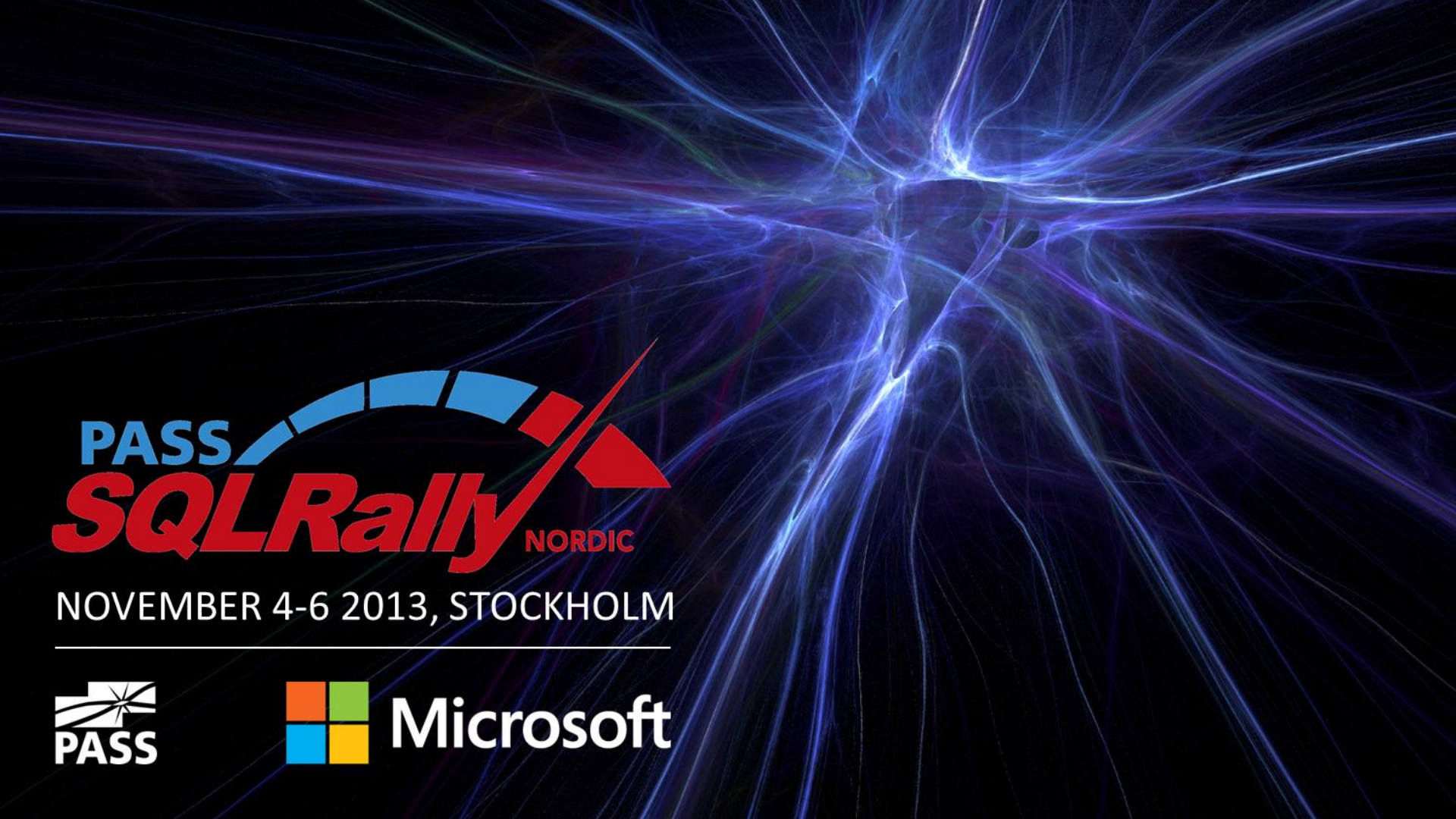
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Optimizing DAX Queries

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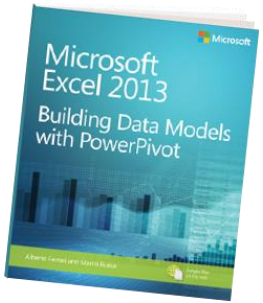
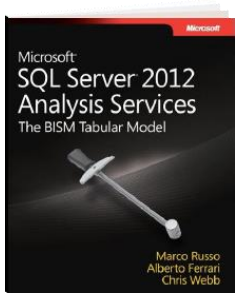
SSAS Maestros – MVP – MCP

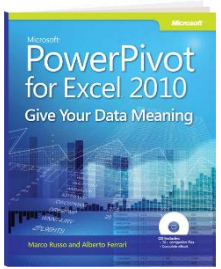
Microsoft Partner
Gold Data Platform
Gold Business Intelligence

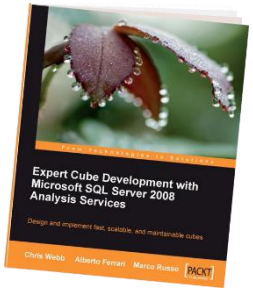
MVP Microsoft Most Valuable Professional

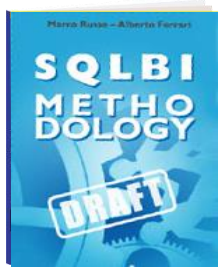
SSAS MAESTRO by Microsoft



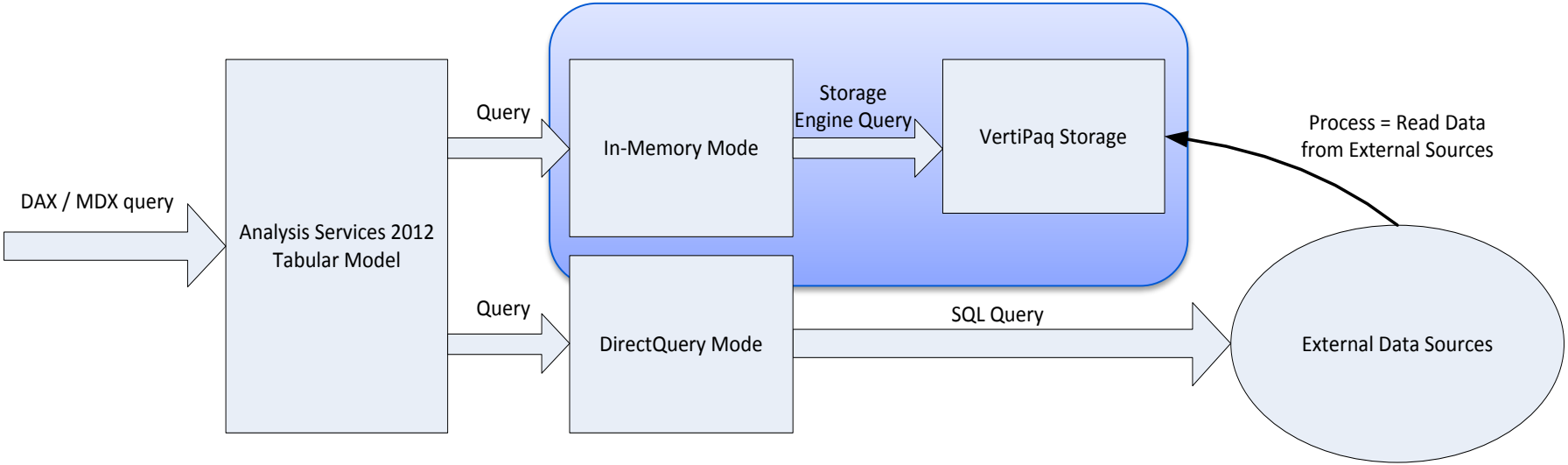








Tabular Query Architecture



Agenda

- What I will try to teach:
  - Tabular Query Architecture
  - Monitoring and Query Plans
  - How to understand and solve performance issues
  - Optimization Examples
- What I do NOT want you to learn:
  - Best practices, without knowing the reasons
  - Remember: best practices are hints, not rules!

Brief introduction to the SSAS Query Engine Architecture

VERTIPAQ AND FORMULA ENGINE

Tabular Two Engines

- Formula Engine
  - Handles complex expressions
  - Single threaded
- Storage Engine (VertiPaq / xVelocity)
  - Handles simple expressions
  - Executes queries against the database
  - Multithreaded

Tabular: Rich & Fast

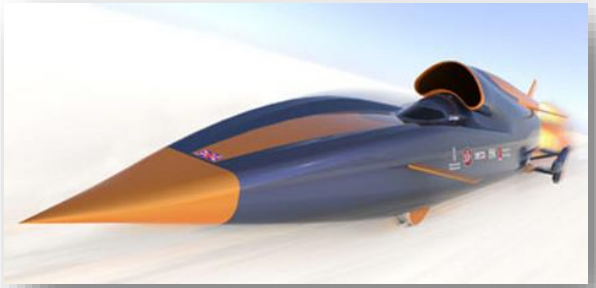
DAX

Rich

Single threaded per query

Designed for expressivity

VertiPaq Query



Simple

One core per segment

Optimized for speed

Formula Engine


Formula Engine
Vertipaq

Trust the Rain Man

- Optimizing DAX means:
  - Reduce FE usage
  - Increase SE usage
- It is very easy,
- Only need to understand who processes what
  - What is computed in FE and in SE?
  - How to move computation in SE?
- Time to dive deeper in the DAX engine

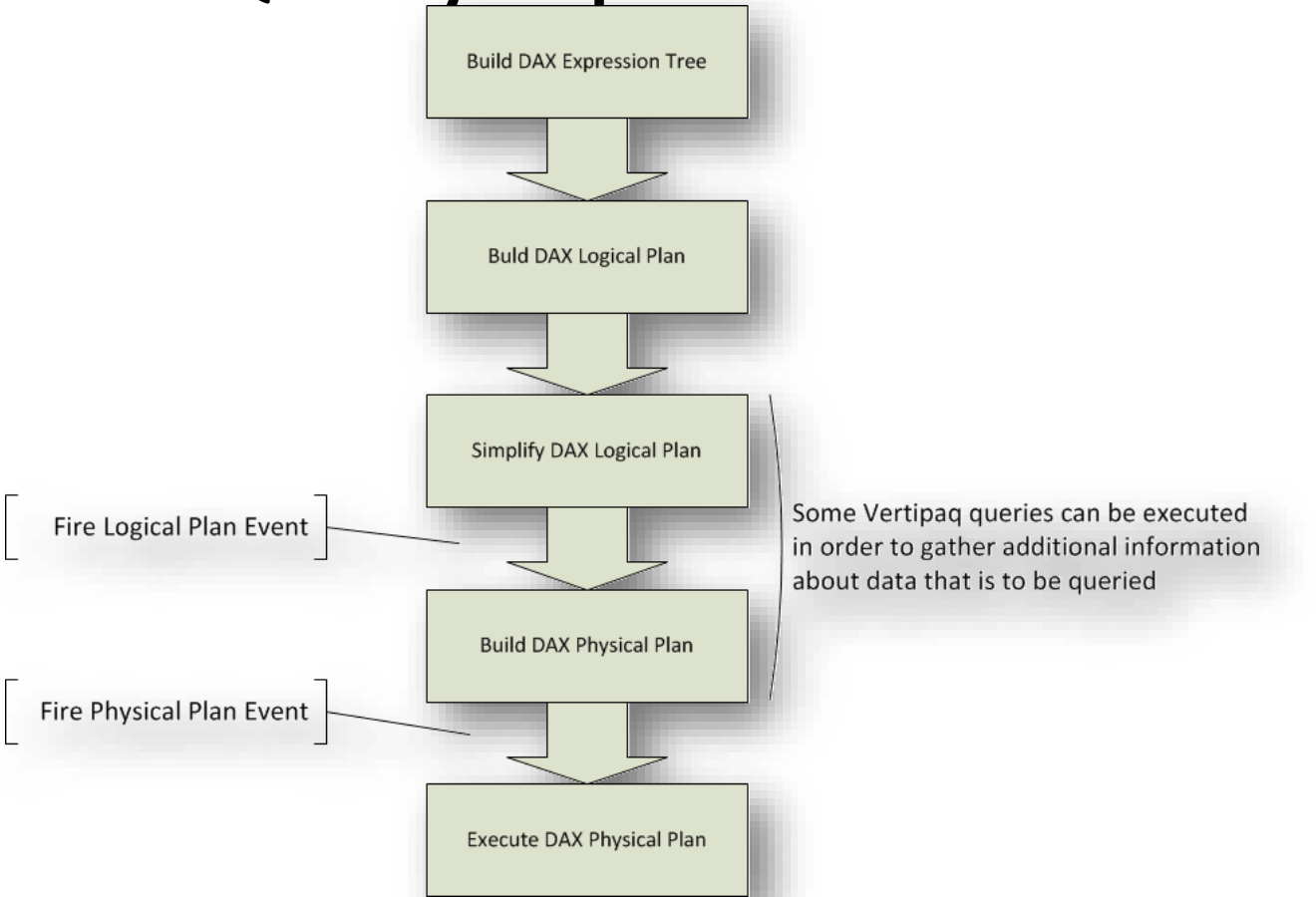
Query plans are useful to get insights from the engines in SSAS

USING QUERY PLANS

Understanding Query Plans

- Logical Query Plan
  - It is the logical flow of the query
  - Fired as standard text
  - Pretty hard to decode
- Physical Query Plan
  - The logical query plan executed by the engine
  - Can be very different from the logical one
  - Uses different operators
- VertiPaq Queries
  - Queries executed by the xVelocity engine

DAX Query Optimization Flow

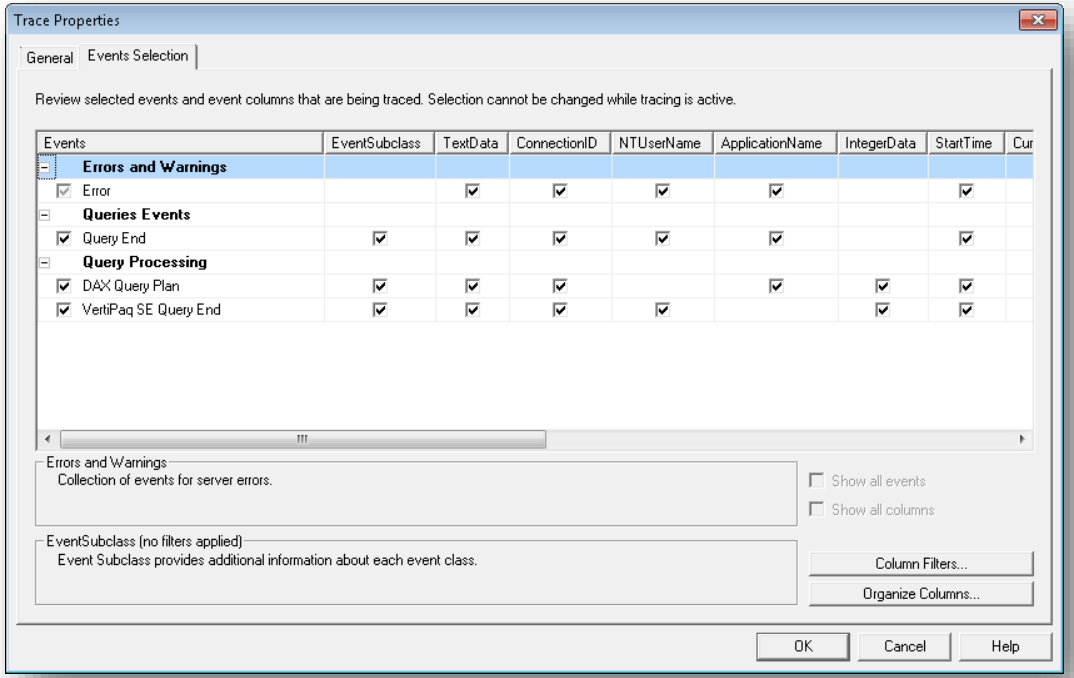


DAX is not cost-based

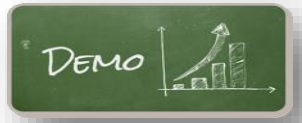
- Unlike SQL Server
- Data is gathered to analyze
  - When to perform filtering
  - How to resolve joins
  - Materialization needs
- Query plan does not change with different row counts

SQL Server Profiler

- Catches events from SSAS
  - Queries Events
  - Query Processing



Monitoring a Query

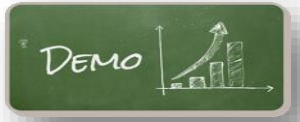


Trace of a simple query, to start looking at the Profiler

```
EVALUATE

    ROW (
        "Result",
        SUM ( 'Internet Sales'[Sales Amount] )
    )
```

Monitoring a Query



Trace of a slightly more complex query, this time we have many VertiPaq SE queries running

```
EVALUATE

CALCULATETABLE(
    SUMMARIZE(
        'Internet Sales',
        Geography[State Province Code],
        "Sales", SUM ( 'Internet Sales'[Sales Amount] )
    ),
    FILTER(
        Customer,
        Customer[Last Name] = "Anand"
    )
)
```

1° VertiPaq Query

The first query is used to understand how many customers exist that satisfy the filter

```
SELECT
    [Customer].[CustomerKey]
FROM
    [Customer]
WHERE
    [Customer].[LastName] = “Anand”
```

2° VertiPaq Query

Query using JOINS inside xVelocity. These joins do not require materialization and can be executed very fast in parallel

```
SELECT
    [Geography].[StateProvinceCode]
FROM [Internet Sales]
          LEFT OUTER JOIN [Customer]
         ON [Internet Sales].[CustomerKey] = [Customer].[CustomerKey]
          LEFT OUTER JOIN [Geography]
         ON [Customer].[GeographyKey] = [Geography].[GeographyKey]
WHERE
          [Customer].[CustomerKey] IN
      (11096, 11989, 17005, 22513, 28899, 15054,
       19626, 20344, 25918, 27141...
      [74 total values, not all displayed]);
```

DAX Query Plan

Simplifed text of the query plan, gives a good idea of what the FE is going to execute. In red the parts executed by xVelocity

```
CalculateTable
    AddColumns
        Scan_VertiPaq
        GroupBy_VertiPaq
            Scan_VertiPaq
        Sum_VertiPaq
            Scan_VertiPaq
           'Internet Sales'[Sales Amount]
    Filter_VertiPaq
        Scan_VertiPaq
        'Customer'[Last Name] = Anand
```

Logical plan and Query side by side

Simplifed text of the query plan, gives a good idea of what the FE is going to execute. In red the parts executed by xVelocity

```
CalculateTable
    AddColumns
        Scan_VertiPaq
        GroupBy_VertiPaq
            Scan_VertiPaq
        Sum_VertiPaq
            Scan_VertiPaq
            [Sales Amount]
    Filter_VertiPaq
        Scan_VertiPaq
        'Customer'[Last Name] = Anand
```

```
EVALUATE
CALCULATETABLE(
    SUMMARIZE(
        'Internet Sales',
        Geography[State Province Code],
        "Sales", SUM( [Sales Amount] )
    ),
    FILTER(
        Customer,
        Customer[Last Name] = "Anand"
    )
)
```

Query Running: Step 1

This query is the first one used to really execute the DAX query.
Note that SUM is executed inside xVelocity, not in the Formula Engine

```
SELECT
    [Geography].[StateProvinceCode],
    SUM([Internet Sales].[SalesAmount])
FROM
    [Internet Sales]
           LEFT OUTER JOIN [Customer]
        ON [Internet Sales].[CustomerKey]=[Customer].[CustomerKey]
           LEFT OUTER JOIN [Geography]
        ON [Customer].[GeographyKey]=[Geography].[GeographyKey]
WHERE
           [Customer].[CustomerKey] IN
        (11096, 11989, ...[74 total values, not all displayed]) VAND
           [Geography].[StateProvinceCode] IN
        ('VIC', 'BC', ...[21 total values, not all displayed]);
```

Query Running: Step 1

This query is identical to the second one computed during optimization and will hit the cache

```
SELECT
    [Geography].[StateProvinceCode]
FROM [Internet Sales]
          LEFT OUTER JOIN [Customer]
         ON [Internet Sales].[CustomerKey] = [Customer].[CustomerKey]
          LEFT OUTER JOIN [Geography]
         ON [Customer].[GeographyKey] = [Geography].[GeographyKey]
WHERE
          [Customer].[CustomerKey] IN
      (11096, 11989, 17005, 22513, 28899, 15054,
       19626, 20344, 25918, 27141...
      [74 total values, not all displayed]);
```

Simple Query Plan

- 4 VertiPaq Queries
  - 2 before execution
  - 2 during execution
    - 1 performed GROUPBY and SUM in VertiPaq
    - 1 hit the cache
- Intermediate results are cached
- Final JOIN performed by Formula Engine
- This is a very good query plan

Other useful info in the Profiler

- There are other useful info
  - CPU Time
  - Duration
  - Event Subclass
- CPU Time >= Duration
  - Many cores run in parallel
  - Only during VertiPaq scans
  - Formula Engine is still single-threaded

Understanding cache usage is one of the key of optimization

THE VERTIPAQ CACHE

What is cached?

- Results of VertiPaq SE Queries are cached
- Nothing else
- Thus, result of FE calculation is not cached
- For MDX queries, the MDX cache is available too, resulting in better cache options

Clear the Cache

Always remember to clear the cache prior to execute any performance test, otherwise numbers will be contaminated. That said, check cache usage too, when optimizing a measure. It is important!

```
<Batch xmlns="http://schemas.microsoft.com/analysisservices/2003/engine">
   <ClearCache>
      <Object>
         <DatabaseID>Adventure Works DW Tabular</DatabaseID>
      </Object>
   </ClearCache>
</Batch>
```

Does SUMX Really Iterate?

This SUMX is resolved inside VertiPaq because it is a simple operation that VertiPaq know how to handle. No iteration happens here.

```
EVALUATE
    ROW (
        "Sum",
        SUMX(
            'Internet Sales',
            'Internet Sales'[Sales Amount] / 'Internet Sales'[Order Quantity] )
    )
```

```
SELECT
    SUM( [Internet Sales].[SalesAmount] / [Internet Sales].[OrderQuantity] )
FROM
    [Internet Sales];
```

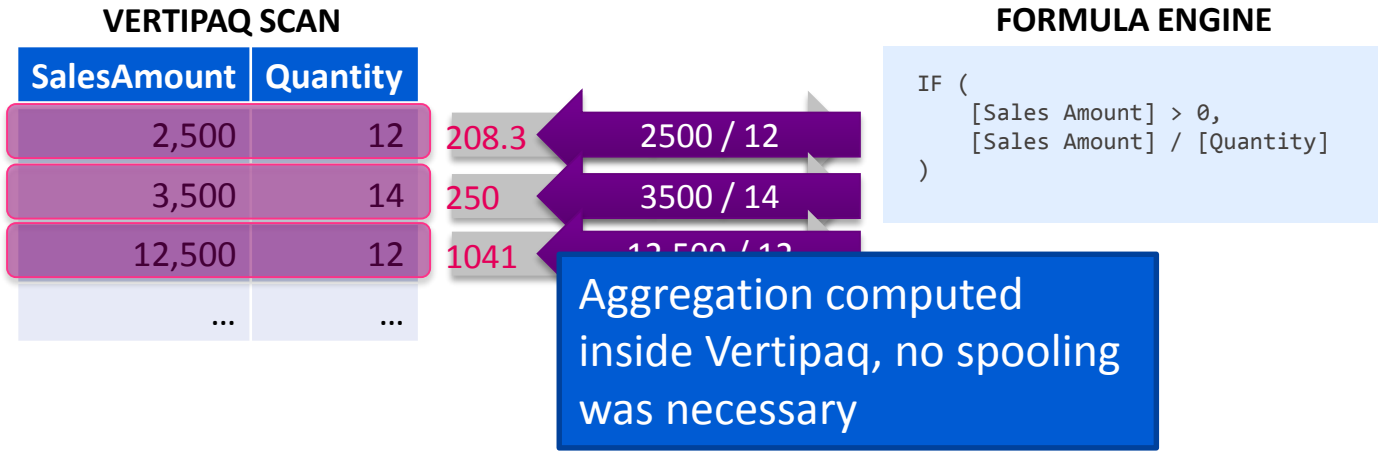
A Story of CallBackDataID

If the expression is too complex, CallbackDataID appears, meaning a call back to formula engine during the VertiPaq scan.

```
EVALUATE
    ROW (
        "Sum",
        SUMX (
            'Internet Sales',
            IF (
                'Internet Sales'[Sales Amount] > 0,
                'Internet Sales'[Sales Amount] / 'Internet Sales'[Order Quantity]
            )
        )
    )
```

```
SELECT
    SUM(
        [CallbackDataID(
            IF (
                'Internet Sales'[Sales Amount] > 0,
                'Internet Sales'[Sales Amount] / 'Internet Sales'[Order Quantity]]
            )
        )]
        (
            PFDATAID( [Internet Sales].[OrderQuantity] ),
            PFDATAID( [Internet Sales].[SalesAmount] )
        )
    )
FROM [Internet Sales];
```

CallBackDataID in Action

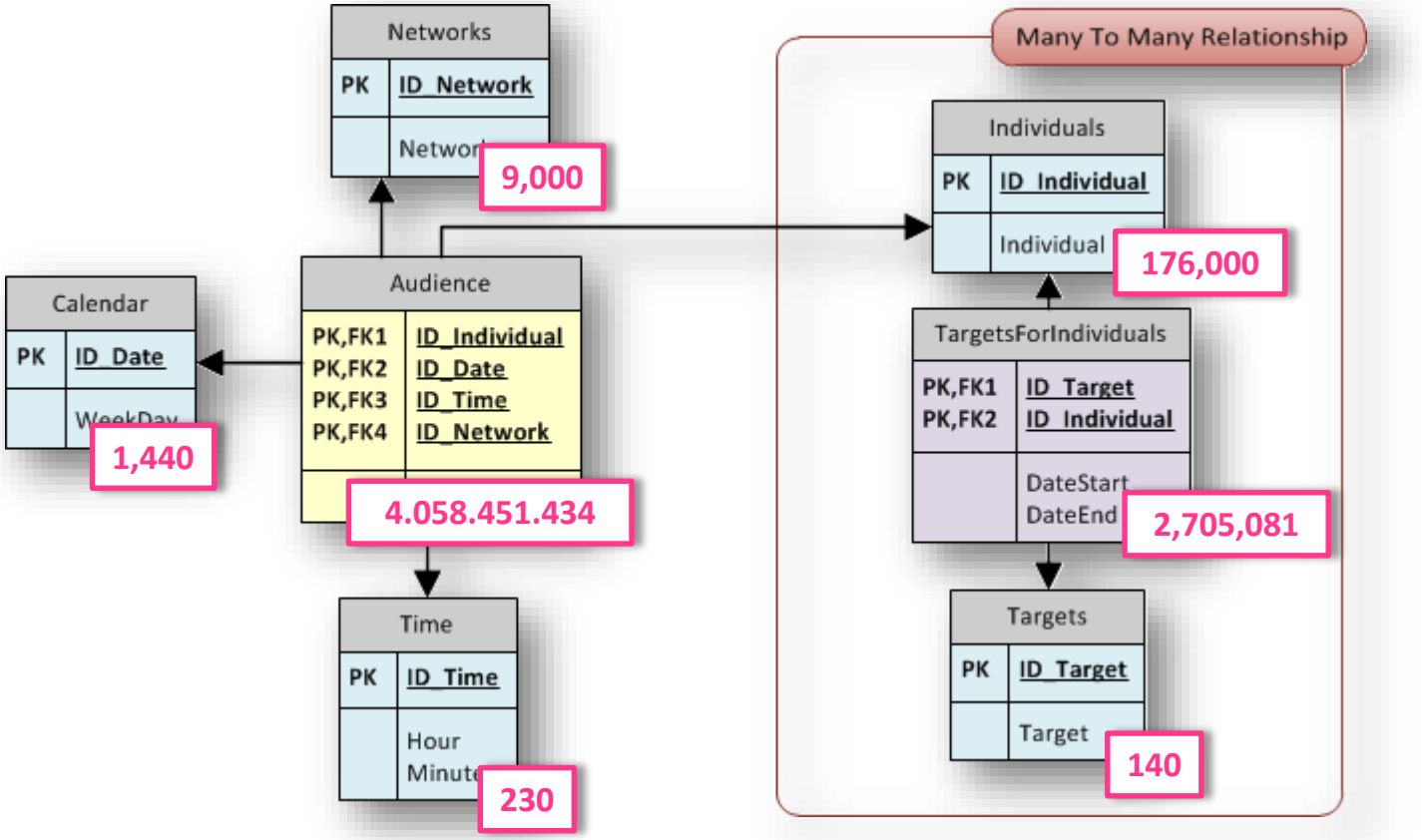



```
SELECT
    SUM(
        [CallbackDataID(
            IF (
                'Internet Sales'[Sales Amount]] > 0,
                'Internet Sales'[Sales Amount]] / 'Internet Sales'[Order Quantity]]
            )
        )]
        (
            PFDATAID( [Internet Sales].[OrderQuantity] ),
            PFDATAID( [Internet Sales].[SalesAmount] )
        )
    )
FROM [Internet Sales];
```

CallBackDataID Performance

- Slower than pure Vertipaq
- Faster than pure Formula Engine
  - Highly parallelized
  - Works on compressed data
- Not cached

The Test Data Model



Why SUMMARIZE is slower than ADDCOLUMNS?

SUMMARIZE VS ADDCOLUMNS

Many ways to SUMMARIZE

- Best practice:
  - Use ADDCOLUMNS instead of SUMMARIZE
- Why?
  - Let us use the profiler to understand it
  - And get a sense out of the statement

Some other best practices…

OTHER OPTIMIZATION TECHNIQUES

Currency Conversion

Two SUMX are converted to two iterations

```
[FirstCurrencyAmount] :=

SUMX(
    DimCurrency,
    SUMX(
        DimDate,
        CALCULATE(
            VALUES( CurrencyRate[AverageRate] )
             * SUM( FactInternetSales[SalesAmount] )
        )
    )
)
```

Currency Conversion

Simple SUMX over CrossJoin is resolved as a single VertiPaq scan with CallbackDataID to compute the multiplication.

```
[SecondCurrencyAmount] :=

SUMX(
    CROSSJOIN(
        DimCurrency,
        DimDate
    ),
    CALCULATE(
       VALUES( CurrencyRate[AverageRate] )
         * SUM( FactInternetSales[SalesAmount] )
    )
)
```

Filter as Soon as You Can

This query computes YTD and QTD inside a loop and then removes empty values.

```
DEFINE
    MEASURE 'Internet Sales'[Sales] =
        CALCULATE( ROUND( SUM( 'Internet Sales'[Sales Amount] ), 0 ) )
    MEASURE 'Internet Sales'[YTD Sales] =
        TOTALYTD( [Sales] , 'Date'[Date] )
    MEASURE 'Internet Sales'[QTD Sales] =
        TOTALQTD( [Sales] , 'Date'[Date] )
EVALUATE

FILTER(
    ADDCOLUMNS(
        CROSSJOIN(
            VALUES( 'Date'[Calendar Year] ),
            VALUES( 'Date'[Month] ),
            VALUES( 'Date'[Month Name] )
        ),
        "Sales", [Sales],
        "YTD Sales", [YTD Sales],
        "QTD Sales", [QTD Sales]
    ),
    NOT ISBLANK( [Sales] )
)
ORDER BY 'Date'[Calendar Year], 'Date'[Month]
```

Filter as Soon as You Can

This second query removes empty rows before computing expensive measures. It runs 7 times faster even if it computes [Sales] twice.

```
DEFINE
    MEASURE 'Internet Sales'[Sales] =
        CALCULATE( ROUND( SUM( 'Internet Sales'[Sales Amount] ), 0 ) )
    MEASURE 'Internet Sales'[YTD Sales] =
        TOTALYTD( [Sales] , 'Date'[Date] )
    MEASURE 'Internet Sales'[QTD Sales] =
        TOTALQTD( [Sales] , 'Date'[Date] )
EVALUATE

ADDCOLUMNS(
    FILTER(
        CROSSJOIN(
            VALUES( 'Date'[Calendar Year] ),
            VALUES( 'Date'[Month] ),
            VALUES( 'Date'[Month Name] )
        ),
        NOT ISBLANK( [Sales] )
    ),
    "Sales", [Sales],
    "YTD Sales", [YTD Sales],
    "QTD Sales", [QTD Sales]
)
ORDER BY 'Date'[Calendar Year], 'Date'[Month]
```

Conclusions

- DAX is not easy to optimize
  - Otherwise, it would be boring…
- Query plans make it possible to optimize
- Learn the difference between FE and SE
- **Test, test, test**!
- Never trust simple rules, including mine ☺

THANK YOU!

- For attending this session and
  PASS SQLRally Nordic 2013, Stockholm