SQLskills Immersion Event

IEPTO1: Performance Tuning and Optimization

Module 10: Indexing Strategies

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Overview

- **Indexing for performance**
  - Design strategies
  - Overall strategies
- **Using the tools for tuning**
  - SET STATISTICS IO ON
  - Showplan
  - Missing indexes
- **Indexing for AND**
- **Indexing for OR**
- **Indexing for joins**
- **Indexing for aggregates**
- **Indexed views v. columnstore indexes**
- **Rowstore indexes v. columnstore indexes**

Indexing for Performance

- **Extremely challenging**
  - Users lie ☺
  - Workload specific
    - Data modifications are impacted by indexes (indexes add overhead to INSERTs/UPDATEs/DELETEs)
    - The type and frequency of the queries needs to be considered
      - This can change over time
      - This can change over the course of the business cycle
  - Need to have an understanding of how SQL Server works in order to create the "RIGHT" indexes – you CANNOT just guess!
- **To do a good job at tuning you must:**
  - Know your data
  - Know your workload
  - Know how SQL Server works!

Indexing Strategies at Design

- **First and foremost: choose a GOOD clustering key**
- **Create your primary keys and unique keys**
- **Create your foreign keys**
  - Manually index your foreign keys with nonclustered indexes
- **Create any nonclustered indexes needed to help with highly selective queries (lookups are OK for highly selective queries)**
- **STOP: this is your "design" base**
- **Add indexes slowly and iteratively over time while learning and understanding your workload as well as query priorities and always re-evaluate if/when things change!**

Indexing Foreign Keys (1 of 2)

- **Helps referential integrity management**
  - When a primary key row is deleted, ALL foreign key references must be checked
    - When the foreign key column does not have an index whose key LEADS with the foreign key definition, then *something* has to be scanned
      - If there's no index that has the foreign key column in it, the table has to be scanned
    - Can be very expensive if there are many foreign key references and/or references from large tables
- **Helps the query optimizer better understand the relationship between tables when they're joined**
  - Foreign key values must exist in the referenced table
  - Foreign key values will reference exactly one row
- **Can help join performance**
  - When the more selective criteria is on the primary key table and SQL Server wants to join TO the foreign key reference

Indexing Foreign Keys (2 of 2)

Employee

ID	LN	FN	MI	…	DID
1	…	…	.	…	…
2	…	…	.	…	63
…	…	…	.	…	…
345	…	…	.	…	…

```
SELECT [e].[LN], [e].[FN], [d].[DID]
FROM [Employee] AS [e]
   JOIN [Department] AS [d]
      ON [e].[DID] = [d].[DID]
WHERE [d].[City] = 'Bellingham'
```

Department

DID	Name	…	City	State
1	…	…	…	…
2	…	…	…	…
…	…	…	…	…
63	…	…	Bellingham	WA

```
SELECT [e].[LN], [e].[FN], [d].[DID]
FROM [Employee] AS [e]
   JOIN [Department] AS [d]
      ON [e].[DID] = [d].[DID]
```

But joining from Department to Employee doesn't work optimally without an index on Employee.DID

Indexing Strategies Overall

- **Good base table indexes and a very small number of indexes to start *(some performance improvements should be handled by good design strategies)***
- **General strategies:**
  - Narrow indexes have **very few** uses!
    - Be careful that your general strategy is NOT:
      - See a WHERE clause, create a single-column index on it
      - To automatically create an index on every column (horrible!)
      - Guessing… or tuning queries randomly (without workload/index analysis)
  - Wider indexes have MANY, MANY more uses!
    - I'm not saying that you need to create indexes that have all of your columns in them but understanding a lot more about internals and how SQL Server works is VERY important for better performance!
  - Columnstore should be considered for large aggregations but lots of other considerations (SQL Server version, reads v. updates, types of queries)

But Will YOUR Queries Use Them?

- **Subset of columns = projection**
  - Do not use * (unless against view)
  - Optimizer has more chances for optimizing query when result set is NARROW (only the required columns)
- **Subset of rows = selection**
  - Use positive search arguments
  - Isolate the column to one side of the expression
    - **USE:** MonthlySalary > value/12 (constant, seekable)
    - **DO NOT USE:** MonthlySalary * 12 > value (must scan)
  - Be cautious with LEADING wildcards
    - **USE:** LastName LIKE 'S%'
    - Avoid just appending %val% to every value (from the app)
- **Consider using views, stored procedures and functions to limit the columns/rows**

Using the Tools

- **USE the tools!**
  - STATISTICS IO
  - Showplan/Missing Index DMVs
  - Database [Engine] Tuning Advisor
  - BEWARE of the limitations of the tools!
    - Missing Index DMVs (and therefore showplan) only tune the plan that was executed – they do not "hypothesize" about alternatives (like DTA does)
    - All of the index recommendation from tools tend to go for "the best" choice rather than good enough choices
    - NONE of the tools do index consolidation…
- **Resources:**
  - Search "Bart Duncan Missing"
  - Glenn's DMV Toolkit
  - A bit of searching – lots of good stuff out there!

SET STATISTICS IO ON (1)

- **Scan count: does not mean table scan**
  - Nothing to do with actual type of access
  - Refers to the number of "accesses" an object
- **Logical reads: number of page accesses in the data cache – specific to this query's execution**
  - A single page can be accessed many times and EVERY one of these will be counted

  * NOTE: Profiler vs. STATISTICS IO = Profiler includes I/Os performed during the execution of the query (for example, lookups into the plan cache, accessing metadata, security information, etc.). Profiler should always be greater than or equal to STATISTICS IO.
- **Physical reads: number of page reads that this query had to wait for – from disk**
- **Read-ahead reads: secondary process which accesses pages from disk ("reading ahead" of the query) so that SQL Server/CPU doesn't have to wait**
- **Lob (logical, physical, and read-ahead) reads: same as the above but for all LOB [(n)text, MAX, XML] as well as limited-LOB data types that have overflowed**

SET STATISTICS IO ON (2)

- **Use logical reads as a general "total"**
  - The cost of getting from A to B in "steps" alone
  - Similar to distance
    - Does not include any traffic [blocking] encountered along the way
    - Does not include any worktables required
  - Doesn't give you the complete picture
- **Use as a piece in the query execution information/puzzle**
  - Usually set in script
  - Can change it in SSMS
    - Tools, Options, Query Execution, Advanced:
      - SET STATISTICS IO ON
      - SET NOCOUNT ON
    - NOTE: Some of these options can have a profound affect on query performance. Should not change the ANSI options.

Showplan

- **Estimated plan**
  - Gives you the plan that SQL Server came up with through optimization – without actually executing it
- **Actual plan**
  - Gives you the plan that SQL Server came up with through optimization – and, executed it
  - This is EXACTLY the same plan [shape] as estimated but includes actual numbers
    - Extremely beneficial in finding cardinality estimation issues
- **Definitely NOT perfect…**
  - What are you really seeing with cached plans and stored procedures…
    - Plans for COMPILED values not the actual value – these can be the most incorrect

Missing Index Hints

- **The "green hint" in showplan, comes from the missing index DMVs**
- **Helpful, but**
  - Not always listed with the query it benefits (consider using SQL Sentry's Plan Explorer)
  - Gives you the index that reduces the most I/O for the plan that was executed
  - Doesn't consider other join types or join orders; doesn't always give the best plan
- **Good to try**
  - If you're ready to believe it and implement the suggestion consider checking to see what the Database [Engine] Tuning Advisor (DTA) recommends
  - Don't just trust it; must consider consolidation
    - Review existing indexes
    - Could you create a slightly-wider but better index? Possibly removing one or more existing indexes?
    - The more you tune – the more you'll find "similar" recommendations

Indexing for AND

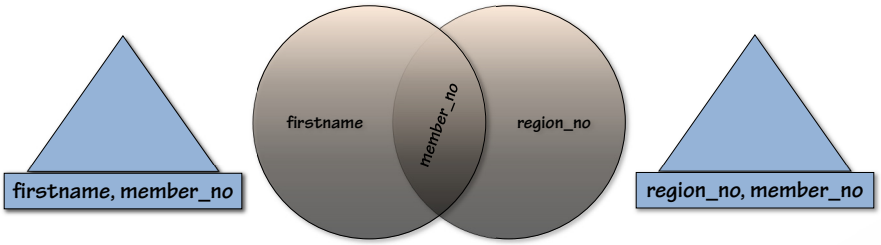
- **AND progressively limits the SET**
- **All conditions MUST be true**
- **Indexing strategies**
  - Evaluate columns in WHERE clause
  - Index any single highly selective set
  - Index a combination of columns to yield a highly selective set
    - Order should be based on the most commonly combined criteria (if all SARGs use equality)
    - Order should be based on the most selective ***predicate*** criteria (if SARGs use varying operators such as >, < or LIKE)
  - If no combination of criteria create a selective set AND it's a high priority query, consider covering the query
    - SQL Server may use index intersection to intersect two relatively small sets (HASH Join), this is likely to be achieved without trying

Index Options

```
SELECT m.Member_No, m.FirstName, m.Region_No
FROM dbo.Member AS m
WHERE m.FirstName LIKE 'K%'
      AND m.Region_No > 6
      AND m.Member_No < 5000
```

- **Table scan (always an option)**
  - Clustered on member_no so a full table scan is unnecessary
  - SQL Server can "seek" with a partial table scan
- **NC index on firstname (K% is not very selective)**
- **NC index on region_no (region_no > 6 is 1/3 of the table)**
- **What does SQL Server do?**

Index Intersection



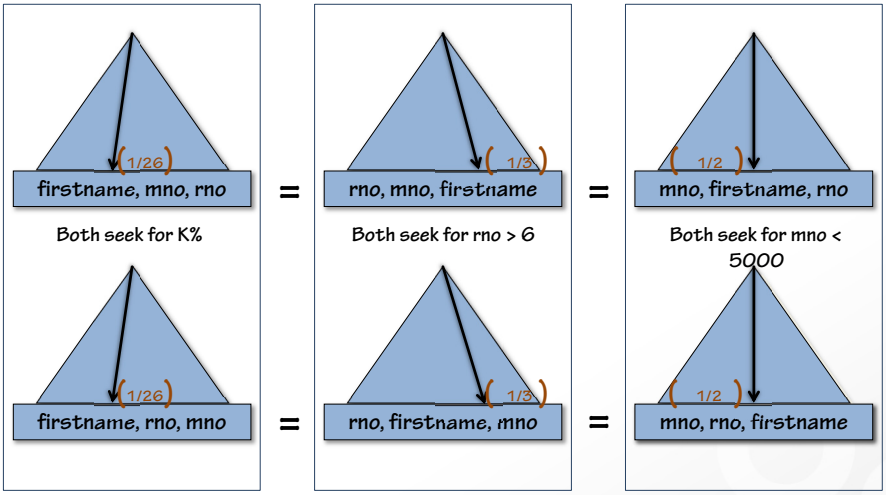
- **Think of each of your nonclustered indexes as sets (as mini tables ordered by the key of the index)**
- **All nonclustered indexes "include" the clustering key in the leaf level of the index**
- **If we could "join" (or intersect) these sets on their common element (member_no) then we could find the data that we need…**
- **And, our query only wants these columns**
- **The intersection of these two indexes covers our query!**

Index Intersection

- **Not the *fastest* option available for performance**
  - Requires more than 1 index to get to the data
  - Potentially requires tempdb space (HASH match)
  - Not something for which I strategize but something that might happen with lower priority queries that aren't covered and for those it's PERFECT
- **If it's a high priority query, you should consider doing with 1 index what you're currently doing with 2!**
  - No temp table
  - Only one index to seek/scan

Index Options

rno = region_no
mno = member_no



All indexes are the same size (same columns) but the ORDER of the columns is different

What's Best Depends On the QUERY!

- **An index that has firstname first is better for THIS query because it's the most selective SET (based on the query, not the data itself)**
- **An index with region_no first is good, possibly better if the firstname might accept leading wildcards such as**
  - WHERE firstname LIKE '%e%'
- **Not as big of a fan of having member_no first**
  - It's the most selective data column (it's unique) but, we already have a clustered index on member_no
  - If a highly selective query were to run then SQL Server could seek into the clustered index…
  - If ALL of the queries supply all three of the parameters then region_no or firstname first would help more queries!
- **Remember, ALL 6 are better than 2 or even a partial table scan!**

Summary: Key Order – How Do You Decide?

- **First and foremost – it depends on the usage of the columns**
  - If you ALWAYS supply LastName and sometimes supply FirstName
    - LastName, FirstName is better than FirstName, LastName
- **Second – it depends on the types of predicates (equality?)**
  - If EVERY query ALWAYS supplies ALL conditions and those conditions are accessed with equality conditions, it does NOT matter:

    ```
    WHERE LastName = 'Tripp' AND FirstName = 'Kimberly'
    ```

  - Then, it doesn't matter (these two indexes are REDUNDANT **in this case**):
    - LastName, FirstName
    - FirstName, LastName
- **Third – what about inequality?**
  - Once you start adding predicates that want inequality (LIKE, <, >, etc.) then you might only benefit (or, be able to seek on) the first condition. So, the 2nd and 3rd condition might be OK just to be in the INCLUDE

Indexing for OR

- **What is OR doing?**
  - Gather individual sets
  - Bring together and ensure that any row that appears in multiple places is only displayed once
  - Sound familiar?
- **IN is just a simplified series of OR conditions**
  - If an index exists to help search on each condition and EVERY specific value is HIGHLY selective, then it will use an index every condition
  - If any condition is not selective enough to use the index then a scan will be performed

Indexing for OR

- **For ideal performance tuning, treat each OR as a different query**
- **Each condition CAN use an index**
  - Each condition has to be *selective enough* to use the index
  - If there are 6 conditions and 5 are selective but 1 isn't then why would SQL Server use 5 different indexes and then still do a table scan…
  - If you have an IN then SQL Server can use the *same* index multiple times but if some of the conditions are selective and one are more are not then you hit the same issue as above – why would SQL Server use an index AND do a table scan!
- **The final step is that an OR cannot return duplicates – SQL Server MUST determine if any rows are in more than one result set.**
  - This often requires a temp table and a sort…

Indexing for OR

OR is Similar to UNION

- OR removes duplicate rows based on row's unique identifier (RID or clustering key)
- UNION removes duplicate rows based on the SELECT list
- This is NOT good enough… you must add the row's key to the SELECT list if you choose to use UNION
- If you're joining multiple tables, you should consider adding EACH table's key to the query
- OR always removes duplicates
  - What if you know there are no duplicates
  - What if you don't care if duplicates are returned
- Consider UNION ALL

Be sure to test this thoroughly as your queries are semantically different when you change from OR to UNION

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Using the Tools for Join Tuning

- Understand how to break down a join
- Understand how to force your join for performance comparisons
- Understand the pros/cons of the showplan recommendations
- Understand how to best use DTA for a more well-rounded recommendation
  - Use DTA from SSMS to see all of the recommendations
  - Know how to use DTA's recommendations iteratively!

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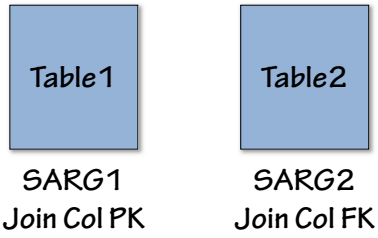
Indexing for Joins

- **Multiple possible join strategies: do you *need* to care?**
- **Items on which to focus:**
  - Most expensive table in the join (you have to start somewhere?!)
  - Most expensive join in the plan (it's probably downstream from the most expensive table and a join on that table)
  - Once you know the problem table AND the problem join, focus on tuning that particular table within that specific join!

Best Options for Joins: Phase I

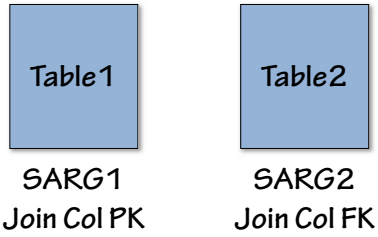


Do you already have individual indexes on each and all of these columns?

Foreign key???

- **One join strategy might use Table1's SARG1 index to Table2's join key index (loop join)**
- **Another could use Table2's SARG1 index to Table1's join key index (loop join)**
- **Another could use only the join key indexes (merge)**
- **What's best depends on the data!**
- **If ALL four indexes exist then the optimizer has the best choices**

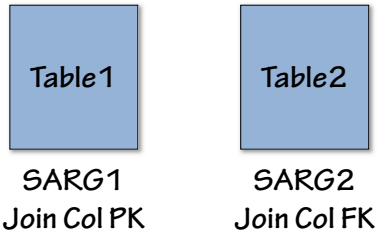
Cover the Combination: Phase II



Still not working?

- **Not using these indexes?**
- **Performance still stinks?**
- **Cover the combo**
  - Problem table (SARG, join): priority for the SARG
  - Problem table (join, SARG): priority for the join
- **Only works when the cardinality of the join is low**

Cover the Query: Phase III

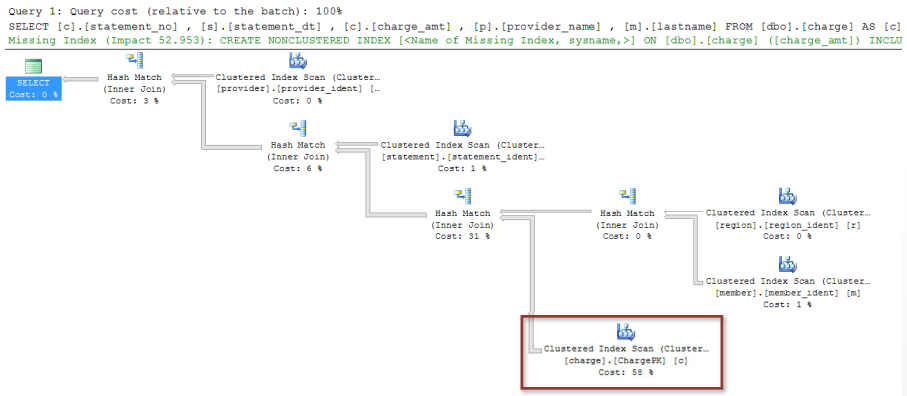


- **Covering the query/queries**
- **Cover the combo first, THEN add the additionally requested columns, with INCLUDE**
  - Problem table (SARG, join): priority for the SARG
  - Problem table (join, SARG): priority for the join

Bringing It All Together (Long Demo)

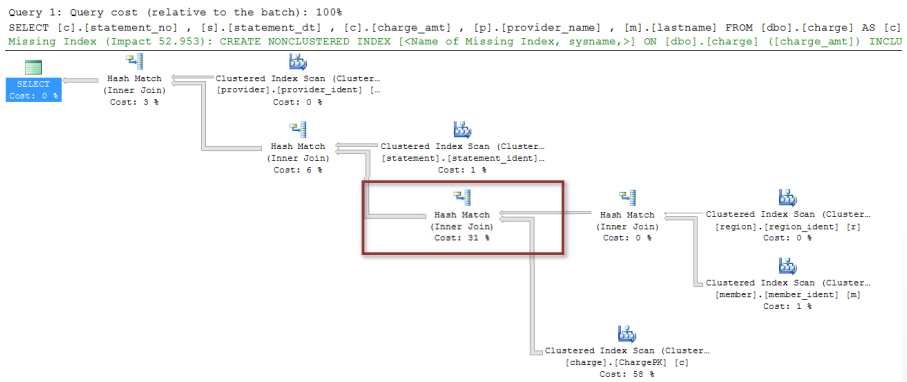
- Pulling apart a plan and describing a lot while I do it…
- Hard-coding a query to create a base-line to go against
- Deciding where to start
  - Analyzing where we have a problem(s)
  - Finding the problem table
  - Finding the problem join
- Evaluating whether or not an index is a good idea
  - Reviewing/debating the "green hint"
  - Using DTA from SSMS to see if the hint is different

Table Scans – Are They Necessary?



- Is the table scan because you're returning the entire table/all columns?
- Or, it is because the right indexes don't exist?
- What table has the highest cost?

Joins – Are All of the Joins Hash Joins?



- Are all of these hash joins because you're tables are large?
- Or, are they because the right indexes don't exist?
- What join has the highest cost?

Manual Tuning Process

- Find the most expensive table in the query (charge)
  - Are there any SARGs – consider what the key would look like with these SARGs independent of the join conditions
- Find the most expensive join in the query (charge joining to member)
  - Figure out which join is the join that your problem table is joining to
- Phase I should be already done
- Phase II should be considered

```
CREATE NONCLUSTERED INDEX Charge_PriorityForSARG
ON [dbo].[charge] ([charge_amt], [member_no])

CREATE NONCLUSTERED INDEX Charge_PriorityForJoin
ON [dbo].[charge] ([member_no], [charge_amt])
```

- Phase III adds any columns not already present, to the INCLUDE

```
INCLUDE ([statement_no], [provider_no])
```

Tuning Goal

- Find the most expensive table in the query (charge)
- Find the most expensive join in the query (charge joining to member)
- Try to tune CHARGE for its join to member… How?
  - Review the green hint:

```
CREATE NONCLUSTERED INDEX MissingIndexDMVRecommendation
ON [dbo].[charge] ([charge_amt])
INCLUDE ([member_no],[provider_no],[statement_no])
```

  - Double-check using DTA (Query, Analyze Query in DTA):

```
CREATE NONCLUSTERED INDEX [DTA_K6_K7_K3_K2]
ON [dbo].[charge]
([member_no], [charge_amt], [statement_no], [provider_no])
```

- Notice how similar these indexes are?
- What do they do, how do they differ?

Result of Manual and Tool-based Tuning

- The missing index DMVs (via the green hint in showplan) came up with:

```
CREATE NONCLUSTERED INDEX MissingIndexDMVRecommendation
ON [dbo].[charge] ([charge_amt])
INCLUDE ([member_no],[provider_no],[statement_no])
```

- Manually, we came up with:

```
CREATE NONCLUSTERED INDEX Charge_PriorityForSARG
ON [dbo].[charge] ([charge_amt], [member_no])
INCLUDE ([statement_no], [provider_no])

CREATE NONCLUSTERED INDEX Charge_PriorityForJoin
ON [dbo].[charge] ([member_no], [charge_amt])
INCLUDE ([statement_no], [provider_no])
```

- The Database Tuning Advisor came up with:

```
CREATE NONCLUSTERED INDEX [DTA_K6_K7_K3_K2]
ON [dbo].[charge]
([member_no], [charge_amt], [statement_no], [provider_no])
```

Benefits of These Indexes?

- **The green hint/the Missing Index DMVs recommendation:**
  - Leads with the column charge_amt
  - This removes the table scan and changes to an index seek
  - This allows filtering by our search argument (charge_amt > 2500)
  - PRO: This helps tune the plan that was chosen/executed
  - CON: They did not hypothesize for alternatives
- **The DTA's recommendation:**
  - Leads with the column member_no
  - This removes the table scan and changes to an index seek
  - This allows the join to change to a loop join
  - PRO: This significantly reduces the cost/time for the join
- **Of the tools – what's better? What gives better performance?**
  - DTA, but, our index was even a bit better given that you can't seek beyond charge_amt (as the SARGs against it are range-based)

Database [Engine] Tuning Advisor

- **It's not always perfect**
- **It sometimes yields the same index recommendation that the missing index DMVs**
- **It often OVER recommends indexes (this is why you want to use it ITERATIVELY after really analyzing where to begin)**
- **It doesn't recommend any forms of index consolidation**
  - This is one of the reasons that a lot of development environments end up over-indexed
- **IF you end up creating the index that was recommended for a particular table, then, go ahead and create the statistics that are recommended for that table**
  - DTA can create multi-column statistics
  - The can give the optimizer other (sometimes VERY useful) ways of using the recommended index!

Join Strategies

- **Loop join**
  - Iterative search on the inner table based on the number of rows that match in the driving table
  - Usually best when the driver (outer table [chosen by SQL Server]) is small
- **Merge join**
  - Processing both tables at the same time using suitably sorted indexes
  - Usually best when the RIGHT indexes exist
    - An index on EACH table that LEADs with the same column (the column being joined) is necessary
- **Hash join**
  - Two-phase operation (build, then probe): build table (smaller set) and probe table (larger set) allowing SQL to join extremely large sets – in MEMORY (can spill)
  - Either side *can* use indexes to make the sets smaller
  - When this occurs on reasonably small tables then it sometimes mean that good indexes don't exist
- **Key points: the strategy I demonstrated works for ALL join types**
  - You do not *need* to know or care about the specific strategy… just give SQL Server the best information from which to choose!

Indexing for Aggregations

- **Two types of aggregates: stream and hash**
- **Try to achieve stream to minimize overhead in temp table creation**
- **Computation of the aggregate still required**
- **Lots of users, contention and/or minimal cache can aggravate the problem!**

Aggregate Query

- Member has 10,000 rows
- Charge has 1,600,000 rows

```
SELECT c.member_no AS MemberNo,
      sum(c.charge_amt) AS TotalSales
FROM dbo.charge AS c
GROUP BY c.member_no
```


Aggregate Query
Table Scan + Hash Aggregate

```
SELECT c.member_no AS MemberNo,
      sum(c.charge_amt) AS TotalSales
FROM dbo.charge AS c
GROUP BY c.member_no
```

- Table scan of charge table
  - Largest structure to evaluate
  - Worst case scenario
- Worktable created to store intermediate aggregated results: OUT OF ORDER (HASH)
- Data returned OUT OF ORDER unless ORDER BY added
- Additional ORDER BY causes another step for SORT, and sorting can be expensive!

Worst Case

- Clustered index scan (table scan) 1,600,000 rows
- Hash aggregate yields 9,114 rows *out of order*
- Sort only has to sort 9,114 rows instead of 1,600,000 rows
- Return data

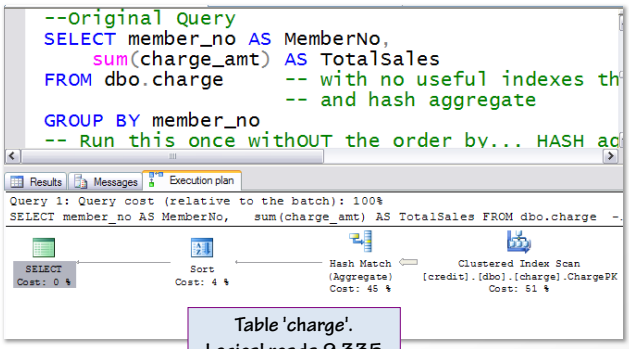


Table 'charge'.
Logical reads 9,335

Aggregate Query
Index Scan + Hash Aggregate

```
SELECT c.member_no AS MemberNo,
      sum(c.charge_amt) AS TotalSales
FROM dbo.charge AS c
GROUP BY c.member_no
```

- **Out of order covering index on charge table**
  - Index exists which is narrower than base table
  - Used instead of table to cover the query
- **Worktable still created to store intermediate aggregated results: OUT OF ORDER (HASH)**
- **Data returned OUT OF ORDER unless ORDER BY added**
- **Additional ORDER BY causes another step for SORT, and sorting can be expensive!**

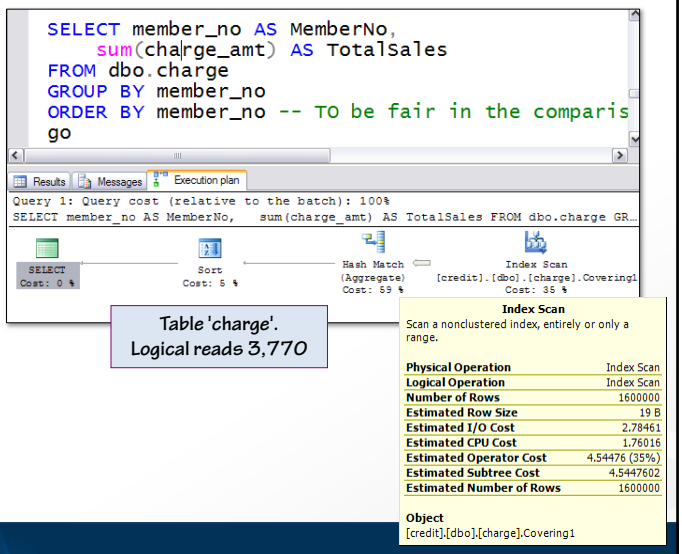
Not as Bad

COVERING
- Index scan
- 1,600,000 narrower rows

Hash aggregate
- yields 9,114 rows out of order

Sort
- only has to sort 9,114 rows instead of 1,600,000 rows

Return data



Aggregate Query
Index Scan + Stream Aggregate

```
SELECT c.member_no AS MemberNo,
      sum(c.charge_amt) AS TotalSales
FROM dbo.charge AS c
GROUP BY c.member_no
```

- **Covering index on charge table (in ORDER of GROUP BY clause)**
  - Index exists which is narrower than base table
  - Used instead of table to cover the query
  - Covers the GROUP BY so data is grouped
- **Less work to aggregate results IN ORDER**
- **Data returned IN ORDER unless ORDER BY/ joins added**
- **Adding an ORDER BY identical to the GROUP BY does NOT cause any additional step for sorting!**

Much Better!

COVERING
- Index scan
- 1,600,000 narrower rows

Stream
- aggregate also yields 9,114 rows IN ORDER

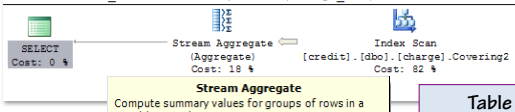
NO SORT REQUIRED

Return data

```
-- Run the query again - you'll see STREAM
SELECT member_no AS MemberNo,
    sum(charge_amt) AS TotalSales
FROM dbo.charge
GROUP BY member_no
ORDER BY member_no -- TO be fair in the comparis
                   -- BUT because this is a
```

Results | Messages | Execution plan

```
Query 1: Query cost (relative to the batch): 100%
SELECT member_no AS MemberNo,   sum(charge_amt) AS TotalSales FROM dbo.charge GR
```



Stream Aggregate
Compute summary values for groups of rows in a suitably sorted stream.

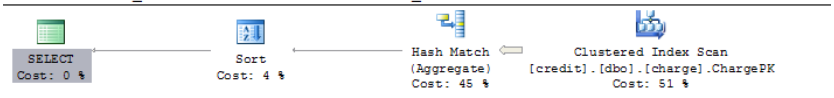
Physical Operation	Stream Aggregate
Logical Operation	Aggregate
Number of Rows	9114
Estimated Row Size	19 B
Estimated I/O Cost	0
Estimated CPU Cost	0.964557
Estimated Operator Cost	0.9645596 (18%)
Estimated Subtree Cost	5.5093198
Estimated Number of Rows	9114

Table 'charge'. Logical reads 3,770

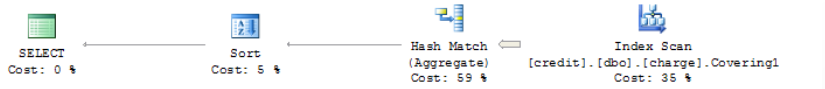
See the Difference?

Results | Messages | Execution plan

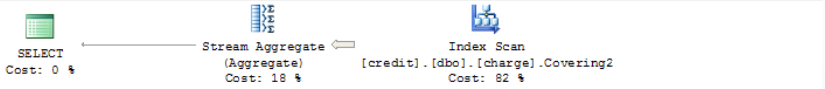
```
Query 1: Query cost (relative to the batch): 48%
SELECT member_no AS MemberNo,   sum(charge_amt) AS TotalSales FROM dbo.charge WITH (…
```




```
Query 2: Query cost (relative to the batch): 36%
SELECT member_no AS MemberNo,   sum(charge_amt) AS TotalSales FROM dbo.charge WITH (…
```




```
Query 3: Query cost (relative to the batch): 16%
SELECT member_no AS MemberNo,   sum(charge_amt) AS TotalSales FROM dbo.charge WITH (…
```



Concerns

- **Hash aggregates**
  - More temp tables
  - More contention in tempdb
  - Larger tempdb required
  - Performance varies on each execution
- **Stream/hash aggregate**
  - Aggregate needs to be computed

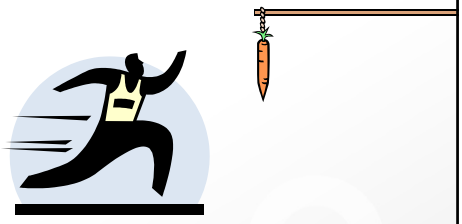
Is there a better way?

Indexed views (2000+)

Columnstore indexes (2012+)

Demo

What kinds of gains can you get?
Will it be worth it?



Views/Indexes: Quick Review

- **Views**
  - Named, saved SELECT statement
  - Tabular data set
  - Data definition (no ORDER BY unless TOP is used)
- **Indexes**
  - Clustered (only 1 per table)
    - Defines order and structure of data
    - Leaf level = data (of the table)
  - Nonclustered (249/999 per table)
    - Separate and duplicated data
    - Automatically maintained
    - Order and structure defined per index

Indexed Views v. Columnstore

Indexed views

- Limited uses in non-Enterprise Editions
- Must be analyzed / created "per query"
  - More complicated to create
  - More storage required
  - More administrative overhead / maintenance
  - More costly to maintain during inserts / updates
- Requires certain session settings to be set

Columnstore indexes

- Some limitations across versions:
  - BOL: Features Supported by Editions
- Only one can be created per table
  - Super easy to create
  - A lot LESS storage required (compression)
  - Less administrative overhead / maintenance
  - Might not be able to do inserts / updates
    - 2012: read-only nonclustered columnstore ONLY
    - 2014: adds read-write CLUSTERED columnstore indexes but these don't allow any other indexes / keys
    - 2016+: is really a MUCH better option
- No session setting requirements

hidden slide w/extra details

Columnstore Indexes by SQL Server Version

- **SQL Server 2008 is the lowest (IMO) version for large tables, performance, scalability**
  - Added data compression (row and page compression)
  - Added filtered indexes / filtered statistics
  - Fixed fast-switching for partition-aligned, indexed views
- **SQL Server 2012 adds read-only, nonclustered columnstore indexes**
  - Some frustrating "batch-mode" limitations for partitioned views (UNION ALL)
    - If you're using PVs then you should upgrade!
- **SQL Server 2014 adds updateable, clustered columnstore indexes**
  - Many of the most frustrating limitations with CS fixed – for example, UNION ALL supports batch mode (which means you can use these with partitioned views)
  - Added "incremental statistics" to help reduce when to rebuild as well as time to rebuild
- **SQL Server 2016+ takes columnstore indexes even further with updateable, nonclustered, columnstore indexes and row-based, nonclustered indexes with clustered, columnstore indexes!**

Row-based Indexes v. Column-based Indexes

Rowstore indexes

- **Support data compression**
  - Row compressed
  - Page compressed
- **Can support point queries / seeks**
- **Wide variety of supported scans**
  - Full / partial table scans (CL)
  - Nonclustered covering scans (NC)
  - Nonclustered covering seeks with partial scans (NC)
- **Biggest problems**
  - More tuning work for analysis: must create appropriate indexes per query and then consolidate
  - Must store the data (not as easily compressed)

Columnstore indexes

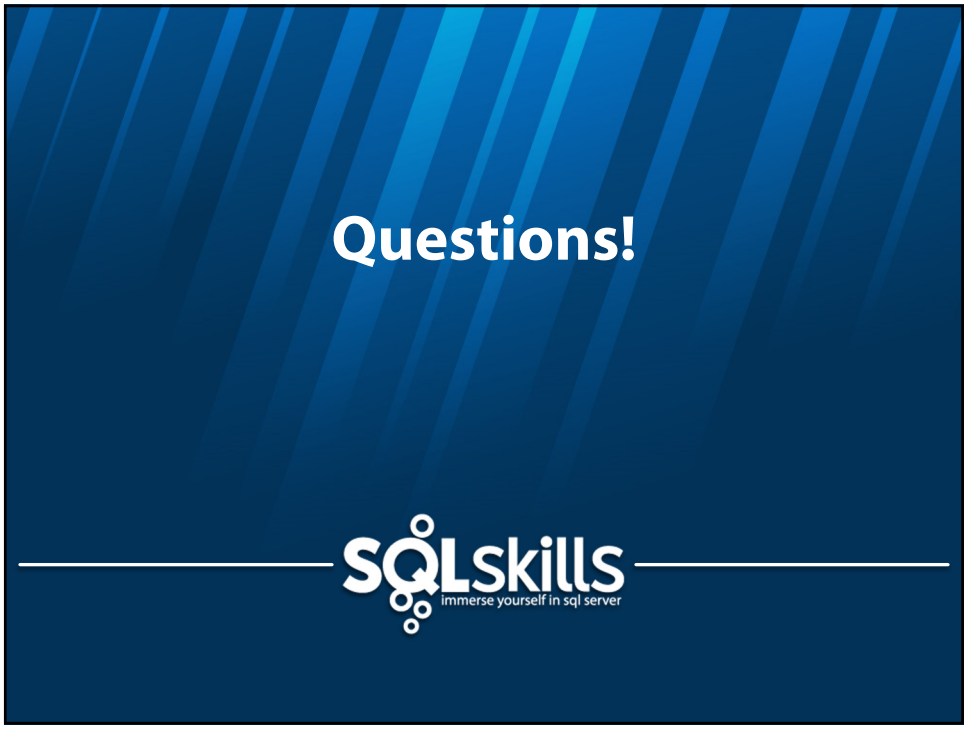
- **Significantly better compression**
  - Columnar data stored together, often allows much higher level of compression
  - COLUMNSTORE / COLUMNSTORE_ARCHIVE
- **Supports large scale aggregations**
- **Support partial scans w/"segment" elimination**
  - Only the needed columns are scanned
  - Data is broken down into row groups (roughly 1M rows) and segments can be eliminated
  - Combine w/partitioning for further elimination
  - Parallelization through batch mode processing
- **Biggest problems**
  - Minimum set for reads is a row group (no seeks)
  - Limitations of features for batch mode by version (fixes in 2014 and 2016)
  - Limitations with other features (less and less by SQL Server version)

Summary

- **Ask for ONLY the data you need**
  - Limit the rows requested with effective WHERE clause criteria
  - Limit the columns requested with effective SELECT lists
- **Work with your developers / architects to create better base structures**
- **Be sure to use key indexes / constraints**
  - Nonclustered for primary key (if, it's not the clustered)
  - Nonclustered for the unique keys (one might actually be your clustered?)
  - MANUALLY index your foreign keys
- **Add nonclustered for highly selective SARGs**
- **Consider covering for high priority/low selectivity**
- **Test, test, test!**

Review

- **Indexing for performance**
  - Design strategies
  - Overall strategies
- **Using the tools for tuning**
  - SET STATISTICS IO ON
  - Showplan
  - Missing indexes
- **Indexing for AND**
- **Indexing for OR**
- **Indexing for joins**
- **Indexing for aggregates**
- **Indexed views v. columnstore indexes**
- **Rowstore indexes v. columnstore indexes**


Questions!
SQLskills
immerse yourself in sql server