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| **SQL query solution patterns**  -a. what can be done with LEFT/RIGHT OUTER JOIN can also be done by a correlated scalar subquery in the select list that can then be renamed with an alias. But in-efficient. You repeat the scalar subquery for every value to be fetched.  -b. CROSS JOIN used for generating sequence of values (either using ROW\_NUMBER or table of 0 to 9 values) with TOP for cutoff, mimicking a loop and transposing/pivoting/unpivoting. For some recursive problems, recursive CTE can be used in place of Loop.  CROSS JOIN/CROSS APPLY not only is used to generate Getnums and then CROSS APPLY can be used with GetNums to mimic a loop. CROSS APPLY can also be used (as can the JOINs) to add move alias definition down to FROM clause (see h down below) and to add columns(as well as rows if relationship is 1-to-many) to result set.  -c. when performing JOINs, think carefully before using AGGREGATE functions if the relationship is not one-to-one. Row repetition! Tables that form the ‘many’ part of the relationship have to be aggregated before joining.  -d. FULL OUTER JOIN is the UNION of results of LEFT and RIGHT OUTER JOINs.  -e. use EXISTS and NOT EXISTS where ever you IN and NOT IN being used.  -f. concatenate row values to create a list: recursive CTE, could possibly do with CROSS APPLY(?), XML PATH(‘’) trick and string\_agg (sql server 2017)  -g. split a list of comma separated numbers(number array) into individual values: CROSS APPLY to walk the string splitting it or use string\_split(sql server 2016). Note that splitting combined with concatenating will solve many problems related to strings.  -h. CROSS APPLY can also be used to move the computed or hardcoded alias from the SELECT phase to the FROM phase. Since FROM is the very first phase, all subsequent phases then can use the alias. Can do this with CTE but if we keep on building on the computed alias, we need multiple CTE built on top of each other. But CROSS APPLY being a table operator, makes the result available to subsequent CROSS APPLY operators in the same FROM clause.  -m. Use JOINs/APPLY/’corelatedsubquery in SELECT list’ whenever you have to reference prior/previous or post/next rows. Can also be done with lag or lead WINDOW funcs. If you want to include the edge cases in LAG/LEAD, you would have to use OUTER APPLY/OUTER JOIN.LAG/LEAD take an ORDER BY argument where as for JOIN/APPLY we could use NON-EQUI JOIN on the column deciding the order along with aggregate funcs MIN/MAX on that column to give us an order without explicitly specifying ORDER BY. Note that with LEFT OUTER JOIN, we would have to use GROUP BY on columns from left had side table(see that use in (i) running total using INNER JOIN section as well). | -i. return rows in random order each time query is executed. Without ORDER BY, the result is set is not guaranteed to be in any order (as it is a set) but still the result rows are in the same random order (again that is not guaranteed). Use NEWID(). NEWID() not producing random ordering inside of OVER clause with ROW\_NUMBER()?  -j. u can unroll the ‘GROUP BY’ rowset inside the ‘OVER’ clause.  -k. TOP N per GROUP. Use ROW\_NUMBER() for low density case and CROSS APPLY with TOP for high density case. Pattern is that since both TOP and OFFSET-FETCH can’t work with GROUP(you would lose the detail), you either use GROUP with ROW\_NUMBER or make use of CROSS APPLY with TOP(N)(or OFFSET-FETCH) with the left hand side providing you the GROUPed column.  Use POC(partitioning, ordering and covering) index strategy.  Partitioning: custid  Ordering: orderdate desc, ordered desc  Covering: empid  For e.g.: 10,000,000 rows in orders table. Index row size is 4+ 8 + 8+4=24 bytes. Roughly 8000/24 = 333 rows per page. So about 10,000,000/333 = 30030 pages in the leaf level of the POC index.  Low density case – 1,000,000 cust X 10 orders, seeks ~3,000,000 random reads, scans ~30,000 seq reads  We do not want a plan that does seek per customer as then we would have 3 X 1,000,000 random reads where 3 would be the number of levels in the b-tree with 10,000,000 rows. Not good. A scan would have used just 30030 sequential reads (30030 is the total number of pages). So we want to use a scan in this case.  High density case – 10 cust X 1,000,000 orders, seeks ~30 random reads, scans ~30030 seq reads  We want a plan that does seek per cust as then we would have 3 X 10 random reads where 3 would be the number of levels in the b-tree with 10,000,000 rows. Very good as compared to a scan which would have used just 30030 sequential reads (30030 is the total number of pages). So we want to use a seek in this case.  -l. WINDOW functions allow to mix details with aggregates. The same can be done with scalar subqueries in the SELECT list. The other technique to do the same is use aggregates separately and JOINing/APPLYing the results (good performance).  ROW\_NUMBER: window func or scalar subquery or LEFT OUTER JOIN. Except window func, the other 2 require UNIQUE column for counting the rows before a particular row. Does a solution exist for case when no UNIQUE col exist? Either you can APPLY NEWID() to each row, save result to temp table and then using it as unique column OR APPLY GetNums. APPLYing GetNums is inefficient as it does Cartesian product.  Running total: window function or scalar subquery or INNER JOIN(<= join) with GROUPing on unique columns from on the 1 side of 1..\*relationship. Easier thing is just add all the LEFT hand side columns to GROUP BY clause |

Examples:

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| CROSS APPLY is deemed to be equal to CROSS JOIN as both do a Cartesian product and when the right hand side result set is empty, the corresponding row from left hand side is also removed from query result. But CROSS JOIN can use co-related subqueries which CROSS JOIN can’t and in that case it behaves as INNER JOIN as you can match rows. CROSS APPLY provides functionality of both CROSS JOIN and INNER JOIN. OUTER APPLY provides functionality of LEFT OUTER JOIN.  SELECT \*  FROM (VALUES(1)) AS A(N)  CROSS APPLY (SELECT \* FROM (VALUES(1)) AS C(NN) WHERE C.NN = A.N) AS B(NN)  --error  SELECT \*  FROM (VALUES(1)) AS A(N)  CROSS JOIN (SELECT \* FROM (VALUES(1)) AS C(NN) WHERE C.NN = A.N) AS B(NN) | PIVOT to spread the values even when the categorical data to be used for spreading does not exist as such but can be inferred  SELECT D, [0] AS DEPTNO, [1] AS [NAME]  FROM (SELECT CTE2.D, CTE2.value, CASE WHEN ISNUMERIC(CTE2.value) = 0 THEN 1 ELSE 0 END AS IsNumber FROM CTE2) AS BASE  PIVOT(MAX(BASE.VALUE) FOR IsNumber IN ([1],[0])) AS PVT  To UNPIVOT multiple sets of columns, can’t use UNPIVOT operator. Use CROSS APPLY:  --custid, qty2012, qty2013, qty2013, val2012, val2013, val2014  --becomes custid, orderyear, qty, val  select s.custid, a.\*  from dbo.sales as s  cross apply (values(2012,qty2012, val2012), (2013,qty2013, val2013), (2014,qty2014, val2014)) as a(orderyear, qty, val) |
| **Loop examples using recursive CTE and CROSS APPLY**:  --USING CROSS APPLY WITH GETNUMS  DECLARE @STR AS VARCHAR(10) = 'KINGS';  SELECT SUBSTRING(@STR, S.N, 1) AS S  FROM (VALUES(1)) AS DUMMY(D)  CROSS APPLY (SELECT \* FROM GetNums(1, LEN(@STR))) AS S(N)  --USING RECURSIVE CTE  DECLARE @STARTPOS AS INT = 1;  ;WITH CTER  AS(  SELECT SUBSTRING(@STR, @STARTPOS, 1) AS S, @STARTPOS AS L  UNION ALL  SELECT SUBSTRING(@STR, L + 1 , 1) AS S, L + 1  FROM CTER AS R  WHERE SUBSTRING(@STR, L + 1 , 1) <> ''  )  SELECT \*  FROM CTER  SELECT TOP(500000) \*, CAST(CONCAT(A.A,B.B,C.C,D.D,E.E,F.F) AS INT) + 1 AS NUM  FROM (VALUES (0),(1),(2),(3),(4),(5),(6),(7),(8),(9)) AS A(A)  CROSS JOIN (SELECT \* FROM (VALUES (0),(1),(2),(3),(4),(5),(6),(7),(8),(9)) AS CP(A)) AS B(B)  CROSS JOIN (SELECT \* FROM (VALUES (0),(1),(2),(3),(4),(5),(6),(7),(8),(9)) AS CP(A)) AS C(C)  CROSS JOIN (SELECT \* FROM (VALUES (0),(1),(2),(3),(4),(5),(6),(7),(8),(9)) AS CP(A)) AS D(D)  CROSS JOIN (SELECT \* FROM (VALUES (0),(1),(2),(3),(4),(5),(6),(7),(8),(9)) AS CP(A)) AS E(E)  CROSS JOIN (SELECT \* FROM (VALUES (0),(1),(2),(3),(4),(5),(6),(7),(8),(9)) AS CP(A)) AS F(F)  ORDER BY NUM  WITH  L0 AS (SELECT 0 AS C FROM (VALUES(1),(1)) AS D(C)),--2  L1 AS (SELECT 0 AS C FROM L0 AS A CROSS JOIN L0 AS B ),--4  L2 AS (SELECT 0 AS C FROM L1 AS A CROSS JOIN L1 AS B ),--16  L3 AS (SELECT 0 AS C FROM L2 AS A CROSS JOIN L2 AS B ),--256  L4 AS (SELECT 0 AS C FROM L3 AS A CROSS JOIN L3 AS B ),--65536  L5 AS (SELECT 0 AS C FROM L4 AS A CROSS JOIN L4 AS B ),--4294967296  NUMS AS (SELECT ROW\_NUMBER() OVER(ORDER BY (SELECT NULL)) AS ROWNUM FROM L5)  SELECT TOP(500000 - 0 + 1) 0 + ROWNUM -1 AS N  FROM NUMS  ORDER BY ROWNUM | f.  --CONCATENATE COLUMN VALUES TO A LIST USING RECURSIVE CTE  --slow but handles special XML characters  ;WITH CTE AS  (  SELECT \*  FROM (VALUES('LAPTOP', 'DELL<'), ('LAPTOP', 'HP'), ('LAPTOP', 'COMPAQ'), ('MAC', 'APPLE')) AS P(PR, SUPP)  )  ,CTE1 AS  (  SELECT \*, ROW\_NUMBER() OVER(PARTITION BY PR ORDER BY SUPP) AS RN  FROM CTE  ),  RECURSIVECTE AS  (  SELECT PR, CAST(CONCAT(SUPP, '') AS VARCHAR) AS LIST, RN  FROM CTE1  WHERE RN = 1  UNION ALL  SELECT R.PR, CAST(CONCAT(R.LIST, ',' + C.SUPP) AS VARCHAR) AS LIST , C.RN  FROM RECURSIVECTE AS R  INNER JOIN CTE1 AS C ON C.RN = R.RN + 1 AND R.PR = C.PR  )  , REVERSEORDER AS  (  SELECT \*, ROW\_NUMBER() OVER(PARTITION BY PR ORDER BY RN DESC) AS REVERSEORDERING  FROM RECURSIVECTE  )  SELECT \*  FROM REVERSEORDER  WHERE REVERSEORDERING = 1  --CONCATENATE COLUMN VALUES TO A LIST USING XML PATH  --Note: SPECIAL XML CHARACTERS LIKE ‘<’ WILL BE ENCODED. Workaround given in T-SQL querying.  ;WITH CTE AS  (  SELECT \*  FROM (VALUES('LAPTOP', 'DELL<'), ('LAPTOP', 'HP'), ('LAPTOP', 'COMPAQ'), ('MAC', 'APPLE')) AS P(PR, SUPP)  )  SELECT A.PR, STUFF((SELECT ',' + B.SUPP FROM CTE AS B WHERE B.PR = A.PR ORDER BY SUPP FOR XML PATH ('')), 1, 1, '')  FROM CTE AS A  GROUP BY PR;  --REQUIRES SQL SERVER 2017. Handles special XML characters  ;WITH CTE AS  (  SELECT \*  FROM (VALUES('LAPTOP', 'DELL<'), ('LAPTOP', 'HP'), ('LAPTOP', 'COMPAQ'), ('MAC', 'APPLE')) AS P(PR, SUPP)  )  SELECT A.PR, STRING\_AGG(SUPP, ',') WITHIN GROUP (ORDER BY SUPP ASC) AS List  FROM CTE AS A  GROUP BY PR; |
| g.  --string split to individual entries  --using cross apply (atleast sql server 2005)  select id, arr, n as indexpos, SUBSTRING(arr, n, CHARINDEX(',', arr + ',', n) - n) as element  from (values('a','6,55,2'), ('b','5,44,6'), ('c','21')) as base(id,arr)  cross apply (select n from GetNums(1,len(base.arr)) as num where num.n = CHARINDEX(',', ',' + base.arr, num.n) ) as a  --generic string split function using cross apply(to be used before sql2016)  go  drop function if exists my\_string\_split  go  create function my\_string\_split(@str as varchar(max), @sep as char(1))  returns table  as  return  select SUBSTRING(@str, n, CHARINDEX(@sep, @str + @sep, n) - n) as element  from (select n from GetNums(1,len(@str)) as num where num.n = CHARINDEX(@sep, @sep + @str, num.n) ) as a  go  select id, arr, sp.element  from (values('a','6,55,2'), ('b','5,44,6'), ('c','21')) as base(id,arr)  cross apply my\_string\_split(base.arr, ',') as sp    --string\_split in sql2016  select \*  from (values(1), (3), (4)) as b(n)  where b.n in (select \* from string\_split('1,2,3', ',')) | h.  select n, a1.newnumber, newnumber2  from (values(1), (3), (4)) as b(n)  cross apply (select n+10) as a1(newnumber)  cross apply (select newnumber+10) as a2(newnumber2)  select n, a1.newnumber, newnumber2  from (values(1), (3), (4)) as b(n)  cross apply (values(n+10)) as a1(newnumber)  cross apply (values(newnumber+10)) as a2(newnumber2)  i.  select top 2\*  from EMP  order by (select null)  select top 2\*  from EMP  order by (select 1)  select top 2\*  from EMP  order by (2) –ORDERING BY COLUMN INDEX, NOT A CONSTANT  select top 2\*  from EMP  order by (NEWID())  --newid() does not seem to work with row\_number to give a random ordering for each execution  select \*, ROW\_NUMBER() over(order by (select null)) as rn  from EMP  select \*, ROW\_NUMBER() over(order by (select 1)) as rn  from EMP  select \*, ROW\_NUMBER() over(order by (select sysdatetime())) as rn  from EMP  select \*, ROW\_NUMBER() over(order by (select newid())) as rn  from EMP  j.  select AVG(sal), ROW\_NUMBER() over(partition by deptno order by sum(sal)) as rn  --,ROW\_NUMBER() over(partition by deptno order by sal) as rn1 --can't do  --, lag(sal) over(partition by deptno order by sum(sal)) as previousRow --can't do this  from emp  group by DEPTNO, JOB |
| -k. The first case uses scan and the second uses seek. Note that ROW\_NUMBER() used a scan and that is what we want. Having the index in place saves us sorting.  --low density case  --create index idx\_my on Sales.Orders(custid, orderdate desc, orderid desc ) include(empid)  ;with cte as  (  select custid, orderdate, orderid, empid, ROW\_NUMBER() over(partition by custid order by orderdate desc, orderid desc ) as rn  from Sales.Orders  )  select custid, orderdate, orderid, empid  from cte  where rn <=3  --high density case  --create index idx\_my on Sales.Orders(custid, orderdate desc, orderid desc ) include(empid)  select so.custid, a.\*  from sales.Customers as so  cross apply (select top(3) orderdate, orderid, empid from sales.orders as so1 where so1.custid = so.custid order by orderdate desc, orderid desc) as a  m.  select e.HIREDATE as currEmpHireDate, Prev.hiredate  from EMP as e  outer apply (select max(e1.HIREDATE) as prevEmpHireDate from emp as e1 where e.HIREDATE> e1.HIREDATE) as Prev(hiredate)  select e.HIREDATE as currEmpHireDate, Max(e1.HIREDATE)  from EMP as e  left outer join EMP as e1 on e.HIREDATE > e1.HIREDATE  group by e.EMPNO, e.HIREDATE | l.  select \*, ROW\_NUMBER() over(order by (select null)) as rn  from EMP  --assume a unique column is present.  select \*, (select count(\*)+1 from emp as e1 where e.EMPNO > e1.EMPNO)  from EMP as e  --assumes unique column present to provide ordering.  select e.\*, COUNT(e1.EMPNO) + 1  from EMP as e  left outer join emp as e1 on e.EMPNO>e1.EMPNO  group by e.EMPNO, e.ENAME, e.JOB, e.MGR, e.HIREDATE, e.SAL, e.COMM, e.DEPTNO  --if no unique column is present. then does not work as shown below  select \*, (select count(\*)+1 from emp as e1 where e.DEPTNO > e1.DEPTNO)  from EMP as e  --no unique column present. What if no unique column is present to give number of rows before a particular row  (like we specify SELECT NULL in ORDER by for ROW\_NUmber).  See accounts table in utilities section below. cartesian product. so not efficient.  select a.fname, a.lname, rn  from accounts as a with(nolock)  cross apply (select count(\*) from accounts) as a1(cnt)  cross apply (select \* from GetNums(1,cnt)) as a2(rn)  group by a.fname, a.lname, rn  --could also use recursive CTE. 2 problems for large tables: very slow and 32767 recursive depth limit  ;WITH CTE AS  (  SELECT a.fname, a.lname, (SELECT COUNT(\*) FROM accounts) AS CNT , 1 AS RN  FROM accounts AS a with(nolock)  UNION ALL  SELECT fname, lname, CNT, RN + 1  FROM CTE  WHERE RN < CNT  )  SELECT fname,lname,rn  FROM CTE  group by fname,lname,rn  --OPTION (MAXRECURSION 1000000); can't use this limit as maximum allowed is 32767  OPTION (MAXRECURSION 32767);  --another option is to add a new unique column to table, save the result as we need to reference it again either using a scalar subquery or joins.  select \*  into #temp  from accounts as e  cross apply (select newid()) as a(id)  --for 10000 rows, the relative cost of scalar sub query was 25% as compared to the left outer join plan given below  select \*, (select count(\*) +1 from #temp as t1 where t.id > t1.id) as rn  from #temp as t  order by rn  --i would have thought that the scalar query above was slower but this is slower(75%>25%)  select t.fname, t.lname, count(t1.id)+1 as rn  from #temp as t  left outer join #temp as t1 on t.id > t1.id  group by t.fname, t.lname, t.id  order by rn  Running total  --running total with window function. Most efficient  select empid, ordermonth, qty, SUM(qty) over(partition by empid order by ordermonth rows between unbounded preceding and current row) as runqty  from dbo.EmpOrders  --running total with scalar sub query. Worst perfromance  select empid, ordermonth, qty, (select sum(qty) from dbo.EmpOrders as e1 where e1.empid=e.empid and e1.ordermonth <= e.ordermonth) as runqty  from dbo.EmpOrders as e  --running total with scalar inner join. 2nd most efficient  select e.empid, e.ordermonth, e.qty, sum(e1.qty) as runqty  from dbo.EmpOrders as e  inner join dbo.EmpOrders as e1 on e1.empid=e.empid and e1.ordermonth <= e.ordermonth  group by e.empid, e.ordermonth, e.qty  order by e.empid, e.ordermonth  Median:could be discrete or continous  SELECT distinct actid,  PERCENTILE\_DISC(0.5) WITHIN GROUP (ORDER BY val) OVER (PARTITION BY actid) AS MEDIAN  FROM dbo.Transactions as t  order by actid  --index PK\_Transactions not beneficial.  --create index idx\_median on dbo.Transactions(actid,val); this POC index is required for performance otherwise same performance as median using window function  --create index idx\_my on dbo.Transactions(actid) include(val);this is also not beneficial as we are orderding by val.  ;with c as  (  SELECT actid, COUNT(VAL) AS cnt, (COUNT(\*)-1)/2 AS ov, 2-count(\*)%2 as fv  FROM Transactions AS T  GROUP BY actid  )  select c.actid, avg(1. \* a.val) as median  from c  cross apply(select \* from dbo.Transactions as t  where t.actid = c.actid  order by val  offset c.ov rows fetch next c.fv rows only) as a  group by c.actid  order by actid |

Utilities:

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| -Generate some values  CREATE TABLE dbo.Accounts  (  actid INT NOT NULL CONSTRAINT PK\_Accounts PRIMARY KEY  );  CREATE TABLE dbo.Transactions  (  actid INT NOT NULL,  tranid INT NOT NULL,  val MONEY NOT NULL,  CONSTRAINT PK\_Transactions PRIMARY KEY(actid, tranid)  );  DECLARE  @num\_partitions AS INT = 100,  @rows\_per\_partition AS INT = 20000;  INSERT INTO dbo.Accounts WITH (TABLOCK) (actid)  SELECT NP.n  FROM TSQLV3.dbo.GetNums(1, @num\_partitions) AS NP;  INSERT INTO dbo.Transactions WITH (TABLOCK) (actid, tranid, val)  SELECT NP.n, RPP.n,  (ABS(CHECKSUM(NEWID())%2)\*2-1) \* (1 + ABS(CHECKSUM(NEWID())%5))  FROM TSQLV3.dbo.GetNums(1, @num\_partitions) AS NP  CROSS JOIN TSQLV3.dbo.GetNums(1, @rows\_per\_partition) AS RPP;  GO | -creating dummy data  --using GO to add a lot of rows repeatedly would be very slow as it is looping one row at a time  declare @accounts as table( fname VARCHAR(20), lname VARCHAR(20))  insert into @accounts  values('Fred', 'Flintstone');  go 10  --use the with(tablock) option for inserting large amounts of data. And remember truncate as well  create table accounts( fname VARCHAR(20), lname VARCHAR(20));  insert into accounts with(TABLOCK)(fname,lname)  select fname,lname  from (values('Fred', 'Flintstone')) as t(fname,lname)  cross apply GetNums(1,10) as a1; |
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