PES UNIVERSITY

ELECTIVE 1: DATABASE TECHNOLOGIES (UE18CS315)

ASSIGNMENT 2

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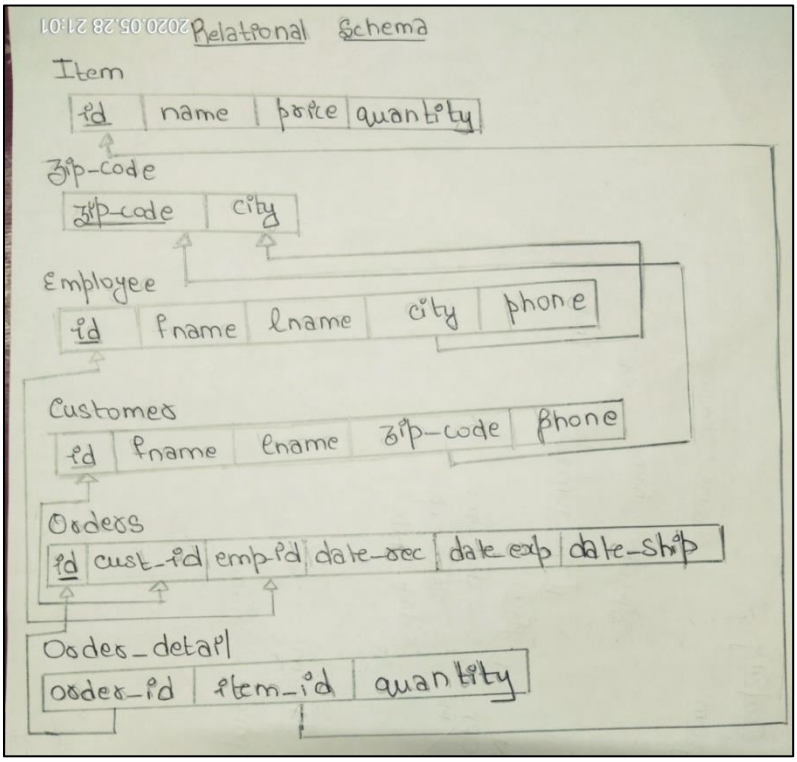
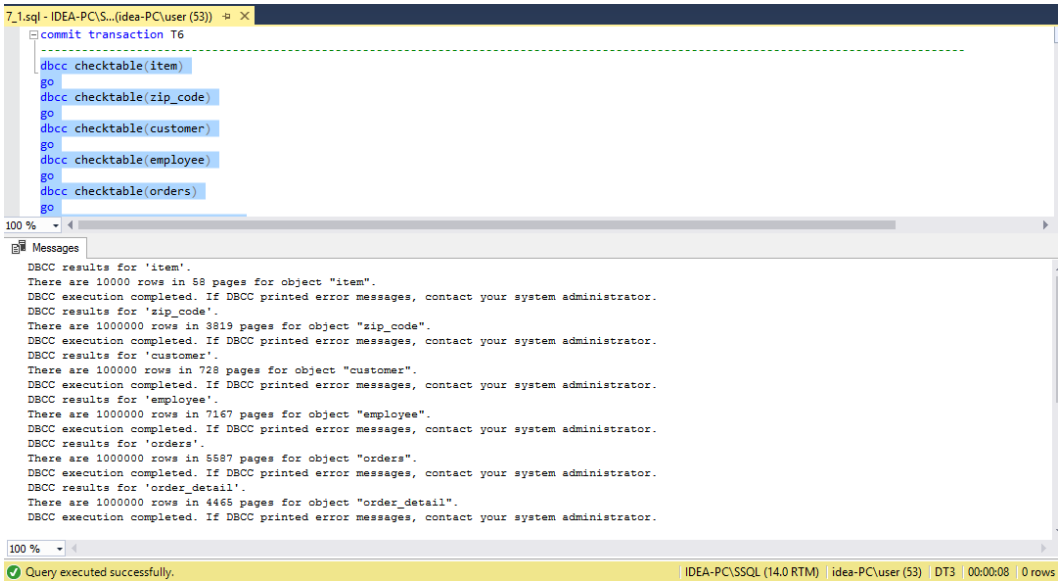
SEMESTER: 5

SECTION: J

Problem statement: Understand the performance improvement of queries by writing it in different ways and comparing the execution plans

E-Commerce Company



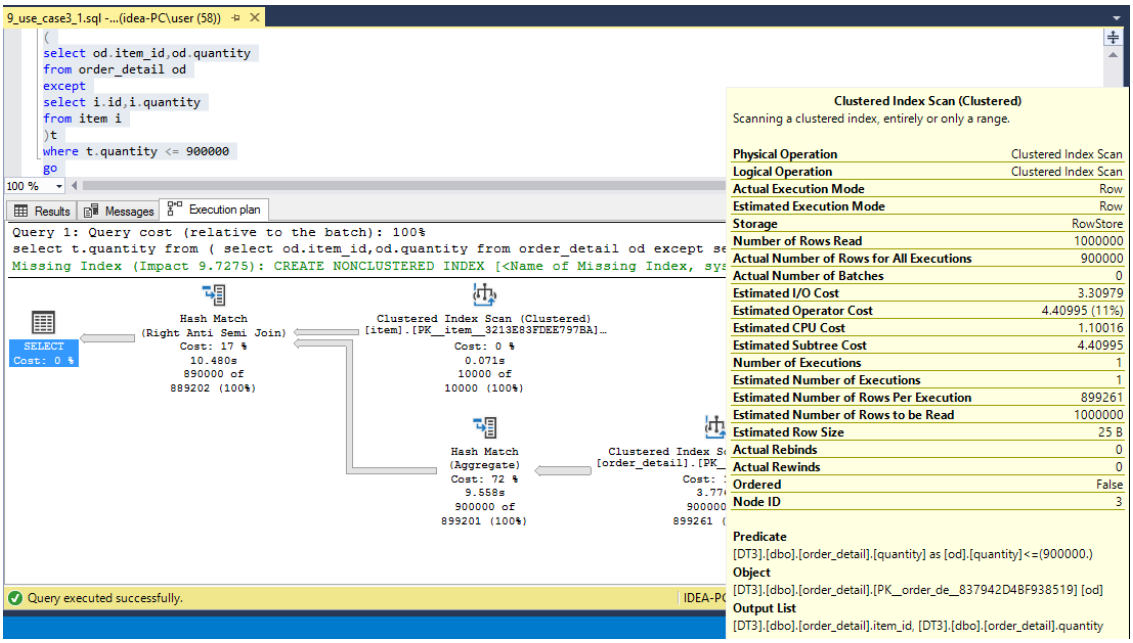


Size of tables: item < customer < orders, order_detail, zip_code, employee

Use case 1:
SQL syntax using NOT IN

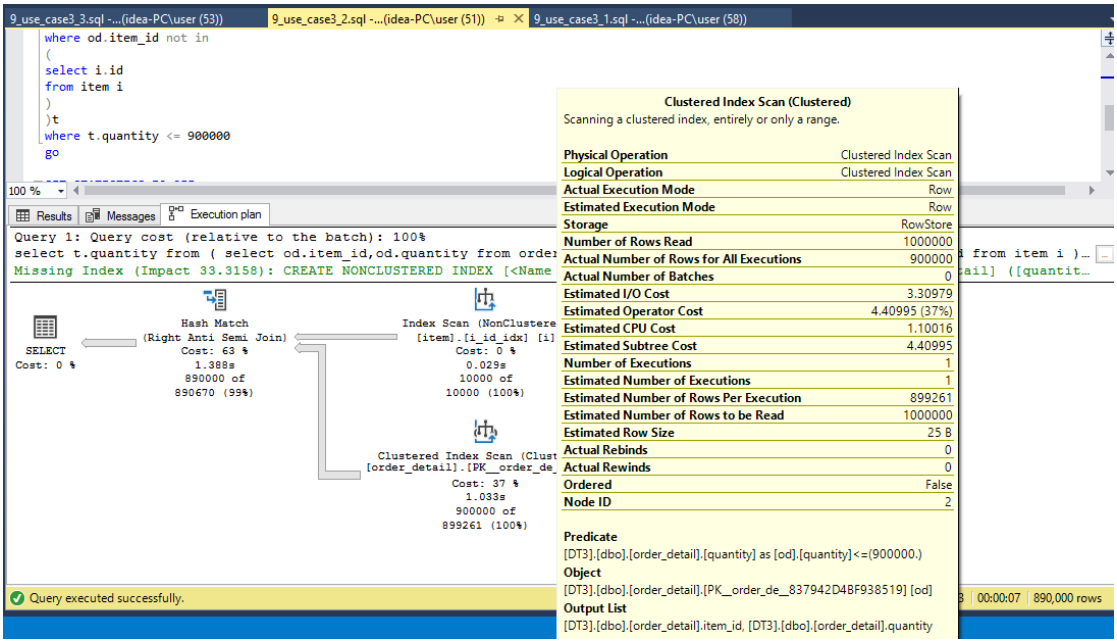
I) except

```
--query
SET STATISTICS IO ON
SET STATISTICS TIME ON

DBCC DROPCLEANBUFFERS
GO
DBCC FREEPROCCACHE
GO

use [DT3]
select t.quantity
from
(
select od.item_id,od.quantity
from order_detail od
except
select i.id,i.quantity
from item i
)t
where t.quantity <= 900000
go



SET STATISTICS IO OFF
SET STATISTICS TIME OFF
```



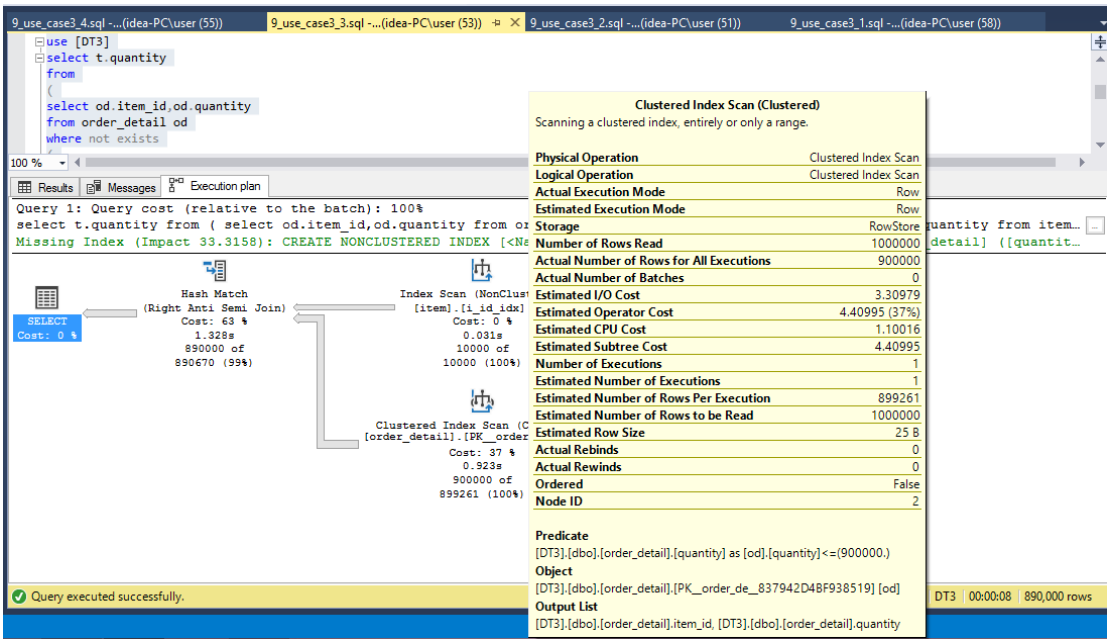
II) not in

```
--query
SET STATISTICS IO ON
SET STATISTICS TIME ON

DBCC DROPCLEANBUFFERS
GO
DBCC FREEPROCCACHE
GO

use [DT3]
select t.quantity
from
(
select od.item_id,od.quantity
from order_detail od
where od.item_id not in
(
select i.id
from item i
)
)t
where t.quantity <= 900000
go

SET STATISTICS IO OFF
SET STATISTICS TIME OFF
```



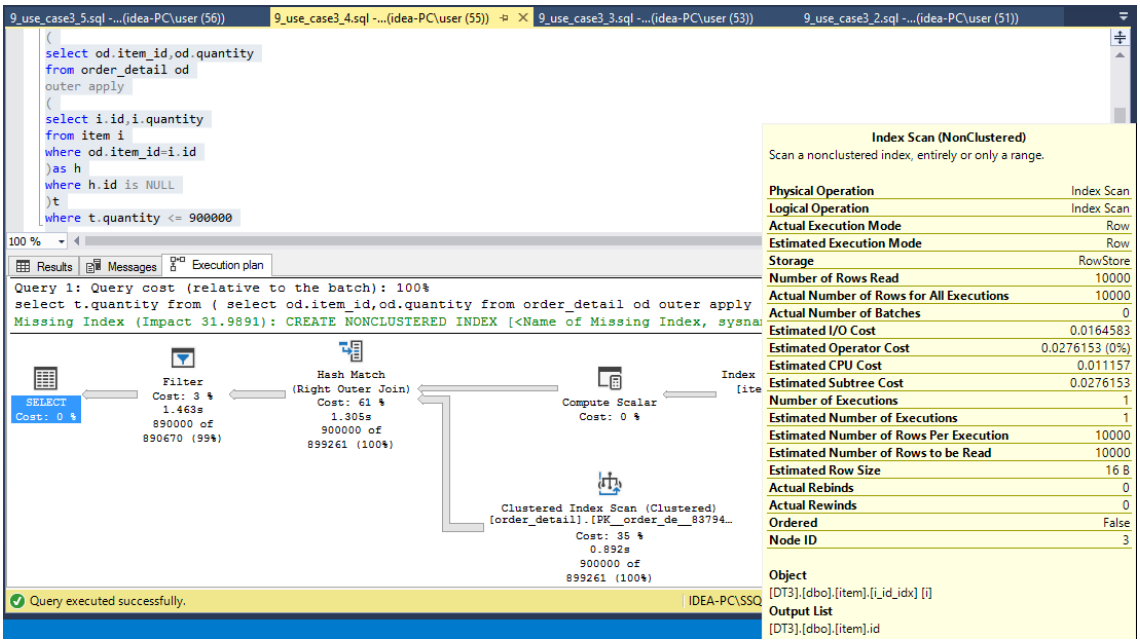
III) not exists

```
--query
SET STATISTICS IO ON
SET STATISTICS TIME ON

DBCC DROPCLEANBUFFERS
GO
DBCC FREEPROCCACHE
GO

use [DT3]
select t.quantity
from
(
select od.item_id,od.quantity
from order_detail od
where not exists
(
select i.id,i.quantity
from item i
where od.item_id=i.id
)
)t
where t.quantity <= 900000
go

SET STATISTICS IO OFF
SET STATISTICS TIME OFF
```



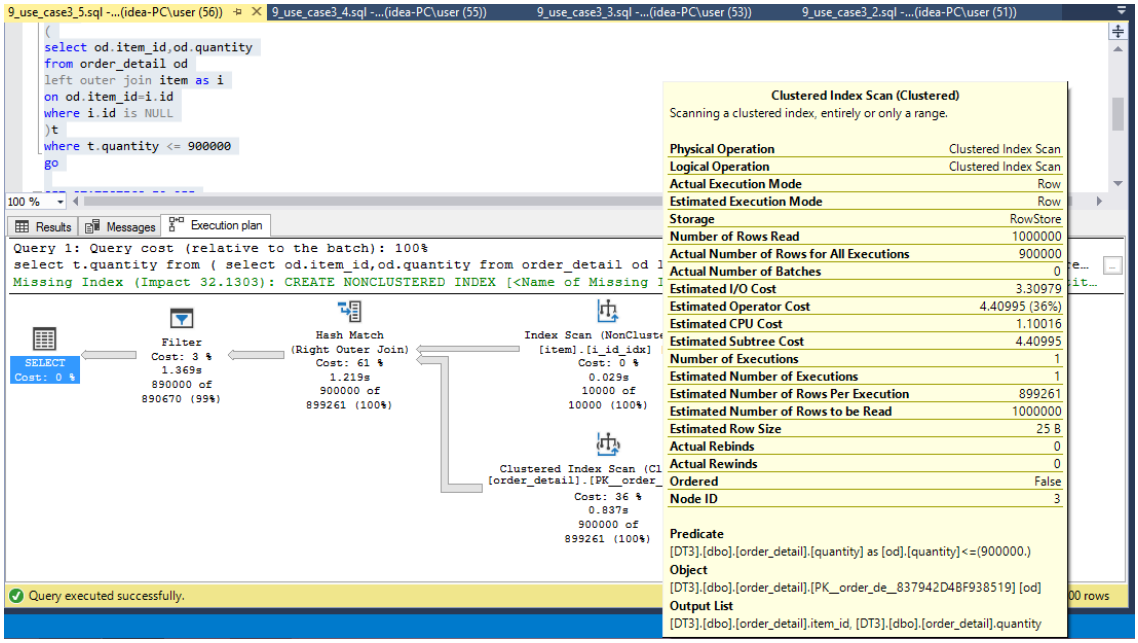
IV) outer apply

```
--query
SET STATISTICS IO ON
SET STATISTICS TIME ON

DBCC DROPCLEANBUFFERS
GO
DBCC FREEPROCCACHE
GO

use [DT3]
select t.quantity
from
(
select od.item_id,od.quantity
from order_detail od
outer apply
(
select i.id,i.quantity
from item i
where od.item_id=i.id
)as h
where h.id is NULL
)t
where t.quantity <= 900000
go

SET STATISTICS IO OFF
SET STATISTICS TIME OFF
```



V) left outer join

```
--query
SET STATISTICS IO ON
SET STATISTICS TIME ON

DBCC DROPCLEANBUFFERS
GO
DBCC FREEPROCCACHE
GO

use [DT3]
select t.quantity
from
(
select od.item_id,od.quantity
from order_detail od
left outer join item as i
on od.item_id=i.id
where i.id is NULL
)t
where t.quantity <= 900000
go

SET STATISTICS IO OFF
SET STATISTICS TIME OFF
```



Comparing each of the five different types of writing 'NOT IN':

	Type 1	Type 2	Type 3	Type 4	Type 5
Operator	except	Not in	Not exists	Outer apply	Left outer join
Rows	890,000	890,000	890,000	890,000	890,000
Time	25 sec	7 sec	8 sec	8 sec	8 sec
Logical reads	60	21	21	21	21
Selection criterion	Quantity <= 90000	Quantity <= 90000	Quantity <= 90000	Quantity <= 90000	Quantity <= 90000
Selection criteria pushed to	Item, order_detail	Order_detail	Order_detail	Order_detail	Order_detail
Remarks	Uses explicit distinct. Plan similar to not in.	Bad choice if target column is nullable. Uses right anti-semi join	Prone to nulls and duplicates. Plans similar to not in and except.	Uses right outer join. More expensive as it brings all matching and unmatched rows and then filters.	Similar plan as outer apply. Need to be careful while selecting columns.

Inference:

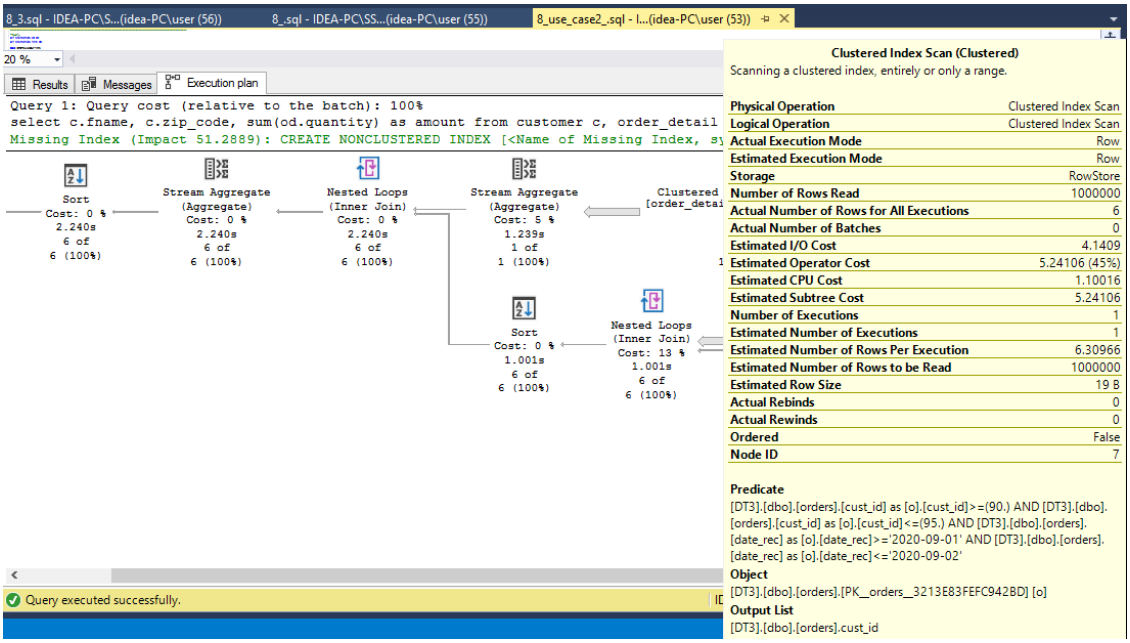
- While executing queries, only those columns are retrieved, that needs to be projected in the result set
- Select criteria on a particular relation, were pushed into the inner queries.
- The logical and physical reads on all the tables in each of the case were similar except in type 1 (i.e., in except the logical reads were higher)
- The filters were never specified in the sub queries but we see that the selection criteria's were pushed and the sub queries were eliminated.
- The plan generated for (type 1, type 2, type 3 are similar and type 4, type 5 had similar plans).
- The estimated cost followed the following order:
  (type 2, type 3 < type 5, type 6 < type)
- Overall we see that the 'not exists' (type 3) has a better performance to its alternatives.

Therefore we see how a query optimizer makes plan for each of the query. It is also intelligent to make an appropriate logical by pushing down the selection criteria to make the relations result fewer tuples and for effective query execution.

Use case 2:
SQL using UNION and confirming that selection criteria are pushed to the appropriate level

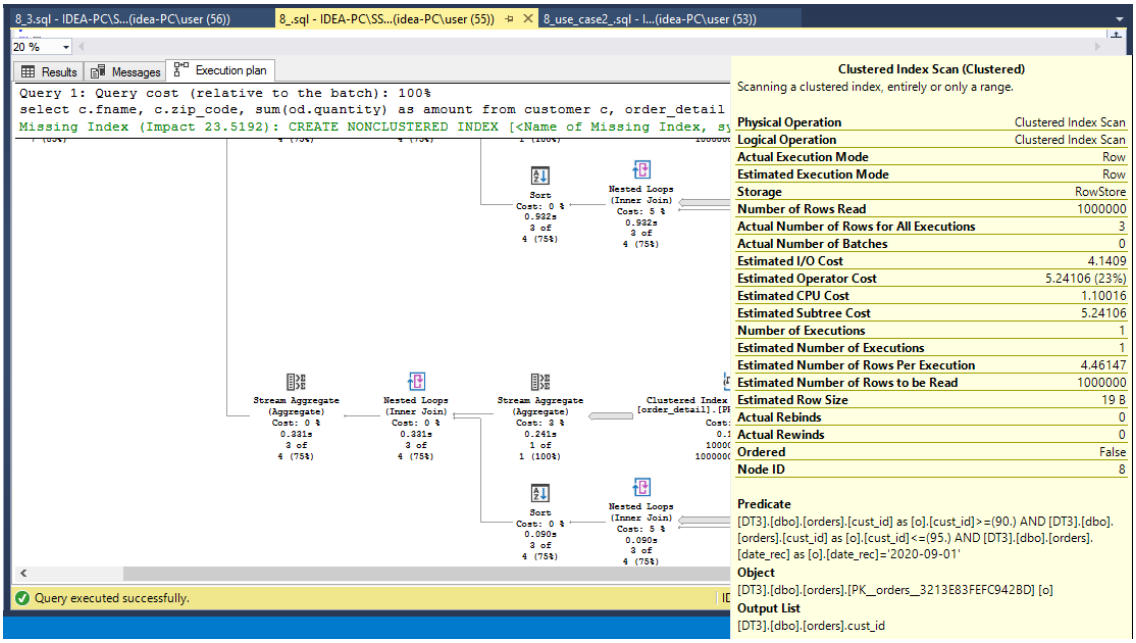
I) selection criterion directly applied and no union used

```
SET STATISTICS IO ON
SET STATISTICS TIME ON

DBCC DROPCLEANBUFFERS
GO
DBCC FREEPROCCACHE
GO

USE [DT3]
GO

select  c.fname,
        c.zip_code,
        sum(od.quantity) as amount
from    customer c,
        order_detail od,
        orders o
where   c.id=o.cust_id and
        c.id between 90 and 95 and
        o.date_rec between '2020-09-01' and '2020-09-02'
group by c.fname,c.zip_code
order by 3 desc
go

SET STATISTICS IO OFF
SET STATISTICS TIME OFF
```



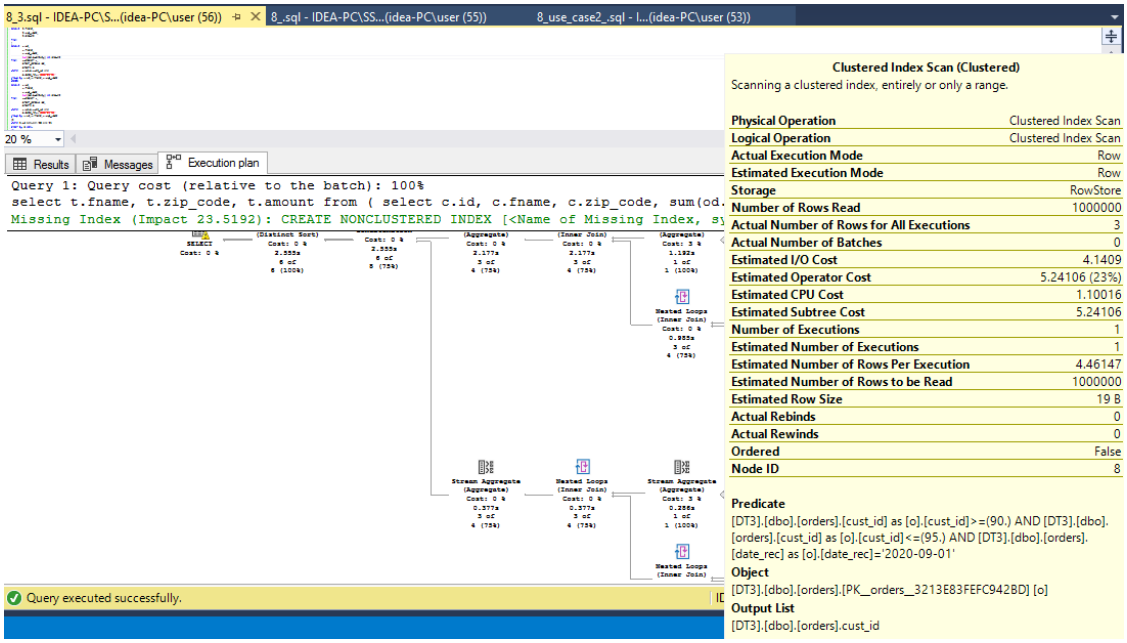
II) selection criterion applied and union operator used

```
GO

select  c.fname,
        c.zip_code,
        sum(od.quantity) as amount
from    customer c,
        order_detail od,
        orders o
where   c.id=o.cust_id and
        c.id between 90 and 95 and
        o.date_rec='2020-09-01'
group by c.fname,c.zip_code
UNION
select  c.fname,
        c.zip_code,
        sum(od.quantity) as amount
from    customer c,
        order_detail od,
        orders o
where   c.id=o.cust_id and
        c.id between 90 and 95 and
        o.date_rec='2020-09-02'
group by c.fname,c.zip_code
order by 3 desc
go

SET STATISTICS IO OFF
```



III) sub queries used, selection criterion applied to outer query, union operator used

```
select  t.fname,
        t.zip_code,
        t.amount
from
(
select  c.id,
        c.fname,
        c.zip_code,
        sum(od.quantity) as amount
from    customer c,
        order_detail od,
        orders o
where   c.id=o.cust_id and
        o.date_rec='2020-09-01'
group by c.id,c.fname,c.zip_code
UNION
select  c.id,
        c.fname,
        c.zip_code,
        sum(od.quantity) as amount
from    customer c,
        order_detail od,
        orders o
where   c.id=o.cust_id and
        o.date_rec='2020-09-02'
group by c.id,c.fname,c.zip_code
)t
where t.id between 90 and 95
order by 3 desc
```



Comparing each of the three different types of writing 'UNION':

	Type 1	Type 2	Type 3
Rows	6	6	6
Time	3 sec	2 sec	5 sec
Selection criteria	Customer id, date_rec	Customer id, date_rec	Customer id, date_rec
Select criteria pushed to	Orders, customer	Orders, customer	Orders, customer
Remarks	The selection criteria were pushed on the tables to be joined	In both part of the union query, the selection criteria were pushed on the tables to be joined	The selection criterions for the outer query were pushed to the inner queries. It's the worst case if the filters weren't pushed.

Inference:

- While executing queries, only those columns are retrieved, that needs to be projected in the result set
- Select criteria on a particular relation, were pushed into the inner queries.
- The logical and physical reads on all the tables in each of the case were similar

- The first tables to be scanned were the tables to be joined on which the selection criterion was applied.
- Even though the queries were written in three different ways, the execution plans for all three were identical.
- The filters were never specified in the sub queries but we see that the selection criteria's were pushed and the sub queries were eliminated.
- The last case, which is a poorly written query, is executed efficiently because of the query optimizer.

Therefore we see how a query optimizer is intelligent enough to make an appropriate logical by pushing down the selection criteria to make the relations result fewer tuples and for effective query execution.

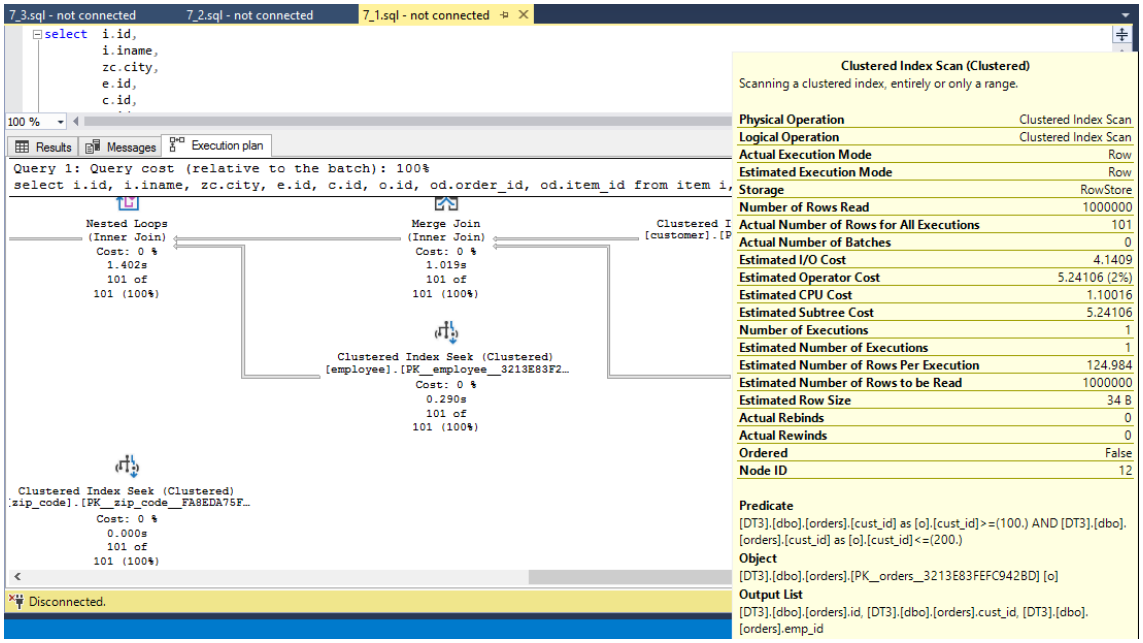
Use case 3:
Multi table join (minimum of 4 tables) – Review the join order of the tables

Number of tables joined: 6

I) selection criteria on customer table

use_case1_join.sql...(idea-PC\user (54))

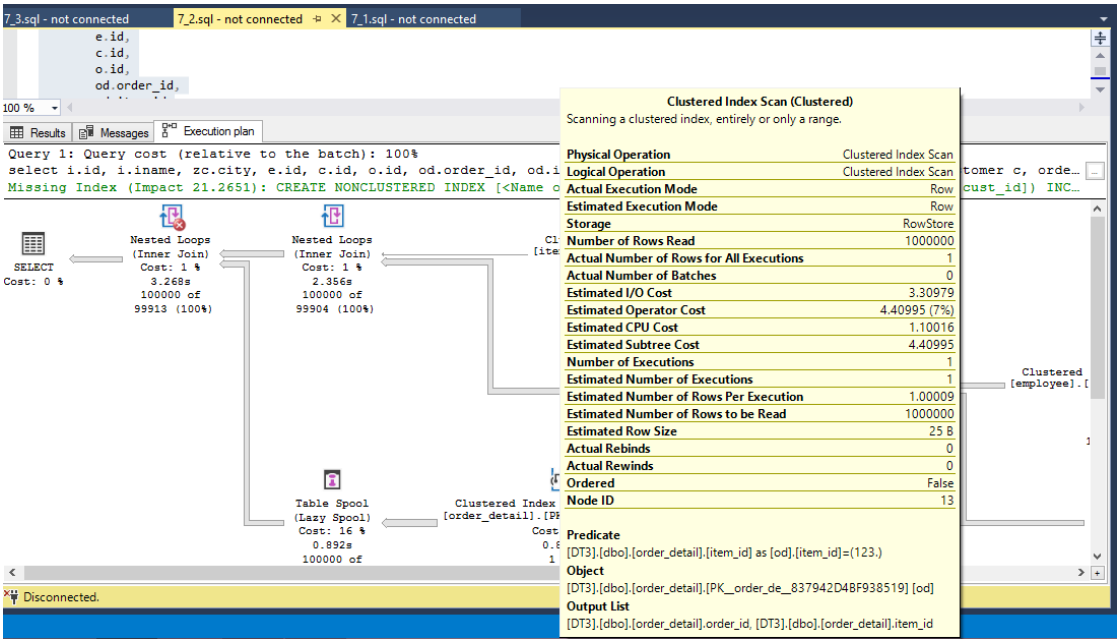
```
--query
SET STATISTICS IO ON
SET STATISTICS TIME ON

DBCC DROPCLEANBUFFERS
GO
DBCC FREEPROCCACHE
GO

select  i.id,
        i.iname,
        zc.city,
        e.id,
        c.id,
        o.id,
        od.order_id,
        od.item_id
from    item i,
        zip_code zc,
        employee e,
        customer c,
        orders o,
        order_detail od
where   c.id between 100 and 200 and
        c.id=o.cust_id and
        od.item_id=i.id and
        e.id=o.emp_id and
        zc.zip_code=c.zip_code
order by 3 desc
go

SET STATISTICS IO OFF
SET STATISTICS TIME OFF
```



II) selection criteria on item table

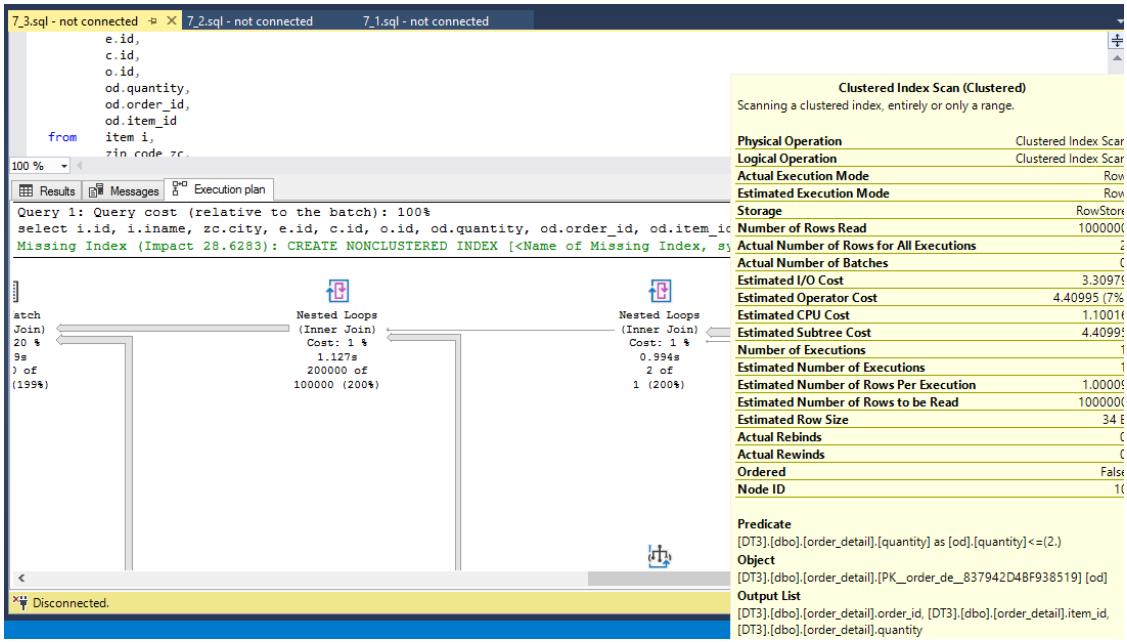
7_use_case1_join.sql...(idea-PC\user (54))

```
----------------------------------------------
--query
SET STATISTICS IO ON
SET STATISTICS TIME ON

DBCC DROPCLEANBUFFERS
GO
DBCC FREEPROCCACHE
GO

select  i.id,
        i.iname,
        zc.city,
        e.id,
        c.id,
        o.id,
        od.order_id,
        od.item_id
from    item i,
        zip_code zc,
        employee e,
        customer c,
        orders o,
        order_detail od
where   --c.id between 200100 and 200110 and
        c.id=o.cust_id and
        od.item_id=i.id and
        e.id=o.emp_id and
        i.id=123 and
        zc.zip_code=c.zip_code
order by 3 desc
go
```



III) selection criteria on order_detail table

```
7_use_case1_join.sql...(idea-PC\user (54))
--query
SET STATISTICS IO ON
SET STATISTICS TIME ON

DBCC DROPCLEANBUFFERS
GO
DBCC FREEPROCCACHE
GO

select  i.id,
        i.iname,
        zc.city,
        e.id,
        c.id,
        o.id,
        od.quantity,
        od.order_id,
        od.item_id
from    item i,
        zip_code zc,
        employee e,
        customer c,
        orders o,
        order_detail od
where   --c.id between 200100 and 200110 and
        c.id=o.cust_id and
        od.item_id=i.id and
        e.id=o.emp_id and
        --i.id=123 and
        od.quantity<=2 and
        zc.zip_code=c.zip_code
order by 3 desc
go
```



Comparing each of the three 'JOIN ' orders:

	Type 1	**Type 2**	**Type 3**
Join criteria	Customer id	Item id	Order quantity
Rows	1,010,000	100,000	200,000
Time	28 sec	4 sec	9 sec
First scanned table	customer	Zip_code	Order_detail
Select criteria pushed to	orders	Order_detail	item
Join order	Customer, orders -> employee -> zip_code -> item -> order_detail	Zip_code, customer -> orders -> employee -> item -> order_detail	Order_detail, item -> customer -> orders -> employee -> zip_code

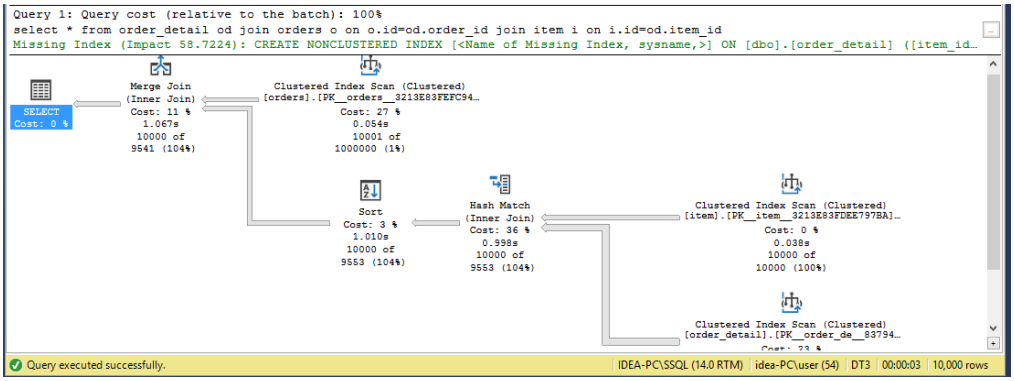
Inference:

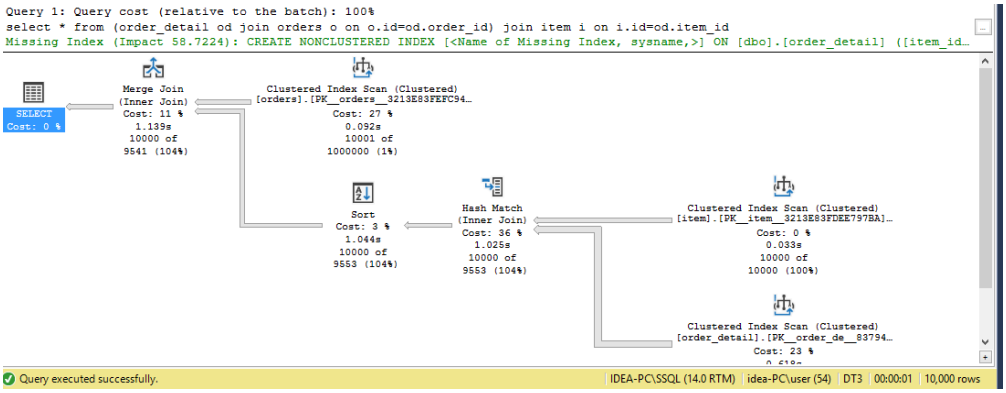
- While joining, only those columns are retrieved, that needs to be projected in the result set
- Select criteria on a particular join, was pushed to the table which it was being joined with
- The logical and physical reads on all the tables in each of the case were similar
- The first tables to be scanned and joined were those on which selection criteria was applied. But in the case of 'type 2' query it was not the case.

Another simple example showing the join order,
Shown below are two queries that are equal, but a join order was forced on the second query by using a nested join:
The logical reads, no of rows returned and time taken by both are similar.

```
select *
from order_detail od
join orders o on o.id=od.order_id
join item i on i.id=od.item_id
```

```
select *
from (order_detail od join orders o on o.id=od.order_id)
join item i on i.id=od.item_id
```





Even though we have specified different join orders in query, the query optimizer follows the same join order in both the cases.

Observation:

* In the execution plans, we normally see two kinds of joins:

I) nested loop inner join
The Nested Loop Join uses one joining table as an outer input table and the other one as the inner input table. The Nested Loop Join gets a row from the outer table and searches for the row in the inner table; this process continues until all the output rows of the outer table are searched in the inner table.

II) Hash match inner join
The Hash Match represents the building of a hash table of computed hash values from each row in the input

The major difference between a hash join and a nested loops join is the use of a full-table scan with the hash join. For certain types of SQL, the hash join will execute faster than a nested loop join, but the hash join uses more RAM resources.
Nested loop is generally chosen when table is significantly small and the larger table has an index on the join key. Hash Match is also better suited for large tables; it uses a hash table and hash match function to match rows. This requires less I/O, but need more CPU and requires lot of memory.

* One of the most important rules of efficient query processing tis to move the selection down the tree as far as they will go without changing what the expression does
Some of the selection rules that we have used were:

- $(\sigma)_{C1 \text{ AND } C2} (R) = (\sigma)_{C1} ((\sigma)_{C2} (R))$
- $(\sigma)_{C} (R \cup S) = ((\sigma)_{C} R \cup (\sigma)_{C} S)$
- $(\sigma)_{C} (R - S) = ((\sigma)_{C} R - (\sigma)_{C} S)$
- $(\sigma)_{C} (R \text{ JOIN } S) = ((\sigma)_{C} R \text{ JOIN } (\sigma)_{C} S)$

Conclusion:

Therefore we see how a query optimizer is intelligent enough to make an appropriate logical plan pertaining to the order and type of join and pushing down the selection criteria to make the relations result fewer tuples and for effective query execution.

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