# A Brief MDX Tutorial Using Mondrian

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# [Pentaho].[Mondrian]

Pentaho: Open source business intelligence suite

- Mondrian - Open Source OLAP Server
- JFreeReport - Open Source Reporting
- Kettle - Open Source Data Integration (ETL)
- Pentaho - Comprehensive Open Source BI Suite
- Weka - Open Source Data Mining

Mondrian

- an OLAP server written in Java
- It implements the MDX language, and the XML for Analysis (XMLA) and JOLAP specifications.
- It reads from SQL and other data sources, and aggregates data in a memory cache.

# Installation

- Installation (the embedded version):
  - Download Mondrian-embedded version and Tomcat
  - Follow the instructions in `install.html`
- Start tomcat (run the `startup.bat`)
- Browse `http://localhost:8080/mondrian-embedded/`

# Motivation

- Every input/output in SQL must be relation

```
SELECT Store.state, SUM(sales)
FROM F, Store, Time
WHERE F.storekey=Store.storekey AND F.timekey=Time.timekey
GROUP BY Store.state
```

```
 CA | 111,111
 IL | 222,222
```

```
SELECT Store.state, Time.quarter, SUM(sales)
FROM F, Store, Time
WHERE F.storekey=Store.storekey AND F.timekey=Time.timekey
GROUP BY Store.state, Time.quarter
```

```
 CA | Q1 | 44,444
 CA | Q2 | 11,111
 ...| ...| ...
 IL | Q4 | 88,888
```

- Typical reporting/analytical applications requires cross-tab

```
    | Q1 | Q2 | Q3 | Q4 |
 CA | ...| ...| ...| ...|
 IL | ...| ...| ...| ...|
```

# Pivot and Unpivot

- SQL can produce cross tab via the CASE construct

```
SELECT Store.state AS STATE,
  SUM(CASE WHEN Time.quarter='Q1' THEN sales END) AS Q1
  ... ... ...
  SUM(CASE WHEN Time.quarter='Q4' THEN sales END) AS Q4
FROM F, Store, Time
WHERE F.storekey=Store.storekey AND F.timekey=Time.timekey
GROUP BY Store.state
```

- PIVOT has been proposed to help.
- MDX can support these types of queries more natually and more efficiently.

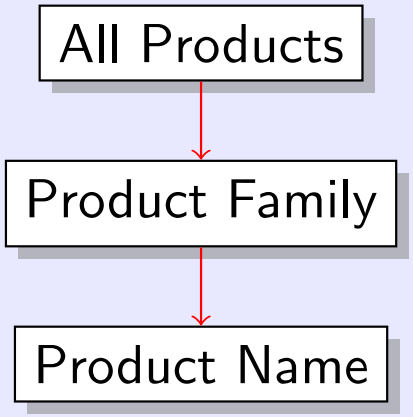
```
SELECT {[Time].[Year].[1997].CHILDREN} ON COLUMNS,
       {[Store].[Store State].MEMBERS} ON ROWS
FROM [Sales]
WHERE ([Measures].[Store Sales])
```

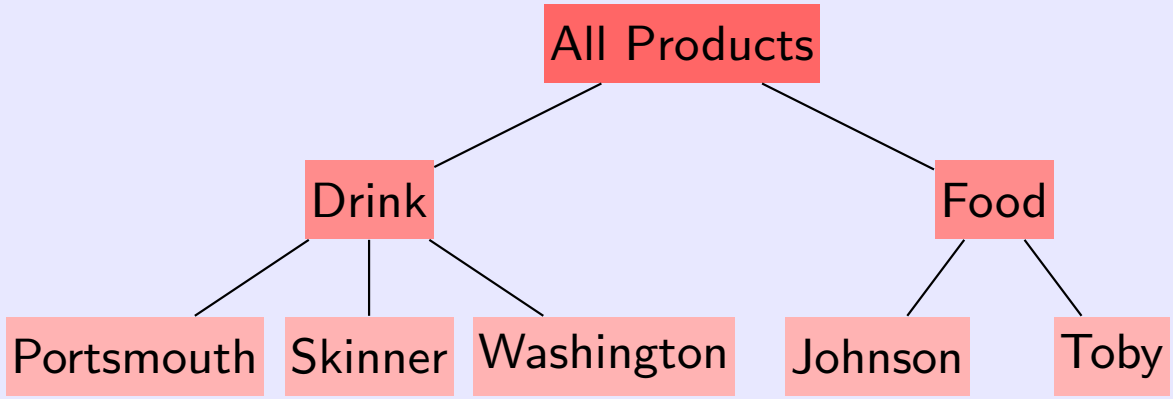
- Who speaks MDX?
  - MS SQL Server 200? Analysis Service (SSAS), Essbase (now owned by Oracle), Mondrian, etc.

# Basic Concepts

- Dimensions and Members
  - A dimension may have several levels
  - Each level has a number of members
- Axes
  - Refers to the "dimensions" of a query's result cube
  - An axis could contain several cube dimensions in combination
- Measures
  - Attributes (of numerical values) to be aggregated and analyzed.
  - They collectively forms the `Measures` dimension.
- Default member: the top-level member (usu. `ALL`)
- Default measure: the first measure specified in the cube
- One can specify the default members/measures or disallow the `ALL` level in the schema
- Tuple
  - to define a slice of data from a cube
  - `([Product].[Product Family].[Drink], [Store].[USA].[CA])`
- Set
  - an ordered collection of zero, one or more tuples
  - usually used to define axis and slicer dimensions
  - `{[Time].[2007].[Q1], [Time].[2007].[Q2] }`

# Example




the `Product` dimension

Members of the `Product` dimension

Return a sets of members:

- `[Product].[Product Family].[Skinner]`
- `[Product].[Product Name].MEMBERS` = { Portsmouth, Skinner, Washington, Johnson, Toby }
- `[Product].[Drink].CHILDREN` = { Portsmouth, Skinner, Washington }
- `[Product].[Drink].[Skinner]:[Washington]` = { Skinner,Washington }
- `DESCENDANTS([Product].[Food], [Product Name])` = { Johnson,Toby }

# FoodMart

- The [Sales] cube
  - Measures: [Unit Sales], [Store Cost], [Store Sales], [Sales Count], [Customer Count], [Promotion Sales].

```
SELECT {[Measures].Members} ON COLUMNS
FROM [Sales]
```

  - Calculated measures: [Profit], [Profit last Period], [Gewinn-Wachstum].

```
SELECT {AddCalculatedMembers([Measures].Members)}
        ON COLUMNS
FROM [Sales]
```

  - Dimensions:
    - [Store]: [Store Country] → [Store State] → [Store City] → [Store Name]
    - [Time]: [Year] → [Quarter] → [Month]
    - ...

## Example

Use Mondrian's workbench to open ./demo/FoodMart.xml.

# MDX is not SQL

## Basic Syntax

```
-- One of the three ways to write comments
SELECT {set 0} on COLUMNS, /* block comment */
        {set 1} on ROWS // line comment
        ...
        {set n} on AXIS(n)
FROM [cube]
WHERE (tuple) // called "slicer dimension"
```

## Note

- No axis or the `WHERE` statement can share any of the same dimensions
- JPivot cannot display results with $> 2$ dimensions

## Key differences between MDX and SQL

- "Cube in, Cube out" for MDX.
- set notation needs to be used after `SELECT`.
- `FROM` clause can name only one cube
- The `WHERE` clause describes the slicer axis (i.e., all the axes that is not a query axis) and is filtered by its default members.

# Example

- A typical query

```
SELECT {[Time].[Year].[1997], [Time].[Year].[1998]} ON COLUMNS,
       {[Store].[Store Name].MEMBERS} ON ROWS
FROM [Sales]
WHERE ([Measures].[Store Sales])
```

- Using the `level.MEMBERS` and `member.CHILDREN` functions

```
SELECT {[Time].[Year].[1997].CHILDREN} ON COLUMNS,
       {[Store].[Store City].MEMBERS} ON ROWS
FROM [Sales]
WHERE ([Measures].[Store Sales])
```

## Output

| | 1997 | 1998 |
|---|---|---|
| **HQ** | ? | ? |
| **Store 6** | ? | ? |
| **Store 7** | ? | ? |
| **...** | ? | ? |

| | Q1 | Q2 | Q3 | Q4 |
|---|---|---|---|---|
| **HQ** | ? | ? | ? | ? |
| **Store 6** | ? | ? | ? | ? |
| **Store 7** | ? | ? | ? | ? |
| **...** | ? | ? | ? | ? |

# Slicer Dimension vs. Filter

- Slicer Dimension

  ➥ *slice on the [Product] dimension*

```
SELECT {[Time].[Year].[1997].CHILDREN} ON COLUMNS,
       {[Store].[Store City].MEMBERS} ON ROWS
FROM [Sales]
WHERE ([Product].[Product Family].[Drink],
        [Measures].[Store Sales])
```

- FILTER(set, search_condition) function.

  ➥ *if we are only interested in stores whose 1997 unit sales exceed 1000*

```
SELECT {[Time].[Year].[1997].CHILDREN} ON COLUMNS,
     FILTER(
       {[Store].[Store City].MEMBERS},
       (Measures.[Unit Sales], [Time].[1997]) > 1000
           ) ON ROWS
FROM [Sales]
WHERE ([Measures].[Store Sales])
```

# ORDER

- Syntax: `ORDER(set, expression, [, ASC | DESC | BASC | BDESC]`
- The "B" prefix indicates the hierarchical order can be broken.

➥ *List all measures for each city in decreasing order of their sales count*

```
SELECT Measures.MEMBERS ON COLUMNS,
    ORDER(
       [Store].[Store City].MEMBERS,
       Measures.[Sales Count], BDESC
         ) ON ROWS
FROM [Sales]
```

➥ *if we are only interested in stores whose name is between "Beverly Hills" and "Spokane"*

```
SELECT Measures.MEMBERS ON COLUMNS,
     ORDER(
       {[Store].[Store City].[Beverly Hills]:[Spoken]},
       [Store].CURRENTMEMBER.Name, BASC
           ) ON ROWS
FROM [Sales]
```

# HEAD and TOPCOUNT

➥ *show me the profit of top-5 cities in terms of sales count*

```
SELECT Measures.[Profit] ON COLUMNS,
       HEAD( ORDER( {[Store].[Store City].MEMBERS},
                    Measures.[Sales Count], BDESC
                  ), 5
           ) ON ROWS
FROM [Sales]
```

| | [Measures].[Profit] |
|---|---|
| [Store].[All Stores].[USA].[OR].[Salem] | $52,394.72 |
| [Store].[All Stores].[USA].[WA].[Tacoma] | $44,884.68 |
| [Store].[All Stores].[USA].[OR].[Portland] | $33,109.85 |
| [Store].[All Stores].[USA].[CA].[Los Angeles] | $32,773.74 |
| [Store].[All Stores].[USA].[CA].[San Diego] | $32,717.61 |

# CROSSJOIN

- Q: all the results so far are 2-dimensional, what about 3D?
- `CROSS JOIN(set1, set2)`

```
SELECT [Time].[1997].CHILDREN ON COLUMNS,
     CROSSJOIN( [Store].[Store State].MEMBERS,
                [Product].[Product Family].MEMBERS
              ) ON ROWS
FROM [Sales]
WHERE (Measures.[Profit])
```

- The query axis (`ROWS`) is the combination of 2 cube dimensions.

# NON EMPTY

- Problem with the previous query: many members in the ROW axis is empty, hence many empty rows.
- It needs a simple filtering — removing empty memebers from the axis.

```
SELECT [Time].[1997].CHILDREN ON COLUMNS,
   NON EMPTY(
     CROSSJOIN( [Store].[Store State].MEMBERS,
                [Product].[Product Family].MEMBERS
              )
            ) ON ROWS
FROM [Sales]
WHERE (Measures.[Profit])
```

# [Advanced MDX].[Calculate Member]

- Calculated Members

```
WITH MEMBER parent.name AS 'expression'
```

- only visible to the query.

```
WITH MEMBER [Time].[1997].[H1] AS
       '[Time].[1997].[Q1] + [Time].[1997].[Q2]'
     MEMBER [Time].[1997].[H2] AS
       '[Time].[1997].[Q3] + [Time].[1997].[Q4]'
SELECT {[Time].[1997].[H1], [Time].[1997].[H2]} ON COLUMNS
       [Store].[Store Name].MEMBERS ON ROWS
FROM [Sales]
WHERE (Measures.[Profit])
```

# [Advanced MDX].[Calculated Members]

- Define and use new measures

```
WITH MEMBER Measures.ProfitPercent AS
       '(Measures.[Store Sales] - Measures.[Store Cost]) /
        (Measures.[Store Cost])'
SELECT [Time].[1997].CHILDREN ON COLUMNS,
       [Store].[Store Name].MEMBERS ON ROWS
FROM [Sales]
WHERE (Measures.[ProfitPercent])
```

➥ *SOLVE_ORDER is important. For those who are interested, see http://msdn2.microsoft.com/en-us/library/ms145539.aspx*

# Architecture of OLAP Servers

| Layer | Description |
|---|---|
| Client | presentation tools (e.g., pivot table), reporting tools, XMLA client applications |
| OLAP Server | parse MDX queries and perform query processing and optimization |
| Storage | Relational or Multidimensional Data Warehouse |

- Mondrian
  - JPivot, JRubik
  - Query rewriting, Caching (roll-up, chunk-based), Materialized view (aggregate table).
  - Relational DBMS as the storage engine (i.e., transform MDX queries into SQL queries)

For those interested to read more:

➥ *Check out tables in `MondrianFoodMart.mdb`, `FoodMart.xml`, `Mondrian 2.2.2 Technical Guide.pdf`*

➥ *Check out LucidDB `http://www.luciddb.org/features.html`, which is specifically built for DW and OLAP*

# References

- MDX Reference @ MSDN:
  http://msdn2.microsoft.com/en-us/library/ms145506.aspx
- The Baker's Dozen: 13 Tips for Querying OLAP Databases with MDX:
  http://www.devx.com/codemag/Article/37460/1954?pf=true
- Tutorial: Introduction to Multidimensional Expression (MDX).
  http://www.fing.edu.uy/inco/grupos/csi/esp/Cursos/cursos_act/2005/DAP_SistDW/Material/2-SDW-Laboratorio1-2005.pdf
- MDX resources: http://www.mosha.com/msolap/mdx.htm