

# Simulation test scenarios – TB

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April 27, 2017

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## 1 Procedures

### 1.1 To buy an ask order BUY

Provided that the asked price  $r_A$  is lower than  $r_S$ , the price registered in the source wallet  $w_S$ , the BUY procedure has five steps:

1. BUY\_1: the balance in  $w_S$  is converted to source coin:  $b_S \times r_S$ ;
2. BUY\_2: That balance is then converted to target, according to the asked rate

$$\frac{b_S \times r_S}{r_A};$$

3. BUY\_3: the purchase, or the amount to be bought, is the minimum among what can be in the wallet and what is being sold:

$$p_T = \min\left(\frac{b_S \times r_S}{r_A}, a_T\right);$$

4. BUY\_4: the purchased amount is subtracted from the balance in the source wallet  $w_S$ :

$$a'_S = a_S - p_T \frac{r_A}{r_S};$$

The ratio  $r_A/r_S$  takes into account that the source coin in the  $w_S$  corresponds to a higher valued target coin.

5. BUY\_5: the purchased amount is added to the balance in the target wallet  $w_T$ :

$$a'_T = a_T + p_T.$$

*OBS:* In a real exchange situation, the  $p_T$  amount is reserved in the source wallet and is only added to the target wallet when a real sale happens: there can be a situation when one or more faster buyers get all the ask offer, or part of it. In that case, the reserved amount (or part of it) can be returned to the normal operation of the source wallet.

### 1.2 To sell for a bid order SELL

Provided that the asked price  $r_B$  is higher than  $r_T$ , the price registered in the target wallet  $w_T$ , the SELL procedure has three steps:

- SELL\_1: the transfer value, or the amount to be sold, is the minimum among what can be in the target wallet and what the bid offer wants to buy:

$$t_T = \min(a_T, b_T);$$

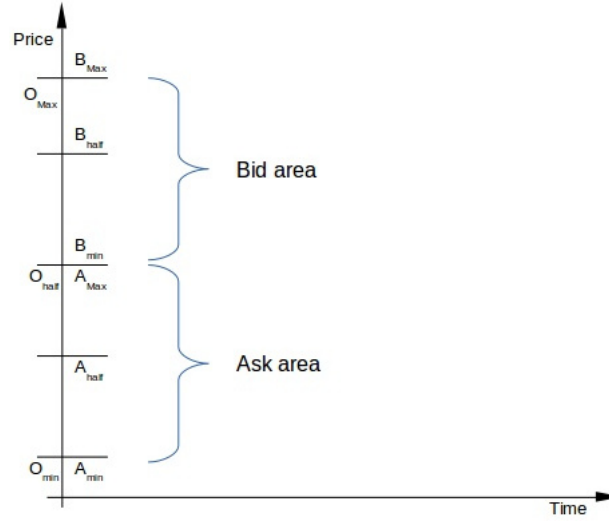
- SELL\_2: the transfer amount is subtracted from the balance in the target wallet  $w_T$ :

$$a'_T = a_T - t_T;$$

- SELL\_3: the purchased amount is added to the balance in the source wallet  $w_S$ :

$$a'_S = a_S + t_T.$$

*OBS:* In a real exchange situation, the  $t_T$  amount is reserved in the target wallet and is only added to the source wallet when a real sale happens: there can be a situation when one or more faster sellers get all the bid offer, or part of it. In that case, the reserved amount (or part of it) can be returned to the normal operation of the source wallet.

Figure 1: Graphical description of scenario *Simple1*

## 2 Simple 1: everything constant

### 2.1 Conditions

- All orders in the range  $[O_{min}, O_{Max}]$ ;
- Middle order at  $O_{half} = (O_{min} + O_{Max})/2$ ;
- All orders have amount  $a$ ;
- Ask orders belong to  $[A_{min}, A_{Max}]$ , where  $A_{min} = O_{min}$ , and  $A_{Max} = O_{half}$ .  
In this scenario, all ask orders have price  $r_A = A_{half} = (A_{min} + A_{Max})/2$ .
- Bid orders belong to  $[B_{min}, B_{Max}]$ , where  $B_{min} = O_{half}$ , and  $B_{Max} = O_{Max}$ .  
In this scenario, all bid orders have price  $r_B = B_{half} = (B_{min} + B_{Max})/2$ .
- There is a wallet for target coin, and another for source coin.

Both wallets are considered in terms of the target coin, even though the source coin wallet in reality has source coin values. That eases the calculations, and is in line with the common practice in the exchanges, where ask and bid orders are given in terms of the target coin only.

The values in the source coin are associated with a conversion rate for the target coin, what permits that;

- The wallet for *target* coin  $w_T$  has an initial amount  $a_t = a$ , and a constant rate

$$r_T = A_{half} = r_A;$$

- The wallet for *source* coin  $w_S$  has an initial amount  $a_S = a$ , and a constant rate

$$r_S = B_{half} = r_B;$$

- The simulation starts with an ask order;
- It is succeeded by a bid order, and then by an ask order – and so on indefinitely: an ask then a bid, then an ask...

## 2.2 Alternative 2.1 – 1st Ask

Here follow the orders:

### 2.2.1 Ask order # 1

When the 1st **ask** order arrives with rate  $A_{half}$ , and an amount  $a$ , the *source* wallet has an amount  $a$ , and a buy price of  $r_S = B_{half}$ . Since the buy rate  $r_S$  is above the ask rate  $A_{half}$ , the target coin will be bought.

- In the BUY\_1 (step 1): the balance is converted to source coin:  $b_S \times r_S = a \times r_S$ ;
- Following the BUY\_2 step (item 2): the balance in source coin is converted to target coin using the  $r_A$  rate:

$$\frac{a \times r_S}{r_A} = a \frac{r_S}{r_A}$$

- Following step BUY\_3 (item 3): Since  $r_S > r_A$ , the expression from BUY\_1 is larger than  $a$ , the amount in the ask order. So, the value to be bought is simply  $a$ ;
- Following step BUY\_4 (item 4): Since  $a$  was used, it is subtracted from the previous balance in the wallet  $w_S$ :

$$a \frac{r_S}{r_A} - a = a \left( \frac{r_S}{r_A} - \frac{r_A}{r_A} \right) = a \frac{r_S - r_A}{r_A}.$$

- Following step BUY\_5 (item 5): the purchased amount  $a$  is added to the balance in the target wallet  $w_T$ . Since it was  $a$  it becomes

$$a'_T = a_T + P_T = a + a = 2a.$$

### 2.2.2 Bid order # 1

Now comes a **bid** order that wants to buy an amount  $a$  of **target** coin, at a rate  $B_{half}$ . Since the sale rate  $r_T = A_{half}$  is below the bid rate, the target coin will be sold. That is: the target will be sold by a price higher than it was bought.

- In the SELL\_1 (step 1.2): The bid offers will buy  $a$  target coins. The target coin has  $2a$  – so the minimum is  $a$ ;
- Following the step SELL\_2 (step 1.2), the minimum computed in the previous item will be subtracted from the target wallet  $w_S$ :

$$a'_T = 2a - a = a.$$

- according to SELL\_3 (item 1.2): the amount transfered from the sale is added to the balance in the source wallet  $w_S$ :

$$\begin{aligned} a'_S = a_S + t_T &= a \frac{r_S - r_A}{r_A} + a \\ &= a \frac{r_S - r_A}{r_A} + a \frac{r_A}{r_A} \\ &= a \left( \frac{r_S - r_A + r_A}{r_A} \right) \\ &= a \frac{r_S}{r_A} \\ &= a \frac{r_B}{r_A}. \end{aligned}$$

Since  $r_S = r_B > r_A$ , the balance in the source wallet is larger than  $a$ .

### 2.2.3 Ask order # 2

Then comes another **ask** order, and it has price  $A_{half}$ , and an amount  $a$ . Since the buy price  $r_S = B_{half}$  is higher than  $A_{half}$ , the target coin will be bought.

- Following step BUY\_1 (item 1): converting the balance  $w_S$  to source coin:

$$a \frac{r_B}{r_A} \times r_S = \frac{r_B^2}{r_A},$$

since  $r_S = r_B$ ;

- Following step BUY\_2 (item 2):

$$a \frac{r_B}{r_A} \times \frac{1}{r_A} = a \frac{r_B^2}{r_A^2};$$

- Following step BUY\_3 (item 3): since  $\frac{r_B^2}{r_A^2} > 1$ , the minimum between the amount in the ask offer and what is in the source wallet  $w_S$  is  $a$ ;
- Following step BUY\_4 (item 4):

$$a'_S = a \frac{r_B^2}{r_A^2} - a = a \frac{r_B^2 - r_A^2}{r_A^2}.$$

- Following step BUY\_5 (item 5):

$$a'_T = a + a = 2a.$$

### 2.2.4 Bid order # 2

Now comes a **bid** order that wants to buy an amount  $a$  of **target** coin, at a rate  $r_B = B_{half}$ . Since the sale rate  $r_T = A_{half}$  is below the bid rate, the target coin will be sold. That is: the target will be sold by a price higher than it was bought.

- In the SELL\_1 (step 1.2):
- Following the step SELL\_2 (step 1.2),
- according to SELL\_3 (item 1.2):

Step #	Order	Balance	
		Source coin	Target coin
0	Start	$a$	$a$
1	Ask # 1		
2	Bid # 1		
3	Ask # 2		
4	Bid # 2		
5	Ask # 3		
6	Bid # 3		
7	Ask # 4		
8	Bid # 4		
9	Ask # 5		
10	Bid # 5		

Table 1: Constant price and amount, starting with an ask order

**2.2.5 Ask order # 3**

**2.2.6 Bid order # 3**

**2.2.7 Ask order # 4**

**2.2.8 Bid order # 4**

**2.2.9 Ask order # 5**

**2.2.10 Bid order # 5**

**2.2.11 History of wallet balances**

**2.3 Alternative 2.2 – 1st Bid**

**3 Simple 2: Simple 1 & relaxing order amount**

**4 Simple 3: Simple 2 & relaxing order sequence**

**5 Simple 4: what next ?**