**To Daiwa Securities Capital Markets
Algorithmic Trading Suites**

Arrival 4.2

14-March-2011
Version 1.5

Simplex Technology, Inc.

【Revision History】

Version	Chapter	Details	Date	Editor
1.00	—	First edition	2010/07/29	Kobayashi
1.10	3.1	Add Volatility to formula of stretch volume ratio.	2010/07/30	Kobayashi
	1	Modify calculation of weighted order schedule. Chart of schedule.		
	4	Add Explanation of "auction with volume limit"		
	5	Add Explanation of "Re-slicing"		
1.20	3.1	Modify formula of stretch volume ratio.	2010/08/02	Kobayashi
	3.2	Modify not to use order exclude point.		
	4	Modify spec of auction, separate with and without volume limit.		
1.30	2	Add start and end participation rate's validation. Add market view.	2010/08/17	Kobayashi
	3.2	If end time is earlier than schedule end time Calculation of average participation rate.		
	4	Modify.		
	5	New add		
1.40	2	Start participation rate and end participation rate.	2010/08/17	Kobayashi
	4	Use auction volume adjust rate only to am and pm open weight. Change the condition of re-slice after auction/ Add SQ case.		
	5	Change judge of re-slice. Add graph of market view. Add example of re-slicing.		
	3.5	Add "Adjust participation ratio"		
1.50	2	Modify algorithm parameter	2010/08/19	Kobayashi
	3	Modify the case that arrival2 cannot get ADV.		
	3.1	Add detail of historical average volume at order receipt time)		
	3.2.1	Add spread vs volatility factor		
	3.3.1	Adjust start and end participation ratio		
	5.2	Add the case that participation ratio fall		
	6	Add parent order amend		
1.54	3.5	Add scaling ratio to calc of participation qty	2010/08/30	Kobayashi
1.55	4	Modify the calculation of volume cap during auction in order to fit VWAP4.1 spec.	2010/09/01	Kobayashi
1.56	4	Add the cap of volume participation at the end of auction in order to avoid too many order sent after auction.	2010/09/03	Kobayashi
1.57	5.2	Modify relicing logic in order to avoid schedule being ahead.	2011/03/08	Kobayashi
1.58	6	Do re-schedule if style parameter is amended.	201103/14	Kobayashi
	5.1	If market view parameter is "Neutral", Arrival4.2 does not re-slice by price move	201103/14	Kobayashi

【Contents】

1. Overview

The purpose of Arrival algorithm is to execute orders so as to minimize the deviation of [the price at the time of receiving order from customer] and [the average execution price], considering the market impact and price risk trade-offs.

Arrival4.2 is based on VWAP4.2 and implements below new features.
1. Reducing the time it takes to complete the order.
2. Increasing the volume at near the time of placing the order.
3. Slicing order with volume limit at am and pm auction, even if volume limit parameter is unset..
4. Automatic re-slicing.

2. Additional algorithm parameter

Following parameters are added to VWAP4.2.
These parameters vary based on style parameter.

No	Parameter	Default	Details
1	Volume projection scaling ratio	2	Cap Actual volume ratio by this ratio if Actual market volume is much larger or smaller than historical average volume when calculate the ratio of Actual market volume to historical average volume at order receipt time. If this value is 2, max ratio = 2 and min ratio = 1/2
2	Volatility scaling ratio	2	Cap volatility scaling. If this value is 2, max ratio = 2 and min ratio = 1/2
3	Start participation ratio	See below [Style] table	・Adjust scaled volume when calculate schedule end time. ・Adjust volume curve ratio by these ratios. ※ Start participation ratio must be greater than or equal to End participation ratio.
4	End participation ratio		
5	AM open participation adjust ratio	1.2	See 4
6	PM open participation adjust ratio	1.0	
7	market view adjust base number	2	See.5.2
8	Price move re-slice threshold	0.25 (σ)	See 5.1
9	Volume difference re-slice threshold	10 (%)	
10	Market view	NEWT	"NEUT", "MOME", "REVE" See 3.2.1
11	Market view value for momentum	2	If customer select "MOME" market view, used this value. It can be 1 decimal place.
12	Market view value for neutral	0	If customer select "NEUT" market view, used this value. It can be 1 decimal place.
13	Market view value for reversion	-2	If customer select "REVE" market view, used this value. It can be 1 decimal place.
14	Must finish	ON	ON/OFF

[Style]

No	Parameter	Passive(%)	Normal(%)	Aggressive(%)
3	Start participation ratio	10	20	30
4	End participation ratio	2	7	10

3. Decide slice schedule

[Term definition]

Actual market volume = market volume at order receipt time.

Historical average volume = average volume of past 20 business days.

Schedule end time = target time that arrival algorithm will slice out total order qty.

Volume curve participation ratio = coefficient applied to volume curve ratio in order that volume curve close to order receipt time may be larger.

Weighted volume curve = volume curve from order receipt time to schedule end time weighted by participation ratio.

1. Create projection volume curve by scaling original volume curve.
   Scaling ratio = Actual Market Volume / Historical Average Volume
2. By the schedule end time, total order qty can be sliced out if participate at the weighted ratio.

※   If there is no volume curve, Arrival2 uses fixed volume curve instead.
    Allocate ADV to each minute according to fixed volume curve ratio.
※   If arrival2 cannot get ADV, suppose actual market volume as ADV * volume ratio of current time (if before open, suppose open volume as ADV * volume ratio of open time). Then calculate ADV from actual volume and volume ratio.
    [Example]
        At 9:05 actual market volume = 5,000 and volume ratio of 9:05 = 0.5%, then ADV = 5,000 / 0.5% = 1,000,000.

3.1 projection volume curve

[A] scaling ratio = Max (1 / Volume projection scaling ratio, Min (Volume projection scaling ratio, actual market volume / historical average volume at order receipt time))

※ historical average volume at order receipt time is accumulation of average volume up to calculate time.

Ratio of passed seconds = seconds that passed after reaching the minute / 60 (except for AM and PM open and close)

Average volume at calculate time = Ratio of passed seconds * average volume of the minute.

※ If fulfill following one or more conditions, scaling ratio scaling ratio is 1.

・ historical average volume at order receipt time = 0,

calculate at 9:07:30

time	open / continuous	average volume	add	accumulation
9:00	open	50000	+ 50000	50000
9:00	continuous	40000	+ 40000	90000
9:01	continuous	2000	+ 2000	92000
9:02	continuous	8000	+ 8000	100000
9:03	continuous	6000	+ 6000	106000
9:04	continuous	1000	+ 1000	107000
9:05	continuous	6000	+ 6000	113000
9:06	continuous	12000	+ 12000	125000
9:07	continuous	6000	+ 6000 * 30 / 60 = 3000	128000

Then, calculate scaled volume of each minute after order receipt time

[B] projection volume = ADV * average volume ratio * [A] scaling volume ratio.

※ If actual market volume is zero, [B] average volume of each minute remains original value. (e.g AM auction)

[Example 1]

before order receipet time (= 9:06)

time	actual market volume	historical average volume
9:00	10	24
9:01	15	20
9:02	8	14
9:03	7	9
9:04	6	5
9:05	9	10
total	55	82

after order receipet time (= 9:06)

time	projection volume	historical average volume
9:06	?	8
9:07	?	7
9:08	?	15
9:09	?	4
9:10	?	6
9:11	?	7
total	?	47

[Graph1-1]

before accept time (= 9:06)

■ actual market volume
■ historical average volume

9:00 9:01 9:02 9:03 9:04 9:05
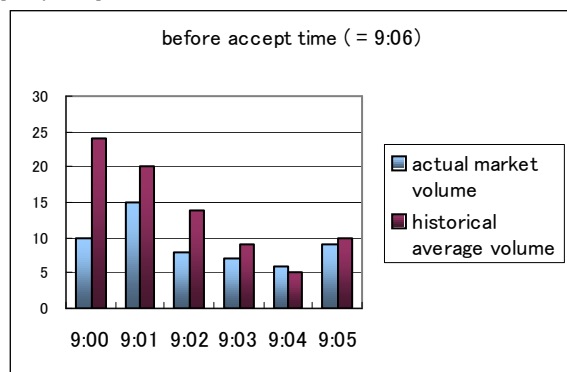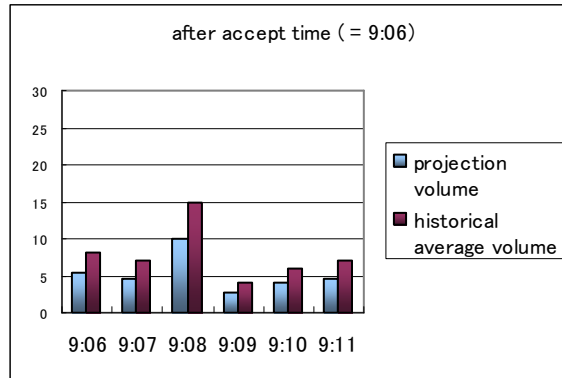
Scaling ratio = 55 / 82 = 0.67

[B] Scaled volume of each minute

= historical average volume * 0.67

after order receipet time (= 9:06)

time	projection volume	historical average volume
9:06	5	8
9:07	5	7
9:08	10	15
9:09	3	4
9:10	4	6
9:11	5	7
total	32	47

[Graph 1-2]

after accept time（= 9:06）

projection volume

historical average volume

9:06 9:07 9:08 9:09 9:10 9:11

3.2 Decide start and end participation ratio

Start participation ratio and end participation ratio are algorithm parameters.
At re-slicing, these ratios are adjusted by market view as follows.

3.2.1 Market View

Market view decides how Arrival2 weight volume curve.
Market view is algorithm parameter and the range is from -4 to 4

(A) difference between arrival price and current market price = x

$$x = （ －1 ＋ （ \text{current market price} ÷ \text{arrival price}） ） ÷ （ \text{yearly volatility} ÷ sqrt(250) ）$$

※ If fulfill following one or more conditions, x = 0.
・ arrival price is zero
・ current market price is zero,.
・ yearly volatility is zero,.

(B) adjust value = y
(B-1) market view > 0

[Buy]
$$y = sgn(x) × （ 1 － \exp(\text{-1} × MarketView × x^2 ÷ π) ）^{0.5}$$

[Sell]
$$y = \text{[above formula]} * (\text{-1})$$

(B-2) market view = 0
$$y = 0$$

(B-3) market view < 0

[Buy]
$$y = sgn(x) × （ 1 － \exp(MarketView × x^2 ÷ π) ）^{0.5} × \text{-1}$$

[Sell]
$$y = \text{[above formula]} * (\text{-1})$$

※ sgn(x) is sign function,
sgn(x):
 if (x = 0) then sign(x) = 0
 if (x > 0) then sign(x) = 1
 if (x < 0) then sign(x) = -1

Above calculation provide number from -1 to 1 (= market view value),
-> [graph 5-1]

Adjust start participation ratio and end participation ratio multiplying <u>market view adjust base number</u> ^ market view value.
(<u>market view adjust base number</u> is algorithm parameter)
-> [graph 5-2]
spread vs volatility factor = Max (1 / Volatility scaling ratio, Min (Volatility scaling ratio, (standard deviation(bp) / (SpreadWeight * average spread)) ^ (0.25)))
    -> SpreadWeight is setup parameter. (arrival2-spread-weight)
    -> "<u>0.25</u>" is setup parameter. (arrival2-spread-sqrt-power)
※ standard deviation(bp) = 10000 * volatility * sqrt((sbPeriod / (270 * 60)) / 250)
※ sbPeriod = (MaxAhead + Max Behind) / 2
※ If fulfill folloing one or more conditions, spread vs volatility factor = 1.
・ arrival2 cannot get statistics data
・ yearly volatility is zero.
・ yearly volatility is empty
・ average spread is zero.
New start participation ratio = Min (50%, start participation ratio * base number ^ market view value * spread vs volatility factor).
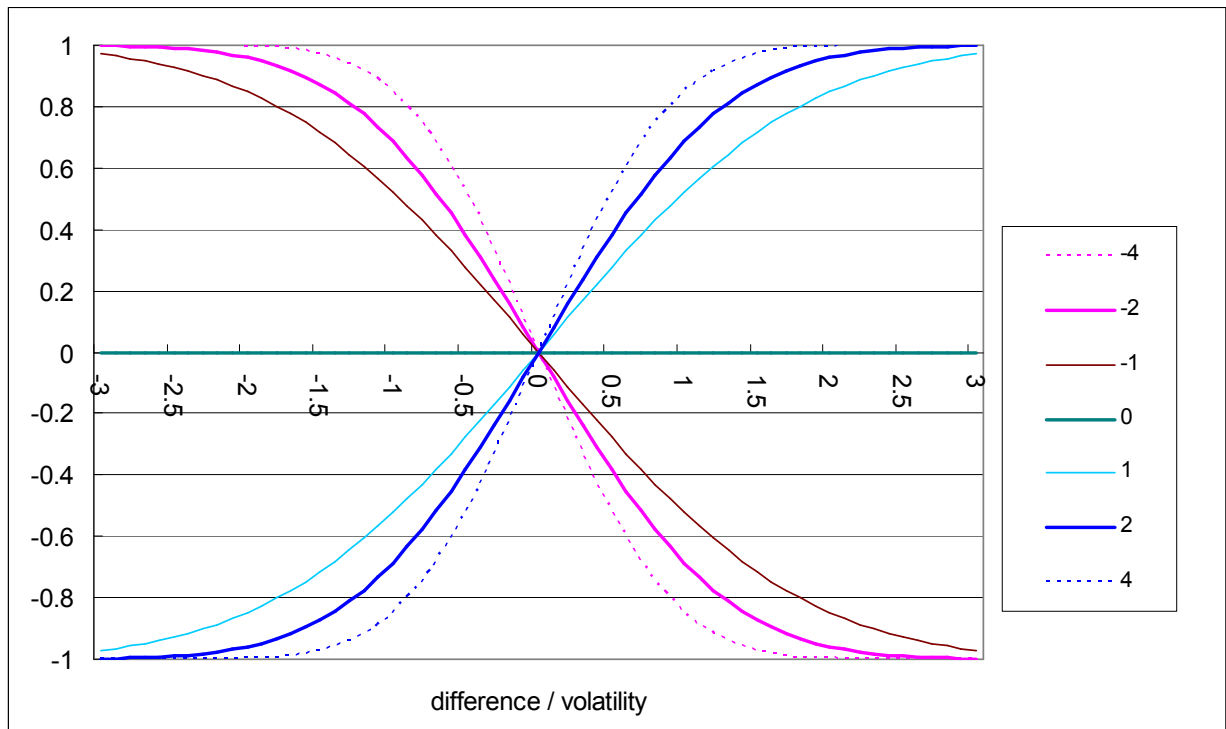New end participation ratio = Min (50%, end participation ratio * base number ^ market view value * spread vs volatility factor).
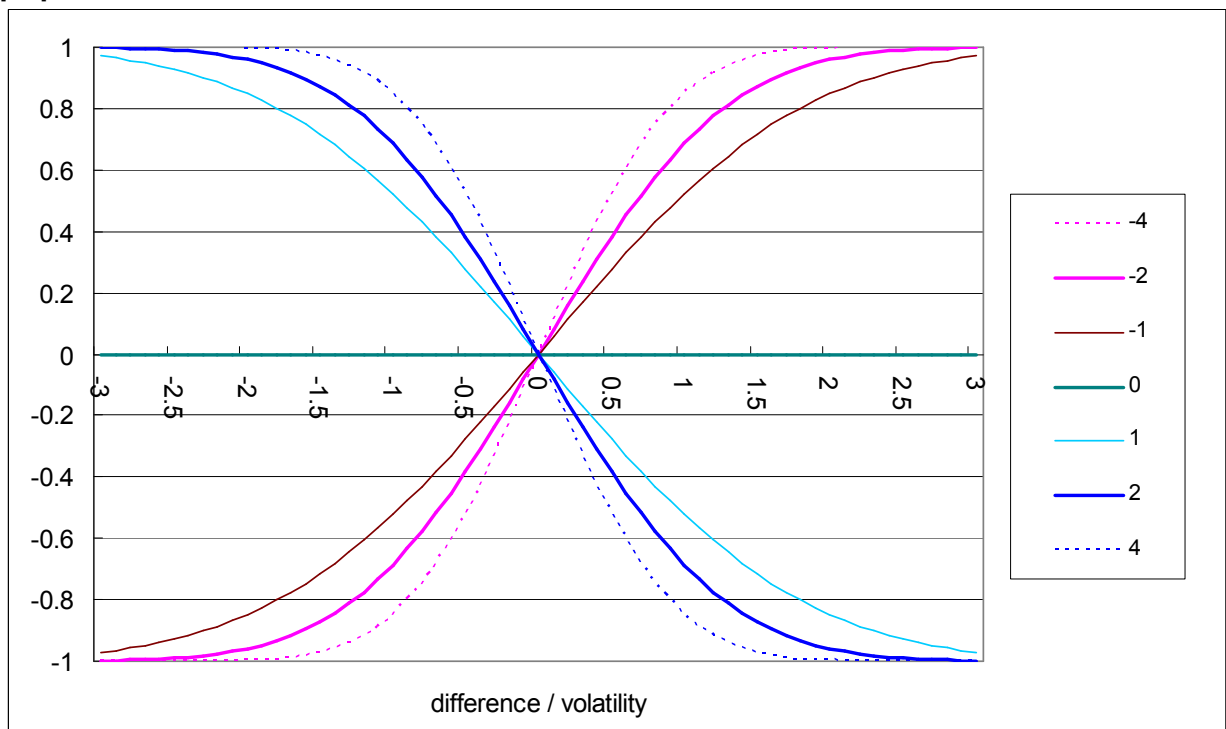
※50% is set up parameter. (arrival2-max-participation-ratio)

Using these participation ratios, Arrival2 slices order.
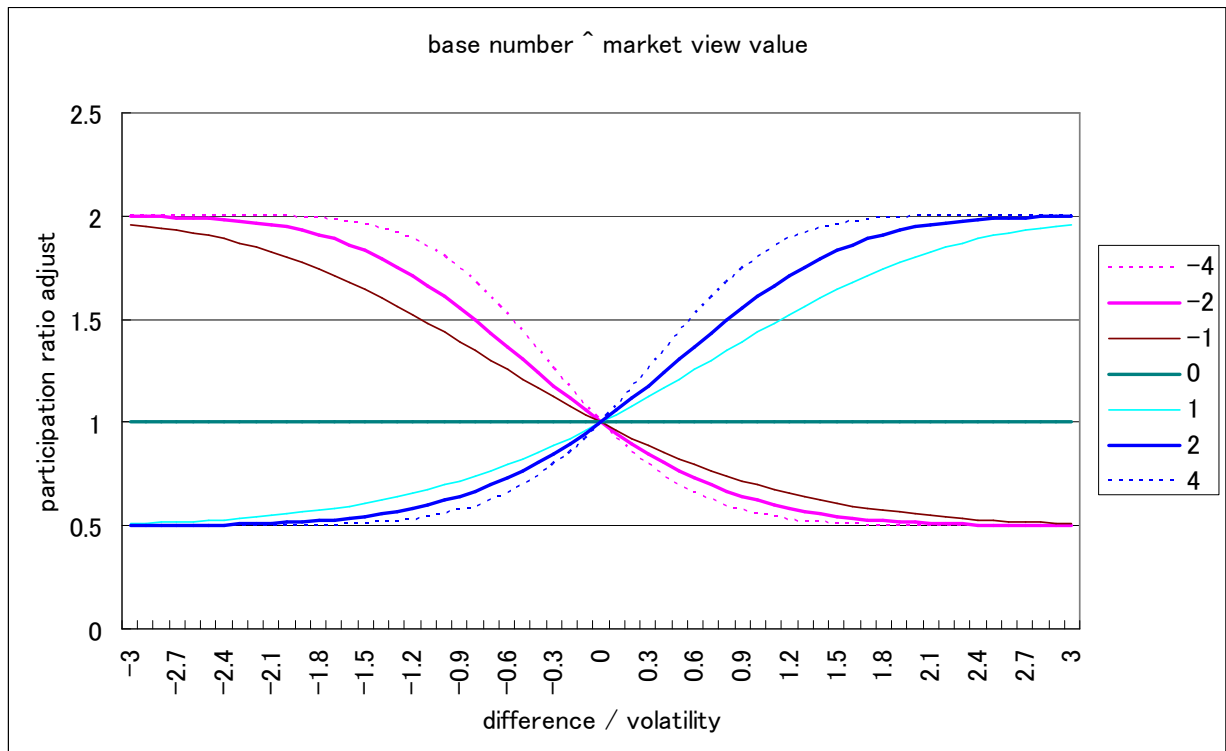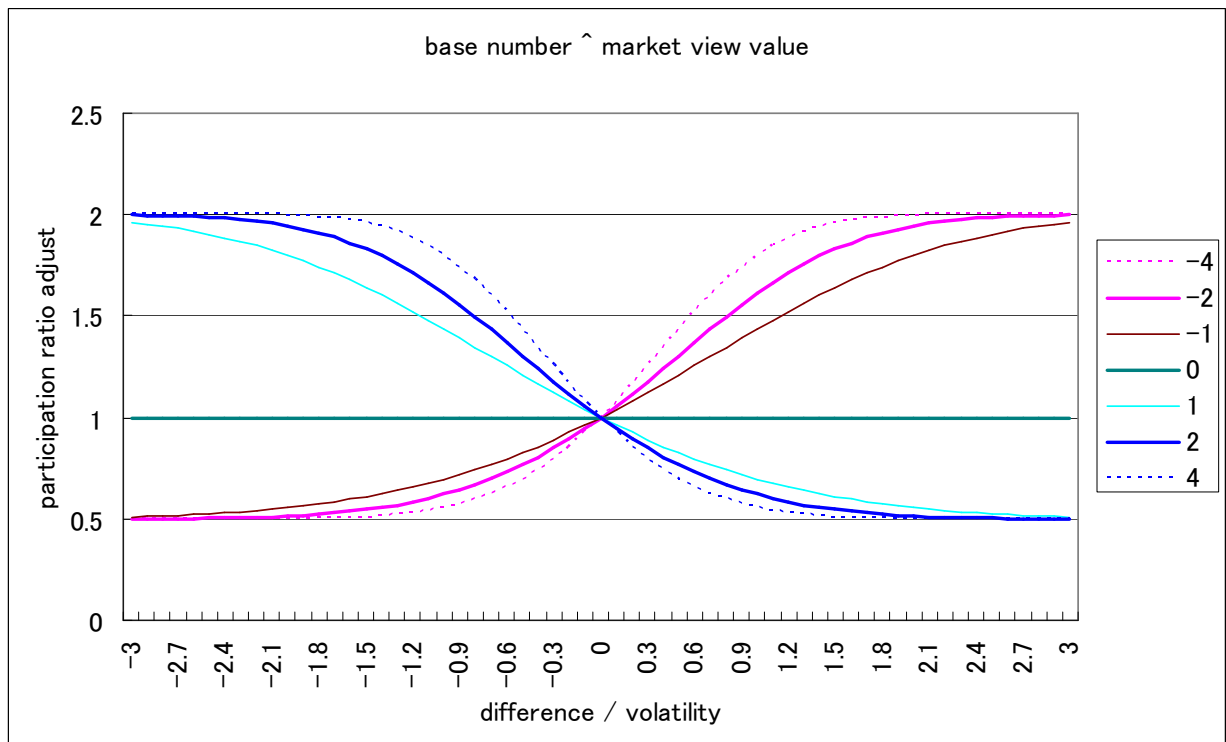
[graph 5-1] market view
[Buy]

difference / volatility

Legend: -4, -2, -1, 0, 1, 2, 4

[Sell]

difference / volatility

Legend: -4, -2, -1, 0, 1, 2, 4

[graph 5-2] Adjustment of participation ratio

[Buy] base number = 2

base number ^ market view value

participation ratio adjust

difference / volatility

- - - -4
—— -2
—— -1
—— 0
—— 1
—— 2
- - - 4

[Sell] base number = 2

base number ^ market view value

participation ratio adjust

difference / volatility

- - - -4
—— -2
—— -1
—— 0
—— 1
—— 2
- - - 4

3.3 Decide order duration

3.3.1 Adjust start and end participation ratio

If accumulation of adjusted projection volume at 15:00 or End Time – order exclude point < order size, arrival2 cannot slice out whole order size.
Then arrival2 set schedule end time to 15:00 or End Time (algorithm parameter) and raise end participation ratio.(end participation ratio must be less than start participation ratio).

If projecton volume is less than order size after raising end participation ratio to start participation ratio, arrival2 obey must finish parameter.
[Must finish parameter =ON]
Raise start and end participation ratio until arrival2 can slice out total order size.

[Must finish parameter =OFF]
Arrival2 slice out ADV * start participation ratio(= end participation ratio).
And leftover qty is allocated to order that start time is 23;59.

3.3.2 Order duration

Average participation ratio = average of start participation ratio and end participation ratio. (both ratio are algorithm parameter)

Accumulate [Scaled volume each minute from order receipt time] * [Average participation ratio], until it reaches order qty.
Schedule end time is the time that accumulation reaches order qty.
If order end time (algorithm parameter or pm close time) is earlier than schedule end time, schedule end time is order end time.

[Example 2]
Order receipt time = 9:06
Parent order qty = 10
Start participation ratio = 0.3
End participation ratio = 0.1

time	9:06	9:07	9:08	9:09	9:10	9:11	9:12	9:13	9:14	9:15	9:16
historical average volume	8	7	15	4	6	7	5	6	8	10	4
scaling ratio	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
projection volume	5.4	4.7	10.1	2.7	4.0	4.7	3.4	4.0	5.4	6.7	2.7
average participation rate	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
adjusted projection volume	1.1	0.9	2.0	0.5	0.8	0.9	0.7	0.8	1.1	1.3	0.5
accumulation of adjusted projection volume	1.1	2.0	4.0	4.6	5.4	6.3	7.0	7.8	8.8	10.2	10.7

multiply
multiply

In this table, the accumulation of scaled volume reaches the parent order qty at 9:15.
Therefore, schedule end time is **9:15**

3.4　Calculate participation ratio

Participation ratio of volume curve is liner interpolation between start participation ratio at order receipt time and end participation ratio at schedule end time. (start and end participation rate are adjusted by market view and spread volatility facctor)

Participation ratio [t] = Start participation ratio - ([t] – order receipt time) / (schedule end time – order receipt time) * (Start participation ratio – End participation ratio)

※　[t] means each minute after order receipt time.
※　If schedule end time – order receipt time, participation ratio = start participation ratio.
※　If this range contains auction, 9:00 (or 12:30) of opening and 9:00 (or 12:30) of continuous are considered the same time.
　　e.g　9:00 (opening): 0.3, 9:00 (continuous session):0.3, 9:01: 0.29, 9:02:0.28 ・・・
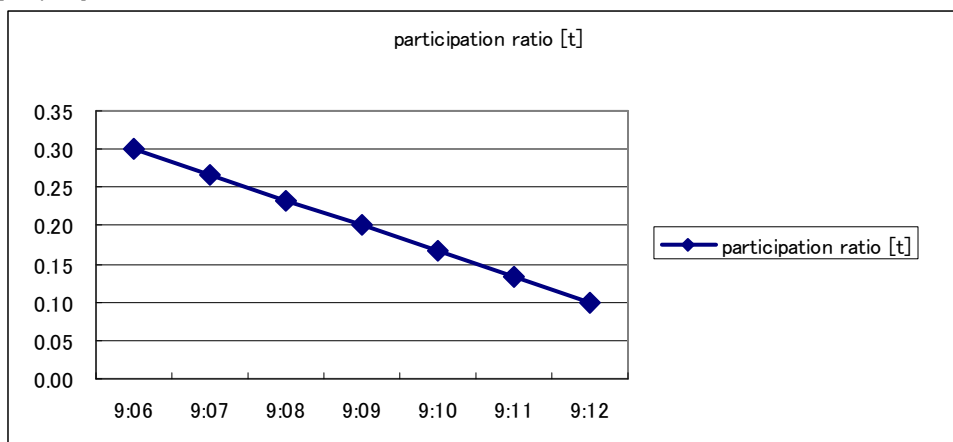
[example 3]
Start participation ratio = 0.3
End participation ratio = 0.1
order receipt time = 9:06
schedule end time = 9:12

time	participation ratio [t]
9:06	0.30
9:07	0.27
9:08	0.23
9:09	0.20
9:10	0.17
9:11	0.13
9:12	0.10

[Graph 3]

3.5 Adjust participation ratio

1. Calculate each time in order duration as follows:

    Participation qty = ADV * scaling ratio * average volume ratio * participation ratio

    ※Volume ratios after schedule end time are zero.

2. Adjust participation ratios by [parent order qty / estimate market volume] in order to slice total parent order qty according to participation rate in order duration.

※   If fulfill following condition, do not adjust participation ratios.

・parent order qty / estimate market volume ≦ 1 .

・parent order qty / estimate market volume ＝ 0.

Estimate volume is calculated as following table.

time	ADV	scaling ratio	volume ratio	participation ratio	participation qty
9:06	10,000	1.00	0.8%	0.30	24
9:07	10,000	1.00	0.7%	0.27	19
9:08	10,000	1.00	1.5%	0.23	35
9:09	10,000	1.00	0.4%	0.20	8
9:10	10,000	1.00	0.6%	0.17	10
9:11	10,000	1.00	0.7%	0.13	9
9:12	10,000	1.00	0.5%	0.10	5
				sum	110

Estimated volume = 110

Parent order qty = 150

Then parent order qty / estimate market volume = 150 / 110

$$= 1.3636$$

・adjust participation ratio = participation ratio * parent order qty / estimate market volume

time	participation ratio	adjusted participation
9:06	0.30	0.41
9:07	0.27	0.36
9:08	0.23	0.32
9:09	0.20	0.27
9:10	0.17	0.23
9:11	0.13	0.18
9:12	0.10	0.14

Then update start and end participation ratio.

Start participation ratio = original start participation ratio * parent order qty / estimate market volume

End participation ratio = original end participation ratio * parent order qty / estimate market volume

※ If original start participation ratio * parent order qty / estimate market volume > 50% (set up parameter),

adjust ratio = 50% / original start participation ratio

50% is set up parameter. (arrival2-max-participation-ratio)

[Example]

Parent order qty = 300

Then parent order qty / estimate market volume = 300 / 110 = 2.7272

Original start participation ratio * parent order qty / estimate market volume = 0.8182 ＞ 50%

Then adjust ratio = 50% / original start participation ratio = 50% / 30% = 1.667

time	participation ratio	adjusted participation ratio
9:06	0.30	0.50
9:07	0.27	0.44
9:08	0.23	0.39
9:09	0.20	0.33
9:10	0.17	0.28
9:11	0.13	0.22
9:12	0.10	0.17

3.6 Calculate order qty at each slices

1. Weighted volume ratio of each minute = original volume ratio * adjusted participation ratio of the minute.
   ※ Volume ratios after schedule end time and before schedule start time are zero.
2. Normalize weighted volume ratio.
3. Accumulate normalized volume ratio.

Then VWAP4.1 calculates below.

4. Multiply parent order qty and accumulation.
5. Calculate scheduled slice qty.

[example 4]

Parent order qty = 50

Adjusted start participation ratio = 0.82

Adjusted end participation ratio = 0.27
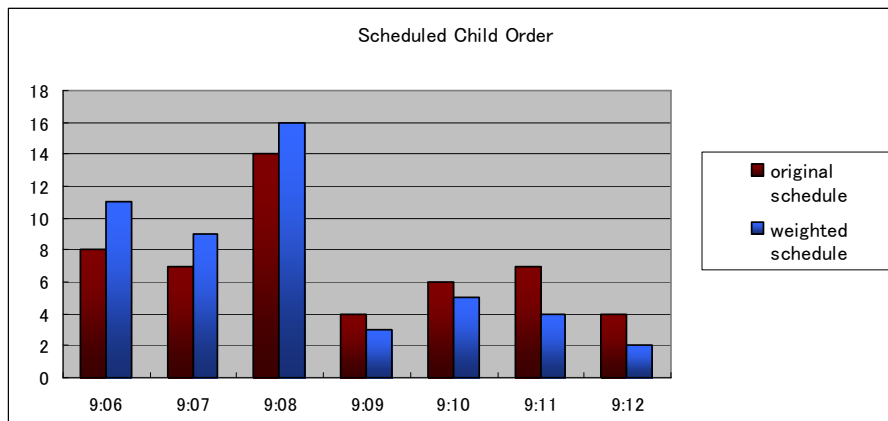
order receipt time = 9:06

schedule end time = 9:12

time	original volume ratio	adjusted participation ratio	weighted volume ratio	normalization of ratio	accumulate of normalized ratio	parent order qty * ratio (roundup)	weighted schedule
9:06	0.8%	0.41	0.33%	22%	22%	11	11
9:07	0.7%	0.36	0.25%	17%	39%	20	9
9:08	1.5%	0.32	0.48%	32%	71%	36	16
9:09	0.4%	0.27	0.11%	7%	78%	39	3
9:10	0.6%	0.23	0.14%	9%	87%	44	5
9:11	0.7%	0.18	0.13%	8%	95%	48	4
9:12	0.5%	0.14	0.07%	5%	100%	50	2

[Graph 4-1]
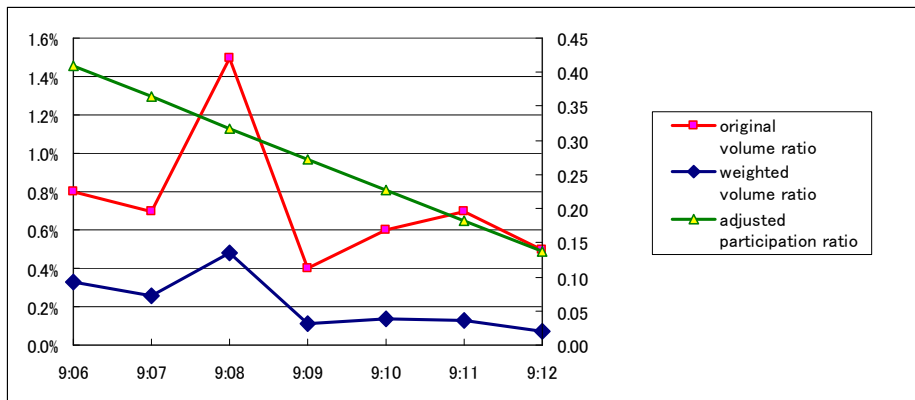
[Graph 4-2]

4. Auction

During auction, send order with volume cap and continue to adjust child order according to estimate of auction volume.

4.1   AM auction

1. Before 8:57 .(at order receipt time)
Schedule 1 slice at 8:57 that order qty is calculated from historical data.
= parent order qty * volume curve ratio at am open.

2. 8:57～end of AM auction
  At sending auction slice and after that, cap trading qty to (A) at 30-seconds intervals (after 8:59:50 cap at least one time).
(A) Participation Ratio * min (Best Bid Vol, Best Ask Vol)
   Participation Ratio = min (Volume Limit, min (<u>50%</u>, participation ratio at AM Open * <u>1.2</u>))
   If volume limit is not set, participation ratio is AM Open Ratio.
※ "<u>50%</u>" is set up parameter (arrival2-auction-participation-cap). This cap is intended to avoid that participation ratio at AM Open is more than 100%.
※ "<u>1.2</u>" is algorithm parameter (AM open participation adjust ratio). Separated form PM.
※ If ALGO accept order between 8:57 and 9:00, immediately send slice that qty is (A).

3. At the end of auction, if limit price is set and some auction slice remain at market adjust trading order immediately as follows.
Cap volume = (0.5lot + Participation Ratio * market vol / (1 - Participation Ratio))
   Particiation Ratio is the same as 2

4. Then check if the parent order is re-sliced or not.
   If do re-slice, do not cancel left child order at auction.

※ If SQ continues until next slice scheduled time, the slice sends as same as auction.

4.2   PM auction

1. Before 12:27 (at order receipt time or 12:27)
Schedule 1 slice at 12:27 that order qty is calculated from historical data.
= parent order qty * volume curve ratio at pm open.

2. 12:27～end of PM auction
At sending auction slice and afrter that, cap trading qty to (B) at 30-seconds intervals (after 12:29:50 cap at least one time).
(B) = Participation Ratio * (AM market vol + estimate of pm auction volume) – trading qty – cum qty
   Participation Ratio = min (Volume Limit, min (<u>50%</u>, participation ratio at PM Open * <u>1.0</u>))
   If volume limit is not set, participation ratio is PM Open Ratio.
※ "<u>50%</u>" is set up parameter (arrival2-auction-participation-cap). This cap is intended to avoid that participation ratio at AM Open is more than 100%.
※ "<u>1.0</u>" is algorithm parameter (PM open participation adjust ratio). Separated from AM.
※ If ALGO accept order between 12:27 and 12:30, immediately send order that qty is (A).

3. Same as AM auction.

4. Same as AM auction.

5. Automatic Re-slicing

5.1　Judgement of Re-slice

1.　Arrival2 judges re-slice or not about every 1minute.
2.　Judge by absolute difference ratio between arrival price and current market price.

Comparing the difference at last re-slicing timing and current difference, if these differences differ by more than or equal to 0.25σ, re-slice

※　0.25σ is algorithm parameter. (= price move re-slice threshold)

※　difference between arrival price and current market price = （ -1 ＋ （ current market price ÷ arrival price） ） ÷ （ yearly volatility ÷ sqrt(250))

※　If fulfill one or more following condition, do not re-slice. Only set current difference
　・difference at last re-slicing timing is null.
　・volatility is zero.
　・arrival price is zero, do not re-slice..

※　difference at last re-slicing timing is null., do re-slice.

※　If market view parameter is "Neutral", Arrival4.2 does not re-slice by price move.

3.　Judge by absolute difference ratio between actual market volume and historical volume.

Comparing the difference at last re-slicing timing and current difference, if these differences differ by more than or equal to 20%, re-slice

※　20% is algorithm parameter (= volume difference re-slice threshold)

※　If fulfill one or more following condition, do not re-slice. Only set current difference
　・actual market volume is zero
　・historical volume is zero.

5.2　Re-slicing

The way of Re-slice is as follows.

1　Create schedule by leaves qty (= parent order qty – cum qty) as follows.
　1.1.　Recalculate schedule end time according to actual market volume at re-slice time.
　　Accumulate scaled volume, until accumulation reaches leaves qty – trading qty.
　1.2.　Reweight volume curve
　　①　At re-slicing, participation ratio of volume curve is liner interpolation between start participation ratio at order receipt time and end participation ratio at <u>new schedule end time.</u> <u>（</u>refer following graph<u>）</u>
　　　※　start participation ratio at order receipt time
　　　　= start participation ratio – (start participation ratio – end participation ratio) * (passed time / original order duration)
　　②　Weight volume curve from re-slicing time to new schedule end time.
2　According to the relation between [the first slice of new schedule] and [trading qty], do following action.
　2.1.　[the first slice of new schedule] < [trading qty] (passive re-slice)
　　①　Cancel or amend down surplus qty with keeping queue priority.
　　②　If one or more cancel request is rejected, recreate schedule by leaves qty.
　　　If all cancel succeed, delete the first slice of new schedule.
　2.2.　[the first slice of new schedule] > [trading qty] (aggressive re-slice)
　　①　Decrease the first slice of new schedule by the trading qty.
　2.3.　[the first slice of new schedule] = [trading qty] (even re-slice)
　　①　Delete the first slice of new schedule.

　※2.1-2.3 are intended to avoid the schedule being ahead after re-slicing.

※ The variation of difference between actual market volume and historical average volume.

In this case, the order end early or later without change of participation ratio, because actual market volume is larger or smaller and order qty of each slice is larger or smaller.

If actual market volume is much less than historical average volume, end time is later.

If actual market volume is much greater than historical average volume, end time is faster.

[Graph 7]
This graph shows the move of start participation ratio and end participation ratio affected by market view adjust ratio.

Orange: Start participation ratio * base number ^ market view value = 35% and end time is faster.
Sky-Blue: Start participation ratio * base number ^ market view value = 25% and end time is later.

weight coefficient when reslice
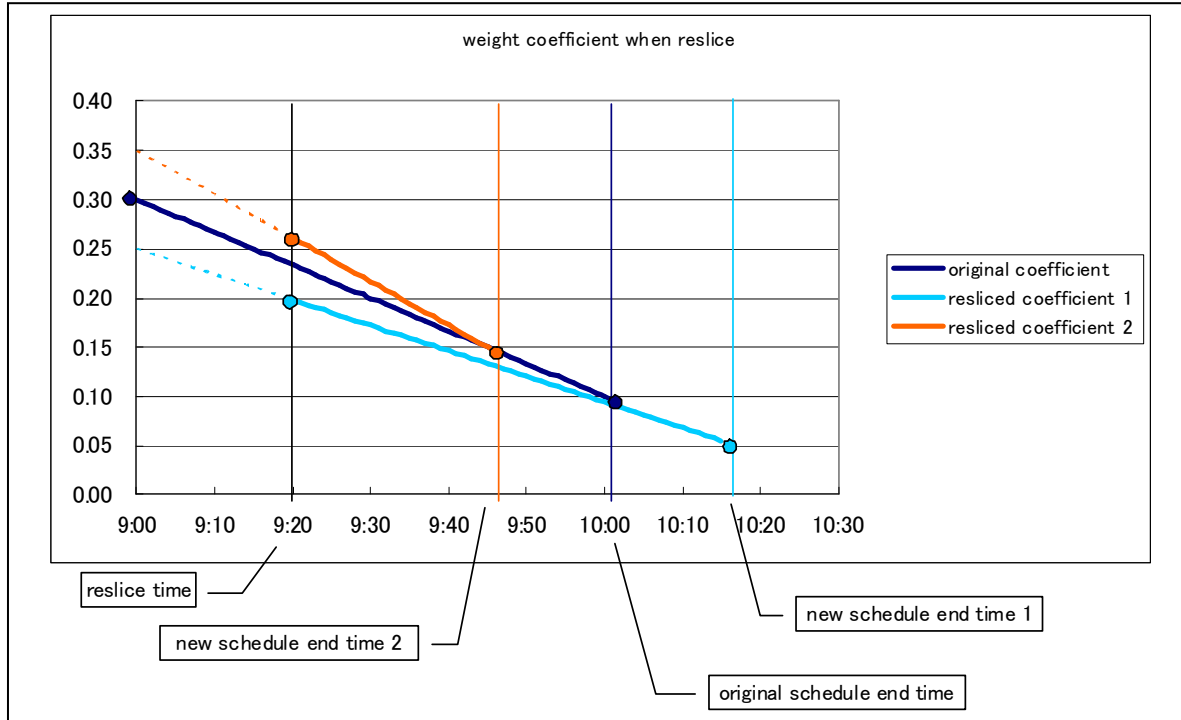
Notes
1.   When style parameter is amended, do not cancel all child order and re-slice.
2.   When pause order, algo user select "cancel trading child order" or "leave trading child order".
3.   Arrival time is accept time of arrival2 strategy order. (new order or strategy amended from another strategy)
4.   If open is delayed, Arrival2 looks the opening time as arrival time.
     If strategy amended from another strategy to arrival2, weight of volume curve based on this arrival time.
5.   start participation ratio at re-slicing is :
     2.4.   auto re-slicing
             newStartPR =startPR - (startPR - endPR) * passed time in original duration / original duration
             StartPR and endPR are raw algorithm parameter. NewStartPR will be adjusted after this calculation.
     2.5.   relice by parent order amend
             newStartPR =startPR
6.   If participation ratio fall, cancel registered order except for registered order at re-slicing time and re-slice from 1 minute later.
             ※ If 1 minute later is order exclude point, do not re-slice.

6. Parent order amend

style : do re-schedule
Market view : reanalyze
Volume : reanalyze