Oedax: Loopring's Open-Ended Dutch Auction Exchange Model

We introduce an enhanced Dutch Auction-based exchange model that allows both buyers and sellers to participate after an auction starts. In this post, we outline the design of such an exchange model and analyze some of its properties.

Dutch Auction

In a Dutch Auction, a fixed amount of asset is put into the auction for sale. The initial ask price starts (much) higher than any open market prices and decreases gradually to zero, according to some pre-specified function. The dutch auction ends if and only if the actual price, calculated by dividing the accumulated money (sent by the bidders) by the number of assets (being sold by sellers), equals the ask-price at a given moment.

Dutch Auctions have some desirable properties. First of all, auctions always settle, guaranteed. Secondly, all participants in the same auction get the same price for settlement, regardless when they participate in the auction and the size of their contributions. This property avoids front-running issues that most order-based exchange models suffer. This same-settlement price property, however, does have a drawback as well—participants tend to withhold until a later time to participate when the ask-price becomes more reasonable instead of during the early phase of the auction.

Dutch Auction is an excellent means of price discovery, especially in a decentralized environment powered by blockchain technology. Specifically, the settlement prices in Dutch Auction can act as decentralized price oracles for smart contracts—assuming the auctions are well known and there are enough participants.

The original Dutch Auction model is designed for one-way asset offering and does not allow additions of assets being sold once the auctions start. We propose an enhanced version called *Open-ended Dutch Auction Exchange*, or *Oedax*, which is more like a bi-directional exchange instead of a one-way auction.

Introducing Oedax

We designed Oedax to facilitate two groups of people, sellers, and buyers, to exchange assets, especially cryptocurrencies or crypto tokens. Therefore in this post, we use crypto tokens as examples for easier description, but Oedax is truly generic and can be applied to the exchange of other types of assets.

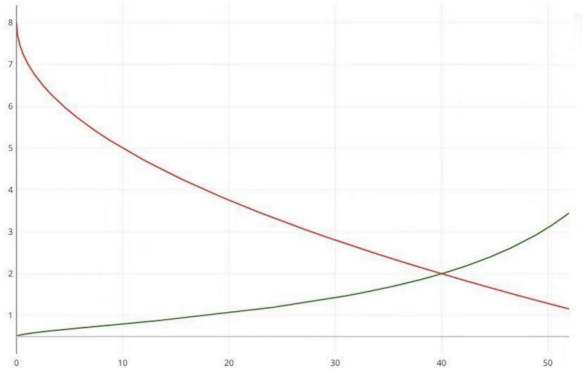
Suppose sellers want to sell *TokenA* for *TokenB*, and buyers want to buy *TokenA* with *TokenB*. Oedax allows buyers to auction off *TokenA* to sellers for *TokenB*, and in the meanwhile and in the very same auction, allows buyers to auction off *TokenB* to sellers for *TokenA*. Therefore an Oedax auction can be perceived as two inner-auctions seemingly integrated with shared parameters.

We further suppose that the fair market price for *TokenA*, with respect to *TokenB*, is `P`; and the initial sell-price of *TokenA in an Oedax auction* is `M*P` where `M > 1` —we call `P` the *target price* and `M` the *price scale factor*. The *duration* of the Oedax auction is `T`, which is the expected time the auction will end if no one ever participated in the auction.

Then we specify two price curves, one for the selling of *TokenA*, i.e, the *Sell Curve (or `SC`)*, and one for the buying of *TokenA*, i.e, the *Buy Curve (or `BC`)*. These two curves are designed to satisfy the following requirements:

- `SC(0) == P*M && SC(T) == P/M` (rule#1);
- `BC(0) == P/M && BC(T) == P*M` (rule#2);
- There exists a time `t`, `t ≤ T`, such that `SC(t) == BC(t) == P` (rule#3).

We further assume the amount of *TokenA* in the auction at any time `t` is `Qs(t)`, and the amount of *TokenB* at any time `t` is `Qb(t)`. Then a horizontal line representing the *actual price* `p(t) = Qb(t)/Qs(t)` can be drawn. We call this horizontal line the *actual price line,* or *APL*. Note that *APL* moves upward if more *TokenB* participates in the auction and downward if more *TokenA* participates in the auction.

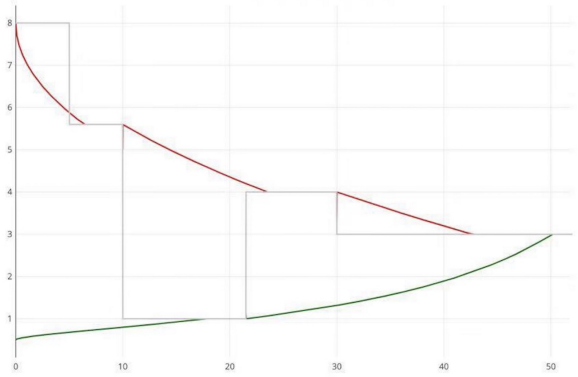


Price Curves (red: Sell Curve, green: Buy Curve) with T = 40, P = 2.0, M = 4.0

Price Bonding and Settlement

An Oedax auction can start with zero *TokenA* and/or *TokenB* deposit, i.e, `Qb(0) == Qs(0) == 0`. As time passes, participants can deposit either *TokenA* or *TokenB* to change the actual price `p`. But Oedax applies some important price bonding rules:

- Once the actual price `p` falls in between SC and BC curves at time `T'`, it should always stay in between the curves to make `BC(t) ≤ p(t) ≤ SC(t)` hold for any `t ≥ T'` until the auction ends (rule#4);
- The Sell Curve cannot drop further down once it meets the actual price line, but it can resume dropping once the actual price line moves downward (so there is room from the Sell Curve to drop further). When resuming dropping down, the Sell Curve must drop from its previous value. If plotted, the Sell Curve seems like it's been cut into pieces and has been partially shifted to the right along the x-axis. The same rule applies to the Buy Curve as well, but in the opposite direction (rule#5);
- The converging of the Sell Curve and the Buy Curve marks the end of the auction. If the actual price line has never fallen in between the price curves, the auction will not settle and all tokens will be returned to participants; otherwise, the actual price line will certainly converge with the two price curves, and the settlement occurs. (rule#6);



An Oedax auction that ends and settles at time 50 and price 3.0—the horizontal gray lines represent the actual prices at different moments.

A well designed Oedax auction should have the actual price line be inside the Buy and Sell Curves before or immediately after the start of the auction to make sure it settles. This will boost user participation. The final settlement price is irrelevant of target price but is supposed to be close to it.

Phases

Oedax auctions only settle if the actual price falls in between the two bonding curves and the actual price line at time `T'`, we call the phase from time `0` to `T'` *phase-1*. Phase-1 has the most uncertainties for participants and should be minimized if possible. `T'` marks the start of *phase-2*, which has fewer uncertainties and guarantees the auction will settle.

We can introduce another parameter N, and once the gap between the two price curves is smaller than or equal to N*P we enter *phase-3*. The other way to define phase-3 is to use time elapsed with respect to T as a measure, e.g., after `0.75T` we enter phase-3. Phase-3 represents a

period where participation in the auction is the least risky and the buy-sell price gap is small enough.

It is certainly possible to define more phases or introduce further finer granularity for classifying auction participation. The general idea is to encourage and reward early participation which is critical for creating more liquidity, and charge fees for later participation. Conceptually, we can treat early participation as market makers and latter participations as takers.

Participation and Cancellation

In phase-1, participants can deposit any amount of *TokenA* or *TokenB* into the auction without restrictions. If withdrawal is permitted, participants can also withdraw any amount of tokens.

After phase-1 and before an auction ends, participants can still deposit more *TokenA* or TokenB in the auction, or withdraw from it, but there are limits on the amounts to assure `BC(t) ≤ p(t) ≤ SC(t)` always hold. Those limits are:

- The deposit limit for *TokenA* is `Qb(t)/BC(t) − Qs(t)`
- The deposit limit for *TokenB* is `Qs(t)*SC(t) − Qb(t)`
- The withdrawal limit for *TokenA* is `Qs(t) − Qb(t)/SC(t)`
- The withdrawal limit for *TokenB* is `Qb(t) − Qs(t)*BC(t)`

To facilitate later participation in large sizes, Oedax can queue the amount beyond the current deposit limit in a waiting list, and when there is a counter-party beyond-limit deposit, Oedax will accept deposits from both buy and sell side to end up with at most one waiting list for either the sell or the buy side. The waiting list will automatically expire at the end of the auction[1].

> *[1] The waiting list idea is contributed by the SECBIT Lab.*

To discourage withdrawal, a fee may apply. An Oedax auction can be configured with withdrawal disabled.

Curves

The two price curves can be defined independently, e.g, one curve can be a straight line and the other curve can be polynomial. But since these two inner auctions are happening in parallel, it may be more reasonable to design the Buy Curve and Sell Curve in such a way that the sell-price and the buy-price develop with the same velocity. We can achieve this by binding SC and BC using:

- `BC(t)*SC(t) == P*P` (rule#7)

With this binding, only one of the two curves needs to be defined to derive the other one.

With this rule enforced, the curves for a *TokenA/TokenB* Oedax and curves for a *TokenB/TokenA* Oedax take the same shape. In other words, this rule makes Oedax *token-symmetrical* — an *ABC/XYZ* auction is the same as an *XYZ/ABC* auction.

> *The Loopring protocol also adapts such a similiar token-symmetrical data modeling approach— a ABC/XYZ sell order is an XYZ/ABC buy order. In our precious posts, we referred it as "unidirectional order modeling".*

Oedax Features

Oedax trading model has the following advantages:

- It does not relay on other types of trading platforms for price discovery or adjustment.
- It allows both sellers and buyers to participate in an auction after the auction starts. Oedax can even allow conditional withdrawal before the auction ends.
- It is possible to accept pre-submitted limit price orders and convert them into Oedax participation once the auction's price range satisfy the order's requirements.
- Oedax auction's final settlement volume is not restricted by the initial deposit of either token and can potentially be much larger than a Dutch auction. Oedax is suited for large trades and is market-making friendly.

Oedax inevitably inherits some shortcomings that Dutch Auctions have, including:

- The trading is not instantaneous, it takes time to end the auction;
- The settlement price is reasonable (close to market price) only when the auction is well aware of and has enough participants.

Use Oedax in Loopring

Oedax will be used by Loopring 2.x to achieve "*fee burning*", a unique token economic feature that enables Loopring relayers to accept any ERC20 tokens as fees, and to pay the protocol smart contract a small percentage of the fees called *the burn*.

Anonymous users can trigger the burn to be auctioned off for LRC token in Oedax auctions, and the purchased LRC will be sent to address `0x0` automatically (our planned LRC ERC20 upgrade will treat this as a special destructive operation and reduce the total LRC supply). Oedax will automate the fee burning process in a trustless and decentralized fashion, which is an essential part of Loopring's governance objective.

We may further provide UI in our wallet for Oedax to make it available for end-users. The fees collected by Oedax auctions will also be auctioned off for LRC to burn via Oedax itself.