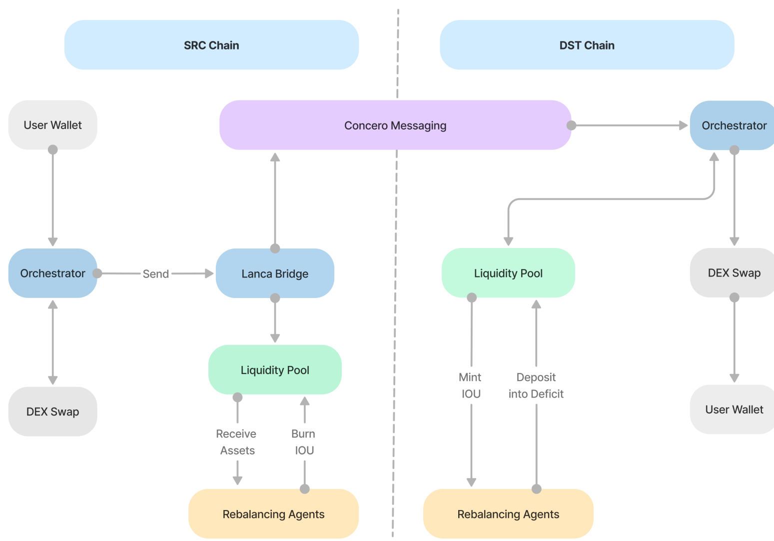

Figure 2. Cross-chain transaction flow: Lanca Bridging Framework architecture

The LBF introduces a novel approach to blockchain bridge by combining secure messaging protocols with dynamic liquidity management. At its core, this system allows trustless asset transfer across multiple blockchain networks while maintaining capital efficiency through an IOU mechanism.

The architecture consists of four primary components operating across Source Chain (SRC chain) and Destination Chain (DST chain), including:

1. **Orchestrator**: Coordinates transaction process and DEX interactions
2. **Lanca Bridge**: Manages cross-chain asset transfer from liquidity pools
3. **Concero Messaging**: Handles secure cross-chain communication
4. **Liquidity Pools with Rebalancing Agents**: Maintains liquidity balance through IOU tokens

When a user initiates a cross-chain transaction, the process follows a systematic flow:

Initial processing (SRC chain). The process begins when a user initiates a transaction from their wallet on the SRC chain. The orchestrator processes the request and, if needed, coordinates with a DEX for token conversion. The transaction is then sent to the Lanca Bridge.

Cross-chain communication. The Lanca Bridge locks the assets in the SRC chain's liquidity pool and triggers the Concero Messaging protocol. This layer guarantees the secure transmission of transaction data and cryptographic proofs between chains.

Destination processing (DST chain). On the DST chain, another orchestrator receives verified transaction data and coordinates with the liquidity pool to receive funding.

Final settlement. The DST chain orchestrator coordinates with DEXs for any required token conversions before sending a desired asset to the user's wallet.

Liquidity management with Rebalancing Agents. The system employs Rebalancing Agents on both chains to maintain liquidity equilibrium:

- SRC's Rebalancing Agent receives assets and burns IOUs
- DST's Rebalancing Agent deposits assets and mints IOUs. This creates a balanced system where corresponding IOU operations match asset transfers and allow efficient capital utilisation.

2.2. Parent-Child Pool Model

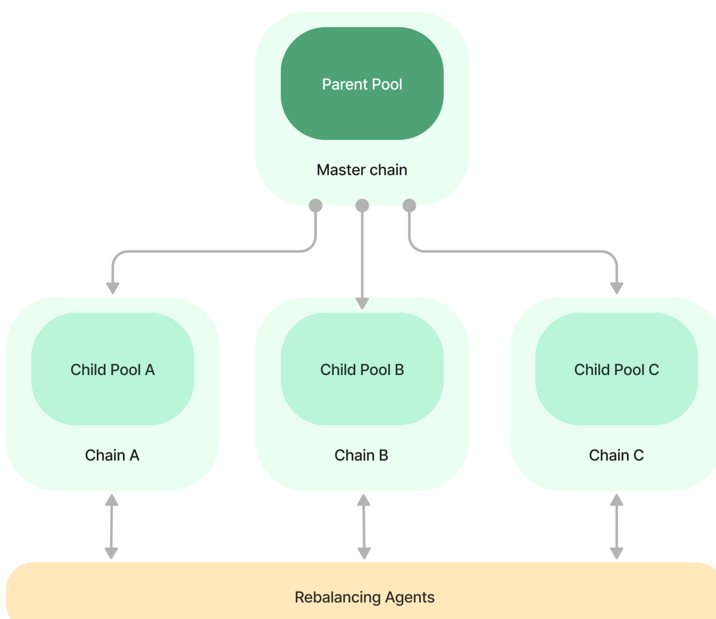

Figure 3. LBF liquidity management architecture

LBF introduces an innovative parent-child pool architecture to facilitate efficient cross-chain liquidity management and bridging operations. The system consists of three key components: a Parent Pool, Child Pools and Rebalancing Agents. A Parent Pool is deployed on the BASE blockchain as its master chain, with the flexibility to migrate to other chains to enhance operational efficiency if required. This Parent Pool acts as the central entry and exit point, interconnecting with Child Pools distributed across various blockchain networks. As liquidity enters the Parent Pool, it undergoes automated distribution to Child Pools through Concero Messaging V2, which also facilitates inter-child pool communication. Each pool maintains a dynamically adjusted liquidity Net-0 value established by the Parent Pool. Through continuous communication between parent and Child Pools regarding transaction activities and pool status, the Parent Pool optimises liquidity Net-0 value across chains to maximise capital efficiency. This adaptive system enables optimal liquidity distribution based on real-time network demands. Rebalancing Agents serve as autonomous monitors of Child Pools, initiating rebalancing operations when pool values fall below their defined thresholds. The detailed mechanics of this rebalancing system are presented in the subsequent section. The architecture allows seamless bridging operations through a lock-and-release mechanism. When users initiate a cross-chain transfer, assets are locked in the SRC chain's child pool while a corresponding message is transmitted via Concero Messaging V2 to the DST chain. Upon message verification, the DST chain's child pool releases an equivalent amount of assets to the user. This design offers several key advantages. First, the efficient reuse of liquidity significantly reduces capital requirements while maintaining high throughput. Second, the parent-child pool model with active Rebalancing Agents ensures all participants receive exposure to fees generated across all supported chains, potentially yielding higher returns. Finally, even though the liquid management design is centralised, it simplifies liquidity provision while maintaining decentralised execution through Child Pools.

2.3. Dual-layer liquidity management system: Parent Pool and Rebalancing Agents

The LBF implements a dual-layer liquidity management system to ensure optimal pool health and operation. The first layer comprises the Parent Pool's continuous monitoring of Child Pools, dynamically adjusting their Net-0 value based on its network activity. The second layer introduces a novel risk-minimised rebalancing mechanism through an IOU-based system, where autonomous Rebalancing Agents earn fees by maintaining equilibrium across liquidity pools.

In particular, the Parent Pool serves as the central coordinator in maintaining optimal liquidity levels across the system. It actively monitors each Child Pool and executes rebalancing operations when needed, using an event-driven approach that considers multiple factors, particularly the chain's activity levels and transaction volumes. While the Parent Pool's regular rebalancing helps maintain overall system equilibrium, short-term imbalances can still occur between these scheduled top-up cycles. To address these temporary imbalances, Rebalancing Agents act as rapid-response participants in the system. These agents complement the Parent Pool's core function by providing quick liquidity adjustments, ensuring the system maintains optimal performance even between the Parent Pool's scheduled rebalancing operations.

These complementary layers work in cooperation to maintain sufficient liquidity across the network, particularly during periods of high activity. When a child pool experiences a liquidity deficit, Rebalancing Agents can deposit assets and receive IOUs, which can later be redeemed from pools with surplus liquidity. This dual-layer approach is crucial for maintaining the overall health and efficiency of the LFB. It ensures that each pool always has sufficient liquidity to facilitate cross-chain transactions and that any temporary imbalances are swiftly corrected. The faster the rebalancing occurs, the smoother and more seamless the user experience can be.

2.3.1. Pool structure In the rebalancing framework, we introduce the concept of a Net-0 liquidity level, which represents the ideal liquidity balance that each child pool should maintain based on the total liquidity in the system. The Parent Pool determines this Net-0 value, as it has a complete record of all the liquidity that has entered the network.

Each liquidity pool is divided into three distinct compartments or "silos" (Figure 3):

1. **Active Liquidity** (Balance up to `Net-0`), holds the operational liquidity up to the Net-0 level. This can be thought of as the pool's working capital.
2. **Fees** (Balance of `Fees` generated by the pool), stores all the fees generated by the pool's operations, keeping these earnings separate from the main liquidity.
3. **Surplus** (Balance above the `Net-0 + Fees`), holds any excess liquidity above the sum of the Net-0 level and the accumulated fees. This Surplus compartment acts as an overflow container for extra liquidity.

In addition to these compartments, the LBF introduces the notion of `Count`, which is a value that indicates whether a pool is in surplus or deficit (Figure 3). The `Count` is calculated by subtracting the sum of the Net-0 liquidity and the Fees from the pool's current balance, as expressed in the following equation:

$$Count = CurrentBalance - (Net - 0 + Fees)$$

* If the Count is *positive*, it means that the pool is in *surplus*. * If the Count is *negative*, it means that the pool is in *deficit*.

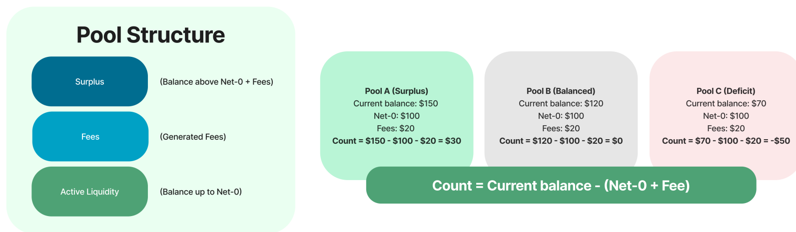

Figure 4. Pool structure and Examples of how "Count" is calculated based on 'Net-0' and 'Fees'

The introduction of these concepts - the Net-0 liquidity level, the three-compartment structure of the pools, and the Count value - forms the foundation of the LBF rebalancing mechanism. These variables provide a straightforward way to track each pool's liquidity status relative to the ideal Net-0 level so that it enables more efficient and responsive rebalancing of liquidity across the network. This, in turn, helps to ensure that each pool has the liquidity it needs to function optimally without tying up excess capital unnecessarily.

The separation of the Fees compartment also allows for clearer accounting of the protocol's fee revenue, which is an important consideration for its long-term sustainability.

2.3.2. Rebalancing Agents The rebalancing mechanism in LBF is facilitated by Rebalancing Agents. These entities play a crucial role in maintaining the balance of liquidity across the network's pools.

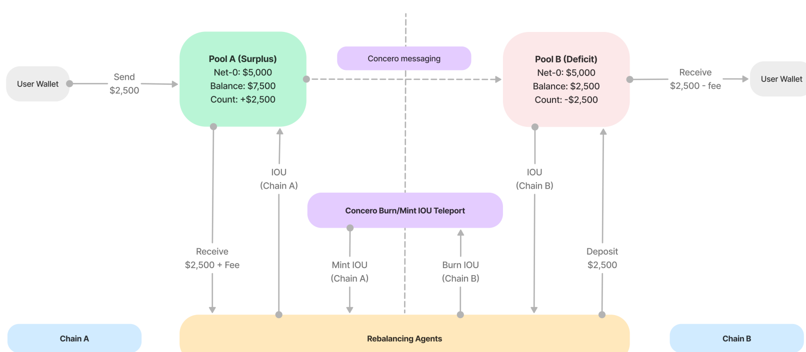

Figure 5. Rebalancing Agents' IOU system flow

The process works as follows: First, the Parent Pool establishes a Net-0 liquidity level for each pool in the system. This Net-0 value represents the ideal amount of liquidity that a pool should hold for the system to be considered balanced. Based on chains activities and volume, it is distributed sufficiently among all the pools, setting their respective Net-0 levels.

Rebalancing Agents continuously monitor the pools, looking for those that are in a deficit state. When Rebalancing Agents identify a pool in deficit, they can choose to deposit their own capital into that pool. In return for this deposit, the Rebalancing Agents receive an equivalent amount of IOU tokens from the system. These IOUs represent a claim on the liquidity that the Rebalancing Agents have injected into the deficit pool.

The existence of a deficit pool implies that there must be another pool in the system that has a surplus of liquidity. The Rebalancing Agents can leverage this by moving their IOUs to the chain where the surplus pool exists. This movement of IOUs is facilitated by Concero's Burn/Mint IOU Teleport, which allows for the burning of IOUs on one chain and their minting on another.

Once on the chain with the surplus pool, the Rebalancing Agents can redeem their IOUs. The redemption process involves presenting the IOUs to the surplus pool and receiving an equivalent amount of liquidity in return. This completes the rebalancing cycle, as the liquidity that was initially deposited into the deficit pool is recovered from the surplus pool on a different chain.

For their service in rebalancing liquidity across the network, the Rebalancing Agents earn a fee. This fee serves as an incentive for Rebalancing Agents to monitor and participate in the liquidity rebalancing process actively. It's important to note that the role of rebalancing agents is distinct from that of typical liquidity providers (LPs). While LPs add liquidity to the system and earn fees from transactions, Rebalancing Agents are specifically focused on identifying and correcting imbalances in liquidity distribution. Their actions help to ensure that all pools maintain an optimal level of liquidity, which is critical for the smooth operation of the LBF.

Also, IOUs can only be redeemed when a pool has a balance exceeding its Net-0 value. This is a critical design constraint that ensures the protocol's core operational liquidity (Active liquidity up to Net-0) remains protected. When a rebalancing agent seeks to redeem IOUs, they must first verify that their target pool maintains a surplus position. If no surplus exists in their preferred chain's pool, the redemption cannot be processed, requiring the agent to either wait for a surplus to develop or seek redemption from other pools in the network that do have surplus positions.

2.3.3. Deposit and withdrawal logic As LPs, the Parent Pool and Rebalancing Agents play a key role in maintaining liquidity equilibrium across Child Pools on multiple chains, it is important to clarify the logic behind the deposit and withdrawal process. This section details the specific flow from LPs deposit into the Parent Pools, how a Parent Pool communicates with Child Pools, and how these Agents deposit assets into pools with a liquidity deficit, receive IOUs representing their deposit, and later redeem those IOUs in pools with excess liquidity to retrieve their original assets plus an additional fee. Understanding this deposit and withdrawal flow is crucial to understanding how LBF leverages the actions of rebalancing agents to ensure assets can flow to where they are needed most in the network.

Deposit Logic

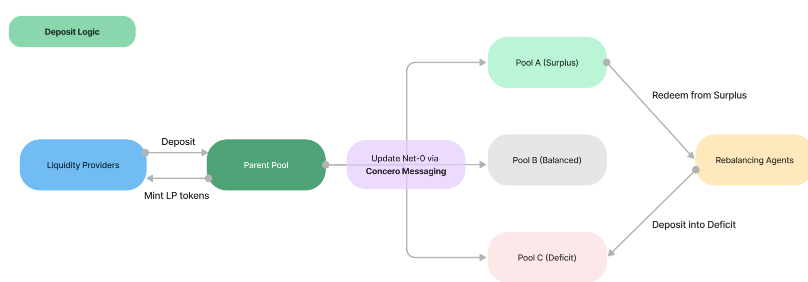

Figure 6. Depositing flows of LBF

The deposit process begins with the LPs sending their assets to the Parent Pool on the master chain (BASE chain for this upgrade). The Parent Pool, serving as the central hub, is responsible for managing the overall liquidity across the LBF.

Upon receiving the deposit from LPs, the Parent Pool mints a corresponding amount of LP tokens to the LPs. These LPs tokens represent the provider's share of the total liquidity in the Lanca system. The minting of tokens follows a formula that considers the size of the deposit relative to the existing liquidity in the pools.

$$LPShare = \frac{User'sDepositedAmount}{TotalPoolValue} \times 100\%$$

$$ShareTokens = \frac{DepositAmount \times CurrentTotalShareTokens}{CurrentPoolValue}$$

Next, the Parent Pool will monitor and update the Net-0 value for each of the connected Child Pools, including itself. The Net-0 value represents the target liquidity level that each pool should maintain to ensure sufficient distribution. The update and communication between the Parent Pool and Child Pools are facilitated via Concero Messaging V2.

Once there are depositing transactions happening on chains, it leads to the state that the Child Pools are in a deficit state, they now require additional liquidity to meet their new Net-0 targets. This is where the Rebalancing Agent comes into play. The agent identifies pools with a deficit and deposits their own assets into those pools to help rebalance the liquidity. In return for their deposit, the Rebalancing Agents received an IOU from the pool. These IOUs serve as proof that the agent can later redeem their deposited assets plus a fee from the Parent Pool with excess liquidity.

Withdrawal Logic

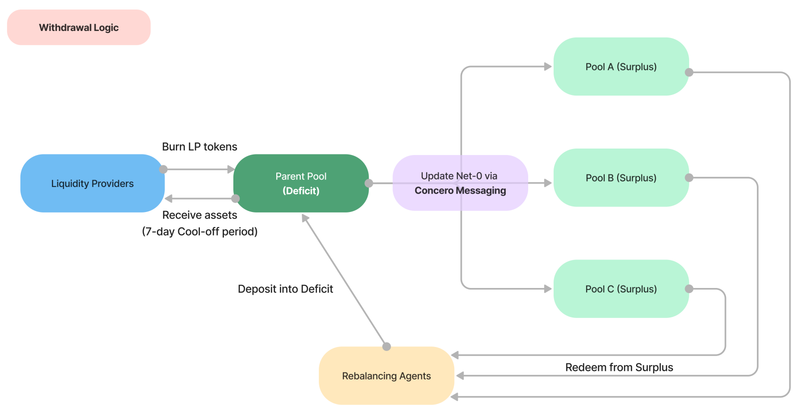

Figure 7. Withdrawal flows of LBF

The withdrawal mechanism in LBF follows a structured process designed to maintain system stability while ensuring LPs can efficiently exit their positions. To protect the protocol's stability, withdrawals incorporate a mandatory 7-day cool-off period. During this time, the provider's assets remain locked while the system executes the necessary rebalancing operations. This cooling period serves multiple purposes: it prevents sudden liquidity shocks, allows for orderly rebalancing of positions across chains, and provides time for the completion of any pending cross-chain transactions.

When an LP initiates a withdrawal request from the parent pool, it triggers a coordinated rebalancing across the network. The Parent Pool executes an automatic update of Net-0 values across all connected child pools via Concero Messaging V2. At this stage, the Parent Pool enters a deficit state because it must provide assets to the withdrawing LP while maintaining its operational requirements. Simultaneously, the Parent Pool adjusts the Net-0 values of all child pools downward through Concero Messaging V2 to reflect this withdrawal. However, since the child pools retain their original asset balance while their Net-0 values decrease, they enter a surplus state.

These Rebalancing Agents can deposit assets into the Parent Pool's deficit position and can subsequently redeem equivalent values from Child Pool,s maintaining surplus positions. This creates an efficient circular flow of liquidity that helps maintain system balance during withdrawals.

Upon completion of the cool-off period and successful rebalancing operations, the liquidity provider receives their withdrawn assets by burning their LP tokens from the provider's position to receive their assets back, including fees, in order to complete the withdrawal cycle. This methodical approach to withdrawals helps maintain the protocol's stability while ensuring fair and efficient exit mechanics for liquidity providers.

2.4. Dynamic Liquidity Rebalancing Algorithm

This section outlines LBF's liquidity rebalancing algorithm for dynamically adjusting the target liquidity (referred to as the "Net-0" value) of child pools based on their liquidity health. The goal is to reallocate liquidity from pools that are overperforming to those under stress while keeping the overall system liquidity constant.

In LBF, liquidity is distributed across multiple child pools. Over time, some pools may not use it liquidity as efficiently as others. To ensure robust liquidity management, our algorithm now calculates a **Liquidity Health Score (LHS)** comprised of two components:

- A **dynamic usage component** based on the **Liquidity Utilisation Ratio (LUR)**, which captures how actively a pool's liquidity is being used.
- A **dynamic flow component** based on the **Net Drain Rate (NDR)**, which tracks the net outflow (relative to Net-0).

Based on the LHS, the parent pool will adjust each pool's target liquidity (Net-0) so that child pools experiencing stress receive additional liquidity, while those operating above target release a portion of their liquidity. The overall total liquidity remains constant.

2.4.1 Key Metrics in the Rebalancing Algorithm As a dynamic usage component, **Liquidity Utilisation Ratio (LUR)** is a crucial metric that measures the ratio of the combined inflow and outflow of a pool relative to its Net-0 value. This measurement helps capture market or usage intensity. The formula for LUR is calculated as follows:

$$LUR = \frac{\text{Total Volume}}{\text{Net-0 Value}} = \frac{\text{Inflow} + \text{Outflow}}{\text{Net-0 Value}}$$

Because the combined flow is expected to be much higher than the Net-0 value, we normalise LUR using a tunable parameter (K):

$$LUR\_Score = 1 - \frac{LUR}{K + LUR}$$

- High LUR_Score (close to 1), it means the total volume (Inflow + Outflow) is low relative to the Net-0 value. The pool is experiencing low activity and is not under significant stress. Little or no adjustment to the Net-0 target is needed.
- Low LUR_Score (close to 0), it means the total volume is very high compared to the Net-0 value. The pool is heavily used and is likely under stress. This signals that the pool may require an increased Net-0 target to handle the high transaction volume.

The constant (K) in the LUR normalisation formula controls how fast the score declines as activity increases. The (K) can be set based on historical data or simulation and iteration.

Especially, (K) can based on the sensitivity of the pool. In terms of Sensitivity:
- A **lower (K)** makes the score drop faster (more sensitive), so even moderate activity yields a low score.
- A **higher (K)** reduces the effect of high volume, requiring extreme activity for a similar score drop.

Based on these factors, it ensures that (K) is well-calibrated to reflect true pool stress and drive appropriate liquidity adjustments.

As a dynamic flow component, **Net Drain Rate (NDR)** is a crucial metric that measures the balance between outflows and inflows in a liquidity pool, normalised by its Net-0 Value. This measurement helps monitor the pool's liquidity stability and potential stress points. The formula for NDR is calculated as follows:

$$NDR = \frac{\text{Outflow} - \text{Inflow}}{\text{Net-0 Value}}$$

The NDR quantifies the net effect of liquidity movements: - NDR ≤ 0: Indicates no net drain or a net inflow, which is ideal. - NDR > 0: Reflects that withdrawals are exceeding deposits, signaling liquidity stress.

To make this metric more meaningful and comparable, we transform the NDR into a standardised score. NDR is transformed into a score as follows:

$$NDR\_Score = \begin{cases} 1, & \text{if } NDR \leq 0 \\ \max(0, 1 - NDR), & \text{if } NDR > 0 \end{cases}$$

- When the NDR is less than or equal to zero (NDR ≤ 0), the pool receives a perfect score of 1, reflecting optimal liquidity conditions.
- For any positive NDR values, the score follows a linear decrease using the formula max(0, 1 - NDR). This means that as the drain rate increases, the score proportionally decreases, but never falls below 0. The maximum function ensures that even in extreme cases of high drain rates, the score maintains a minimum value of 0.

2.4.2 Liquidity Health Score (LHS) The two sub-scores are combined into a single Liquidity Health Score (LHS) using weight-based averaging. The formula for LHS is as follows:

$$LHS = W_1 \times LUR_Score + W_2 \times NDR_Score$$

At the first iteration, we set the weights as 0.7 for LUR and 0.3 for NDR, supposing that the dynamic usage component is more important than the dynamic flow component. This weight will be adjusted in future iterations based on the performance of the pool during testnet. The formula for LHS is as follows:

$$LHS = 0.7 \times LUR_Score + 0.3 \times NDR_Score$$

- A higher LHS (closer to 1) indicates a well-balanced pool.
- A lower LHS signals liquidity stress.

2.4.3 Dynamic Rebalancing Mechanism Based on the LHS, we adjust each pool's target liquidity (Net-0) to reallocate funds cumulatively while ensuring that the overall liquidity remains constant. The steps are as follows:

Step 1: Define a Weighting Function

We use a simple function to calculate a weighting factor $f(LHS)$, which increases a pool's weight if its LHS is below 1:

$$f(LHS) = 1 + \alpha \cdot (1 - LHS)$$

where:

- α is a sensitivity parameter, e.g., $\alpha = 1$.
- A lower LHS results in a higher $f(LHS)$, meaning that a pool under stress "deserves" additional liquidity.

Note: The alpha (α) parameter is a crucial control mechanism in our dynamic liquidity rebalancing system that determines how aggressively the system responds to liquidity imbalances. When a pool's Liquidity Health Score (LHS) deviates from the ideal value of 1:

- A higher α causes more aggressive rebalancing responses to liquidity stress
- A lower α results in more gentle, conservative adjustments

Step 2: Calculate the Weight for Each Pool

For each pool (i), the weight (W_i) is given by:

$$W_i = \text{Original Net-0}_i \times f(LHS_i)$$

Let the total weight for all (N) pools be:

$$W_{\text{total}} = \sum_{i=1}^{N} W_i$$

Step 3: Compute the New Target Liquidity (New Net-0)

Each pool's new target liquidity is determined by:

$$\text{New Net-0}_i = \frac{W_i}{W_{\text{total}}} \times \text{Total Liquidity}$$

This formula ensures that while each pool's target is adjusted, the overall liquidity remains constant.

2.4.4 Example of Rebalancing 5 Pools Consider a system with 5 pools and a total system Net-0 of $500k. The initial pool states are as follows:

Pool	Current Balance	Net-0 Value	Outflow (24h)	Inflow (24h)
A	$120k	$100k	$80k	$60k
B	$85k	$100k	$150k	$140k
C	$95k	$100k	$200k	$180k
D	$110k	$100k	$40k	$50k
E	$90k	$100k	$90k	$70k

Step 1: Calculate the LUR and LUR_Score

Using

$$LUR = \frac{\text{Inflow} + \text{Outflow}}{\text{Net-0 Value}}$$

and with (K=5):

$$LUR\_Score = 1 - \frac{LUR}{5 + LUR}$$

For each pool:

Pool	LUR Calculation	LUR Value	LUR Score
A	(80k + 60k)/100k	1.40	0.78
B	(150k + 140k)/100k	2.90	0.63
C	(200k + 180k)/100k	3.80	0.57
D	(40k + 50k)/100k	0.90	0.85
E	(90k + 70k)/100k	1.60	0.76

Step 2: Calculate NDR and NDR_Score

For each pool, using:

$$NDR = \frac{\text{Outflow} - \text{Inflow}}{\text{Net-0 Value}}$$

and

$$NDR\_Score = \begin{cases} 1, & \text{if } NDR \leq 0 \\ 1 - NDR, & \text{if } NDR > 0 \end{cases}$$

Pool	NDR Calculation	NDR Value	NDR Score
A	$(80k - 60k)/100k$	0.20	0.80
B	$(150k - 140k)/100k$	0.10	0.90
C	$(200k - 180k)/100k$	0.20	0.80
D	$(40k - 50k)/100k$	-0.10	1.00
E	$(90k - 70k)/100k$	0.20	0.80

Step 3: Calculate the Liquidity Health Score (LHS)

We combine the scores with a 70/30 weighting:

$$LHS = 0.7 \times LUR\_Score + 0.3 \times NDR\_Score$$

Pool	LHS Calculation	LHS Score
A	$0.7 \times 0.78 + 0.3 \times 0.80$	0.79
B	$0.7 \times 0.63 + 0.3 \times 0.90$	0.71
C	$0.7 \times 0.57 + 0.3 \times 0.80$	0.64
D	$0.7 \times 0.85 + 0.3 \times 1.00$	0.90
E	$0.7 \times 0.76 + 0.3 \times 0.80$	0.77

Step 4: Calculate Weighting Factors

Using the weighting function ($f(LHS) = 1 + (1 - LHS)$) (with $\alpha = 1$):

Pool	f(LHS) Calculation	f(LHS) Value	Weight Calculation	Weight
A	1 + (1 - 0.79)	1.21	$100k \times 1.21$	$121k
B	1 + (1 - 0.71)	1.29	$100k \times 1.29$	$129k
C	1 + (1 - 0.64)	1.36	$100k \times 1.36$	$136k
D	1 + (1 - 0.90)	1.10	$100k \times 1.10$	$110k
E	1 + (1 - 0.77)	1.23	$100k \times 1.23$	$123k

Total Weight = 121k + 129k + 136k + 110k + 123k = $619k

Step 5: Calculate New Net-0 Values

Each pool's new Net-0 is given by:

$$\text{New Net-0}_i = \frac{W_i}{\text{Total Weight}} \times \text{Total Liquidity}$$

Pool	Calculation	Final Allocation
A	$(121k/619k) \times 500k$	$97.8k
B	$(129k/619k) \times 500k$	$104.2k
C	$(136k/619k) \times 500k$	$109.9k
D	$(110k/619k) \times 500k$	$88.9k
E	$(123k/619k) \times 500k$	$99.4k

These new targets ensure that pools with higher activity (lower LHS) receive increased liquidity, while more stable pools see a reduction.

Results

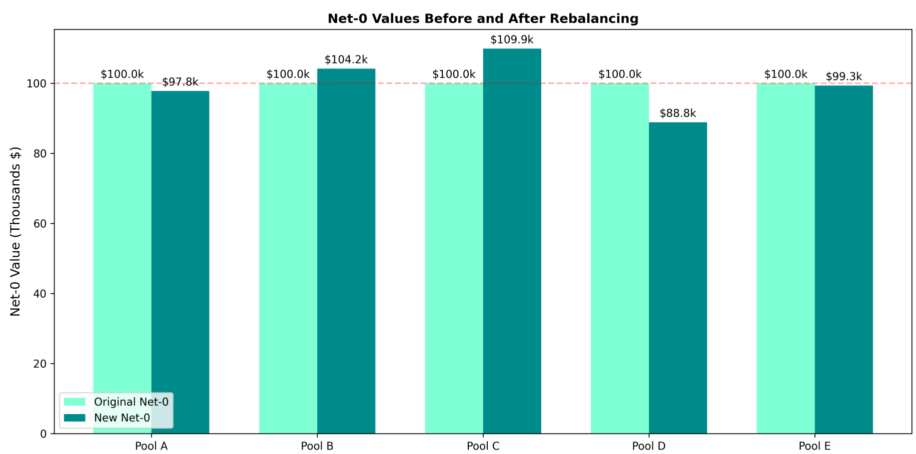

Figure 8. Net-0 Values Before and After Rebalancing

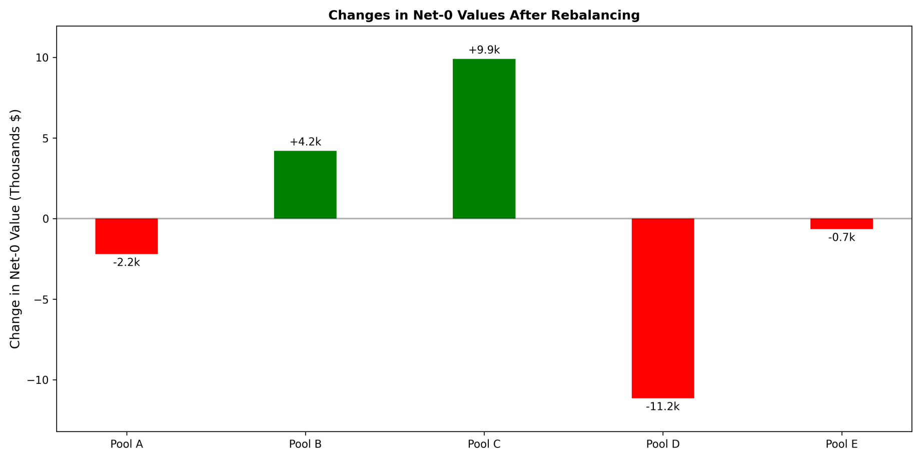

Figure 9. Changes in Net-0 Values After Rebalancing

The rebalancing algorithm effectively redistributes liquidity based on pool activity and stress levels. Looking at the changes in Net-0 values:

- **Pool C** received the largest increase (+$9.9k) due to its high transaction volume ($380k total volume), indicating the algorithm correctly identified its need for additional liquidity.
- **Pool B** also gained liquidity (+$4.2k) as it showed significant activity ($290k total volume).
- **Pool D** saw the largest reduction (-$11.2k) as it demonstrated the lowest activity ($90k total volume) and had positive net inflow.
- **Pools A and E** experienced minor adjustments (-$2.2k and -$0.7k, respectively) reflecting their moderate activity levels.

2.4.5 Conclusion The results of our rebalancing algorithm demonstrate its effectiveness in optimising liquidity across the system. The algorithm successfully accomplishes three key objectives. First, it accurately identifies which pools are experiencing stress from high transaction volumes, ensuring that pools under pressure are detected. Second, it carefully moves liquidity from pools with lower activity to those with higher demand, creating a more balanced system. Finally, it preserves the total amount of liquidity in the system while improving how that liquidity is distributed across different pools.

By using LUR (Liquidity Utilisation Ratio) and NDR (Net Drain Rate) as our key metrics, we can accurately measure both how active each pool is and its current stress level. These measurements then guide our rebalancing decisions, ensuring that liquidity flows to where it's needed most. The final allocation numbers confirm that our approach leads to meaningful and appropriate adjustments in pool liquidity levels.

3. Incentivisation Mechanism of Underserved chains

LBF's vision is to support all blockchain networks, ensuring extensive coverage across diverse chains. However, this broad support inherently results in varying activity levels across different chains, with some experiencing higher transaction volumes than others. Consequently, certain liquidity pools may remain in deficit for extended periods.

To address this, LBF implements a **dynamic bounty mechanism** that incentivises rebalancing activities, particularly targeting underserved chains. This system encourages **Rebalancing Agents** to maintain balanced liquidity across all supported networks, regardless of transaction volumes or market activity. In return, they receive a bounty in the form of the **LANCA native token**.

3.1. The Bounty Calculation Mechanism

The foundation of the bounty calculation mechanism is built on four essential components that work together to create a balanced and adaptable incentive system:

$$Reward = Deficit \times TimeFactor \times UtilisationFactor \times GovernanceMultiplier$$

3.2. LBF Progressive Reward Model

Based on the foundation bounty formula, we developed LBF's Progressive Reward Model. This model introduces a novel approach to incentivising liquidity rebalancing while maintaining protocol sustainability.

The core formula balances three critical dimensions:

$$B_{prog} = D_{prog} \times \underbrace{(T^p \times r)}_{\text{Time Weight}} \times \underbrace{\left[1 + \frac{(U - U_{base})}{100} \times k\right]}_{\text{Utilisation Factor}} \times \underbrace{G}_{\text{Governance}}$$

It is designed to address the dual challenges of immediate deficit resolution and long-term token emission control, this mechanism employs time-weighted urgency factors (`T^p x r`) and utilisation-sensitive multipliers (`[1 + (U - U_base)/100 × k]`) within a mathematically constrained framework.

Let's break down the formula:

1. **Reward** `B`: Reward in native token (LANCA)
2. **Base Deficit** `D`: Represents the immediate USD value needed to balance the pool. This ensures rewards directly correspond to the protocol's liquidity requirements.
3. **Time Weight** `(T^p x r)`: Creates gradual early growth that accelerates over time, balancing urgency with emission control.
    - `T`: Hours since the deficit started

- `p`: Time exponent (0 < p < 1) controlling growth speed (0.5 by default)
- `r`: Growth rate coefficient

4. **Utilisation Factor `[1 + (U - U_base)/100 x k]`** : Increases rewards when utilisation exceeds safe levels, protecting pool health.
   - `U`: Current pool utilisation percentage, e.g. 80%

   - `U_base`: a threshold utilisation percentage where rewards escalate, e.g. 65%
   - `k`: Sensitivity factor
5. **Governance Multiplier `G`**: DAO-controlled parameter for system-wide reward adjustments.

As LBF will transition to a DAO-driven protocol, the DAO will be able to adjust the parameters to suit the needs of the community. The DAO control parameters are listed below. However, at the initial stage, the Lanca team will set the parameters to ensure the protocol is sustainable and stable.

DAO Control Parameters

Parameter	Purpose	Adjustment Range
r	Speed of time-based growth	0.1% - 10% per hour
U_base	Utilisation starting point	50-75%
k	Utilisation sensitivity	1-3
G	Global reward scale	0.5-1.5

3.3. Reward Model Comparison

Before coming up with the progressive reward model, we have tested the linear and exponential growth models for the bounty mechanism. The formula for the linear growth and exponential growth are as follows:

Linear Growth Model's formula

$$B_{lin} = D \times \underbrace{(1 + rT)}_{\text{Linear Growth}} \times \underbrace{\left[1 + \frac{(U - U_{base})}{100} \times k\right]}_{\text{Utilisation Factor}} \times G_{lin}$$

- **Linear Rate (r):** Constant hourly growth coefficient

Exponential Growth Model's formula

$$B_{exp} = D \times \underbrace{e^{\lambda T}}_{\text{Exponential Growth}} \times \underbrace{\left[1 + \frac{(U - U_{base})}{100} \times k\right]}_{\text{Utilisation Factor}} \times G_{exp}$$

- **Growth Coefficient (λ):** Continuous compounding rate

In our testing, we found significant issues with traditional reward models that use either linear or exponential calculations. When rewards grow in a straight line (linear) or multiply exponentially over time, they create two main problems: they give out too many rewards too quickly in the beginning, and they continue growing steadily even after 24 hours, making them unsustainable in the long term.

To address these limitations, we developed an innovative progressive reward model with three major improvements. At its core, our model uses a special mathematical approach called sub-linear temporal scaling, where rewards grow more slowly over time instead of increasing at a constant or exponential rate. This creates a better balance between rewarding quick responses and maintaining controlled, sustainable growth over longer periods. We retained the existing system that adjusts rewards based on participation levels, which helps maintain the health of the reward pool.

Additionally, we introduced four carefully chosen governance parameters that allow precise fine-tuning of the system: a base rate, a baseline utilisation level, a utilisation sensitivity and a governance factor.

This enhanced approach represents a significant advancement in Lanca's incentive system. By addressing the fundamental weaknesses of traditional models while maintaining stability and flexibility in governance, our progressive reward model offers a more sustainable and adaptable solution for the long-term success of the protocol.

3.4. Model Analysis

3.4.1. Comparative Analysis between Linear, Exponential and Progressive Model To evaluate the performance of the three models, we set the following test parameters:

- Base deficit: $1,000
- Current pool utilisation: 85%
- Utilisation threshold: 65%
- Time range: 1 to 48 hours

Model Configurations

Model	Growth Mechanism	Key Parameters
Progressive	Square root scaling	p=0.5, r=5%, G=0.5
Linear	Constant hourly rate	r=5%, G=0.5
Exponential	Compounding growth	λ=5%, G=0.5

Key Findings

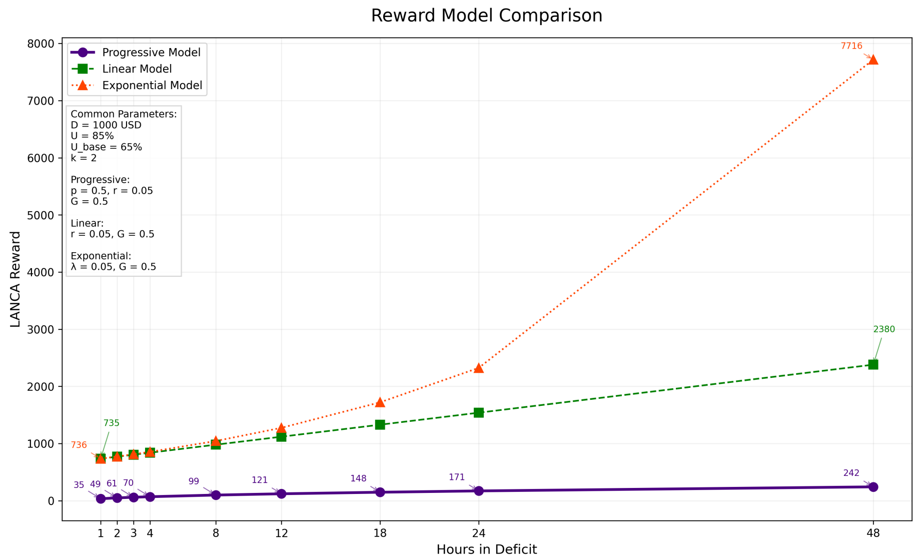

Figure 10. Reward Model Comparison: Linear, Exponential and Progressive Model

Our detailed analysis demonstrates the clear advantages of the progressive reward model for managing and incentivising rebalancing agents. Through experimental testing over a 48-hour period, we observed distinct performance patterns that highlight the progressive model's superior ability to maintain controlled scaling compared to conventional approaches.

The progressive model implements a carefully calibrated reward structure that begins at 35 LANCA tokens (representing 3.5% of the base deficit) in the first hour and scales to 242 LANCA (24.2% of deficit) by the 48-hour mark. This structured approach achieves remarkable efficiency, maintaining emissions at 96% below the exponential model while ensuring that rebalancing operations remain economically viable. A key strength of the model lies in its decreasing hourly growth rate, which declines from 6.54 tokens per hour to 2.08 tokens per hour, effectively encouraging prompt action while deterring speculative behavior.

From a protocol sustainability perspective, the progressive model exhibits exceptional risk management characteristics. While traditional models show concerning growth patterns—with exponential and linear models reaching multipliers of 7.72x and 2.38x respectively at 48 hours—our progressive model maintains a conservative 0.24x multiplier. This controlled growth approach successfully protects protocol reserves while preserving adequate incentives for timely liquidity provision. Notably, the protocol allows the DAO to adjust these rates based on community needs and market conditions.

The model's effectiveness is driven by strategic mechanisms. First, it provides economically viable immediate rewards of 35 LANCA within the first hour. Second, its anti-speculative design limits final rewards to just 6.9% of what an exponential model would provide. Third, it ensures predictable maximum outflows, capped at $\sqrt{48}$ multiplied by 35 LANCA. These features, combined with the model's declining marginal reward rate, create a robust framework that aligns the interests of rebalancing agents with the network's overall health requirements.

Our experimental results conclusively demonstrate that the progressive model successfully balances the dual imperatives of immediate liquidity provision and long-term protocol sustainability, marking a significant advancement in incentivisation strategies.

3.4.2. Flexibility of the Progressive Model To further demonstrate the flexibility of the progressive model, we have simulated the reward curve for different settings of the growth speed control, utilisation alert level and global reward scale. The parameters are listed in the figure below.

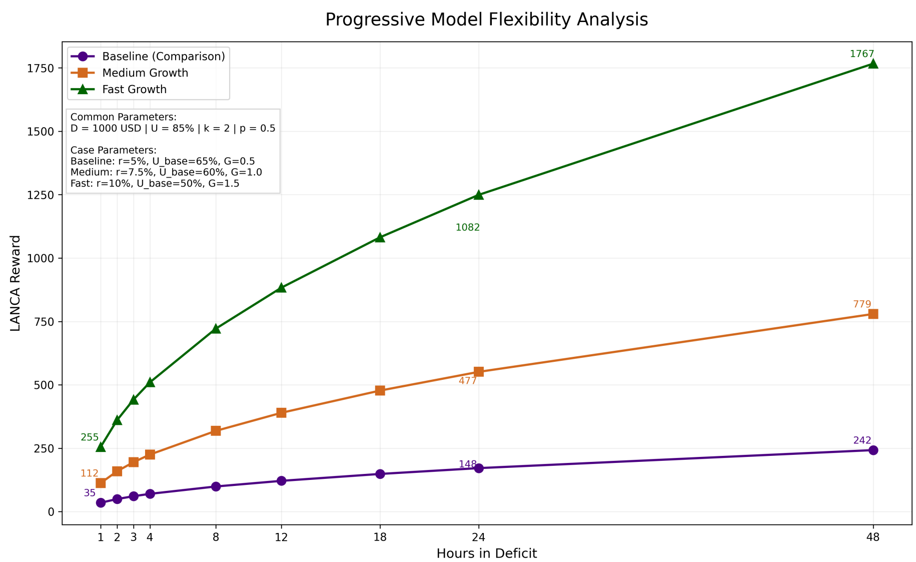

Figure 1: Flexibility of Progressive Model

Figure 11. Progressive Model's Reward Curve Simulation

Growth Reward and Growth Pattern

Configuration	1hr Reward	48hr Reward	Growth Pattern
Conservative	$35	$242	6.9x
Balanced	$112	$779	6.9x

Configuration	1hr Reward	48hr Reward	Growth Pattern
High-Incentive	$255	$1,767	6.9x

The progressive model incorporates flexible configuration options that enable communities to adjust reward levels while maintaining predictable and controlled growth patterns. Through three key adjustable parameters, the system delivers precise control over incentive distribution while preserving its fundamental stability characteristics.

The first parameter, Growth Speed Control, allows adjustment of the base rate between 0.1% and 10%, proportionally scaling rewards across all time periods. Under conservative settings at 5%, a $1,000 deficit generates 35 tokens in the first hour. Increasing the rate to 7.5% triples early rewards to 112 tokens, while a 10% setting provides 255 tokens. Importantly, these adjustments maintain the same controlled growth curve regardless of the chosen rate.

The second parameter, Utilisation Alert Level, defines the threshold at which bonus rewards become active. Communities can set this between 50% and 75%, with lower thresholds providing earlier warning signals for developing liquidity shortages, while higher thresholds concentrate rewards on critical emergency situations. This flexibility allows protocols to fine-tune their response to market conditions.

The third parameter, Global Reward Scale, acts as a universal multiplier that can be set between 0.5x and 1.5x, proportionally adjusting all reward distributions. At maximum settings of 1.5x, 48-hour rewards can reach 1,767 tokens while preserving the same growth patterns observed in baseline configurations.

A notable characteristic of this system is that all configurations maintain an identical 6.9x growth ratio from 1-hour to 48-hour rewards. This consistency is achieved through three key design principles: the preservation of core square root temporal scaling, parameter adjustments that only affect reward magnitudes, and predictable protocol cost growth.

This carefully engineered flexibility enables communities to safely increase rewards during periods of high demand without risking unsustainable exponential growth. Through a democratic governance process, DAO members can adjust these settings via simple majority voting, ensuring the system remains responsive to market needs while maintaining long-term protocol sustainability.

4. Security and risk mitigation

The Lanca Bridging Framework's innovative cross-chain liquidity management system introduces several security considerations that require comprehensive mitigation strategies.

4.1. Critical Risk Vectors

The framework's parent-child pool architecture presents significant security challenges, particularly regarding centralisation risks. The Parent Pool, as the primary liquidity management hub, represents a critical point of vulnerability where compromise could affect the entire network of Child Pools. This architectural consideration necessitates robust security controls to prevent cascading failures.

Cross-chain communication dependencies, facilitated through Concero Messaging V2 and Chainlink CCIP, introduce potential vulnerabilities in message verification and transaction finality. These systems must maintain strict cryptographic integrity to prevent message manipulation that could disrupt asset flows between chains.

The IOU mechanism, while essential for liquidity rebalancing, presents unique security challenges in its burn-and-mint processes. Potential exploitation of nonce validation or transaction ordering could lead to double-spending attacks or unauthorised asset creation across chains.

4.2. Secondary Risk Considerations

Beyond the primary risk vectors, the framework faces several operational security challenges. Smart contract implementation risks exist within the complex liquidity management logic, requiring thorough validation and testing protocols. The role of Rebalancing Agents introduces potential market manipulation risks through front-running or coordinated actions that could affect liquidity distribution.

Governance mechanisms, while necessary for protocol adaptability, present additional attack surfaces through parameter manipulation. Integration risks also exist where external services and oracle data feeds could be compromised, affecting system operations.

4.3. Mitigation Strategy

The framework implements a comprehensive security architecture combining technical controls, economic incentives, and operational safeguards:

Technical Controls: The Parent Pool employs multi-signature validation protocols and undergoes regular security audits. Cross-chain messaging implements threshold signature schemes and mandatory confirmation periods to ensure transaction integrity. Smart contracts incorporate formal verification and extensive testing protocols.

Economic Security: Rebalancing Agents might maintain bonded collateral subject to slashing conditions, creating strong disincentives for malicious behaviour. The dynamic bounty system adjusts incentives based on network conditions to maintain balanced liquidity distribution.

Operational Safeguards: Continuous monitoring systems track transaction patterns and liquidity movements to detect abnormal activity. The governance DAO maintains the ability to adjust security parameters rapidly in response to emerging threats.

This multi-layered security approach ensures the framework's resilience while maintaining operational efficiency in facilitating cross-chain liquidity management. Regular security assessments and protocol upgrades ensure the system remains protected against evolving threats in the blockchain ecosystem.

5. Implementation

The LBF implementation will be available through a developer-friendly SDK that enables seamless, permissionless integration into any project. This SDK empowers developers to effortlessly incorporate cross-chain liquidity management into their applications, allowing them to join the cross-chain era and significantly boost their project's liquidity. By abstracting the underlying complexities,

LBF paves the way for a flexible, decentralised, and secure bridging solution that can drive innovation and scalability across diverse blockchain networks.

6. Governance and tokenomics

Lanca is a community-driven protocol, and the governance is vested in the Lanca DAO. The DAO is responsible for making decisions on the protocol's direction, including the protocol's parameters and upgrades. At the moment, there is no finalised governance and tokenomics model for LBF. However, the Lanca team will be responsible for the initial governance of LBF.

7. Conclusion

The Lanca Bridging Framework (LBF) represents a transformative step forward toward achieving true chain unification by employing innovative cross-chain liquidity management techniques.

Central to its design is a dual liquidity management system that seamlessly integrates a parent-child pool architecture with a dynamic, IOU-based rebalancing mechanism. In this system, the Parent Pool serves as the master liquidity hub, efficiently allocating assets across various child pools based on real-time network demands, while autonomous Rebalancing Agents monitor and adjust liquidity imbalances through prompt asset injections and secured IOU redemptions. This dual approach not only minimises idle capital but also enhances capital efficiency across chains, ensuring robust liquidity even during periods of market volatility.

Complemented by secure cross-chain communication protocols—Concero Messaging V2 and Chainlink CCIP—the LBF guarantees transaction integrity and rapid asset settlement. Moreover, its permissionless integration via a developer-friendly

SDK empowers any project to enter the cross-chain era, significantly boosting liquidity and scalability while reducing reliance on centralised intermediaries.

In essence, LBF's innovative architecture and dual liquidity management system pave the way for a truly interconnected and resilient blockchain ecosystem, driving forward a vision of seamless value transfer and chain unification.

8. References

[1] CoinGecko. (2024). Top Layer 1 (L1) Coins by Market Cap | CoinGecko. [online] Available at: https://www.coingecko.com/en/categories/layer-1 [Accessed 6 Feb. 2025].

[2] CoinGecko. (2024b). Top Layer 2 (L2) Coins by Market Cap | CoinGecko. [online] Available at: https://www.coingecko.com/en/categories/layer-2 [Accessed 6 Feb. 2025].

[3] Swift. (2023). Successful blockchain experiments unlock potential of tokenisation. [online] Available at: https://www.swift.com/news-events/news/successful-blockchain-experiments-unlock-potential-tokenisation.

[4] OKX (2024). Our Research Brief with Economist Impact is Live: Digital Assets as the New Alternative for Institutional Investors. [online] OKX. Available at: https://www.okx.com/learn/okx-economist-impact-report [Accessed 6 Feb. 2025].