

# Starport

A Multi-Asset Limit Order Station

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**Abstract:** In this work, we present Starport: a generalization of the central limit order book to an arbitrary number of assets. Starport breaks the traditional pairwise asset paradigm and introduce limit orders that can be filled with multiple assets. In doing so, Starport unifies the liquidity fragmented across a set of assets under a single pool, increasing capital expressivity and efficiency while preserving the price control granted by traditional order books. With an internal router between orders with a common intermediary asset, Starport further deepens liquidity — providing takers with better prices over more fragmented exchanges, and makers with higher inventory turnover. This monolithic architecture may also significantly reduce the operational costs of trading (L1 fees), as a single transaction can post orders that otherwise may have required dozens of transactions.

Starport Labs

# 1 Motivation

With the establishment and growth of automated market makers (AMMs), including concentrated liquidity variants (CLAMMs), and highly optimized central limit order books (CLOBs), the flourishing world of decentralized finance (DeFi) on Solana shows much promise in the years to come. Together, these primitives provide solutions for trade among many types of assets. For example, CLAMMs and stable swap AMMs effectively mediate trade among groups of highly correlated assets such as liquid staking tokens or stablecoins, while CLOBs provide a powerful price discovery engine between more volatile asset pairs. Nevertheless, there are several problems that many of these DeFi primitives leave unsolved: liquidity fragmentation, and capital expressivity and efficiency. **Starport**, the world’s first multi-asset central limit order station in all of finance, aims to ameliorate these issues.

## 2 Starport: Liquidity Defragmentation, and Capital Expressivity and Efficiency

Starport ameliorates the aforementioned issues by breaking the traditional pairwise asset paradigm inherent to order books, allowing one-to-all trades between the assets present in a Starport. Accomplishing this requires introducing a new type of limit order, and abandoning the "book" for new data structures for order accounting. We cover the latter first, since it makes understanding the former more intuitive.

### 2.1 Limit Order Catalogs

To understand the generalization of the order book, we must first reinterpret limit order books. A limit order book can be understood as a set of two lists of orders sorted by price<sup>1</sup>. Every order book makes the distinction between the base and quote asset, and specifies a common tick size, base lot size, and quote lot size. This can be reinterpreted as two distinct **Catalogs** that simply list one posted asset (the asset being sold), and the price per lot for the asset that they are willing to accept. With this reinterpretation, it is easy to understand how one can add a third catalog and expand each of the catalogs to allow prices to be optionally specified for any of the other assets associated with the other catalogs. Figure 1 summarizes this train of thought and shows a sample extension to three assets.

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<sup>1</sup>And submission time or any other prioritization attribute.

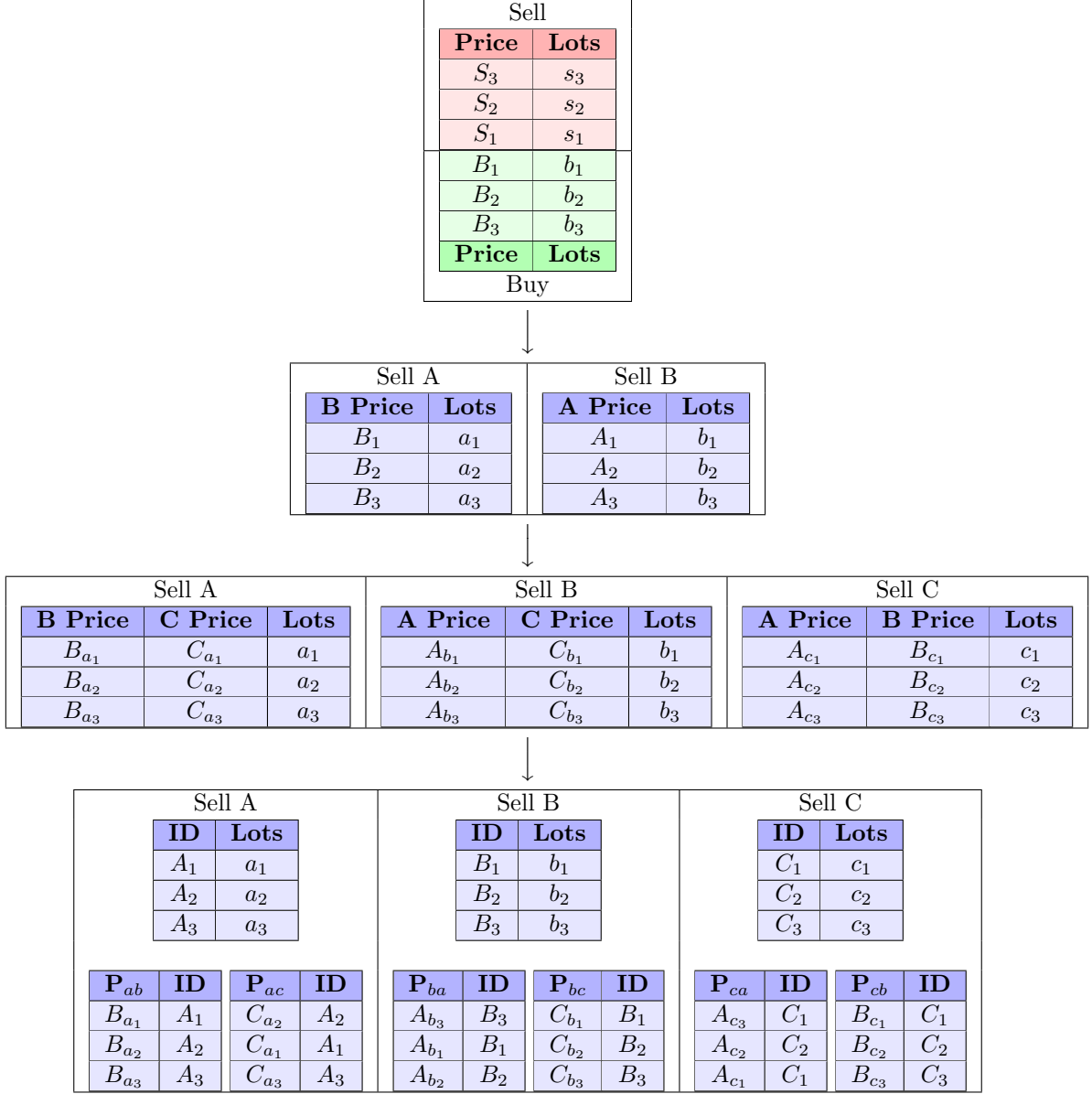


Figure 1: Visualization of the generalization of the order book. (First) Traditional buy and sell side. (Second) An almost-equivalent formulation: a Starport with two assets. Note that it is not exactly equivalent because Catalog A specifies a lot size for asset A, while Catalog B specifies a lot size for asset B. (Third) Without loss of generality, an example extending the formulation to three assets. At this stage, there is no unique total ordering for the posted orders across all price columns. (Fourth) Restructuring tables to be indexed by each column price.  $P_{ij}$  is short for price of asset  $i$  in terms of  $j$ . Some sample sorting is shown. e.g. with price  $B_{a_1} < B_{a_2}$  but  $C_{a_2} < C_{a_1}$ .

## 2.2 Starport Order

The schematic of the Starport limit order is summarized in Figure 2. Instead of having a base asset, quote asset, and a flag to distinguish between buys and sells, the posted asset specified assumes the equivalent role of the base asset. The order type  $T$  can be specified as Limit, Post, Immediate, Fill-Or-Kill. Limit and Post orders are sell orders, while Immediate and Fill-Or-Kill orders are buy orders. Limit orders have the usual definition, with partial fills for selling the posted asset at execution time and posted orders which are valid until expiration. Post orders are identical to Limit orders, except that they are aborted if there is a partial fill at execution time. Immediate orders are orders to buy lots of posted asset using any of the ask assets at the limit price specified at the time of execution – partials fills are allowed. Fill-Or-Kill orders are identical to Immediate orders, except that partial fills are not allowed.

Base Lots Posted	Price of Base in Quote Lots	Side
$N$	$P_1$	$S$

Posted Asset	Assets A Lots Posted	B Price	C Price	D Price	Type
$A$	$N$	$P_1$	$P_2$	$P_3$	$T$

Figure 2: Top (grey): A traditional limit order: all orders are in terms of the base asset. Bottom (blue): An order for a Starport with 4 assets. Any strict subset of the  $P_i$  can be null, which limits the assets that can fill the order. (Not shown: common attributes such as expiration time.)

### 2.2.1 Additional Order Types

Two additional independent order types are available on a Starport: **Omnibus** and **Alexandria**. One is geared toward makers and the other toward takers.

**Omnibus:** On traditional order books, market makers often submit sets of pairs of orders on each side of the book. These pairs typically share an expiration time. An Omnibus order allows a market maker to similarly post orders across all of the catalogs on the Starport. Essentially, it merges a set of Limit/Post orders into a more compact instruction, specifying only one expiration time and order type. Additionally, on a system like Solana, it eliminates all redundant account, instruction, and other validations that would be done repeatedly when posting several individual orders.

**Alexandria:** Alexandria orders are one-to-one asset orders that are internally routed through orders containing a common intermediary asset. That is, a user attempting to go from some source asset to some destination asset can be routed through the purchase and sale of some other asset on the Starport if orders to sell and buy the intermediary asset exist. This type of order is only useful on a Starport with more than two assets, as there are no intermediary assets to route through with only two assets. By invoking orders that would not usually be filled, offering Alexandria orders deepens liquidity and reduces price impact for users while simultaneously increasing volume for maker orders on less popular routes. See Figure 3 for a visualization.

This generalization of the limit order has far-reaching ramifications. In regards to liquidity fragmentation, a smaller fraction of a market maker’s portfolio is required to have open orders of equal size across the same pairs at any single point in time. In regards to capital expressivity, such

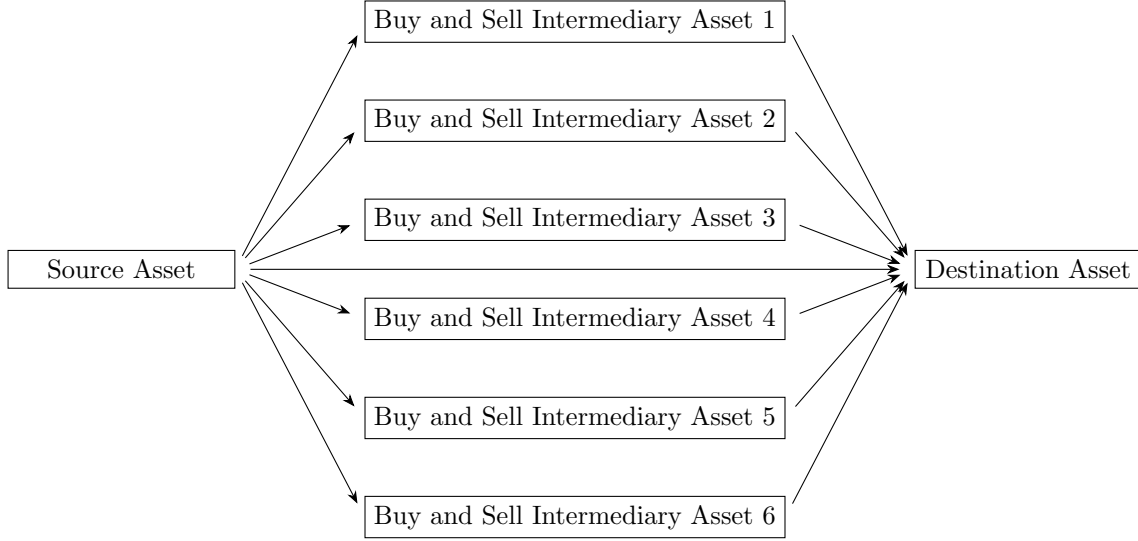


Figure 3: An Alexandria order on a Starport with 8 assets. The direct route plus all routes including an intermediary asset are considered when filling the order.

an order is in the worst case only as expressive as a traditional limit order (when only one price  $P_i$  is not null). Inverting this statement implies that a traditional limit order suppresses expressivity — always forcing only one price  $P_i$  to be not null. In regards to capital efficiency, all else equal, an order with more than one non-null  $P_i$  can expect to be filled faster than an order with only one non-null  $P_i$ . This implies that market makers on a Starport can expect higher inventory turnover for the same capital<sup>2</sup>. This is further enhanced with the additional volume from the internal router used by the Alexandria order. Altogether, all else equal, users making markets for a set of assets on a Starport should expect higher returns compared to market making on the corresponding set of order books. If the Starport hosts a group of highly correlated assets<sup>3</sup>, a market maker can expand from a single pair to the entire set and capture order flow across the other assets with little additional market risk<sup>4</sup>.

Another benefit of a Starport containing many assets is the reduction in the operational costs of market making as it relates to transaction fees. We begin first with an analysis of transaction fees on Solana. Consider a high frequency trader that updates an order book every slot. One transaction every 400 ms would cost approximately 394 SOL per year. At a price of \$100 per SOL that is almost \$40,000 per year to update orders on the book. Consider a Starport with 8 assets containing 28 possible asset pairs. Making just five of these pairs independently would cost market makers \$200,000 a year according to our previous calculation. However, on a Starport, orders can be posted on all 28 pairs (56 sides) or any subset thereof using an Omnibus order with just one transaction per update (\$40,000 per year for one transaction per slot).

<sup>2</sup>Or equal inventory turnover with less capital, allowing them to make other markets instead.

<sup>3</sup>Examples include some quote asset such as USDC and one set of: liquid staking tokens, equal-expiry options with similar strike prices, associated in-game assets such as armor sets or potion sets.

<sup>4</sup>External risks such as vulnerable bridges or smart contracts that back one or several of the tokens or assets on the Starport are still present, e.g. depegging, drained reserves, etc.

The idea of a multi-asset exchange is not new. Particularly, there exists constant product automated market makers with multiple assets. However, the constant product curve (or any other uninformed curve) makes them an ineffective option for liquidity providers outside of stable swaps. To our knowledge, there is not yet a CLAMM implementation for more than two assets. Starport Labs is currently researching this as a future product. It is not yet clear if there can exist an implementation which allows users to opt out of supplying liquidity on particular asset within the CLAMM, so such a product would serve different use cases than a Starport.

## 3 Drawbacks and Limitations

At Starport Labs, we aim to build the future while remaining transparent and honest. As part of this philosophy, we delineate some of the drawbacks and currently known limitations of Starport in this section.

### 3.1 Large Data Requirements

The current implementation of Starport does not allow for only a sparse set of routes to be traded. A Starport with  $N$  assets contains  $N(N-1)$  catalogs. Thus, with a large number of assets (roughly  $\geq 8$ ), the amount of data required on-chain can grow to be tens of megabytes. It is worth noting that traditional order books run into the same issue, except that not all  $\frac{N(N-1)}{2}$  trading routes need be made available. Nevertheless, this can be ameliorated either with a sparse implementation, or by limiting the catalog capacity for larger Starports which is currently constant across all Starports.

### 3.2 Monolithic Design: Parallelization

Starport takes inspiration from the success of Solana’s monolithic design. Just as Solana offers atomic composability of programs and state, Starport offers atomic composability of liquidity. But, this has its trade-offs. In the initial implementation of Starport, write locks are taken across all catalogs, even if trades are not routed through them. This reduces the capacity for parallelism that is easily achievable with separate traditional order books (analog with sharded blockchains). To summarize, there is a spectrum between liquidity defragmentation and parallelization — it goes without saying Starport Labs believes this is a prudent compromise. Designing a more sparse implementation that reduces the number of write locks is an active area of research internally.

## 4 Conclusion

We introduced a generalization of the central limit order book to an arbitrary number of assets. We discussed the necessary changes that need to be made to the limit orders and internal accounting. We characterize the many benefits of this generalization, which can be summarized as the defragmentation of liquidity and the enhanced expressivity and efficiency of capital. We also discussed some of the drawbacks and limitations of this design, justify the trade-offs made, and discuss our plans for future improvements.