C++ Workshop Series for UoM

Flower Exchange – Group Project

LSEG

Flower Exchange Group Project

- Two persons per group
- Duration - Two weeks
- This is the only Assessment for this workshop
- *Date of completion – 04th October 2024
- *Demonstration of the project – 17th October 2024 at LSEG Technology Malabe

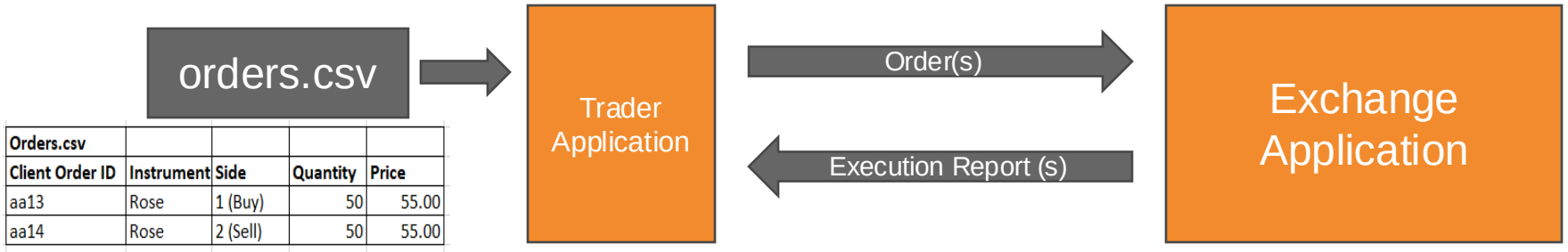
*Exact dates to be decided by the university

LSEG

Flower Exchange Story

- The flower exchange is a system which supports basic trading.
- **Trader Application** - Traders can submit buy or sell orders for flowers via the Trader Application.
- **Exchange Application** - will process the incoming order against existing orders in the order container(known as Order Book) and do a full or partial execution.
- Every order is replied with an Execution Report by the **Exchange Application** indicating the status of the order.
- Orders sometimes could be rejected due to quantity limitations, invalid flower type, etc.

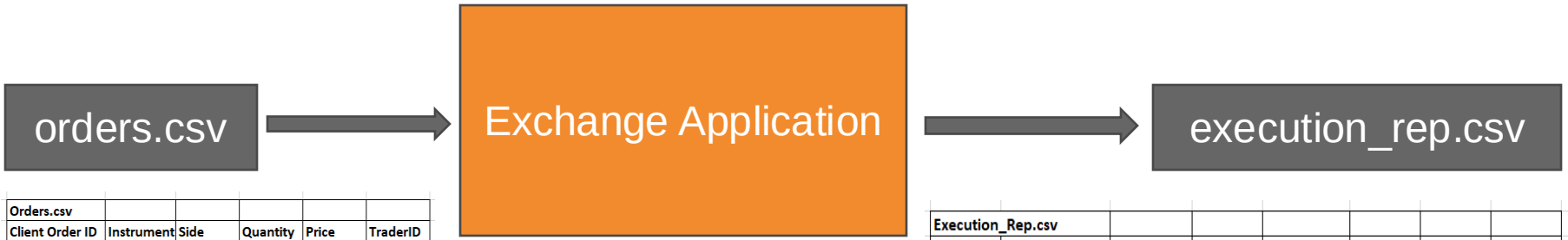
Flower Exchange – High Level Architecture



Orders.csv				
Client Order ID	**Instrument**	**Side**	**Quantity**	**Price**
aa13	Rose	1 (Buy)	50	55.00
aa14	Rose	2 (Sell)	50	55.00

Execution_Rep.csv						
Order ID	**Client Order ID**	**Instrument**	**Side**	**Exec Status**	**Quantity**	**Price**
ord1	aa13	Rose	1	New	50	55.00
ord2	aa14	Rose	1	Fill	50	55.00
ord1	aa13	Rose	1	Fill	50	55.00

Flower Exchange – A simpler implementation (2nd option)



Orders.csv					
Client Order ID	Instrument	Side	Quantity	Price	TraderID
aa13	Rose	1 (Buy)	50	55.00	TR05
aa14	Rose	2 (Sell)	50	55.00	TR03

Execution_Rep.csv							
Order ID	Client Order ID	Instrument	Side	Exec Status	Quantity	Price	Trader ID
ord1	aa13	Rose	1	New	50	55.00	TR05
ord2	aa14	Rose	1	Fill	50	55.00	TR03
ord1	aa13	Rose	1	Fill	50	55.00	TR05

Basically, read an **orders.csv** fila and produce an **execution_rep.csv** file

Flower Exchange – Input order

Field Name	Type	Possible Values	Mandatory	Notes
Client Order ID	String	Alpha numeric string (max 7 chars)	Yes	This unique ID identifies the submitted order
Instrument	String	{Rose, Lavender, Lotus, Tulip, Orchid)	Yes	We will limit the instruments for these 5 types only
Side	Int	1 : Buy ; 2 : Sell	Yes	Specifies if the input order is a buy order or a sell order
Price	double	Price > 0.0	Yes	Price of one unit
Quantity	int	{10, 20, 30, …. , 1000} Order size must be a a multiple of 10. Min 10, Max 1000	Yes	Quantity of the order

LSEG

Flower Exchange – Output Execution Report

Field Name	Type	Possible Values	Mandatory	Notes
Client Order ID	String	Alpha numeric string (max 7 chars)	Yes	This is the Client Order ID of the submitted order
Order ID	String	Alpha numeric string	Yes	System generated unique order ID
Instrument	String	{Rose, Lavender, Lotus, Tulip, Orchid)	Yes	We will limit the instruments for these 5 types only
Side	Int	1 : Buy ; 2 : Sell	Yes	Specifies if the order is a buy order or a sell order
Price	double	Price > 0.0	Yes	Price of one unit
Quantity	int	{10, 20, 30, …. , 1000} Order size must be a a multiple of 10. Min 10, Max 1000	Yes	Quantity of the order
Status	int	0 – New 1 – Rejected 2 – Fill 3 - Pfill	Yes	The status of the execution report
Reason	String	Max 50 chars	No	Contains the reject reason, when an order is not accepted into the system due to validation failure
Transaction Time	**String**	**YYYYMMDD-HHMMSS.sss**	**Yes**	**Every execution report should have the transaction time in the given format. This data can be used to check the speed and optimize your code**

LSEG

Order book – Example 1

- Exchange app maintains one order book for each Instrument (flower type). Since there are 5 types of Instruments, there will be five separate order books in our system.
- Orderbook has two sides. Buy (blue), Sell (pink)
- Initially the orderbook is empty
- The order book receives an order. (Side = Sell, Price = 55.00, Qty = 100)
- This order will go inside sell side of the order book, and an execution report with status “New” will be disseminated

Side = 1 : Buy Side

Side = 2 : Sell Side

Orderbook : Rose (Initially empty)

Order ID	Qty	Price	Price	Qty	Order ID

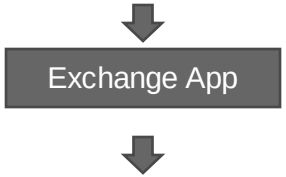
100 @ 55.00

Orderbook : Rose – (After the 100 @ 55.00 order enters the book)

Order ID	Qty	Price	Price	Qty	Order ID
			55.00	100	ord1

order.csv

Cl. Ord.ID	Instrument	Side	Quantity	Price
aa13	Rose	2	100	55.00



execution_rep.csv

Order ID	Cl. Ord. ID	Instrumen	Side	Exec Statu	Quantity	Price
ord1	aa13	Rose	2	New	100	55.00

LSEG

Order Book - Example 2

order.csv

Cl. Ord.ID	Instrument	Side	Quantity	Price
aa13	Rose	2	100	55.00
aa14	Rose	2	100	45.00
aa15	Rose	1	100	35.00

1. Sell 100 @ 55.00

Orderbook : Rose (Initial state)

Order ID	Qty	Price	Price	Qty	Order ID

2. Sell 100 @ 45.00

State - 1

Order ID	Qty	Price	Price	Qty	Order ID
			55.00	100	ord1

3. Buy 100 @ 35.00

State – 2

Order ID	Qty	Price	Price	Qty	Order ID
			45.00	100	ord2
			55.00	100	ord1

State – Final

Order ID	Qty	Price	Price	Qty	Order ID
ord3	100	35.00	45.00	100	ord2
			55.00	100	ord1

LSEG

Order Book - Example 2

order.csv

Cl. Ord.ID	Instrument	Side	Quantity	Price
aa13	Rose	2	100	55.00
aa14	Rose	2	100	45.00
aa15	Rose	1	100	35.00

Exchange App

execution_rep.csv

Order ID	Client Order	Instrumen	Side	Exec Status	Quantity	Price
ord1	aa13	Rose	2	New	100	55.00
ord2	aa14	Rose	2	New	100	45.00
ord3	aa15	Rose	1	New	100	35.00

LSEG

Order Book - Example 3 (A FILL execution)

order.csv

Cl. Ord.ID	Instrument	Side	Quantity	Price
aa13	Rose	2	100	55.00
aa14	Rose	2	100	45.00
aa15	Rose	1	100	45.00

Passive order (an incoming order which goes into the OB without exeucuting)

Aggressive order (an incoming order which executes)

1. Sell 100 @ 55.00

3. Buy 100 @ 45.00

Orderbook : Rose (Initial state)

Order ID	Qty	Price	Price	Qty	Order ID

State – 2

Order ID	Qty	Price	Price	Qty	Order ID
			45.00	100	ord2
			55.00	100	ord1

2. Sell 100 @ 45.00

State - 1

Order ID	Qty	Price	Price	Qty	Order ID
			55.00	100	ord1

State – Final

Order ID	Qty	Price	Price	Qty	Order ID
			55.00	100	ord1

LSEG

Order Book - Example 3

order.csv

Cl. Ord.ID	Instrument	Side	Quantity	Price
aa13	Rose	2	100	55.00
aa14	Rose	2	100	45.00
aa15	Rose	1	100	45.00

Exchange App

execution_rep.csv

Order ID	Client Order	Instrumen	Side	Exec Status	Quantity	Price
ord1	aa13	Rose	2	New	100	55.00
ord2	aa14	Rose	2	New	100	45.00
ord3	aa15	Rose	1	Fill	100	45.00
ord2	aa14	Rose	2	Fill	100	45.00

LSEG

Order book

- Buy side of the orderbook is sorted in the ascending order of the price. (Higher the buy price, more attractive the order)
- Sell side of the orderbook is sorted in the descending order of the price. (Lower the sell price, more attractive the order)
- Orders with the same price are ordered in the time priority. (Priority sequence)

Orderbook : Rose

Pr.Seq	Order ID	Trader ID	Qty	Price	Price	Qty	Trader ID	Order ID	Pr.Seq
1	ord5	..	100	4.00	5.00	200	..	ord2	1
1	ord4	..	200	3.00	5.00	100	..	ord3	2
2	ord6	..	200	3.00	6.00	100	..	ord1	1

Order Book - Example 4 (A PFILL execution)

order.csv

Cl. Ord.ID	Instrument	Side	Quantity	Price
aa13	Rose	2	100	55.00
aa14	Rose	2	100	45.00
aa15	Rose	1	200	45.00

1. Sell 100 @ 55.00

Orderbook : Rose (Initial state)

Order ID	Qty	Price	Price	Qty	Order ID

2. Sell 100 @ 45.00

State - 1

Order ID	Qty	Price	Price	Qty	Order ID
			55.00	100	ord1

3. Buy 200 @ 45.00

State – 2

Order ID	Qty	Price	Price	Qty	Order ID
			45.00	100	ord2
			55.00	100	ord1

State – Final

Order ID	Qty	Price	Price	Qty	Order ID
ord3	100	45.00	55.00	100	ord1

LSEG

Order Book - Example 4

order.csv

Cl. Ord.ID	Instrument	Side	Quantity	Price
aa13	Rose	2	100	55.00
aa14	Rose	2	100	45.00
aa15	Rose	1	200	45.00

Exchange App

execution_rep.csv

Order ID	Client Order	Instrumen	Side	Exec Status	Quantity	Price
ord1	aa13	Rose	2	New	100	55.00
ord2	aa14	Rose	2	New	100	45.00
ord3	aa15	Rose	1	Pfill	100	45.00
ord2	aa14	Rose	2	Fill	100	45.00

LSEG

Order Book - Example 5 (A FILL execution with a twist)

order.csv

Cl. Ord.ID	Instrument	Side	Quantity	Price
aa13	Rose	1	100	55.00
aa14	Rose	1	100	65.00
aa15	Rose	2	300	1.00

The execution price of an aggressive order is decided by the orderbook

1. Buy 100 @ 55.00

Orderbook : Rose (Initial state)

Order ID	Qty	Price	Price	Qty	Order ID

2. Buy 100 @ 65.00

State - 1

Order ID	Qty	Price	Price	Qty	Order ID
ord1	100	55.00			

3. Sell 300 @ 1.00

State – 2

Order ID	Qty	Price	Price	Qty	Order ID
ord2	100	65.00			
ord1	100	55.00			

State – Final

Order ID	Qty	Price	Price	Qty	Order ID
			1.00	100	ord3

LSEG

Order Book - Example 5

order.csv

Cl. Ord.ID	Instrument	Side	Quantity	Price
aa13	Rose	1	100	55.00
aa14	Rose	1	100	65.00
aa15	Rose	2	300	1.00

Exchange App

execution_rep.csv

Order ID	Client Order	Instrumen	Side	Exec Status	Quantity	Price
ord1	aa13	Rose	1	New	100	55.00
ord2	aa14	Rose	1	New	100	65.00
ord3	aa15	Rose	2	PFill	100	65.00
ord2	aa14	Rose	1	Fill	100	65.00
ord3	aa15	Rose	2	PFill	100	55.00
ord1	aa13	Rose	1	Fill	100	55.00

Order Book - Example 6

order.csv

Cl. Ord.ID	Instrument	Side	Quantity	Price
aa13	Rose	1	100	55.00
aa14	Rose	1	100	65.00
aa15	Rose	2	300	1.00
aa16	Rose	1	100	2.00

1. Buy 100 @ 55.00
2. Buy 100 @ 65.00

Orderbook : Rose (Initial state)

Order ID	Qty	Price	Price	Qty	Order ID

3. Sell 300 @ 1.00

State – 2

Order ID	Qty	Price	Price	Qty	Order ID
ord2	100	65.00			
ord1	100	55.00			

4. Buy 100 @ 2.00

State – State 3

Order ID	Qty	Price	Price	Qty	Order ID
			1.00	100	ord3

Final state

Order ID	Qty	Price	Price	Qty	Order ID

LSEG

Order Book - Example 6

order.csv

Cl. Ord.ID	Instrument	Side	Quantity	Price
aa13	Rose	1	100	55.00
aa14	Rose	1	100	65.00
aa15	Rose	2	300	1.00
aa16	Rose	1	100	2.00

Exchange App

execution_rep.csv

Order ID	Cl. Ord. ID	Instrumen	Side	Exec Statu	Quantity	Price
ord1	aa13	Rose	1	New	100	55.00
ord2	aa14	Rose	1	New	100	65.00
ord3	aa15	Rose	2	PFill	100	65.00
ord2	aa14	Rose	1	Fill	100	65.00
ord3	aa15	Rose	2	PFill	100	55.00
ord1	aa13	Rose	1	Fill	100	55.00
ord4	aa16	Rose	1	Fill	100	1.00
ord3	aa15	Rose	2	Fill	100	1.00

Flower Exchange – Input validations

- An order will be rejected if
  - It does not contain a required field
  - It is for an invalid Instrument
  - It contains an invalid side
  - Its price is not greater than 0
  - Its quantity is not a multiple of 10
  - Its quantity is outside the range (min = 10 max = 1000)

- A Rejected execution report is generated when validations are failed

Order Book - Example 7 (Input Validations)

order.csv

Cl. Ord.ID	Instrument	Side	Quantity	Price
aa13		1	100	55.00
aa14	Rose	3	100	65.00
aa15	Lavender	2	101	1.00
aa16	Tulip	1	100	-1.00
aa17	Orchid	1	1000	-1.00

Exchange App

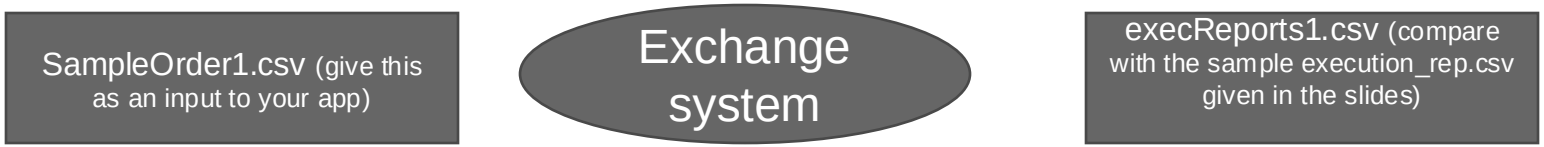
execution_rep.csv

Order ID	Cl. Ord. ID	Instrumen	Side	Exec Status	Quantity	Price	Reason
ord1	aa13		1	Reject	100	55.00	Invalid instrument
ord2	aa14	Rose	3	Reject	100	65.00	Invalid side
ord3	aa15	Lavender	2	Reject	101	1.00	Invalid size
ord4	aa16	Tulip	1	Reject	100	-1.00	Invalid price
ord3	aa17	Orchid	1	Reject	1000	-1.00	Invalid size

A validation failure results in a Rejected Execution Report

Flower Exchange – Verify your system

- We have provided you 6 sample input files (order.csv) and corresponding sample output files (exec_rep.csv) files in the previous examples.
- When developing your system, test your system with the sample input files we provided and verify your system produces the same output as in the sample execution_rep.csv files



Compare :

- exeReports.csv generated by your system matches the sample execution_rep.csv – Pass
- exeReports.csv generated by your system produces a different output to sample execution_rep.csv – Fix your bugs, and re-test
- Note that the order of the execution reports in your file does not have to be the same as ours. But the content should be the same.

Flower Exchange – Evaluation

- Demonstration and code review – You will demonstrate the system and we will do a code review with you.
- Project will be evaluated for the design, coding practices, efficiency of the program and the speed of the program.
- During the demo, we will test your application against our test data (orders.csv) and verify the functional accuracy.
- To test the speed of the program we will input a large orders.csv and measure the time taken to produce the resulting exec_reports.csv