Bharatiya Vidya Bhavan's
SARDAR PATEL INSTITUTE OF TECHNOLOGY
(Autonomous Institute Affiliated to Mumbai University)
Munshi Nagar, Andheri (West), Mumbai-400058
Information Technology Department

Academic Year: 2022-2023 Class: TE Sem.: VI
Course: IT331-ADBMS

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Course	Advanced Database management system
Lab	2

Aim :
Design a distributed database by applying the concept of horizontal fragmentation

Scenario:

A retail chain database where customer info, customer orders and store inventory is stored. Storing all of this data in a centralized database could lead to slow queries, increased network latency and reduced availability in case of server failure.

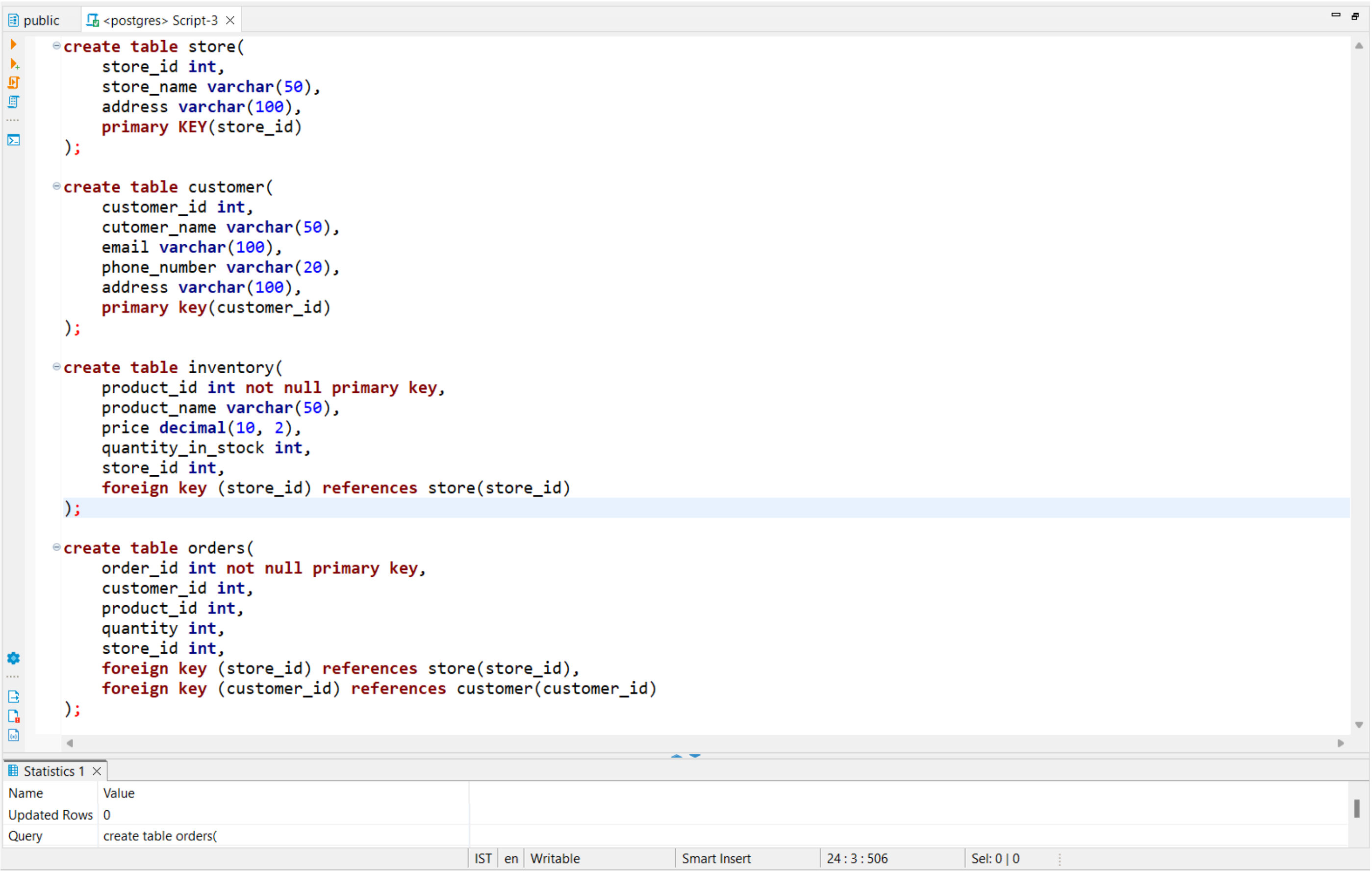
Therefore, we can fragment tables according to our scenario.

We can fragment the inventory and orders table by the store location. This means that each fragment will contain only the orders for a specific store.

This ensures that each store has access only to their inventory and orders data, which improves data security and reduces risk of errors.

Queries:

1. Creation of table



```
create table store(
    store_id int,
    store_name varchar(50),
    address varchar(100),
    primary KEY(store_id)
);

create table customer(
    customer_id int,
    cutomer_name varchar(50),
    email varchar(100),
    phone_number varchar(20),
    address varchar(100),
    primary key(customer_id)
);

create table inventory(
    product_id int not null primary key,
    product_name varchar(50),
    price decimal(10, 2),
    quantity_in_stock int,
    store_id int,
    foreign key (store_id) references store(store_id)
);

create table orders(
    order_id int not null primary key,
    customer_id int,
    product_id int,
    quantity int,
    store_id int,
    foreign key (store_id) references store(store_id),
    foreign key (customer_id) references customer(customer_id)
);
```


Name	Value
Updated Rows	0
Query	create table orders(

2. Inserting tuples into tables

public | <postgres> Script-3 | store | inventory | orders

```sql
-- Insertion

INSERT INTO store (store_id, store_name, address) VALUES
    (1, 'Store A', '123 Main St.'),
    (2, 'Store B', '456 Elm St.');

INSERT INTO customer (customer_id, cutomer_name, email, phone_number, address) VALUES
    (1, 'John Doe', 'johndoe@example.com', '555-1234', '123 Main St.'),
    (2, 'Jane Smith', 'janesmith@example.com', '555-5678', '456 Elm St.'),
    (3, 'Bob Johnson', 'bobjohnson@example.com', '555-9101', '123 Main St.'),
    (4, 'Sara Lee', 'saralee@example.com', '555-1212', '456 Elm St.'),
    (5, 'Mike Brown', 'mikebrown@example.com', '555-3434', '123 Main St.'),
    (6, 'Emily Davis', 'emilydavis@example.com', '555-5656', '456 Elm St.'),
    (7, 'Tom Wilson', 'tomwilson@example.com', '555-7878', '123 Main St.'),
    (8, 'Jenny Garcia', 'jennygarcia@example.com', '555-9090', '456 Elm St.'),
    (9, 'David Kim', 'davidkim@example.com', '555-2323', '123 Main St.'),
    (10, 'Karen Lee', 'karenlee@example.com', '555-4545', '456 Elm St.');

INSERT INTO inventory (product_id, product_name, price, quantity_in_stock, store_id) VALUES
    (1, 'Product A', 10.99, 100, 1),
    (2, 'Product B', 20.99, 50, 2),
    (3, 'Product C', 5.99, 200, 1),
    (4, 'Product D', 15.99, 75, 2),
    (5, 'Product E', 8.99, 150, 1),
    (6, 'Product F', 25.99, 25, 2),
    (7, 'Product G', 12.99, 125, 1),
    (8, 'Product H', 30.99, 10, 2),
    (9, 'Product I', 7.99, 175, 1),
    (10, 'Product J', 18.99, 60, 2);
```

Statistics 1

Name	Value
Updated Rows	10
Query	INSERT INTO customer (customer_id, cutomer_name, email, phone_number, address) VALUES
	(1, 'John Doe', 'johndoe@example.com', '555-1234', '123 Main St.'),
	(2, 'Jane Smith', 'janesmith@example.com', '555-5678', '456 Elm St.'),
	(3, 'Bob Johnson', 'bobjohnson@example.com', '555-9101', '123 Main St.'),
	(4, 'Sara Lee', 'saralee@example.com', '555-1212', '456 Elm St.'),

IST | en | Writable | Smart Insert | 36 : 13 : 771 | Sel: 0 | 0

```sql
INSERT INTO orders (order_id, customer_id, product_id, quantity, store_id) VALUES
    (1, 1, 1, 2, 1),
    (2, 2, 3, 1, 1),
    (3, 3, 5, 4, 1),
    (4, 4, 2, 3, 2),
    (5, 5, 4, 1, 2),
    (6, 6, 8, 2, 2),
    (7, 7, 10, 3, 2),
    (8, 8, 7, 1, 1),
    (9, 9, 9, 2, 1),
    (10, 10, 6, 1, 2);
```

Statistics 1

Name	Value
Updated Rows	10
Query	INSERT INTO orders (order_id, customer_id, product_id, quantity, store_id) VALUES
	(1, 1, 1, 2, 1),
	(2, 2, 3, 1, 1),
	(3, 3, 5, 4, 1),
	(4, 4, 2, 3, 2),

Tables:

Store table:

store | Enter a SQL expression to filter results (use Ctrl+Space)

	store_id	store_name	address
1	1	Store A	123 Main St.
2	2	Store B	456 Elm St.

Inventory table:

inventory | Enter a SQL expression to filter results (use Ctrl+Space)

	product_id	product_name	price	quantity_in_stock	store_id
1	1	Product A	10.99	100	1
2	2	Product B	20.99	50	2
3	3	Product C	5.99	200	1
4	4	Product D	15.99	75	2
5	5	Product E	8.99	150	1
6	6	Product F	25.99	25	2
7	7	Product G	12.99	125	1
8	8	Product H	30.99	10	2
9	9	Product I	7.99	175	1
10	10	Product J	18.99	60	2

Customer table:

customer | Enter a SQL expression to filter results (use Ctrl+Space)

	customer_id	cutomer_name	email	phone_number	address
1	1	John Doe	johndoe@example.com	555-1234	123 Main St.
2	2	Jane Smith	janesmith@example.cor	555-5678	456 Elm St.
3	3	Bob Johnson	bobjohnson@example.cc	555-9101	123 Main St.
4	4	Sara Lee	saralee@example.com	555-1212	456 Elm St.
5	5	Mike Brown	mikebrown@example.co	555-3434	123 Main St.
6	6	Emily Davis	emilydavis@example.cor	555-5656	456 Elm St.
7	7	Tom Wilson	tomwilson@example.cor	555-7878	123 Main St.
8	8	Jenny Garcia	jennygarcia@example.cc	555-9090	456 Elm St.
9	9	David Kim	davidkim@example.com	555-2323	123 Main St.
10	10	Karen Lee	karenlee@example.com	555-4545	456 Elm St.

Orders table:

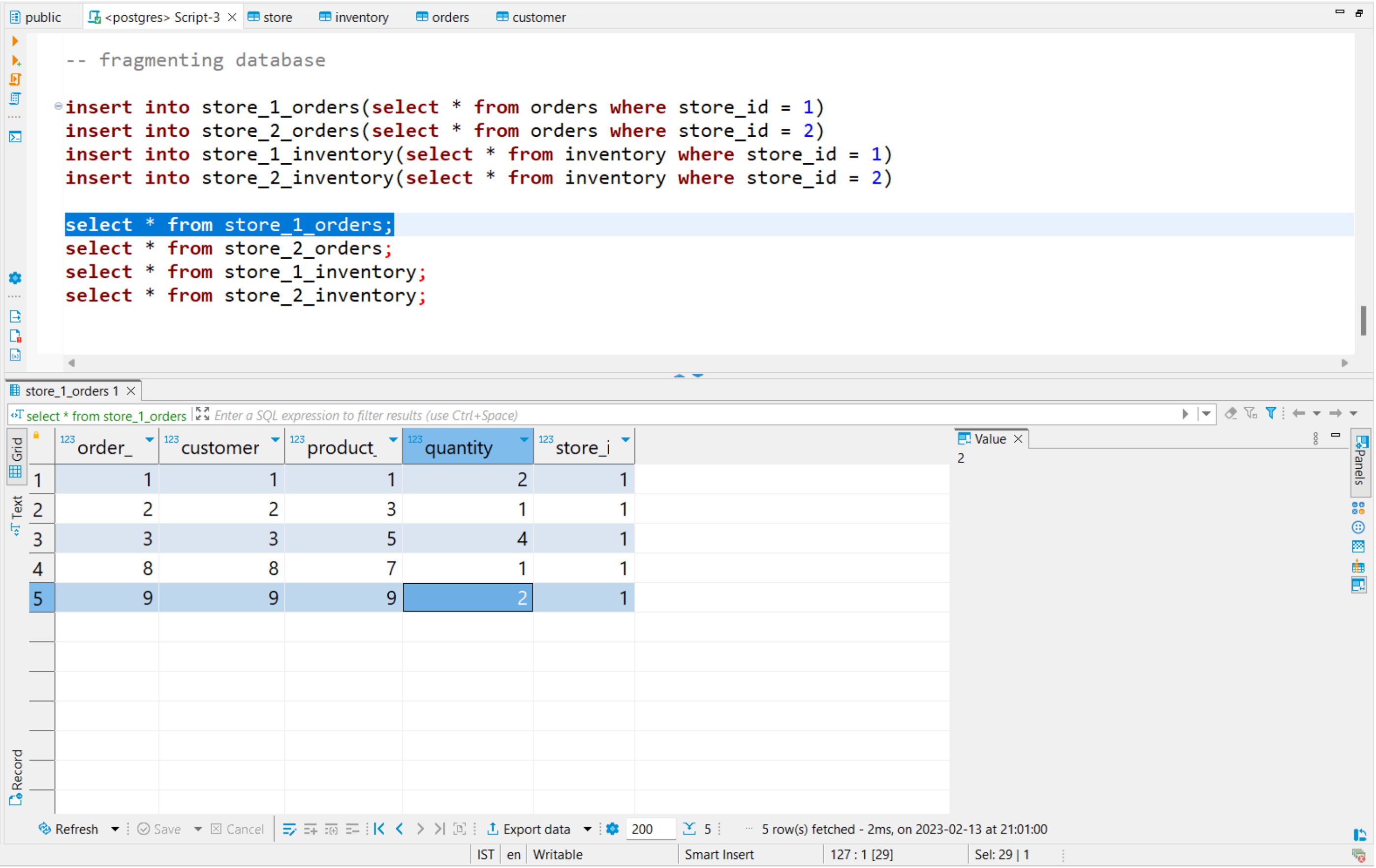
orders | Enter a SQL expression to filter results (use Ctrl+Space)

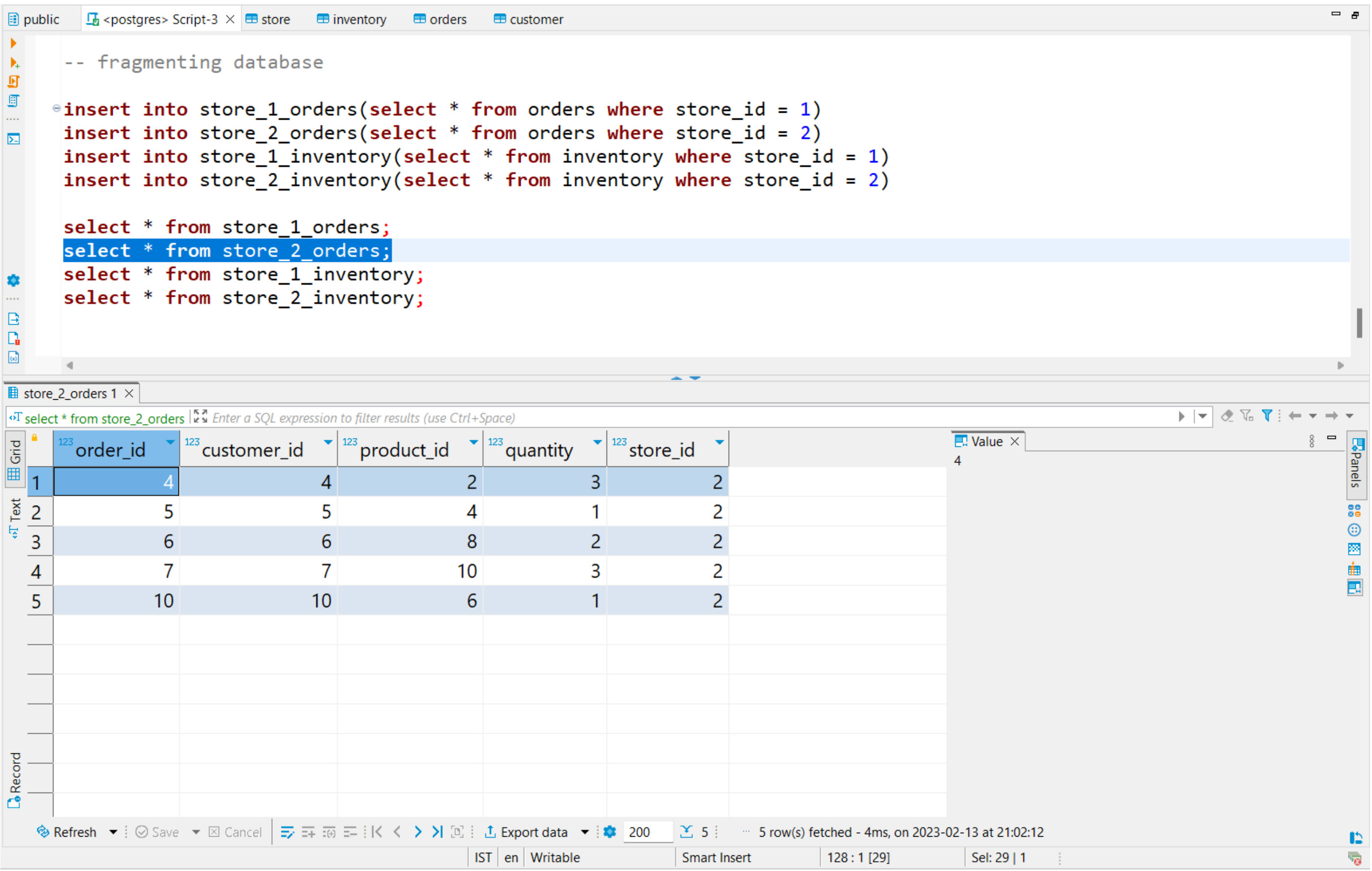
	order_id	customer_id	product_id	quantity	store_id
1	1	1	1	2	1
2	2	2	3	1	1
3	3	3	5	4	1
4	4	4	2	3	2
5	5	5	4	1	2
6	6	6	8	2	2
7	7	7	10	3	2
8	8	8	7	1	1
9	9	9	9	2	1
10	10	10	6	1	2

Fragmenting the database by stores:

```sql
-- fragmenting the database : horizontanly
-- We will fragment the inventory table into 2 separate tables by store_id
-- We will fragment the orders table into 2 separate tables also by store_id

create table store_1_inventory(
    product_id int not null primary key,
    product_name varchar(50),
    price decimal(10, 2),
    quantity_in_stock int,
    store_id int,
    foreign key (store_id) references store(store_id)
);

create table store_1_orders(
    order_id int not null primary key,
    customer_id int,
    product_id int,
    quantity int,
    store_id int,
    foreign key (store_id) references store(store_id),
    foreign key (customer_id) references customer(customer_id)
);

create table store_2_inventory(
    product_id int not null primary key,
    product_name varchar(50),
    price decimal(10, 2),
    quantity_in_stock int,
    store_id int,
    foreign key (store_id) references store(store_id)
);

create table store_2_orders(
    order_id int not null primary key,
    customer_id int,
    product_id int,
    quantity int,
    store_id int,
    foreign key (store_id) references store(store_id),
    foreign key (customer_id) references customer(customer_id)
);
```

Name	Value
Updated Rows	0


public
<postgres> Script-3
store
inventory
orders
customer
-- fragmenting database
insert into store_1_orders(select * from orders where store_id = 1)
insert into store_2_orders(select * from orders where store_id = 2)
insert into store_1_inventory(select * from inventory where store_id = 1)
insert into store_2_inventory(select * from inventory where store_id = 2)
select * from store_1_orders;
select * from store_2_orders;
select * from store_1_inventory;
select * from store_2_inventory;
store_1_orders 1
select * from store_1_orders
Enter a SQL expression to filter results (use Ctrl+Space)
order_ customer product_ quantity store_i
1 1 1 1 2 1
2 2 2 3 1 1
3 3 3 5 4 1
4 8 8 7 1 1
5 9 9 9 2 1
Value
2
Refresh
Save
Cancel
Export data
200
5
5 row(s) fetched - 2ms, on 2023-02-13 at 21:01:00
IST
en
Writable
Smart Insert
127 : 1 [29]
Sel: 29 | 1


public
<postgres> Script-3
store
inventory
orders
customer
-- fragmenting database
insert into store_1_orders(select * from orders where store_id = 1)
insert into store_2_orders(select * from orders where store_id = 2)
insert into store_1_inventory(select * from inventory where store_id = 1)
insert into store_2_inventory(select * from inventory where store_id = 2)
select * from store_1_orders;
select * from store_2_orders;
select * from store_1_inventory;
select * from store_2_inventory;
store_2_orders 1
select * from store_2_orders
Enter a SQL expression to filter results (use Ctrl+Space)
order_id customer_id product_id quantity store_id
1 4 4 2 3 2
2 5 5 4 1 2
3 6 6 8 2 2
4 7 7 10 3 2
5 10 10 6 1 2
Value
4
Refresh
Save
Cancel
Export data
200
5
5 row(s) fetched - 4ms, on 2023-02-13 at 21:02:12
IST
en
Writable
Smart Insert
128 : 1 [29]
Sel: 29 | 1

```sql
-- fragmenting database

insert into store_1_orders(select * from orders where store_id = 1)
insert into store_2_orders(select * from orders where store_id = 2)
insert into store_1_inventory(select * from inventory where store_id = 1)
insert into store_2_inventory(select * from inventory where store_id = 2)

select * from store_1_orders;
select * from store_2_orders;
select * from store_1_inventory;
select * from store_2_inventory;
```

store_1_inventory 1

select * from store_1_inventory

	product_id	product_name	price	quantity_in_stock	store_id
1	1	Product A	10.99	100	1
2	3	Product C	5.99	200	1
3	5	Product E	8.99	150	1
4	7	Product G	12.99	125	1
5	9	Product I	7.99	175	1

5 row(s) fetched - 8ms, on 2023-02-13 at 21:02:48

```sql
-- fragmenting database

insert into store_1_orders(select * from orders where store_id = 1)
insert into store_2_orders(select * from orders where store_id = 2)
insert into store_1_inventory(select * from inventory where store_id = 1)
insert into store_2_inventory(select * from inventory where store_id = 2)

select * from store_1_orders;
select * from store_2_orders;
select * from store_1_inventory;
select * from store_2_inventory;
```

store_1_inventory 1

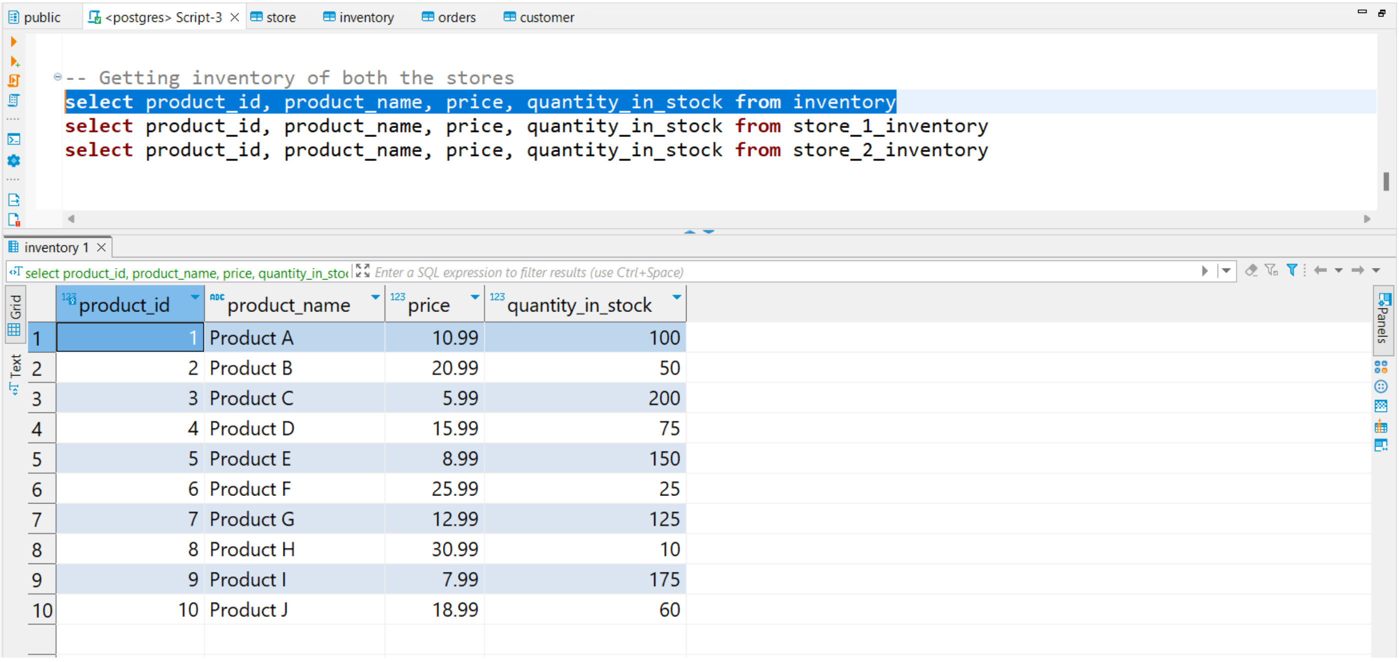
select * from store_1_inventory

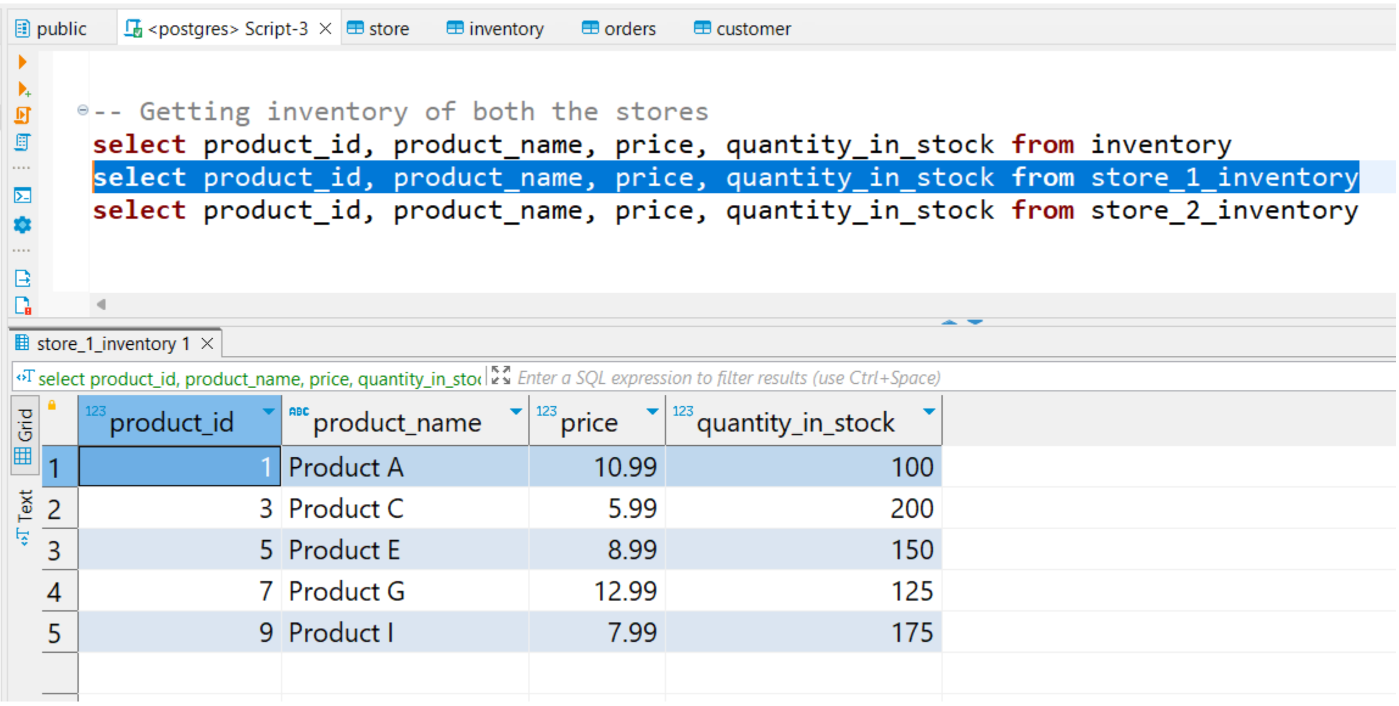
	product_id	product_name	price	quantity_in_stock	store_id
1	1	Product A	10.99	100	1
2	3	Product C	5.99	200	1
3	5	Product E	8.99	150	1
4	7	Product G	12.99	125	1
5	9	Product I	7.99	175	1

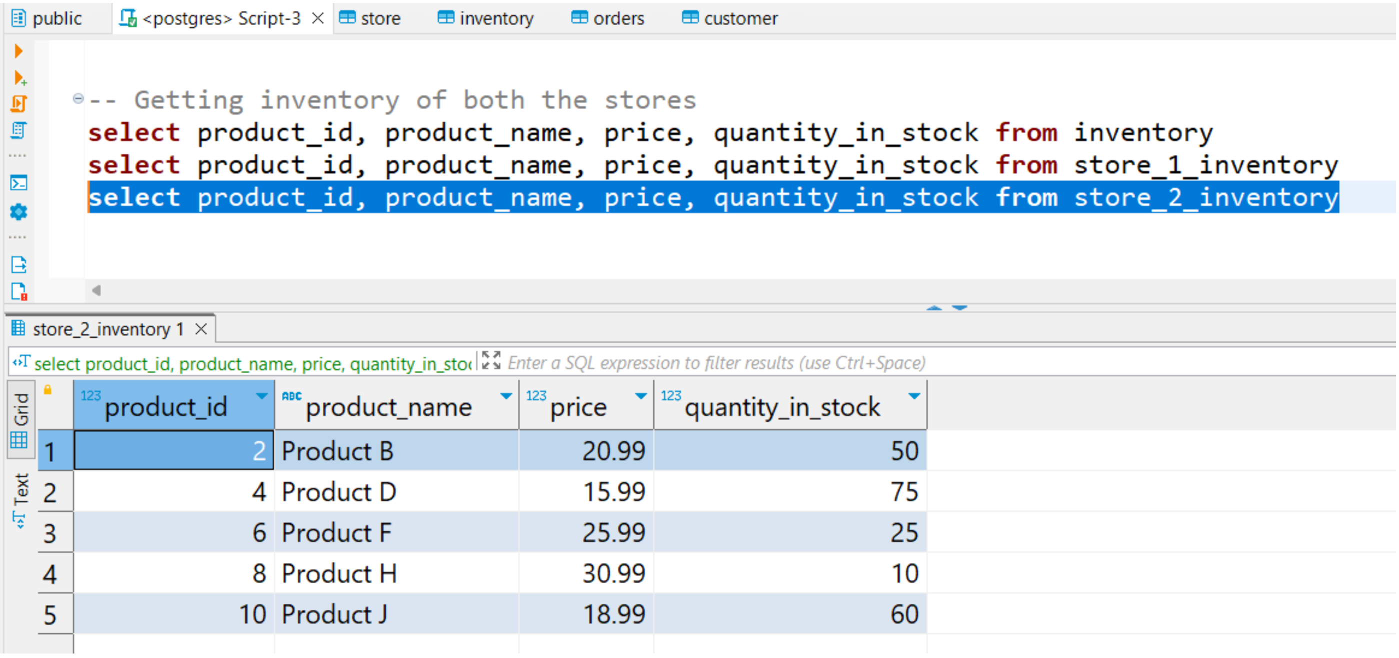
5 row(s) fetched - 8ms, on 2023-02-13 at 21:02:48

Running Queries in the fragmented tables

1) Here in the below query I am getting the info of inventory of the both stores





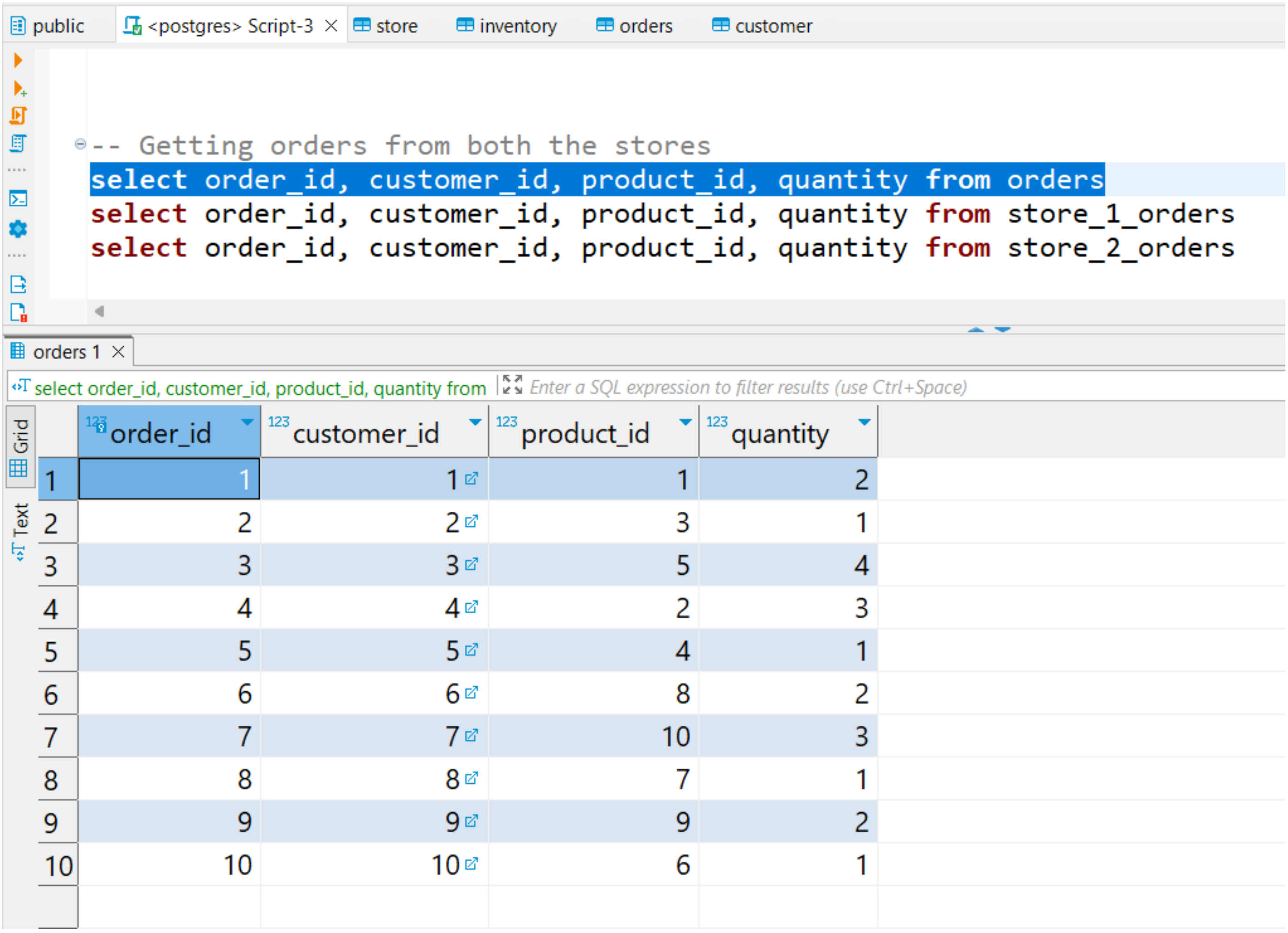


```sql
-- Getting inventory of both the stores
select product_id, product_name, price, quantity_in_stock from inventory
select product_id, product_name, price, quantity_in_stock from store_1_inventory
select product_id, product_name, price, quantity_in_stock from store_2_inventory
```

store_2_inventory 1

	product_id	product_name	price	quantity_in_stock
1	2	Product B	20.99	50
2	4	Product D	15.99	75
3	6	Product F	25.99	25
4	8	Product H	30.99	10
5	10	Product J	18.99	60

2) Here in the below query I am getting the orders from both the stores



```sql
-- Getting orders from both the stores
select order_id, customer_id, product_id, quantity from orders
select order_id, customer_id, product_id, quantity from store_1_orders
select order_id, customer_id, product_id, quantity from store_2_orders
```

orders 1

	order_id	customer_id	product_id	quantity
1	1	1	1	2
2	2	2	3	1
3	3	3	5	4
4	4	4	2	3
5	5	5	4	1
6	6	6	8	2
7	7	7	10	3
8	8	8	7	1
9	9	9	9	2
10	10	10	6	1

```sql
-- Getting orders from both the stores
select order_id, customer_id, product_id, quantity from orders
select order_id, customer_id, product_id, quantity from store_1_orders
select order_id, customer_id, product_id, quantity from store_2_orders
```

store_1_orders 1

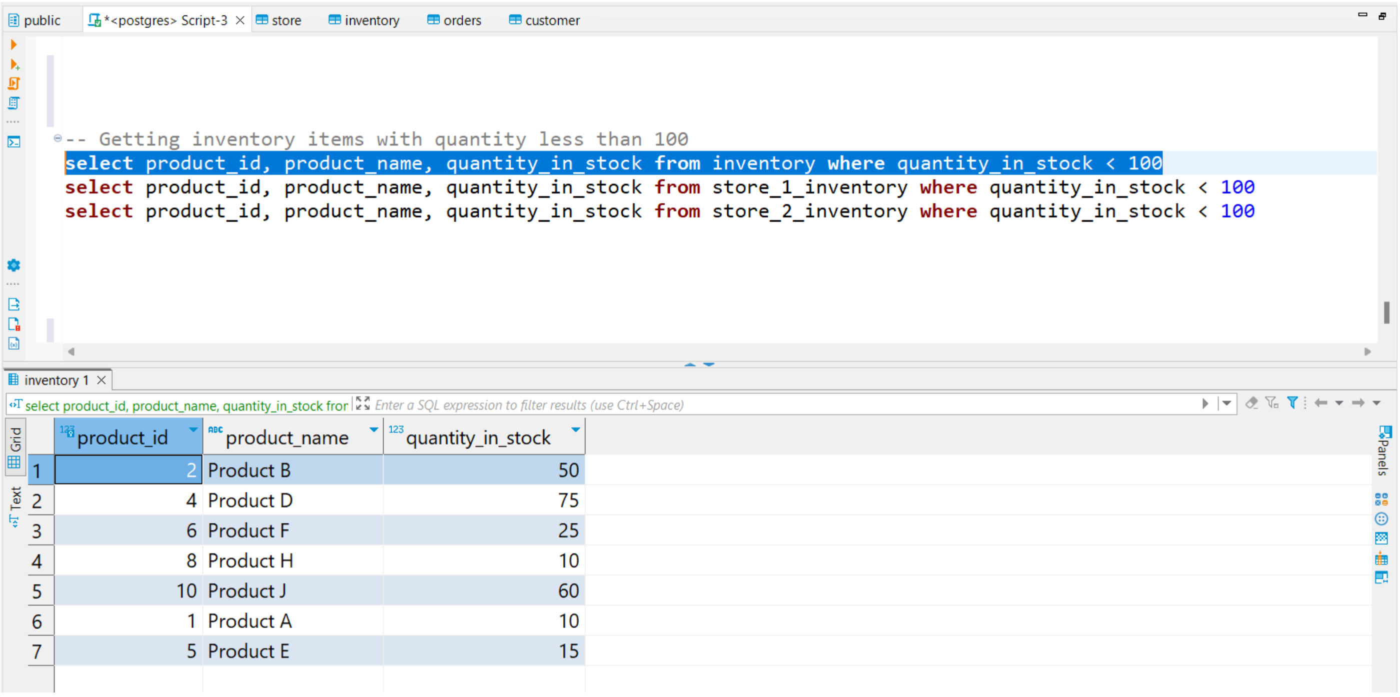
	order_id	customer_id	product_id	quantity
1	1	1	1	2
2	2	2	3	1
3	3	3	5	4
4	8	8	7	1
5	9	9	9	2

```sql
-- Getting orders from both the stores
select order_id, customer_id, product_id, quantity from orders
select order_id, customer_id, product_id, quantity from store_1_orders
select order_id, customer_id, product_id, quantity from store_2_orders
```

store_2_orders 1

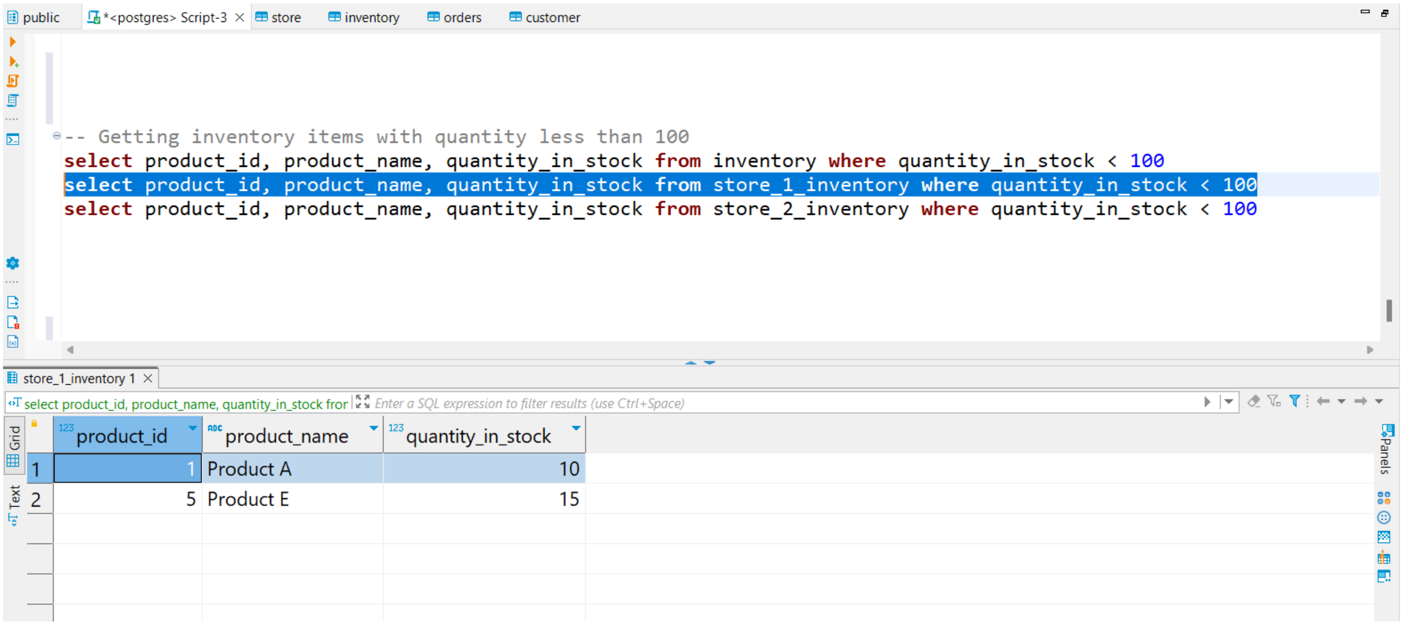
	order_id	customer_id	product_id	quantity
1	4	4	2	3
2	5	5	4	1
3	6	6	8	2
4	7	7	10	3
5	10	10	6	1

3) We are querying inventory items with quantity less than 100



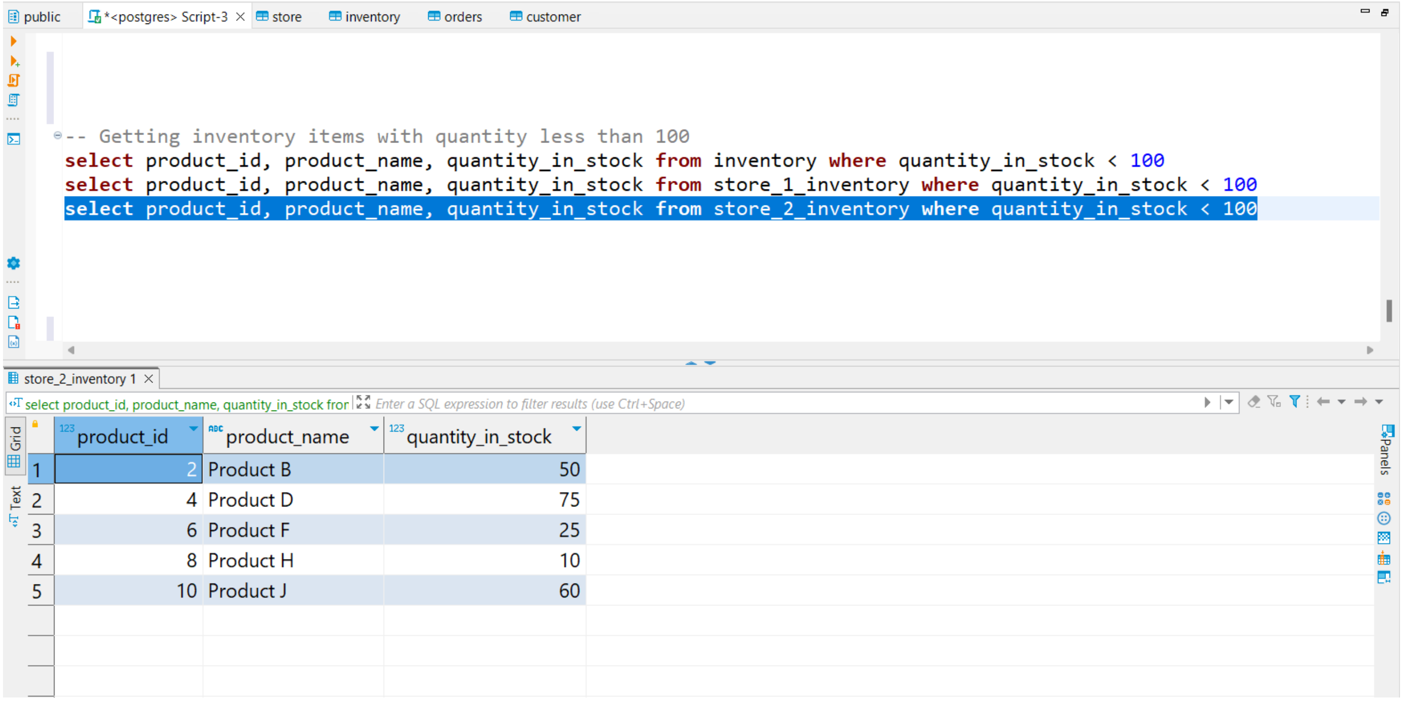
```sql
-- Getting inventory items with quantity less than 100
select product_id, product_name, quantity_in_stock from inventory where quantity_in_stock < 100
select product_id, product_name, quantity_in_stock from store_1_inventory where quantity_in_stock < 100
select product_id, product_name, quantity_in_stock from store_2_inventory where quantity_in_stock < 100
```

	product_id	product_name	quantity_in_stock
1	2	Product B	50
2	4	Product D	75
3	6	Product F	25
4	8	Product H	10
5	10	Product J	60
6	1	Product A	10
7	5	Product E	15

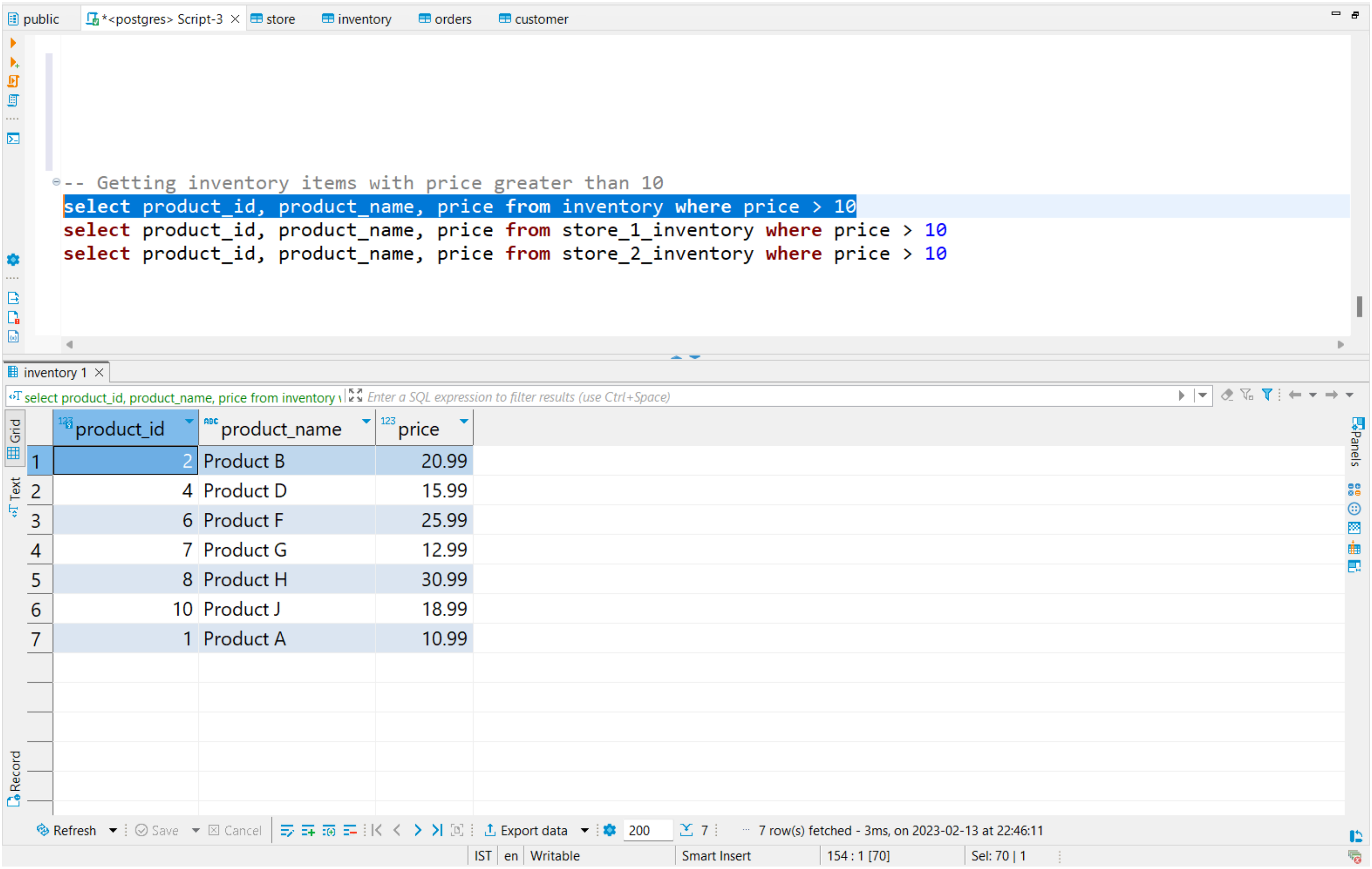


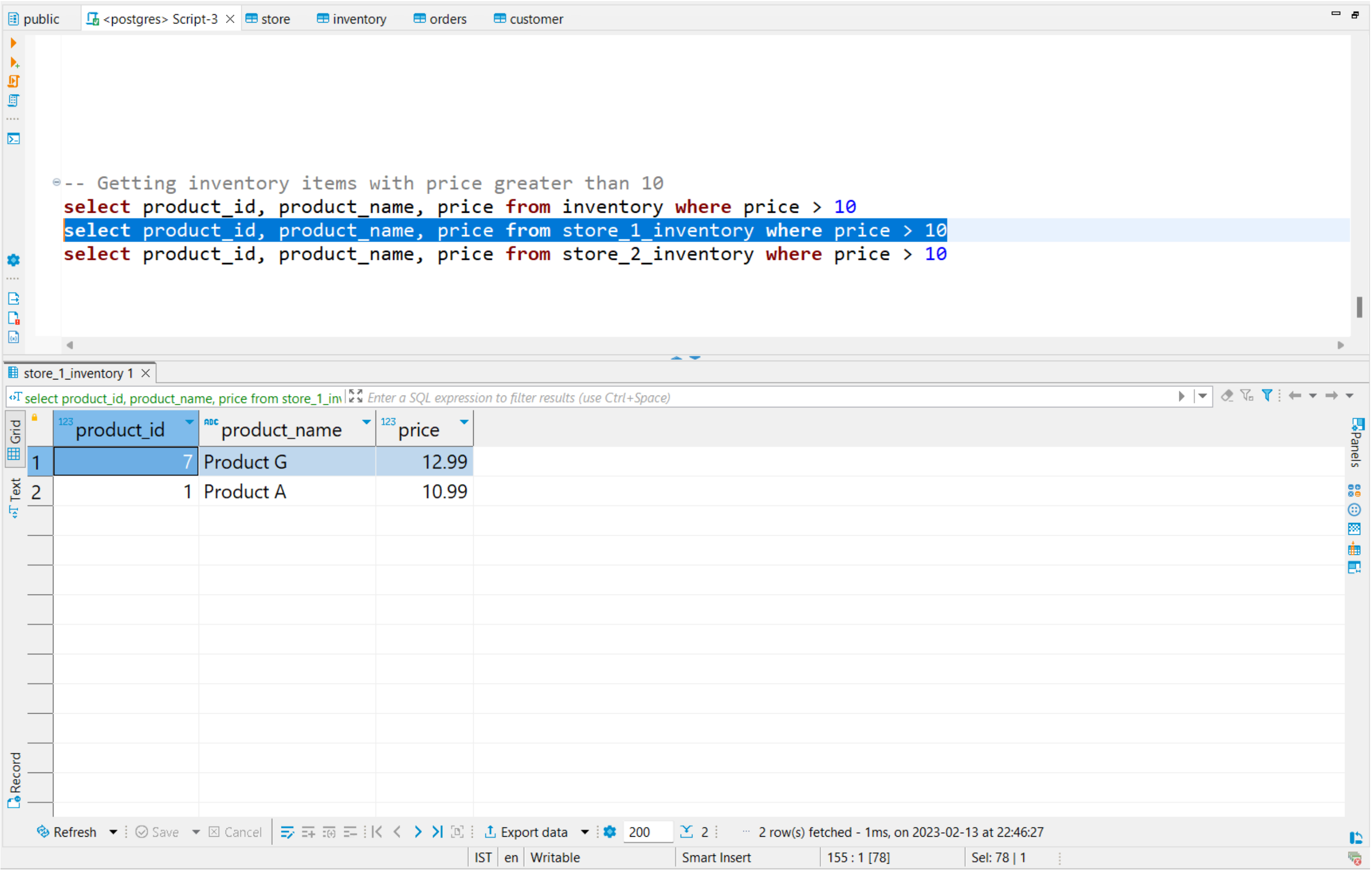
```sql
-- Getting inventory items with quantity less than 100
select product_id, product_name, quantity_in_stock from inventory where quantity_in_stock < 100
select product_id, product_name, quantity_in_stock from store_1_inventory where quantity_in_stock < 100
select product_id, product_name, quantity_in_stock from store_2_inventory where quantity_in_stock < 100
```

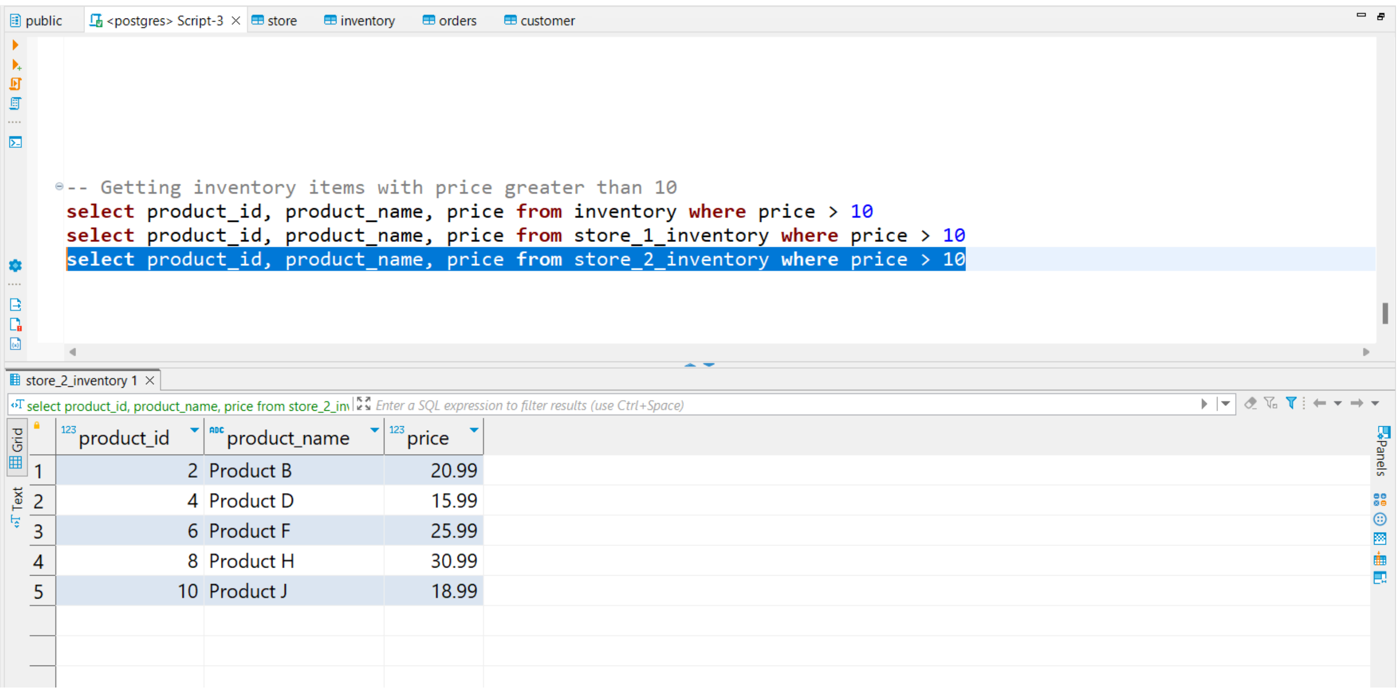
	product_id	product_name	quantity_in_stock
1	1	Product A	10
2	5	Product E	15



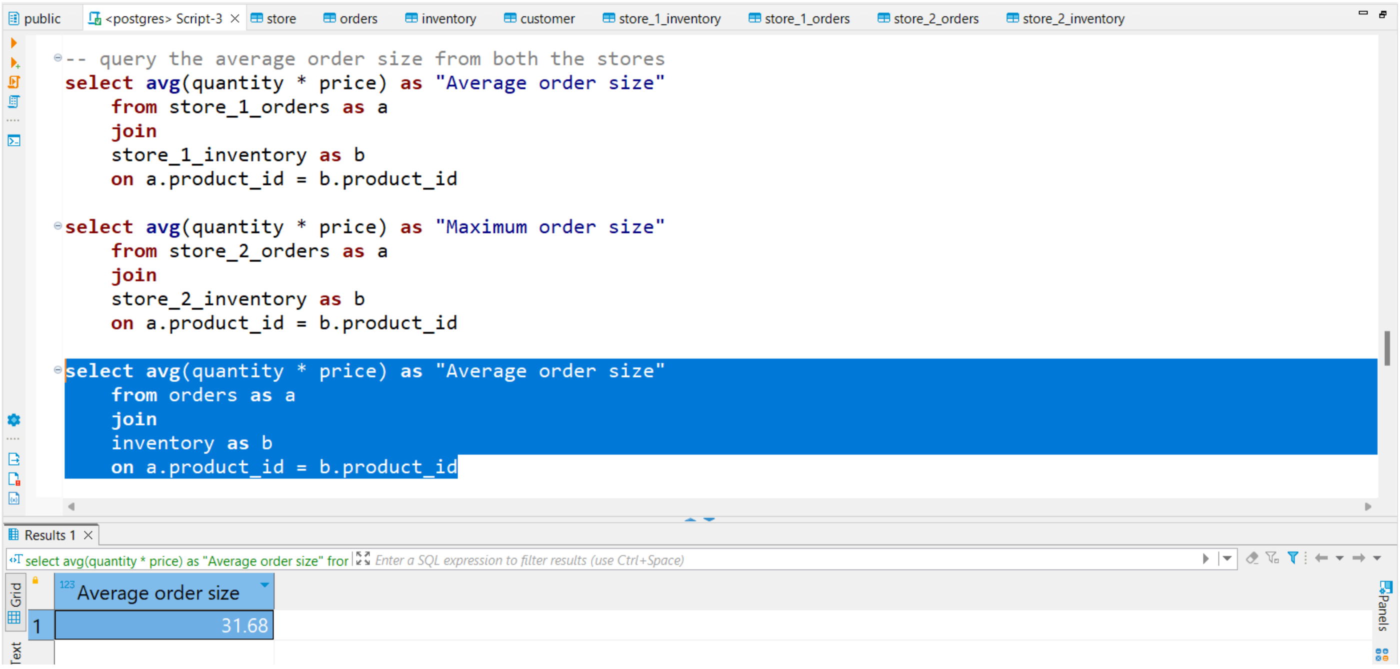
4) Now, we are querying the inventory items with price greater than $10

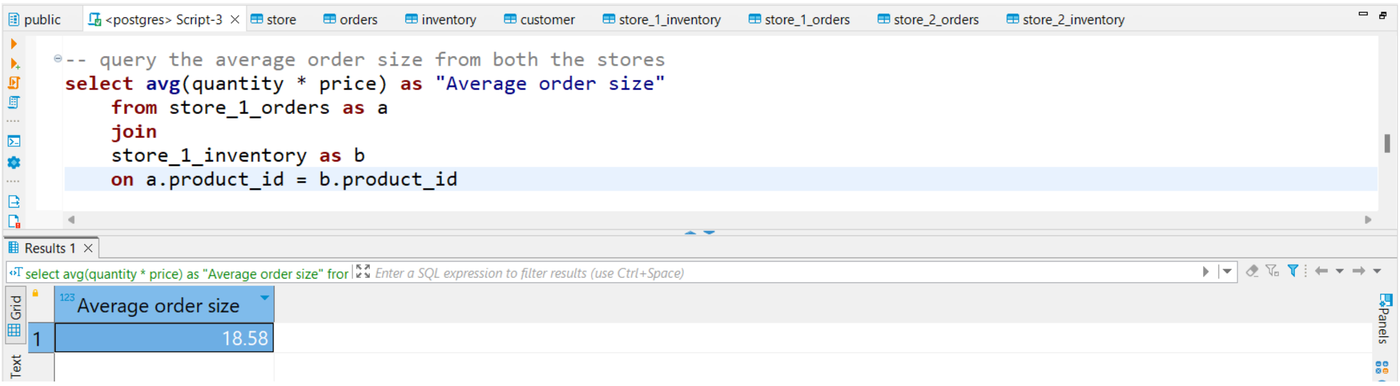


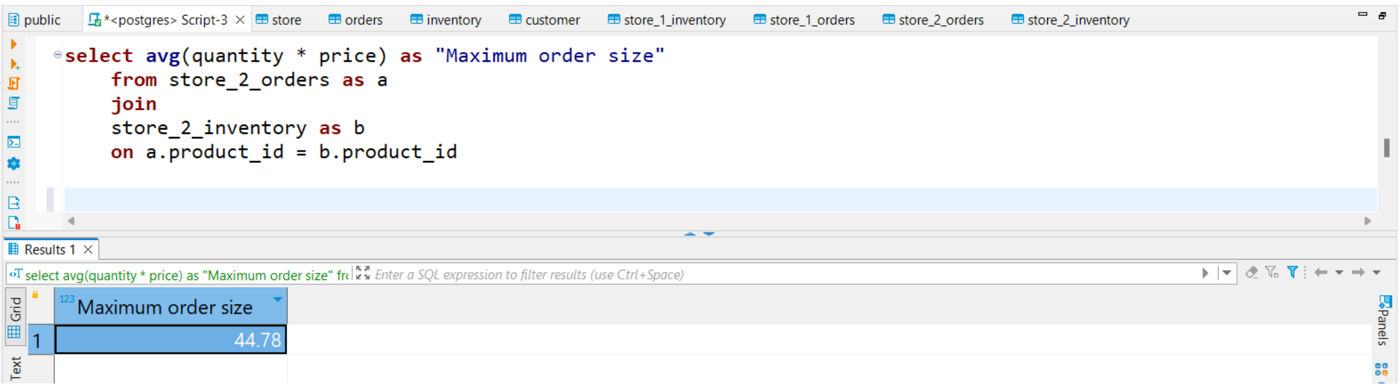

public
<postgres> Script-3
store
inventory
orders
customer
-- Getting inventory items with price greater than 10
select product_id, product_name, price from inventory where price > 10
select product_id, product_name, price from store_1_inventory where price > 10
select product_id, product_name, price from store_2_inventory where price > 10
store_1_inventory 1
select product_id, product_name, price from store_1_in
Enter a SQL expression to filter results (use Ctrl+Space)
product_id
product_name
price
1 7 Product G 12.99
2 1 Product A 10.99
Refresh
Save
Cancel
Export data
200
2
2 row(s) fetched - 1ms, on 2023-02-13 at 22:46:27
IST
en
Writable
Smart Insert
155 : 1 [78]
Sel: 78 | 1


public
<postgres> Script-3
store
inventory
orders
customer
-- Getting inventory items with price greater than 10
select product_id, product_name, price from inventory where price > 10
select product_id, product_name, price from store_1_inventory where price > 10
select product_id, product_name, price from store_2_inventory where price > 10
store_2_inventory 1
select product_id, product_name, price from store_2_in
Enter a SQL expression to filter results (use Ctrl+Space)
product_id
product_name
price
1 2 Product B 20.99
2 4 Product D 15.99
3 6 Product F 25.99
4 8 Product H 30.99
5 10 Product J 18.99

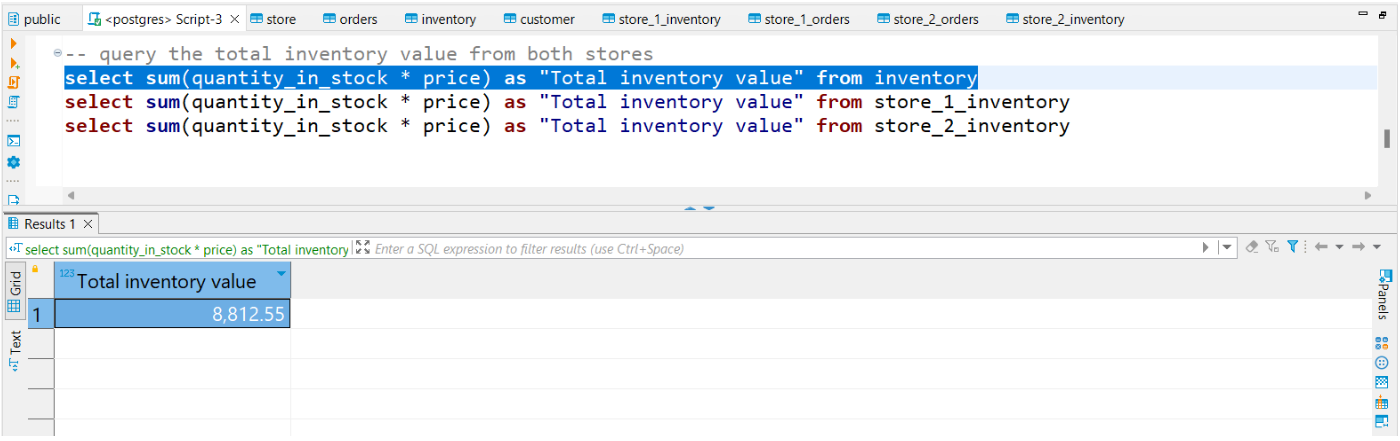
5) Average order size at each store, it can be used to calculate profits of the store

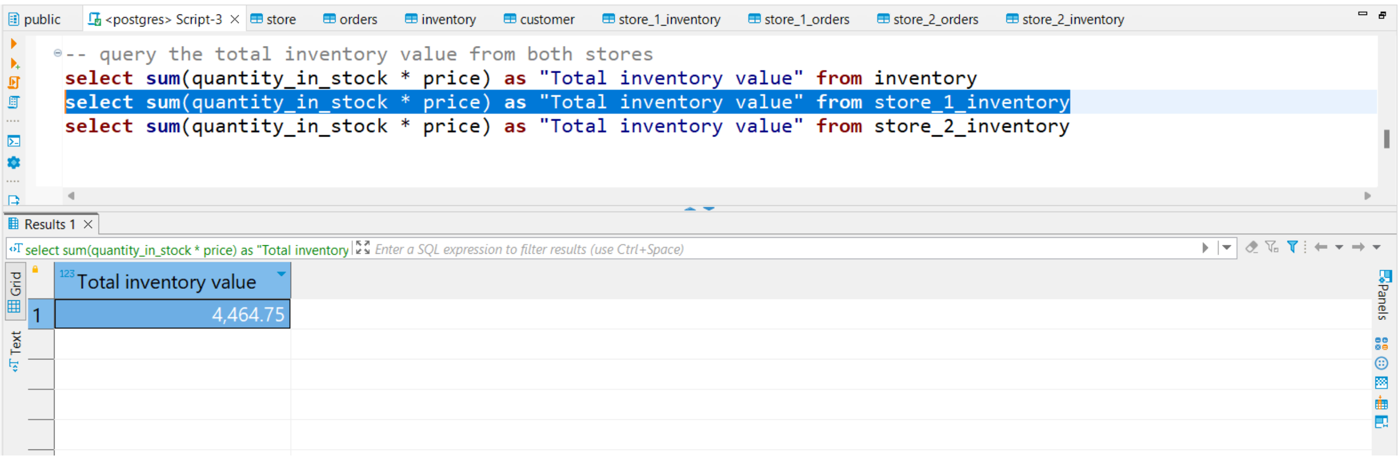


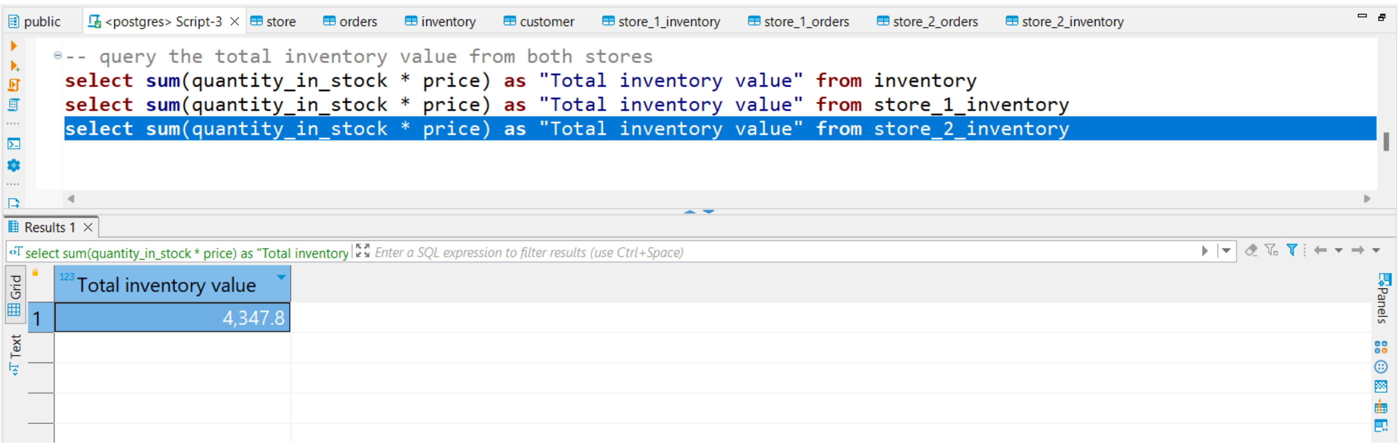




6) Query to Find the Total inventory value of the stores







7) Query to find the customers who have find the products in nearest store

```sql
-- query to find customers who have bought the product from nearest store
select c.customer_id, c.cutomer_name, c.email, c.phone_number, o.store_id, c.address
    from customer as c
    join
    orders as o
    on c.customer_id = o.order_id
    join
    store as s
    on s.store_id = o.store_id
    where c.address = s.address
```

	customer_id	cutomer_name	email	phone_number	store_id	address
1	1	John Doe	johndoe@example.com	555-1234	1	123 Main St.
2	3	Bob Johnson	bobjohnson@example.com	555-9101	1	123 Main St.
3	4	Sara Lee	saralee@example.com	555-1212	2	456 Elm St.
4	6	Emily Davis	emilydavis@example.com	555-5656	2	456 Elm St.
5	9	David Kim	davidkim@example.com	555-2323	1	123 Main St.
6	10	Karen Lee	karenlee@example.com	555-4545	2	456 Elm St.

```sql
select c.customer_id, c.cutomer_name, c.email, c.phone_number, o.store_id, c.address
from customer as c
join
store_1_orders as o
on c.customer_id = o.order_id
join
store as s
on s.store_id = o.store_id
where c.address = s.address
```

	customer_id	cutomer_name	email	phone_number	store_id	address
1	1	John Doe	johndoe@example.com	555-1234	1	123 Main St.
2	3	Bob Johnson	bobjohnson@example.com	555-9101	1	123 Main St.
3	9	David Kim	davidkim@example.com	555-2323	1	123 Main St.

```sql
select c.customer_id, c.cutomer_name, c.email, c.phone_number, o.store_id, c.address
    from customer as c
    join
    store_2_orders as o
    on c.customer_id = o.order_id
    join
    store as s
    on s.store_id = o.store_id
    where c.address = s.address
```

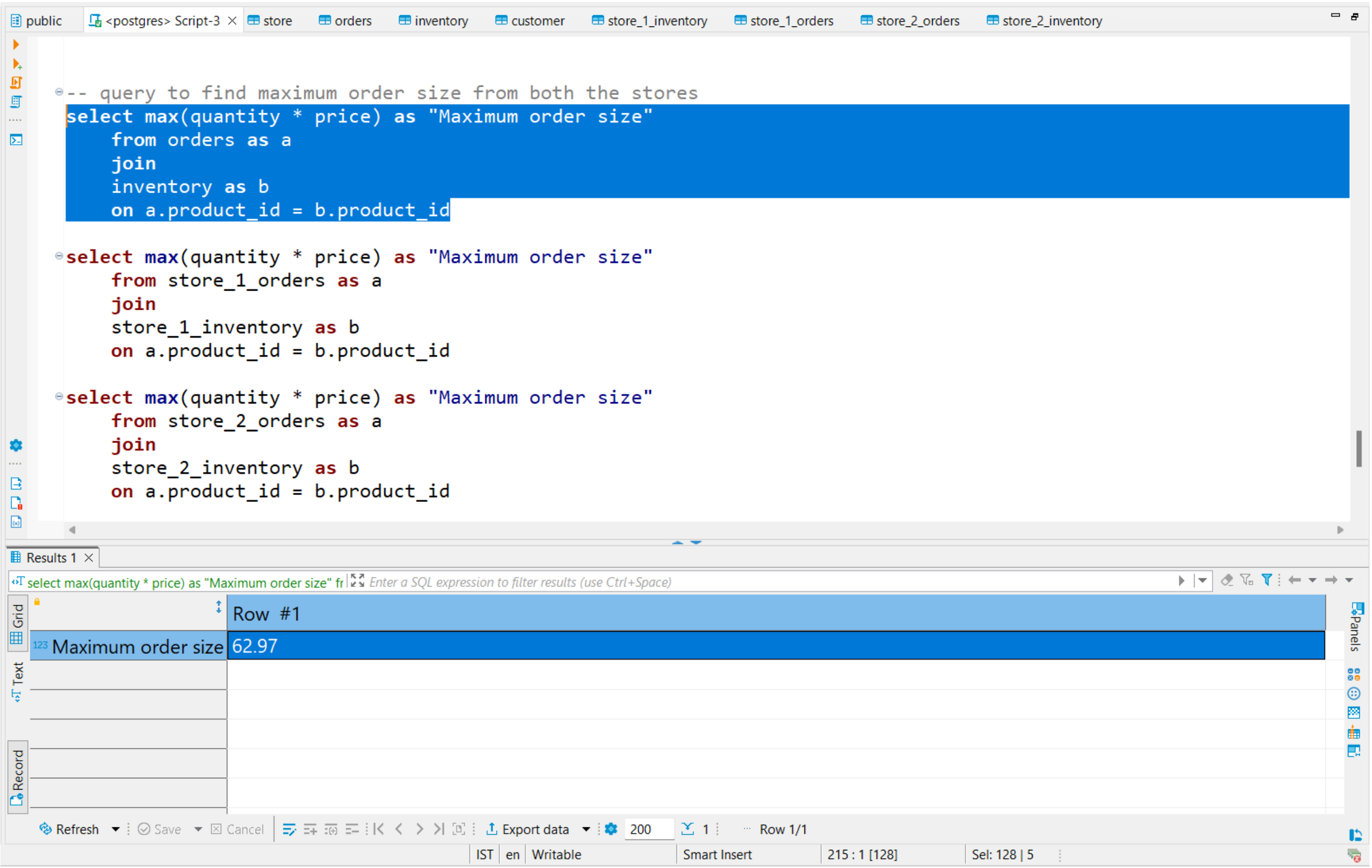
customer(+) 1

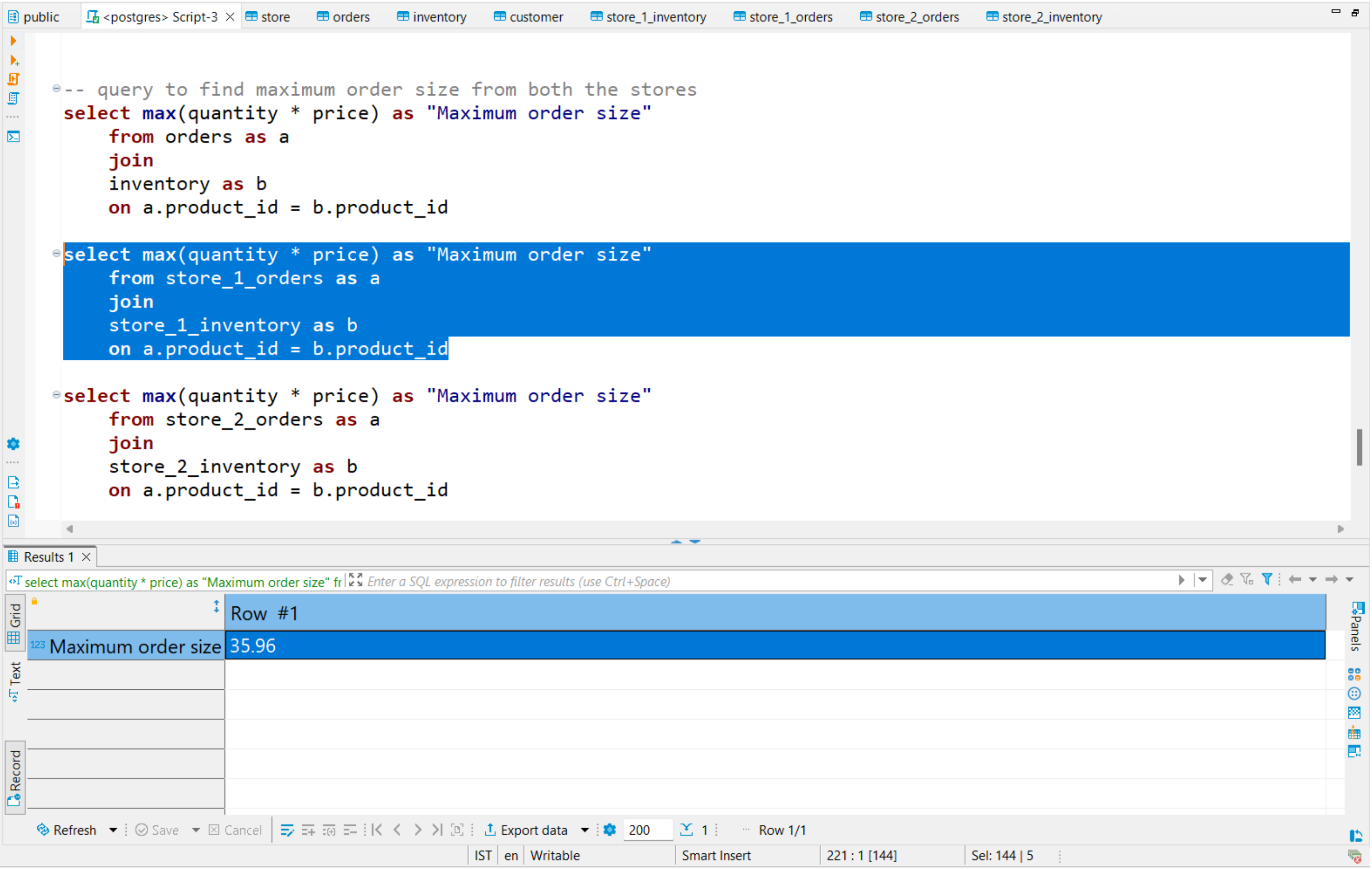
select c.customer_id, c.cutomer_name, c.email, c.phone

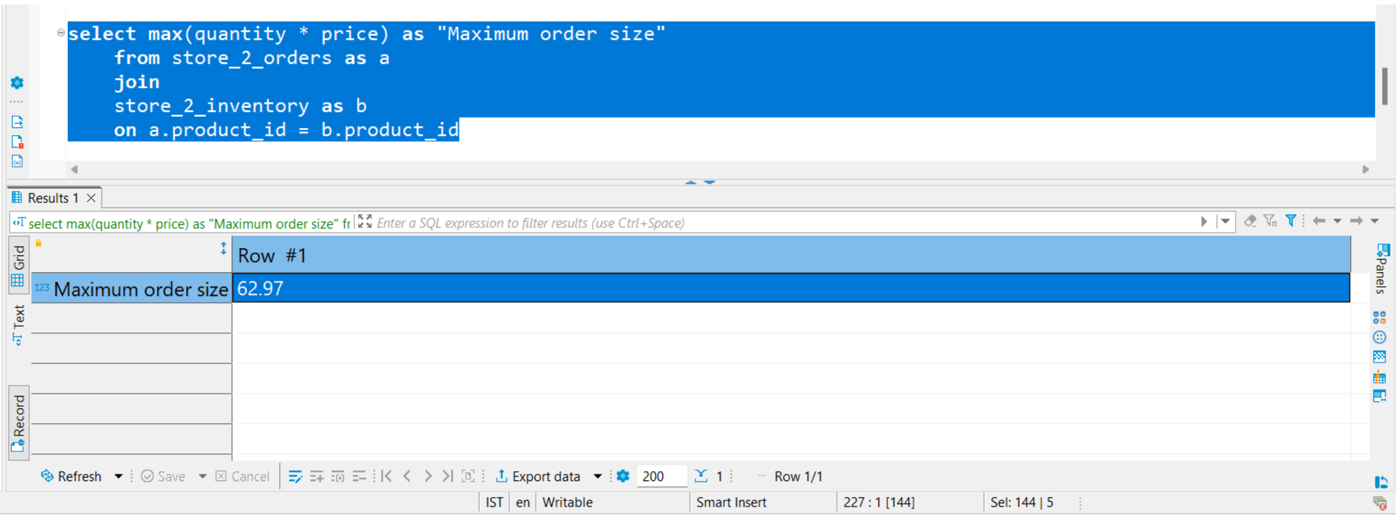
	customer_id	cutomer_name	email	phone_number	store_id	address
1	4	Sara Lee	saralee@example.com	555-1212	2	456 Elm St.
2	6	Emily Davis	emilydavis@example.com	555-5656	2	456 Elm St.
3	10	Karen Lee	karenlee@example.com	555-4545	2	456 Elm St.

3 row(s) fetched - 3ms, on 2023-02-13 at 23:37:44

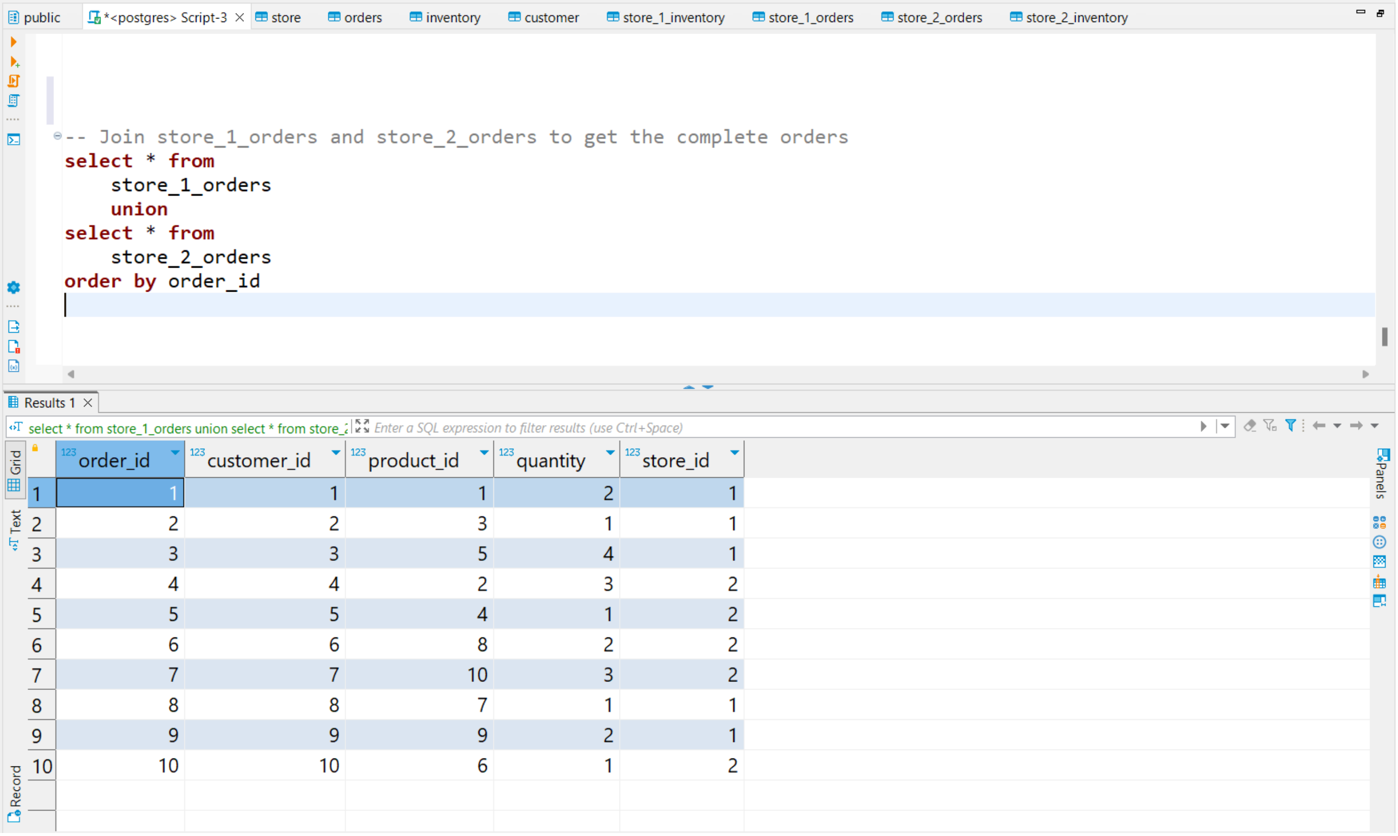
8) Query to find the maximum order size from both the stores




public
<postgres> Script-3
store
orders
inventory
customer
store_1_inventory
store_1_orders
store_2_orders
store_2_inventory
-- query to find maximum order size from both the stores
select max(quantity * price) as "Maximum order size"
from orders as a
join
inventory as b
on a.product_id = b.product_id
select max(quantity * price) as "Maximum order size"
from store_1_orders as a
join
store_1_inventory as b
on a.product_id = b.product_id
select max(quantity * price) as "Maximum order size"
from store_2_orders as a
join
store_2_inventory as b
on a.product_id = b.product_id
Results 1
select max(quantity * price) as "Maximum order size" fr
Enter a SQL expression to filter results (use Ctrl+Space)
Row #1
Maximum order size
35.96
Grid
Text
Record
Panels
Refresh
Save
Cancel
Export data
200
1
Row 1/1
IST
en
Writable
Smart Insert
221 : 1 [144]
Sel: 144 | 5


select max(quantity * price) as "Maximum order size"
from store_2_orders as a
join
store_2_inventory as b
on a.product_id = b.product_id
Results 1
select max(quantity * price) as "Maximum order size" fr
Enter a SQL expression to filter results (use Ctrl+Space)
Row #1
Maximum order size
62.97
Grid
Text
Record
Panels
Refresh
Save
Cancel
Export data
200
1
Row 1/1
IST
en
Writable
Smart Insert
227 : 1 [144]
Sel: 144 | 5

9) Joining store_1_orders and store_2_orders to get the complete Orders table



```sql
-- Join store_1_orders and store_2_orders to get the complete orders
select * from
    store_1_orders
    union
select * from
    store_2_orders
order by order_id
```

	order_id	customer_id	product_id	quantity	store_id
1	1	1	1	2	1
2	2	2	3	1	1
3	3	3	5	4	1
4	4	4	2	3	2
5	5	5	4	1	2
6	6	6	8	2	2
7	7	7	10	3	2
8	8	8	7	1	1
9	9	9	9	2	1
10	10	10	6	1	2

10) Joining store_1_inventory and store_2_inventory to get the complete inventory table

```sql
-- Join store_1_inventory and store_2_inventory to get the complete inventory
select * from
    store_1_inventory
    union
select * from
    store_2_inventory
order by product_id
```

	product_id	product_name	price	quantity_in_stock	store_id
1	1	Product A	10.99	10	1
2	2	Product B	20.99	50	2
3	3	Product C	5.99	200	1
4	4	Product D	15.99	75	2
5	5	Product E	8.99	15	1
6	6	Product F	25.99	25	2
7	7	Product G	12.99	125	1
8	8	Product H	30.99	10	2
9	9	Product I	7.99	175	1
10	10	Product J	18.99	60	2

Correctness rules of fragmentation

Fragmentation is the major concept in distributed databases. We fragment a table horizontally, vertically, or both and distribute the data to different sites (servers at different geographical locations).

While we perform the fragmentation process, as a result we expect the following as outcomes;

- We should not lose data because of fragmentation
- We should not get redundant data because of fragmentation Hence, to ensure these properties we need to verify whether we performed the fragmentation correctly or not. For this verification we use the correctness rules.

The rules are as follows;

- **Completeness** -

To ensure that there is no loss of data due to fragmentation. Completeness property ensures this by checking whether all the records which were part of a table (before fragmentation) are found in at least one of the fragments after fragmentation. We can see in the above queries that the Total number of unique ids in the inventory and orders table match with the number of unique ids in the sum of two fragmented tables.

- **Reconstruction** -

This rule ensures the ability to reconstruct the original table from the fragments that are created. This rule is to check whether the functional dependencies are preserved or not.

If a table R is partitioned into fragments R1, R2, …, Rn,
then Reconstruction insists the following; R = R1 U R2 U … U Rn

For the above scenario we can see that the Union of the two tables gives us back the original table thus making sure that Reconstruction is possible.

- **Disjointness** -

This rule ensures that no record will become a part of two or more different fragments during the fragmentation process.

If a table R is partitioned into fragments R1, R2, …, Rn,
then Disjointness insists the following; R1 ∩ R2 ∩ … ∩ Rn = Null set

For the above scenario we see that the relations "<" and ">=" do not share any common values thus inherently satisfying the Disjoint condition.

Lossless decomposition

Lossless join decomposition is a way to decompose a relation R into two or more relations R1, R2 such that their natural join returns the original relation R. This helps to eliminate data redundancy in a database while retaining the original data. The decomposed tables can be joined together to reconstruct the original relation R. Only the normal forms 1NF, 2NF, 3NF, and BCNF are suitable for lossless join decomposition. The common attribute used for decomposition must be a candidate key or a super key in either R1, R2, or both.

Conclusion:

By performing the above experiment:

- I learnt how to apply horizontal fragmentation on a table and fragmentation increases the efficiency by distributing the database
- I learnt how to check whether the fragmentation was correct by checking the correctness rules and about lossless decomposition