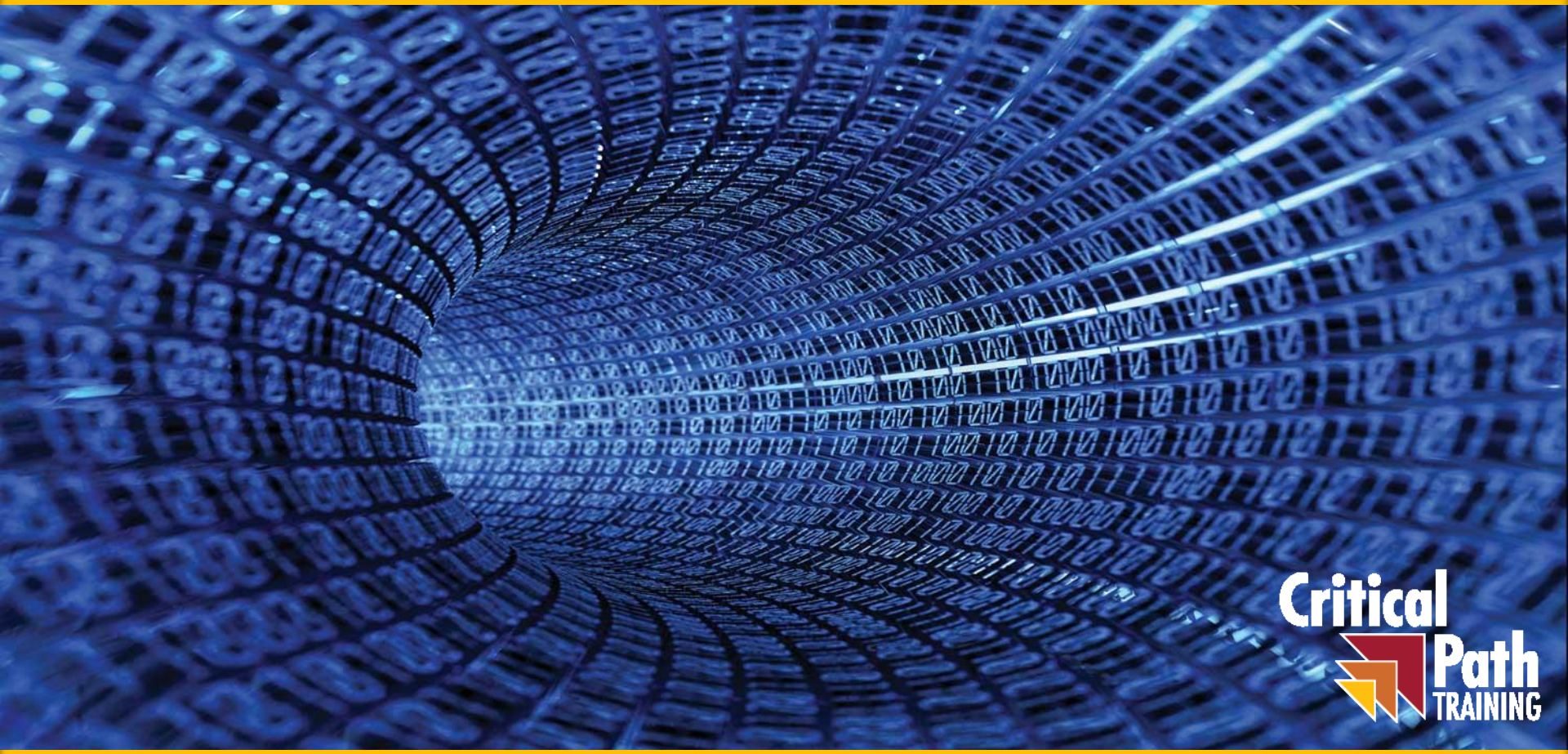
Designing a Data Model with Power BI Desktop



Agenda

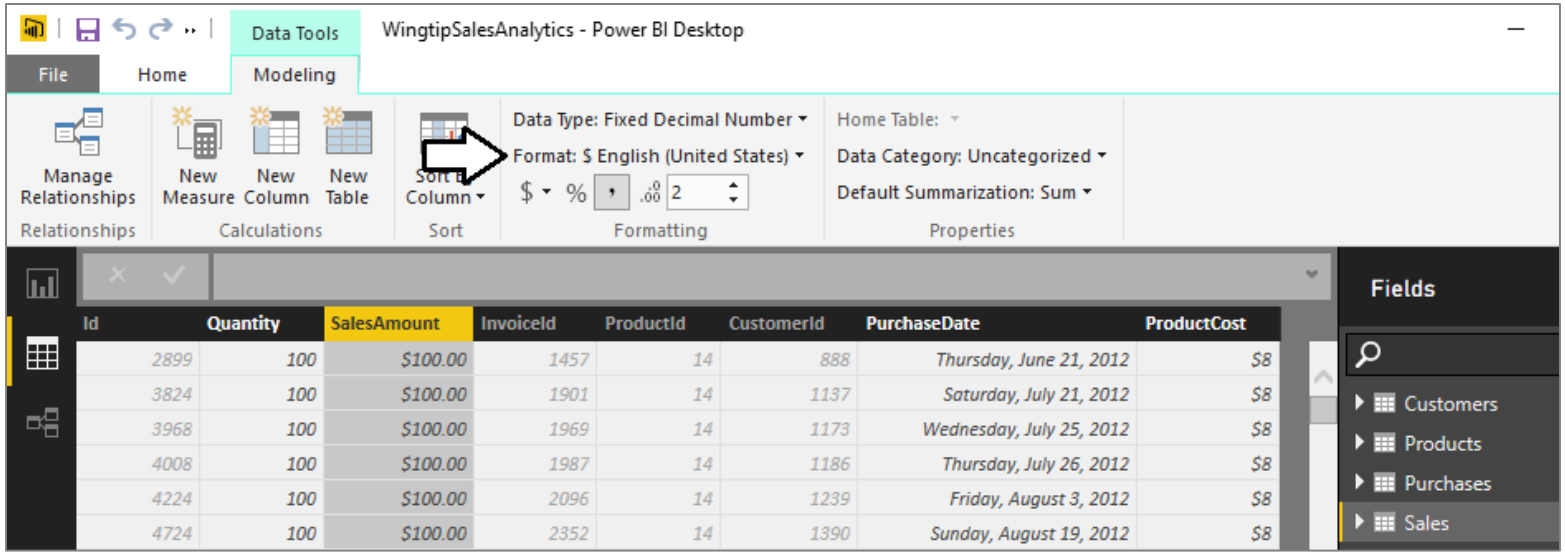
- Data Modeling Fundamentals
- Creating Table Relationships
- Using the DAX Calculate Function
- Calendar Tables and Time Intelligence
- Advanced Design Techniques

Data Modeling with Power BI Desktop

- Steps to create a data model with Power Pivot
  - Create relationships between tables
  - Modify native columns (e.g. set formatting and data category)
  - Create calculated columns
  - Create measures
  - Create dimensional hierarchies
  - Add Calendar table(s)

Formatting Columns

- Each column has its own formatting properties
  - Formatting propagated to reports and visuals
  - Makes it easier on data model consumers



Id	Quantity	SalesAmount	InvoiceId	ProductId	CustomerId	PurchaseDate	ProductCost
2899	100	$100.00	1457	14	888	Thursday, June 21, 2012	$8
3824	100	$100.00	1901	14	1137	Saturday, July 21, 2012	$8
3968	100	$100.00	1969	14	1173	Wednesday, July 25, 2012	$8
4008	100	$100.00	1987	14	1186	Thursday, July 26, 2012	$8
4224	100	$100.00	2096	14	1239	Friday, August 3, 2012	$8
4724	100	$100.00	2352	14	1390	Sunday, August 19, 2012	$8

Working with DAX

- DAX is the language used to create data models
  - DAX stands for "**D**ata **A**nalysis E**x**pression Language"
- DAX expressions are similar to Excel formulas
  - They always start with an equal sign (=)
  - DAX provides many built-in functions similar to Excel
- DAX Expressions are unlike Excel formulas…
  - DAX expressions cannot reference cells (e.g. A1 or C4)
  - Instead DAX expressions reference columns and tables

```
=SUM('Sales'[SalesAmount])
```

Calculated Columns vs Measures

- Calculated Columns (aka Columns)
  - Evaluated based on context of a single row
  - Evaluated when data is loaded into memory

```
Column1 = <DAX expression>
```

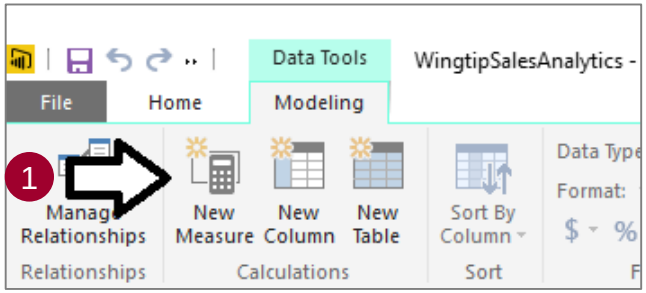
- Measures
  - Evaluated at query time based on current filter context
  - Commonly used for aggregations (e.g. SUM, AVG, etc.)
  - Used more frequently than calculated columns

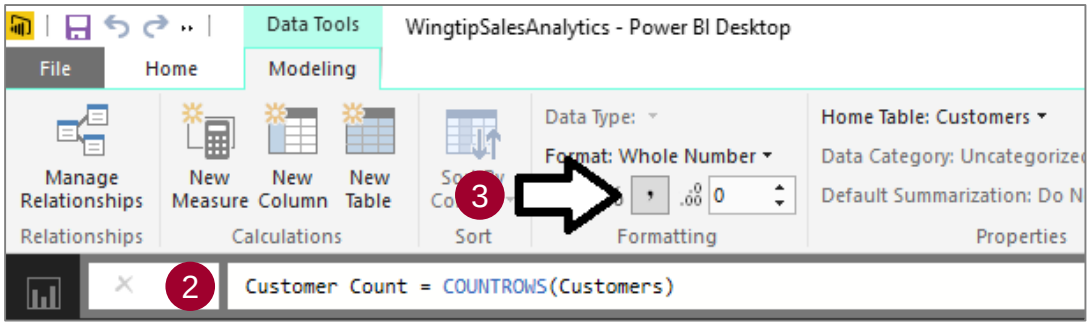
```
Measure1 = <DAX expression>
```

Creating Measures

- Measures have advantage over calculated columns
  - They are evaluated based on the current evaluation context

- Creating a measure with Power BI Desktop
  1. Click New Measure button
  2. Give measure a name and write DAX expressions
  3. Configure formatting





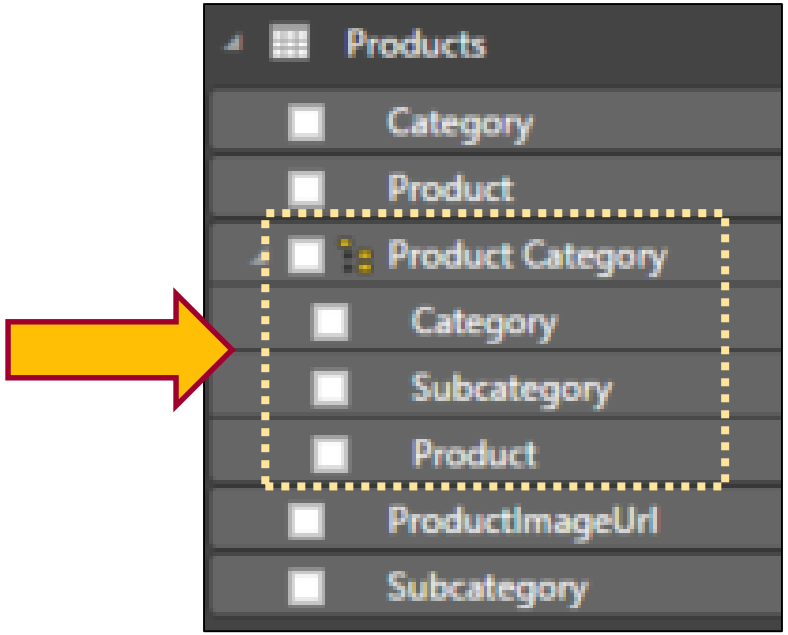
Creating Variables in DAX Expressions

- Variables can be added at start of expression
  - Use **VAR** keyword once for each variable
  - Use **RETURN** keyword to return expression value

```
Budget Key =
  VAR BudgetYear = YEAR([Date])
  VAR BudgetMonth = "Q" & FORMAT([Date],"q")
RETURN
  BudgetYear & "-" & BudgetMonth & "-" & [Category]
```

Dimensional Hierarchies

- Hierarchy created from two or more columns
  - All columns in hierarchy must be from the same table
  - Defines parent-child relationship between columns
  - Provides path to navigate through data
  - Provides path to drill down into greater level of detail

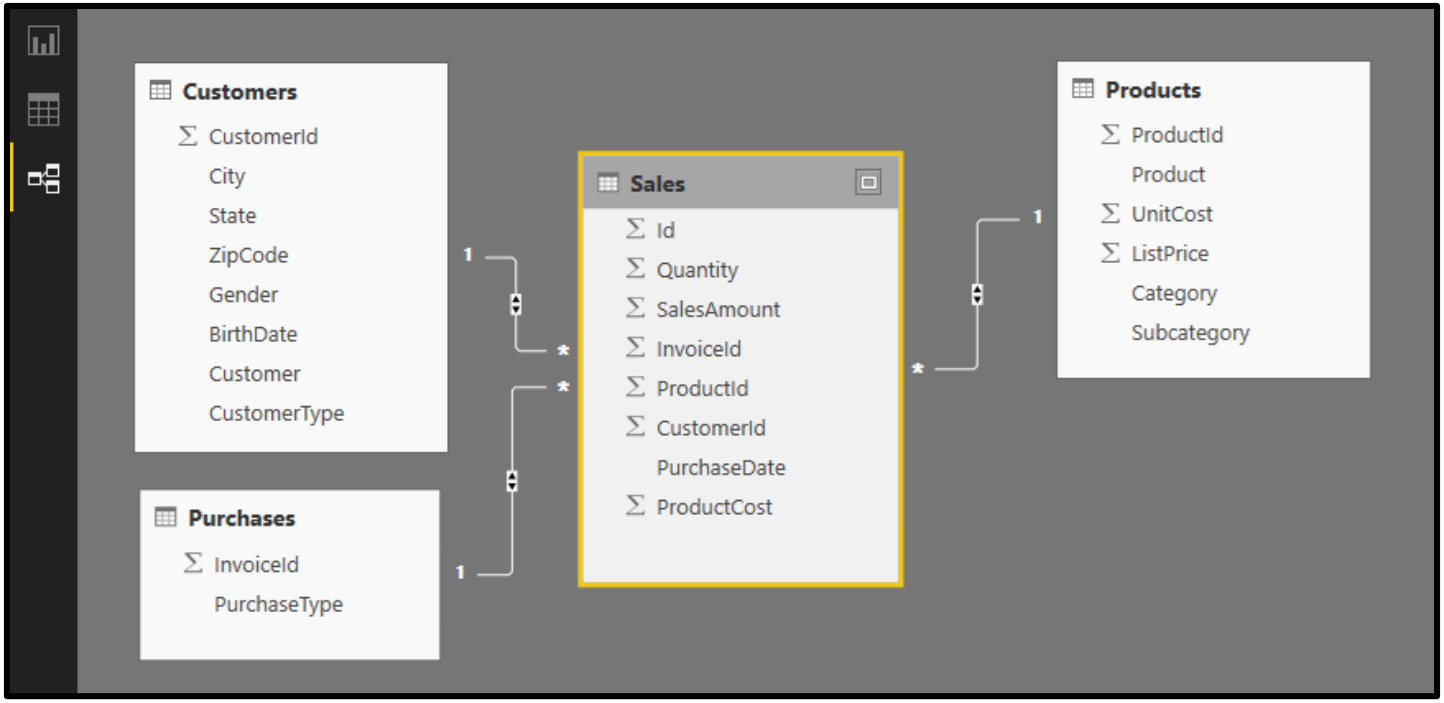


Agenda

- ✓ Data Modeling Fundamentals
- ➢ Creating Table Relationships
- Using the DAX Calculate Function
- Calendar Tables and Time Intelligence
- Advanced Design Techniques

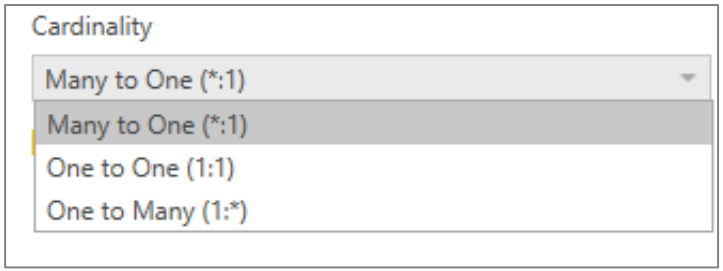
Table Relationships

- Tables in data model associated with relationships
  - Relationships based on single columns
  - Tabular model supports [1-to-1] and [1-to-many] relationships

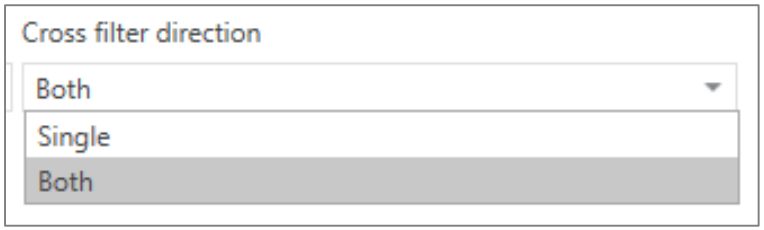


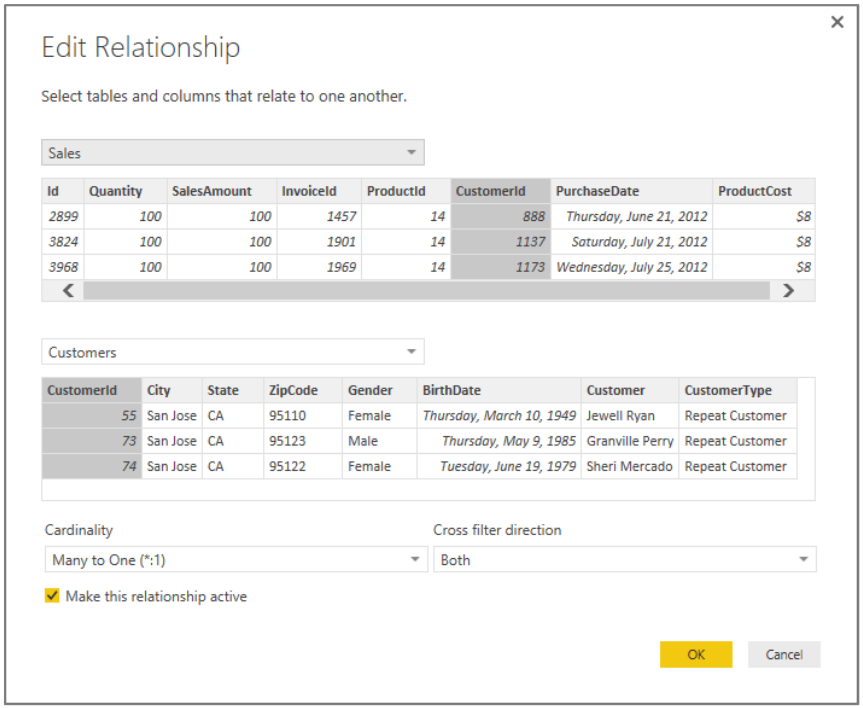
Relationship Properties

- Cardinality



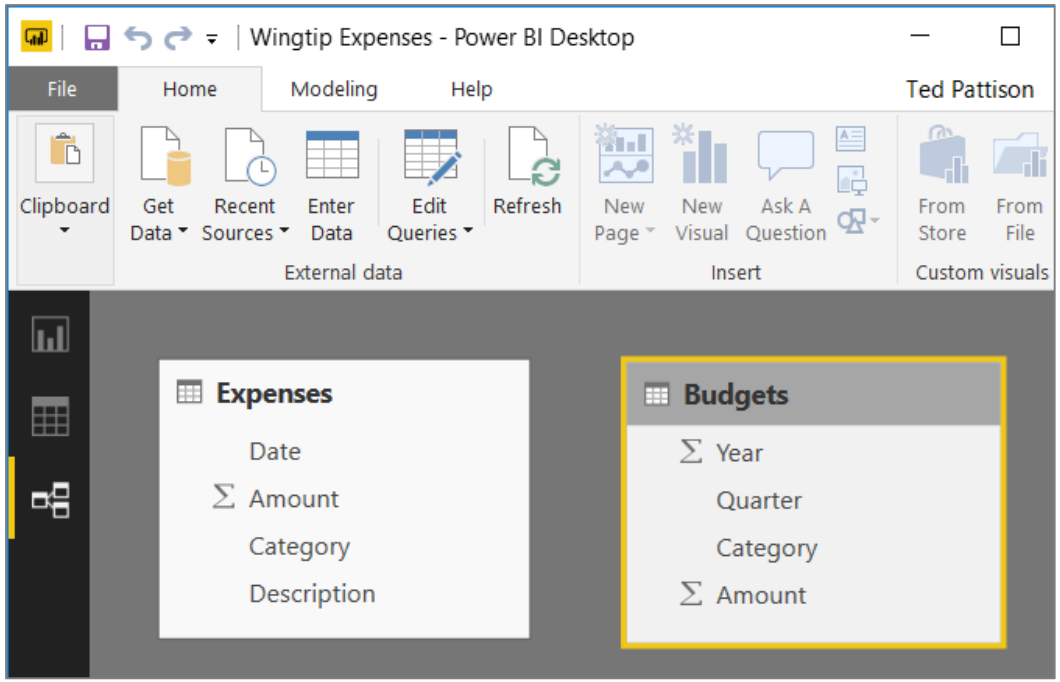
- Cross filter direction





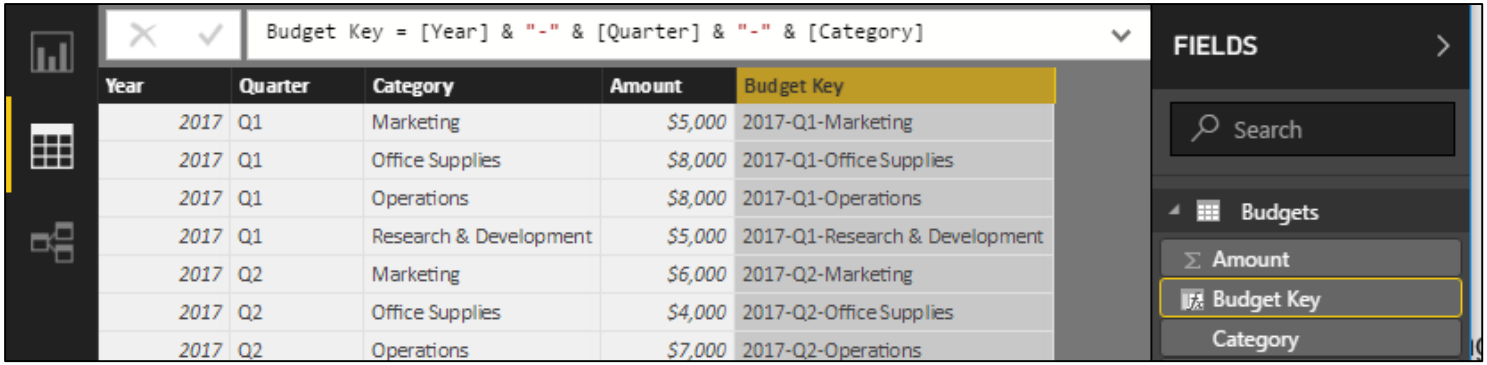
How Do You Create a Relationship Here?

- Two tables don't have fields to create relationship
  - The solution is to create two new calculated columns



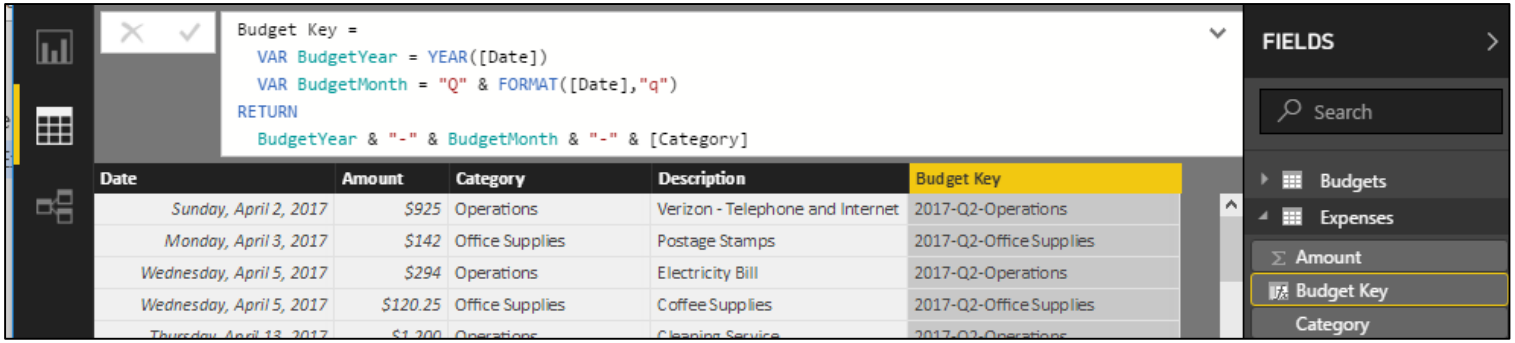
Creating Composite Key Fields

- Create composite key column in Budgets



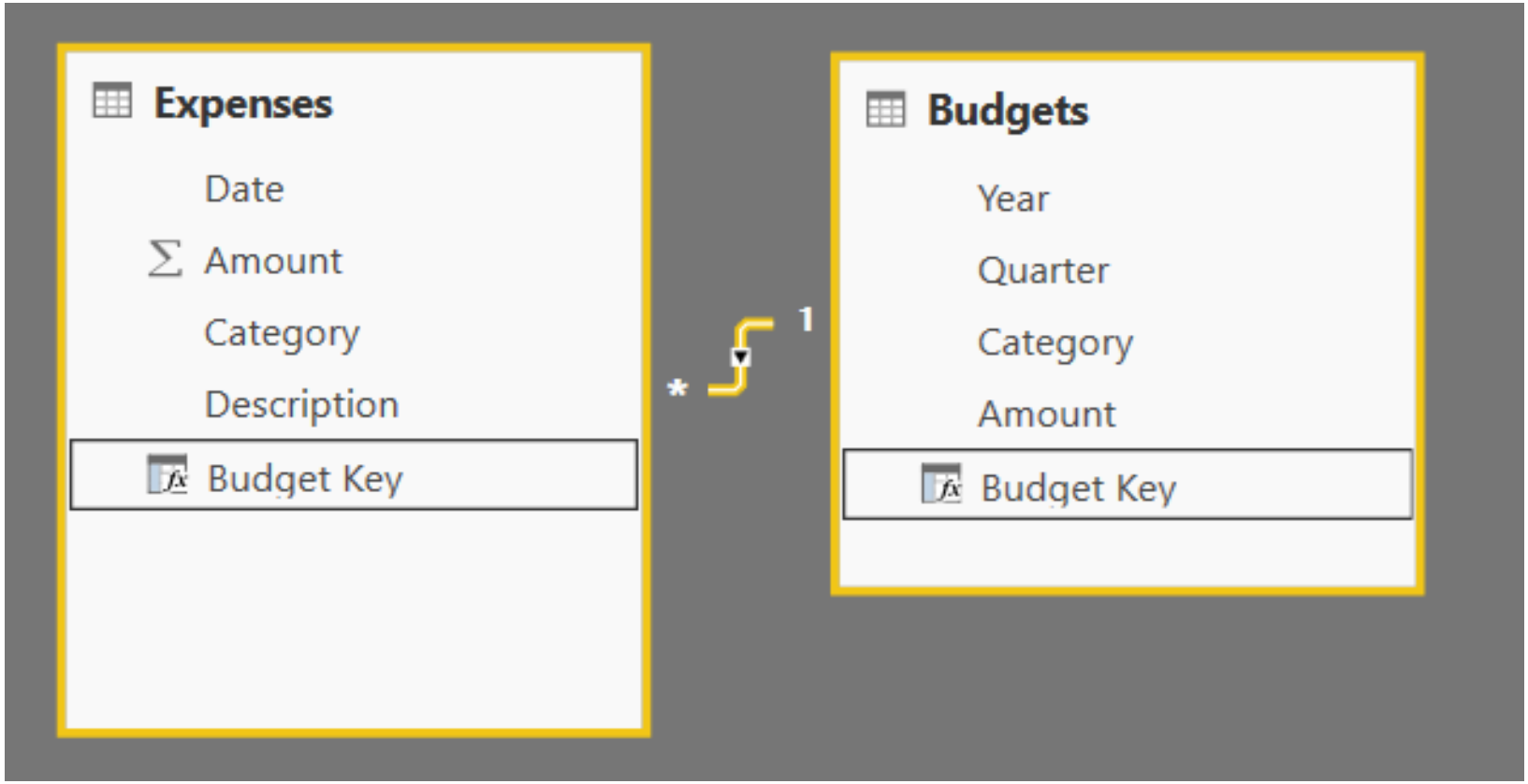
Year	Quarter	Category	Amount	Budget Key
2017	Q1	Marketing	$5,000	2017-Q1-Marketing
2017	Q1	Office Supplies	$8,000	2017-Q1-Office Supplies
2017	Q1	Operations	$8,000	2017-Q1-Operations
2017	Q1	Research & Development	$5,000	2017-Q1-Research & Development
2017	Q2	Marketing	$6,000	2017-Q2-Marketing
2017	Q2	Office Supplies	$4,000	2017-Q2-Office Supplies
2017	Q2	Operations	$7,000	2017-Q2-Operations

- Create composite key column in Expenses



Date	Amount	Category	Description	Budget Key
Sunday, April 2, 2017	$925	Operations	Verizon - Telephone and Internet	2017-Q2-Operations
Monday, April 3, 2017	$142	Office Supplies	Postage Stamps	2017-Q2-Office Supplies
Wednesday, April 5, 2017	$294	Operations	Electricity Bill	2017-Q2-Operations
Wednesday, April 5, 2017	$120.25	Office Supplies	Coffee Supplies	2017-Q2-Office Supplies
Thursday, April 13, 2017	$1,200	Operations	Cleaning Service	2017-Q2-Operations

Create Relationship Using Composite Keys



Agenda

- ✓ Data Modeling Fundamentals
- ✓ Creating Table Relationships
- ➢ Using the DAX Calculate Function
- Calendar Tables and Time Intelligence
- Advanced Design Techniques

A Tale of Two Evaluation Contexts

- Row Context
  - Context includes all columns in iteration of current row
  - Used to evaluate DAX expression in calculated column
  - Only available in measures with iterator function (e.g. SUMX)

- Filter Context
  - Context includes filter(s) defining current set of rows
  - Used by default to evaluate DAX expressions in measures
  - Can be fully ignored or partially ignored using DAX code
  - Not used to evaluate DAX in calculated columns

Understanding Row Context

- Row context used to evaluate calculated columns

```
City = [City Name] & ", " & [State]
```

	Age Group	Sales Region	State Name	SalesRegionSort	City
48	Ages 40 TO 49	Western Region	California	1	San Jose, CA
74	Ages 65 and over	Western Region	California	1	San Jose, CA
73	Ages 65 and over	Western Region	California	1	San Jose, CA
25	Ages 18 TO 23	Western Region	California	1	San Jose, CA
61	Ages 50 TO 65	Western Region	California	1	San Jose, CA
65	Ages 65 and over	Western Region	California	1	San Jose, CA

```
Age = Floor( (TODAY()-Customers[BirthDate])/365, 1)
```

Customer	Customer Type	Age	Age Group	Sales Region	State Name
Lucile Blake	One-time Customer	48	Ages 40 TO 49	Western Region	California
Rochelle Owen	One-time Customer	74	Ages 65 and over	Western Region	California
Corinne Finch	One-time Customer	73	Ages 65 and over	Western Region	California

Understanding Iterators Like SUMX

- Standard aggregation functions (e.g. SUM) have no row context
  - You can use SUM to sum values of a single column
  - You cannot use SUM to sum results of an expressions

```
Gross Margin = SUM( Sales[SalesAmount]-Sales[ProductCost] )
```

The SUM function only accepts a column reference as an argument.

- Iterator functions (e.g. SUMX) iterate through rows in target table

```
Gross Margin = SUMX(Sales, Sales[SalesAmount]-Sales[ProductCost] )
```

  - First argument accepts expressions that evaluates to table of rows
  - Second argument accepts expression that is evaluated for each row

Understanding Filter Context

- Visuals apply various filters in different evaluation contexts

Month in Year	2012	2013	2014	2015	Total
January	$6,306	$164,334	$385,275	$512,822	$1,068,737
February	$48,815	$126,501	$358,244	$597,684	$1,131,244
March	$53,958	$243,676	$381,309	$532,123	$1,211,067
April	$52,601	$300,872	$381,157	$602,751	$1,337,381
May	$61,756	$334,948	$438,261	$647,276	$1,482,241
June	$76,756	$321,715	$378,749	$608,448	$1,385,668
July	$104,408	$287,800	$359,744	$620,316	$1,372,268
August	$111,167	$298,483	$457,312	$678,499	$1,545,461
September	$110,716	$376,207	$505,332	$613,974	$1,606,229
October	$145,999	$362,943	$602,448	$620,735	$1,732,125
November	$156,751	$340,228	$545,572	$590,220	$1,632,770
December	$147,593	$331,526	$581,977	$686,814	$1,747,910
Total	**$1,076,826**	**$3,489,234**	**$5,375,379**	**$7,311,660**	**$17,253,100**

Filters on this evaluation

[Year] = 2015

[Month in Year] = "October"

- Filter context also affected by slicers and other filters

Sales Region

- Select All
- Central Region
- Eastern Region
- Western Region

Customer Type

- One-time customer
- Repeat Customer

Month in Year	2012	2013	2014	2015	Total
January	$425	$50,169	$61,295	$76,614	$188,503
February	$13,891	$40,133	$63,670	$101,542	$219,236
March	$19,121	$58,411	$73,839	$84,180	$235,551
April	$19,128	$53,711	$67,919	$91,762	$232,520
May	$22,939	$64,259	$78,668	$109,689	$275,555
June	$29,082	$50,564	$73,504	$88,047	$241,197
July	$34,809	$62,971	$69,053	$80,749	$247,582
August	$36,096	$61,217	$76,009	$94,719	$268,041
September	$39,415	$68,653	$82,697	$94,805	$285,570
October	$51,994	$69,122	$99,344	$84,177	$304,637
November	$47,020	$52,548	$85,924	$74,611	$260,102
December	$50,580	$66,260	$102,088	$94,877	$313,804
Total	**$364,500**	**$698,018**	**$934,009**	**$1,075,771**	**$3,072,298**

Filters on this evaluation

[Year] = 2015

[Month in Year] = "October"

[Sales Region] = "Western Region"

[Customer Type] = "Repeat Customer"

Using the CALCULATE Function

- CALCULATE function provides greatest amount of control
  - First argument defines expression to evaluate
  - Second argument defines table on which to evaluate expression
  - You can evaluate expressions with or without current filter context

```
Pct of All Products =
DIVIDE(
    SUM( Sales[SalesAmount] ),
    CALCULATE(
        Sum (Sales[SalesAmount] ),
        ALL(Products[Category], Products[Subcategory], Products[Product])
    )
)
```

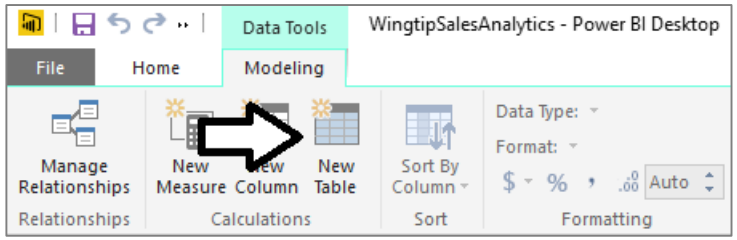
```
Pct of Product Category =
DIVIDE(
    SUM( Sales[SalesAmount] ),
    CALCULATE(
        Sum (Sales[SalesAmount] ),
        ALL( Products[Subcategory], Products[Product] )
    )
)
```

Agenda

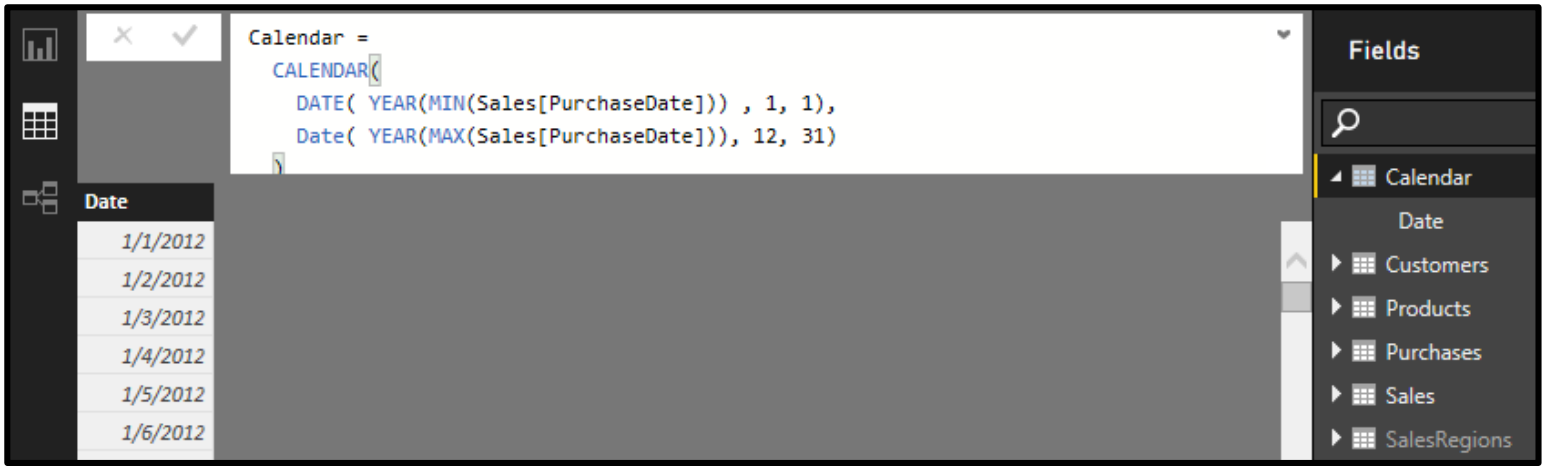
- ✓ Data Modeling Fundamentals
- ✓ Creating Table Relationships
- ✓ Using the DAX Calculate Function
- ➢ Calendar Tables and Time Intelligence
- • Advanced Design Techniques

Creating Calendar Table as Calculated Table

- Use **New Table** command in ribbon



- Create calendar table using DAX **CALENDAR** function



Adding Columns to Calendar Table

- Creating the **Year** column

```
Year = YEAR('Calendar'[Date])
```

Date	Year
1/1/2012	2012
1/2/2012	2012
1/3/2012	2012

- Creating the **Quarter** column

```
Quarter = YEAR('Calendar'[Date]) & "-Q" & FORMAT('Calendar'[Date], "q")
```

Date	Year	Quarter
01/01/2012	2012	2012-Q1
01/02/2012	2012	2012-Q1
01/03/2012	2012	2012-Q1
01/04/2012	2012	2012-Q1
01/05/2012	2012	2012-Q1

- Creating the **Month** column

```
Month = FORMAT('Calendar'[Date], "MMM yyyy")
```

Date	Year	Quarter	Month
1/1/2012	2012	2012-Q1	Jan 2012
1/2/2012	2012	2012-Q1	Jan 2012
1/3/2012	2012	2012-Q1	Jan 2012

Configuring Sort Columns

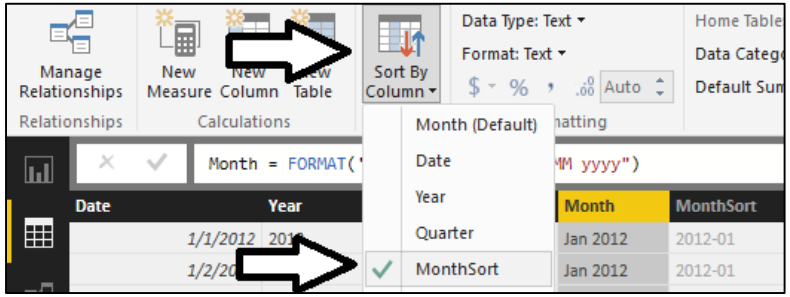
- Month column will not sort in desired fashion by default
  - For example, April will sort before January, February and March

- Creating a sort column for the **Month** column
  - **MonthSort** sorts alphabetically & chronologically at same time

```
MonthSort = FORMAT('Calendar'[Date], "yyyy-MM")
```

Date	Year	Quarter	Month	MonthSort
1/1/2012	2012	2012-Q1	Jan 2012	2012-01
1/2/2012	2012	2012-Q1	Jan 2012	2012-01

  - Configure **Month** column with **MonthSort** as sort column



Columns for Month in Year and Day in week

- Creating the **Month in Year** column

```
Month in Year = FORMAT('Calendar'[Date], "MMMM")
```

Date	Year	Quarter	Month	MonthSort	Month in Year
1/1/2012	2012	2012-Q1	Jan 2012	2012-01	January
1/2/2012	2012	2012-Q1	Jan 2012	2012-01	January

- Creating the **MonthInYearSort** column

```
MonthInYearSort = MONTH('Calendar'[Date])
```

Date	Year	Quarter	Month	MonthSort	Month in Year	MonthInYearSort
1/1/2012	2012	2012-Q1	Jan 2012	2012-01	January	1
1/2/2012	2012	2012-Q1	Jan 2012	2012-01	January	1

- Creating the **Day of Week** column

```
Day of Week = FORMAT('Calendar'[Date], "dddd")
```

Date	Year	Quarter	Month	MonthSort	Month in Year	MonthInYearSort	Day of Week
1/1/2012	2012	2012-Q1	Jan 2012	2012-01	January	1	Sunday
1/2/2012	2012	2012-Q1	Jan 2012	2012-01	January	1	Monday

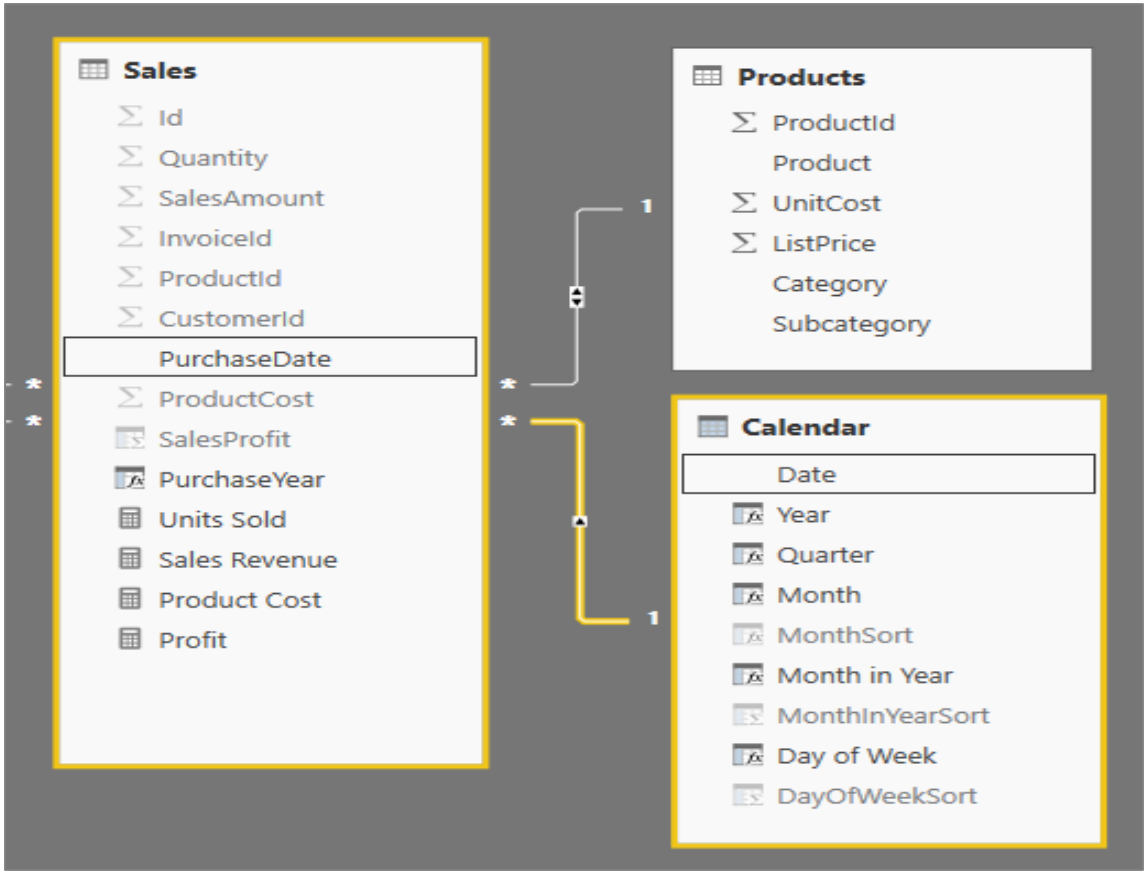
- Creating the **DayOfWeekSort** column

```
DayOfWeekSort = WEEKDAY('Calendar'[Date], 2)
```

Date	Year	Quarter	Month	MonthSort	Month in Year	MonthInYearSort	Day of Week	DayOfWeekSort
1/1/2012	2012	2012-Q1	Jan 2012	2012-01	January	1	Sunday	7
1/2/2012	2012	2012-Q1	Jan 2012	2012-01	January	1	Monday	1
1/3/2012	2012	2012-Q1	Jan 2012	2012-01	January	1	Tuesday	2
1/4/2012	2012	2012-Q1	Jan 2012	2012-01	January	1	Wednesday	3

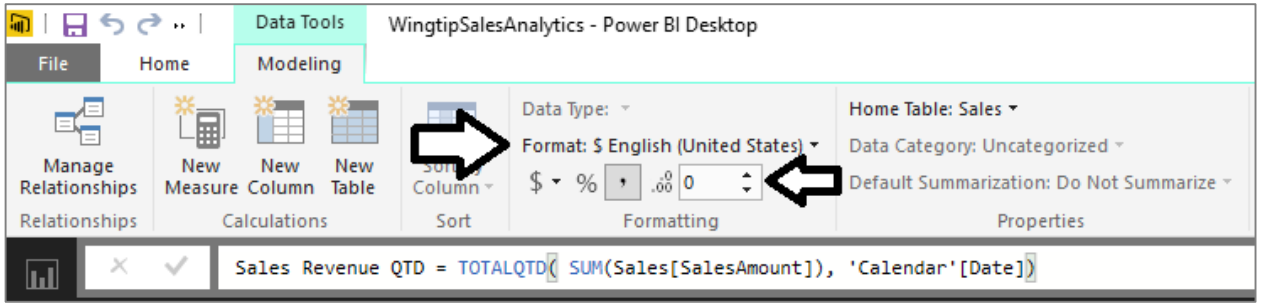
Integrating Calendar Table into Data Model

- Calendar table needs relationship to one or more tables

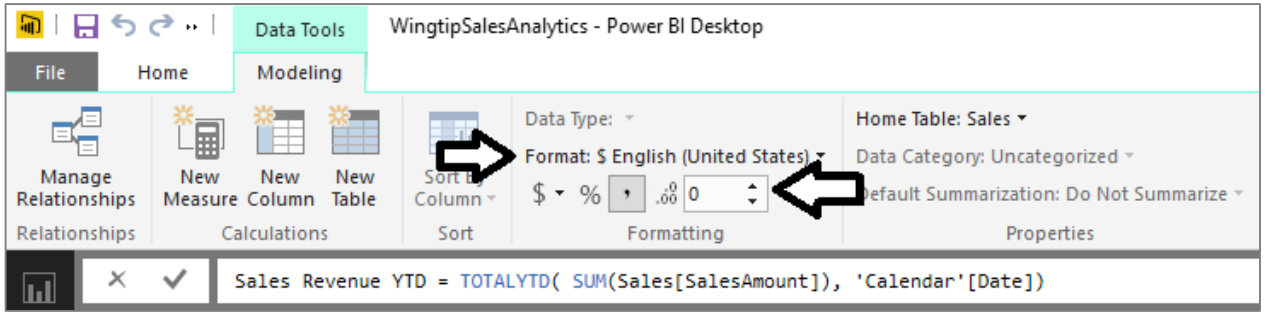


Calculated Fields for QTD and YTD Sales

- TOTALQTD function calculates quarter-to-date totals

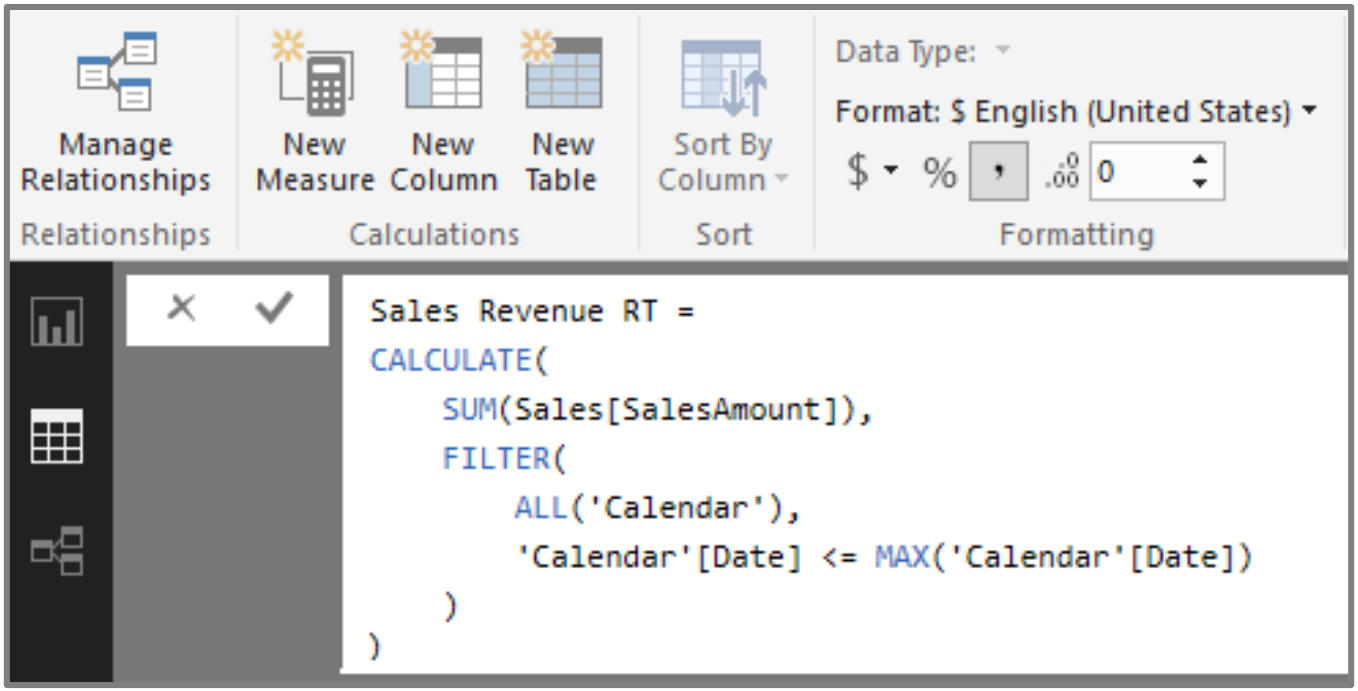


- TOTALYTD function calculates year-to-date totals



Creating Running Total using CALCULATE

- Calculate a running total of sales revenue across years
  - This must be done using **CALCULATE** function



Sales Growth PM Measure - First Attempt

- Create a measure named Sales Growth PM

```
Sales Growth PM =
DIVIDE(
  SUM(Sales[SalesAmount]) -
  CALCULATE(
    SUM(Sales[SalesAmount]),
    PREVIOUSMONTH(Calendar[Date])
  ),
  CALCULATE(
    SUM(Sales[SalesAmount]),
    PREVIOUSMONTH(Calendar[Date])
  )
)
```

- Use measure in matrix evaluating month and quarter
  - Measure returns correct value when filtered by Month
  - Measure returns large, erroneous value when filtered by Quarter

Year	Quarter	Month	Sales Revenue	Sales Growth PM
2014	2014-Q1	Jan 2014	$629,969	-18.13 %
		Feb 2014	$609,637	-3.23 %
		Mar 2014	$628,618	3.11 %
		Total	**$1,868,225**	**142.79 %**
	2014-Q2	Apr 2014	$661,588	5.24 %
		May 2014	$748,193	13.09 %
		Jun 2014	$814,333	8.84 %
		Total	**$2,224,114**	**253.81 %**
	2014-Q3	Jul 2014	$788,469	-3.18 %

Using the ISFILTERED Function

- ISFILTERED function used to determine when perform evaluation

```
Sales Growth PM =
IF(
  ( ISFILTERED(Calendar[Month]) && NOT(ISFILTERED(Calendar[Date])) ),
  DIVIDE(
    SUM(Sales[SalesAmount]) -
    CALCULATE(
      SUM(Sales[SalesAmount]),
      PREVIOUSMONTH(Calendar[Date])
    ),
    CALCULATE(
      SUM(Sales[SalesAmount]),
      PREVIOUSMONTH(Calendar[Date])
    )
  ),
  BLANK()
)
```

- Expression returns Blank value when evaluation context is invalid

Year	Quarter	Month	Sales Revenue	Sales Growth PM
2014	2014-Q1	Jan 2014	$629,969	-18.13 %
		Feb 2014	$609,637	-3.23 %
		Mar 2014	$628,618	3.11 %
		Total	**$1,868,225**	
	2014-Q2	Apr 2014	$661,588	5.24 %
		May 2014	$748,193	13.09 %
		Jun 2014	$814,333	8.84 %
		Total	**$2,224,114**	
	2014-Q3	Jul 2014	$788,469	-3.18 %
		Aug 2014	$869,143	10.23 %

Agenda

- ✓ Data Modeling Fundamentals
- ✓ Creating Table Relationships
- ✓ Using the DAX Calculate Function
- ✓ Calendar Tables and Time Intelligence
- ➢ Advanced Design Techniques

Creating Tables Dynamically using DAX

Bookmarks - Power BI Desktop

File | Home | Modeling | Help | Ted Pattison

Manage Relationships | New Measure | New Column | New Table | New Parameter | Sort by Column | Data type: | Format: | Auto | Home Table: | Data Category: Uncategorized | Default Summarization: Don't sum

Relationships | Calculations | What If | Sort | Formatting | Properties

```
Sales Regions =
DATATABLE (
    "State", STRING,
    "State Name", STRING,
    "Sales Region", STRING, {
 { "AK", "Alaska", "Western Region" },
 { "AL", "Alabama", "Central Region" },
 { "AR", "Arkansas", "Central Region" },
 { "AZ", "Arizona", "Western Region" },
 { "CA", "California", "Western Region" },
 { "CO", "Colorado", "Western Region" },
```

State	State Name	Sales Region
AK	Alaska	Western Region
AL	Alabama	Central Region
AR	Arkansas	Central Region
AZ	Arizona	Western Region
CA	California	Western Region

FIELDS

Search

- Sales
- Calendar
- Customers
- Products
- Purchases
- Sales Regions
  - Sales Region
  - State
  - State Name
- SalesRegionsSort

Working with UNICHAR Characters

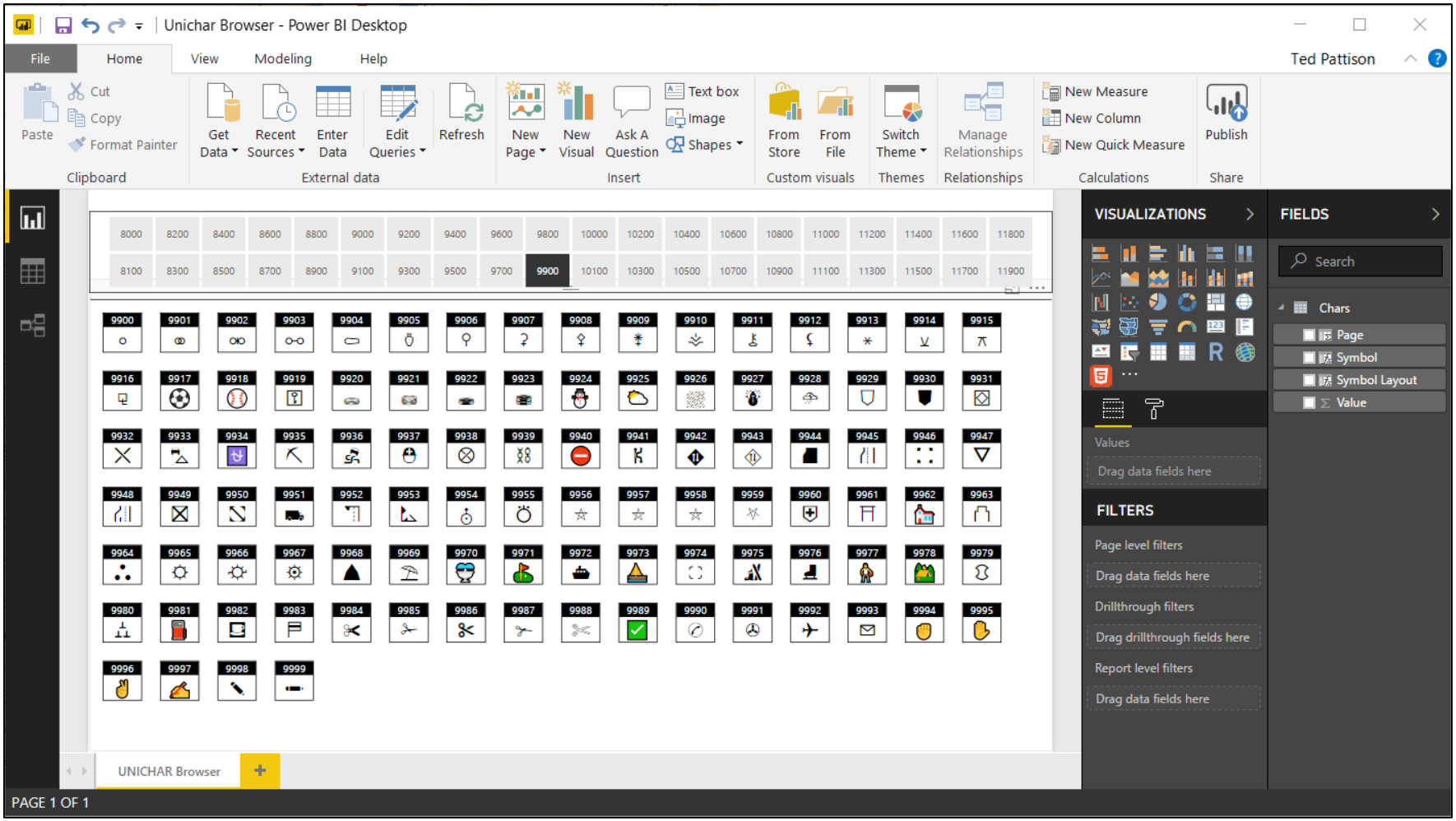
- Create a measure to return a single UNICHAR character
  - There are many different UNICHAR characters with symbols

```
Status =
IF(
    [Budget Used] > 1,
    UNICHAR(9940),
    UNICHAR(9989)
)
```

  - UNICHAR character symbols can be displayed in table or matrix

Year	Actual Expenses	Budget	Budget Used	Status
2017	**$85,073.74**	**$92,000**	**92.47%**	✅
Q1	**$20,788.42**	**$26,000**	**79.96%**	✅
Marketing Budget for Q1 of 2017	$3,780.77	$5,000	75.62%	✅
Office Supplies Budget for Q1 of 2017	$7,191.65	$8,000	89.90%	✅
Operations Budget for Q1 of 2017	$7,446.00	$8,000	93.08%	✅
Research & Development Budget for Q1 of 2017	$2,370.00	$5,000	47.40%	✅
Q2	**$18,283.31**	**$22,000**	**83.11%**	✅
Marketing Budget for Q2 of 2017	$5,769.46	$6,000	96.16%	✅
Office Supplies Budget for Q2 of 2017	$2,602.85	$4,000	65.07%	✅
Operations Budget for Q2 of 2017	$7,581.00	$7,000	108.30%	⛔

The UNICHAR Browser Demo



Summary

- ✓ Data Modeling Fundamentals
- ✓ Creating Table Relationships
- ✓ Using the DAX Calculate Function
- ✓ Calendar Tables and Time Intelligence
- ✓ Advanced Design Techniques