

# Set Operators, Derived Tables and CTE's



Presented by Steve Stedman and Aaron Buma

# Welcome

- Welcome to all those joining us remotely.
  - For any questions via Google On Air Broadcasts, we will address most of these at the end of the training.
- Training provided by Emergency Reporting
  - <http://EmergencyReporting.com>
- Presented by Steve Stedman and Aaron Buma

# Live Broadcast

- Using Google On Air Broadcasts
  - There is about a 40 to 50 second delay from live to what you see.
  - We are still learning how to properly use Google On Air Broadcasts. Please be patient.
  - Session will be available on my YouTube Channel about an hour after it the presentation ends.
    - <http://SteveStedman.com/YouTube>

# Questions

- We will have time for questions at the end of the session.
- Q&A available via Google On Air Hangout panel. Click the 3x3 grid icon near the top right, then select Q&A to see what people are asking, or to ask your own question.
- When you ask a question, it shows up for us about 40 to 50 seconds delayed.

# Agenda

- Set Operators
- Derived Tables
- Common Table Expressions

# Set Operations

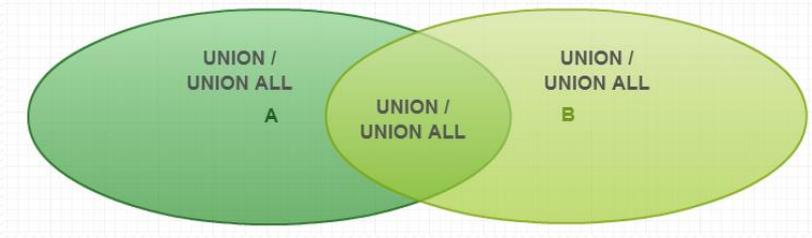


Presented by Aaron Buma

# Agenda

- UNION Types
  - UNION
  - UNION ALL
- INTERSECT
- EXCEPT

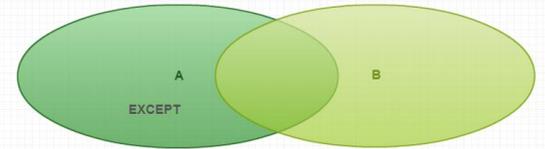
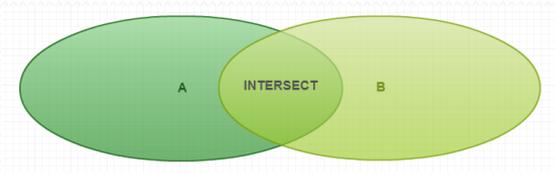
# UNION TYPES



- UNION
  - Requires same data types and number of columns
  - Acts like a 'distinct', it won't return duplicates
- UNION ALL
  - Similar to UNION, but will return duplicates
- ORDER BY – is applied to entire results
- Up to 256 queries can be “UNION”ed together

# INTERSECT and EXCEPT

- Same field and data type matching as UNION
- Only used with two tables
- INTERSECT –
  - Results that only match all tables
- EXCEPT- Results from the first query, not matching results from the second



# Derived Tables



Presented by Steve Stedman

# Derived Tables

--use a sub query AKA.... A Derived Table Query

```
SELECT *
```

```
FROM (
```

```
SELECT *,  
        RANK() OVER(ORDER BY i.UnitRetail ASC) AS rankUnitCost  
FROM dbo.Inventory AS i
```

```
) AS derivedTable
```

```
WHERE derivedTable.rankUnitCost <= 5;
```

# Nested Derived Tables

```
SELECT *  
FROM (
```

```
SELECT *, AVG(derivedTable.UnitRetail) OVER() AS averageCheapest  
FROM (
```

```
SELECT *,  
        RANK() OVER(ORDER BY i.UnitRetail ASC) AS rankUnitCost  
FROM dbo.Inventory AS i
```

```
) AS derivedTable
```

```
WHERE derivedTable.rankUnitCost <= 5
```

```
) AS secondDerivedTable
```

```
WHERE secondDerivedTable.UnitRetail > secondDerivedTable.averageCheapest;
```

# Derived Table in the WHERE

```
SELECT *,  
        RANK() OVER(ORDER BY i.UnitRetail ASC) AS rankUnitCost  
FROM dbo.Inventory AS i  
WHERE i.UnitRetail >
```

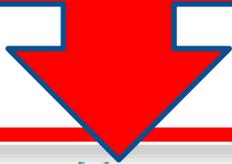
```
(SELECT DISTINCT AVG(UnitRank) OVER()
```

```
FROM (
```

```
SELECT RANK() OVER(ORDER BY UnitRetail ASC) AS UnitRank  
FROM dbo.Inventory
```

```
) as t)
```

**DANGER:** will be run once for each row in the result set. May introduce serious performance issues.



```
SELECT *,
```

```
(SELECT DISTINCT AVG(UnitRank) OVER()  
FROM (  

```

```
SELECT RANK() OVER(ORDER BY UnitRetail ASC) AS UnitRank  
FROM dbo.Inventory
```

```
) AS t)
```

```
AS derivedTableColumn
```

```
FROM dbo.Inventory AS i
```

# Demo

Derived Tables

# Common Table Expressions

CTE



Presented by Steve Stedman

# CTE Book

- Published May 2013

Today's topic comes from Chapter 1, 2, 3, 4, 6,  
7 and 9  
Of  
**SQL Server Common Table  
Expression**

## SQL Server Common Table Expressions

A Joes 2 Pros® T-SQL Tutorial on  
Everything CTE including Performance,  
Recursion, Nesting, with Functions, and  
the use of Multiple CTEs together.



Steve Stedman

Rick A. Morelan, Tony Smithlin, Sandra Howard

# CTE – Agenda

- Introduction to Memory Tables and CTEs
- Simple CTE
- CTE Instead of a Derived Table
- Multiple CTE in a Query
- Data Paging
- CTEs in Stored Procedures, Functions and Views
- Introduction To Recursive CTEs

# Chapter 1 and 2

Introduction to Memory Tables and  
CTEs

# Memory Tables

- Virtual Tables
  - Derived Table
  - Sub query
- Views
- Temporary Named Result Set
  - Temp Tables
  - Table Variables
- Common Table Expressions

```
CREATE VIEW [dbo].[DeptView]
AS
SELECT id, department, parent
FROM Departments;
```

```
CREATE TABLE #deptTempTable (
    id int,
    department VARCHAR (200),
    parent int
);
```

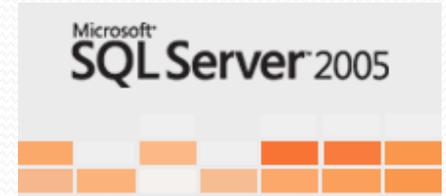
```
DECLARE @deptTableVariable TABLE(
    id int,
    department VARCHAR (200),
    parent int
);
```

# What is a CTE

- A type of a virtual table
- Similar to the ease of a temporary table
- Sort of like a derived table
- Like a temporary named result set
- Acts like a temporary view, or a run time view

# Availability of CTEs

- TRANSACT SQL feature that I wish I had learned about 10 years ago, CTE's were introduced in SQL Server 2005
- All versions of SQL Server since SQL 2005 and all variations of SQL Server support CTEs
- CTEs are available in SQL Azure



# Why Use Common Table Expressions?

- Simplify your query – test one part at a time
- Recursion
  - Computer Science: When a function calls itself
  - SQL Server: When a query calls itself
- Make derived table queries more readable
- Alternative to a temp table or a table variable

# CTE Syntax - WITH

- Queries start with WITH not SELECT
- Can be confusing if you are assuming that any query to select data would start with a SELECT
- The scope of the CTE is confined to a single query
- A CTE just seems a little weird, until you master the syntax

# Simple CTE Syntax

```
;WITH expression_name [(column_name[,...n])]  
AS  
(  
    CTE_query_definition  
)  
  
SELECT <column_list>  
    FROM expression_name;
```

# Demo

Simple CTE

# Reminder

- If a CTE is not the first statement in a batch it must be preceded with a semicolon

# Chapter 3

CTEs Instead of Derived Tables

# CTE Instead of a Derived Table

- Simplifies the query – allows for cleaner code
- Does not improve the performance
- More value for large derived table queries in that the TSQL is cleaner and easier to read and understand
- Eliminates accidents by duplicating derived table queries  
TSQL code

# Derived Table Without a CTE

```
SELECT q1.department, q2.department
FROM (SELECT id, department, parent
      FROM Departments) AS q1
INNER JOIN (SELECT id, department, parent
            FROM Departments) AS q2
ON q1.id = q2.parent
WHERE q1.parent IS NULL;
```

# Convert a Derived Table to a CTE

- Find the first occurrence of the derived table query to be broken out. Create a name for it and add “CTE” to the name.
- Copy the derived table definition, including the parentheses, and leave the new name as the placeholder.
- Paste the query, copied earlier, above the SELECT statement.
- At the top of the query add the CTE declaration using the same name from step 1.
- Find all other occurrences of the same derived table query and replace them with the CTE name.
- Clean up the formatting and test the query.

# CTE for Derived Table Re-use

```
;WITH deptCTE (id, department, parent) AS
```

```
(SELECT id, department, parent
```

```
FROM Departments)
```

```
SELECT q1.department, q2.department
```

```
FROM deptCTE q1
```

```
INNER JOIN deptCTE q2 on q1.id = q2.parent
```

```
WHERE q1.parent is null;
```

# Demo

Chapter 3

# CTE Instead of a Derived Table

## Summary

- Most derived tables can be easily converted to a CTE
- Copy and paste errors can be reduced by using a CTE
- Using a CTE doesn't improve the performance over a similar query written with derived tables
- For a CTE that is referenced multiple times the CTE query is not reused, it is executed multiple times

# Chapter 6

Multiple CTEs in a Query

# Multiple CTE's In A Single Query

- You can include multiple CTE's by comma separating them:

**;**WITH firstCTE AS

(query goes here)

,secondCTE AS

(second query goes here)

SELECT \* FROM firstCTE

INNER JOIN secondCTE on ...

# Steps to add a Second CTE

1. Add a comma at the end of the first CTE, after the closing parentheses.
2. After the comma, on the next line, declare the name of the new CTE.
3. After the name of the new CTE add the optional columns declaration.
4. Add the AS keyword followed by opening and closing parentheses.
5. Inside of the parentheses add the new CTE query.
6. Call the CTE query from the outer SELECT statement.

# Demo: Multiple CTE

```
;WITH Fnames (Name) AS
(
    SELECT 'John' UNION SELECT 'Mary' UNION SELECT 'Bill'
)
, Lnames (Name) AS
(
    SELECT 'Smith' UNION SELECT 'Gibb' UNION SELECT 'Jones'
)
SELECT F.Name FirstName, L.Name LastName
    FROM Fnames F
    CROSS JOIN Lnames AS L;
```

# Nested CTE's

- Russian Dolls – матрёшки
- Pronounced Ma-Trosh-Key.



- A Nested CTE query can only reference itself or CTE queries declared earlier in the query.

# Nested CTE Example

```
;WITH cte0 AS
(
  SELECT 1 AS num
)
, cte1 AS
(
  SELECT num + 1 AS num
    FROM cte0
)
, cte2 AS
(
  SELECT num + 1 AS num
    FROM cte1
)
SELECT *
  FROM cte2;
```

# Demo

Chapter 6

# Chapter 7

Data Paging With a CTE

# Data Paging

- To achieve data paging without CTE it usually involves selecting TOP x, then TOP 2x then top 3x, each time taking longer and longer to get to the data that is needed.
- Data paging can be simplified and not a challenge to create with CTE's.
- TSQL 2012 introduces the OFFSET and FETCH keywords which is easier to use than a CTE for data paging, and more efficient.

# Data Paging Page 1

	TableName	ColumnName	RowNum
1	Departments	department	1
2	Departments	id	2
3	Departments	parent	3
4	filestream_tombstone_2073058421	oplsn_bOffset	4
5	filestream_tombstone_2073058421	oplsn_fseqno	5
6	filestream_tombstone_2073058421	oplsn_slotid	6
7	filestream_tombstone_2073058421	rowset_guid	7
8	filestream_tombstone_2073058421	status	8
9	filestream_tombstone_2073058421	transaction_sequence_num	9
10	filestream_tombstone_2073058421	file_id	10

# Data Paging Page 2

	TableName	ColumnName	RowNum
1	filestream_tombstone_2073058421	filestream_value_name	11
2	filestream_tombstone_2073058421	column_guid	12
3	queue_messages_1977058079	conversation_handle	13
4	queue_messages_1977058079	conversation_group_id	14
5	queue_messages_1977058079	binary_message_body	15
6	queue_messages_1977058079	fragment_size	16
7	queue_messages_1977058079	fragment_bitmap	17
8	queue_messages_1977058079	message_id	18
9	queue_messages_1977058079	message_sequence_number	19
10	queue_messages_1977058079	message_type_id	20

# Data Paging Page 3

	TableName	ColumnName	RowNum
1	queue_messages_1977058079	next_fragment	21
2	queue_messages_1977058079	validation	22
3	queue_messages_1977058079	status	23
4	queue_messages_1977058079	service_contract_id	24
5	queue_messages_1977058079	service_id	25
6	queue_messages_1977058079	priority	26
7	queue_messages_1977058079	queuing_order	27
8	queue_messages_2009058193	queuing_order	28
9	queue_messages_2009058193	priority	29
10	queue_messages_2009058193	service_id	30

# Demo: Data Paging

```
;WITH TablesAndColumns AS (  
    SELECT OBJECT_NAME(sc.object_id) AS TableName,  
           name AS ColumnName,  
           ROW_NUMBER()  
           OVER (ORDER BY object_name(sc.object_id))  
           AS Row  
    FROM sys.columns sc )  
SELECT *  
FROM TablesAndColumns  
WHERE Row BETWEEN (@pageNum - 1) * @pageSize + 1  
           AND @pageNum * @pageSize ;
```

# Demo: SQL Server 2012 and

## Beyond Data Paging

```
SELECT OBJECT_NAME(sc.object_id) AS TableName,  
       name AS ColumnName
```

```
FROM sys.columns sc
```

```
ORDER BY TableName
```

```
OFFSET (@pageNum - 1) * @pageSize ROWS  
FETCH NEXT @pageSize ROWS ONLY;
```

- An alternative to CTE's for data paging if you are using SQL Server 2012 or newer

# Demo

Chapter 7

# Chapter 9

CTEs in Stored Procedures,  
Functions and Views

# CTEs in Stored Procedures, Functions and Views

# Demo

Chapter 9

# Chapter 4

Introduction to Recursive CTEs

# 4. Recursive CTE

- Considered recursive when the CTE references itself
- Recursion stops
  - When the recursive query produces no results
  - Or specify MAXRECURSION
- Uses
  - Hierarchical listing of categories
  - Recursive calculations
  - Much, much more...

# Recursion Overview

- Sum the numbers from 1 to 10 without recursion

$$55 = 10 + 9 + 8 + 7 + 6 + 5 + 4 + 3 + 2 + 1$$

- Sum the numbers from 1 to 10 recursively

$$55 = 10 + (\text{sum of numbers 1 to 9})$$

$$55 = 10 + (9 + (\text{sum of numbers 1 to 8}))$$

$$55 = 10 + (9 + (8 + (\text{sum of numbers 1 to 7})))$$

- Eventually we get to:

$$55 = 10 + (9 + (8 + (7 + (6 + (5 + (4 + (3 + (2 + 1))))))))))$$

# Recursive Terminology

- Anchor Query
  - Start the recursion
  - One or more anchor queries
- Recursive Query
  - The part that repeats
  - One or more recursive queries
- MAXRECURSION
  - The number of times to repeat the recursive query
  - Default is 100
  - MAXRECURSION of 0 implies no maximum

# Demo: Recursive CTE

```
;WITH DepartmentCTE(DeptId, Department, Parent, Lvl)  
AS
```

Step 1. Declare the CTE and Columns

# Demo: Recursive CTE

```
;WITH DepartmentCTE(DeptId, Department, Parent, Lvl)
AS
( SELECT id AS DeptId, Department, parent, 0 AS Lvl
  FROM Departments
  WHERE parent IS NULL
```

Step 2 – Add the Anchor Query

# Demo: Recursive CTE

```
;WITH DepartmentCTE(DeptId, Department, Parent, Lvl)
AS
( SELECT id AS DeptId, Department, parent, 0 AS Lvl
  FROM Departments
 WHERE parent IS NULL
 UNION ALL
```

Step 3 – Add the UNION ALL to connect to the recursive query

# Demo: Recursive CTE

```
;WITH DepartmentCTE(DeptId, Department, Parent, Lvl)
```

```
AS
```

```
( SELECT id AS DeptId, Department, parent, 0 AS Lvl
```

```
FROM Departments
```

```
WHERE parent IS NULL
```

```
UNION ALL -- and now for the recursive part
```

```
SELECT d.id AS DeptId, d.Department, d.parent,
```

```
DepartmentCTE.Lvl + 1 AS Lvl
```

```
FROM Departments d
```

```
INNER JOIN DepartmentCTE
```

```
ON DepartmentCTE.DeptId = d.parent)
```

Step 4 – Add the recursive Query

# Demo: Recursive CTE

```
;WITH DepartmentCTE(DeptId, Department, Parent, Lvl)
AS
( SELECT id AS DeptId, Department, parent, 0 AS Lvl
  FROM Departments
 WHERE parent IS NULL
 UNION ALL -- and now for the recursive part
  SELECT d.id AS DeptId, d.Department, d.parent,
         DepartmentCTE.Lvl + 1 AS Lvl
   FROM Departments d
  INNER JOIN DepartmentCTE
    ON DepartmentCTE.DeptId = d.parent)
SELECT *
FROM DepartmentCTE
ORDER BY parent;
```

# Demo

Chapter 4

# Recursive CTE Notes

- Recursion stops
  - When the recursive query produces no results
  - Or specify MAXRECURSION
- Using TSQL functions for recursion allows for 32 levels of recursion
- Using CTE for recursion allows for 32767 levels of recursion in the MAXRECURSION option, but much more if you set MAXRECURSION to 0.
  - I have confirmed up to 100,000,000 levels of recursion.

# Bonus Material

Download the samples and there are many additional CTE examples at the end of the file.

# Quiz 1. CTE Executions

As a named result set, the CTE is only run once even if it is referenced multiple times in a query.

True or False?

**FALSE** The CTE is executed once for EACH time that it is referenced in a query.

# Quiz 1. CTE Executions Explained

```
;WITH deptCTE(id, department, parent) AS
```

```
(SELECT id, department, parent  
FROM Departments)
```

```
SELECT q1.department, q2.department
```

```
FROM deptCTE q1
```

```
INNER JOIN deptCTE q2 on q1.id = q2.parent
```

```
WHERE q1.parent is null;
```

- In this example the deptCTE is executed twice

# Quiz 2. CTEs are proprietary

CTEs are proprietary to Microsoft SQL Server.

True or False?

**FALSE** Common Table Expressions are supported by several major database platforms, among them PostgreSQL, DB2, Oracle and SQL Server, defined in SQL-99 spec

# Quiz 3. CTE and Hierarchical Queries

CTEs are a great way to create recursive hierarchical queries.

True or False?

**TRUE** Recursive hierarchical queries are easy to write with a CTE. CTE's save time, are easy to follow, and work great for hierarchical data.

# Quiz 5. Database Versions

SQL Server only supports CTE's on SQL Server Enterprise Edition 2008R2 and newer.

True or False?

**FALSE** Common Table Expressions have been supported since SQL Server 2005 and are available in all versions.

# Quiz 6. CTEs and Nesting

CTEs can be nested and one CTE can reference an earlier CTE.

True or False?

**TRUE** Common Table Expressions can be nested. Just define multiple CTE's and reference an earlier CTE from a later one.

# Quiz 7. Indexing CTEs

Indexes can be added to CTEs to boost performance.  
True or False?

**FALSE** A Common Table Expression is a temporary, "inline" view - you cannot add an index to a CTE.

# Quiz 8. VIEW vs CTE

Which performs better, a non-recursive CTE or a VIEW?

They are the same.

- The big gain is the recursive CTE, which you can't achieve with a view.

# Quiz 9. CTE's and Data Paging

CTE's are a great way to do Data Paging for a result grid.

True or False

It Depends.....

SQL Server 2012 and 2014 have the new OFFSET and FETCH clause on select statements, which is easier than CTE's. For 2005, 2008 and 2008R2 the CTE is the best option.

# Quiz 10. CTE's and TempDB

CTE's are similar to Temp Tables or Table Variables in their use of TempDB?

True or False

**FALSE** Temp Tables and Table Variables both use TempDB, CTE's do not.....

- See my blog posting for all the details on this one.
  - <http://stevestedman.com/?p=2053>
  - It is more than we have time to prove today.

# Quiz 11:

- INTERSECT can be replaced with:
  - An UPDATE statement
  - A LEFT JOIN
  - An INNER JOIN
  - An INNER JOIN with DISTINCT

# Quiz 12:

- EXCEPT can be replaced with:
  - An UPDATE statement
  - A LEFT JOIN, filtering on NULL join column
  - An INNER JOIN
  - An INNER JOIN with DISTINCT

# Quiz 13:

- With tables that have many duplicates, which will return more rows:
  - UNION
  - UNION ALL

# Any Questions?

- Set Operators
- Derived Tables
- Common Table Expressions

# For More Information

- Visit <http://EmergencyReporting.com> to find out more about Emergency Reporting.
- Aaron on the web
  - <http://AaronBuma.com>
  - Twitter: @AaronDBuma
- Steve on the web
  - <http://SteveStedman.com>
  - twitter: @SqlEmt

# Tune in next week

- Thursday 2/17 at 9:00am (pacific time).
- Topics
  - Derived Table Queries (ie Subqueries)
    - Correlated Sub Queries
    - Sub Query Extensions (ANY, ALL, SOME)
    - Exists
  - OUTPUT Clause