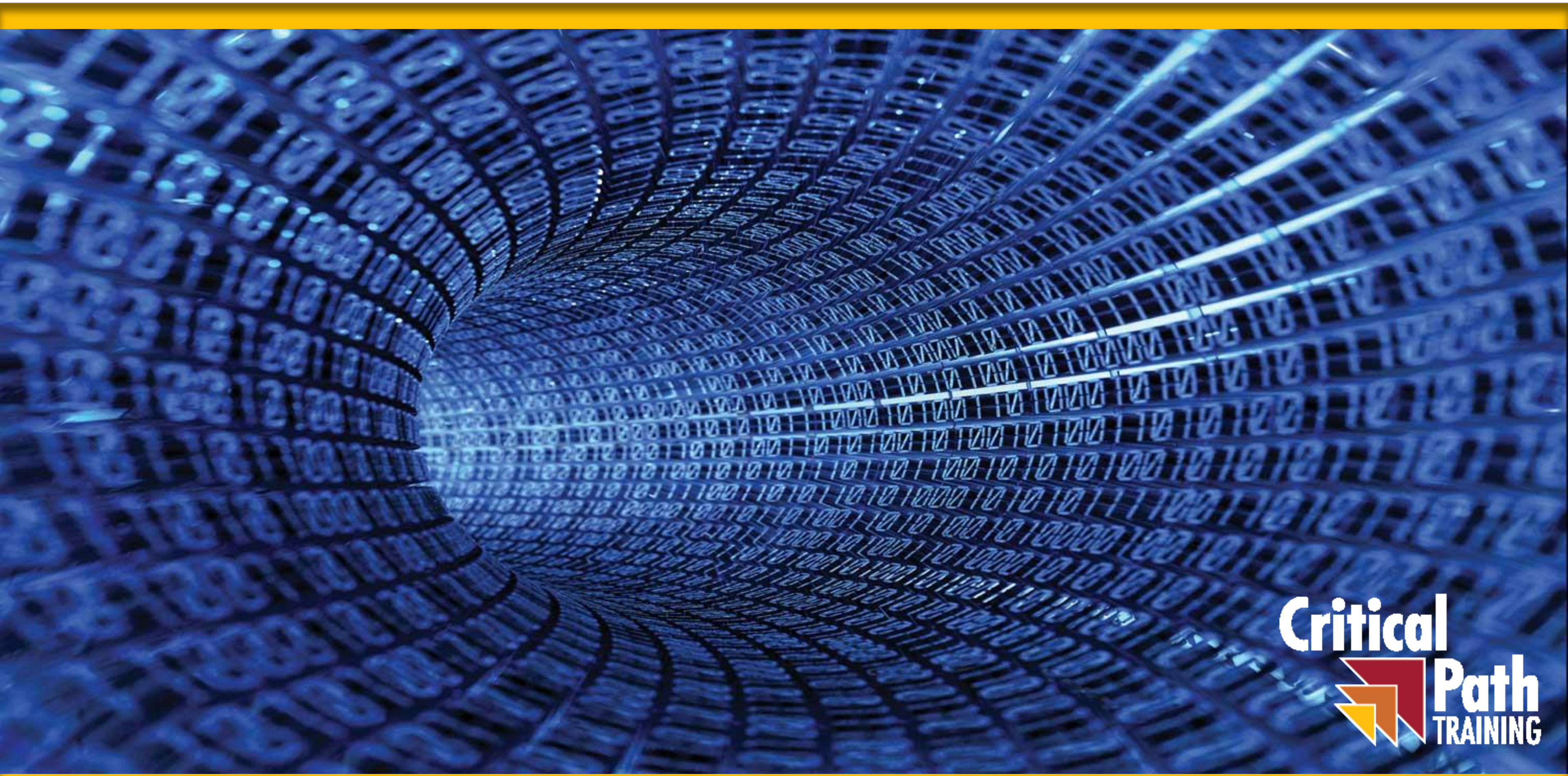
Designing a Data Model with Power BI Desktop



Critical Path TRAINING

Agenda

- Modeling Data in Power BI Desktop
- Understanding Table Relationships
- Writing DAX Expressions
- Creating Calculated Columns
- Creating Measures to Aggregate Data
- Adding Geographic Fields to a Data Model

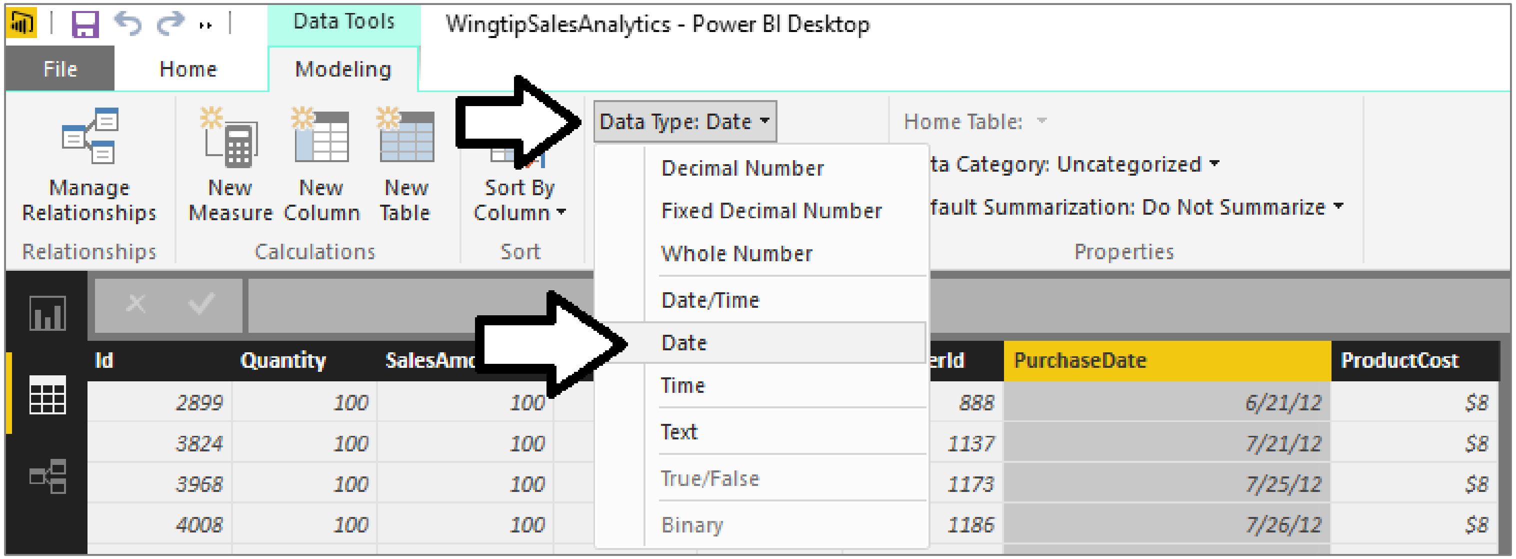
Data Modeling with Power BI Desktop

- Steps to create a data model with Power Pivot
  - Create relationships between tables
  - Modify columns (rename, set formatting, convert type)
  - Create calculated columns
  - Create measures
  - Add column metadata
  - Create dimensional hierarchies
  - Add Calendar table(s)

Covered in next module

Converting Column Types

- Power Pivot allows you to convert columns
  - Alternative to converting column with Power Query



Data Type: Date

Home Table:

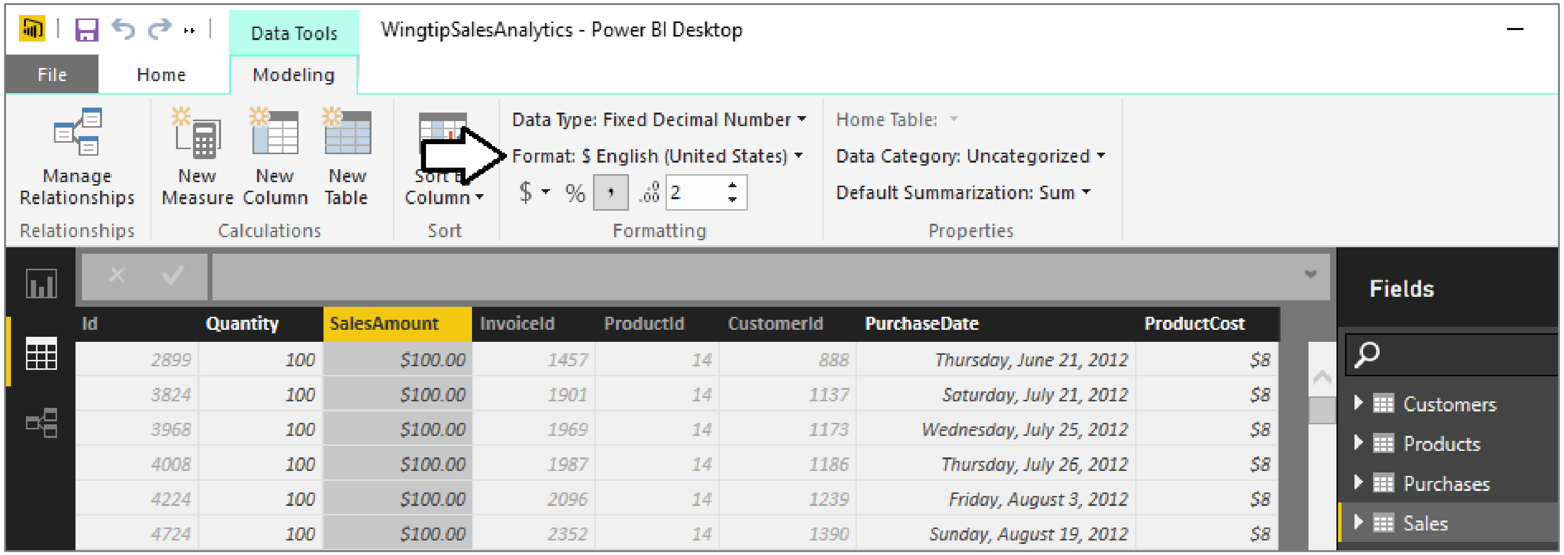
ta Category: Uncategorized

fault Summarization: Do Not Summarize

Id	Quantity	SalesAmc	erId	PurchaseDate	ProductCost
2899	100	100	888	6/21/12	$8
3824	100	100	1137	7/21/12	$8
3968	100	100	1173	7/25/12	$8
4008	100	100	1186	7/26/12	$8

Formatting Columns

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



Data Type: Fixed Decimal Number
Format: $ English (United States)
$ % , .00 2
Home Table:
Data Category: Uncategorized
Default Summarization: Sum

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

Agenda

- ✓ Modeling Data in Power BI Desktop
- ➢ Understanding Table Relationships
- Writing DAX Expressions
- Creating Calculated Columns
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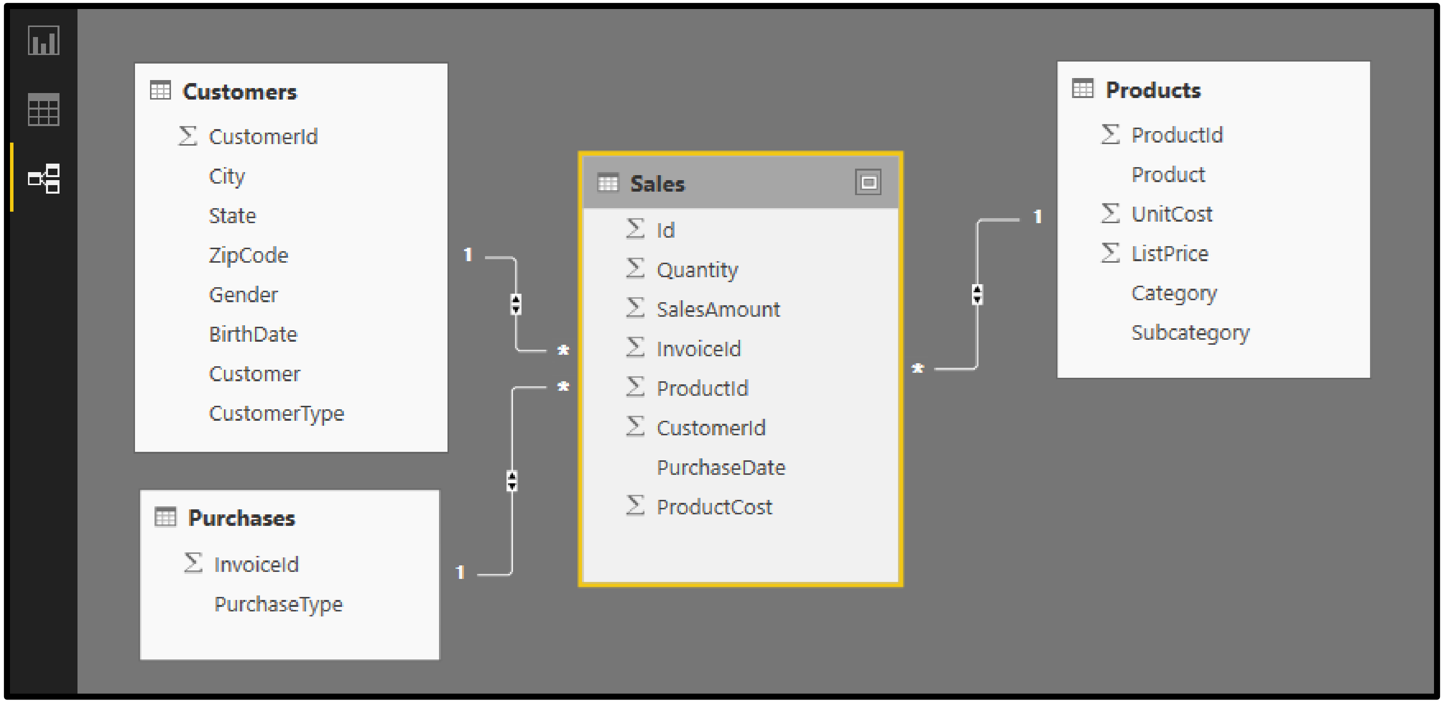
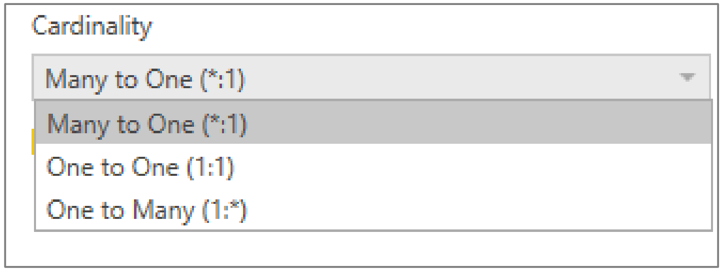
Table Relationships

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



Relationship Properties

- Cardinality



Cardinality

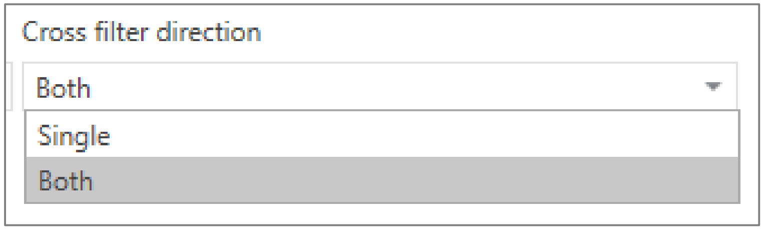
Many to One (*:1)

Many to One (*:1)

One to One (1:1)

One to Many (1:*)

- Cross filter direction

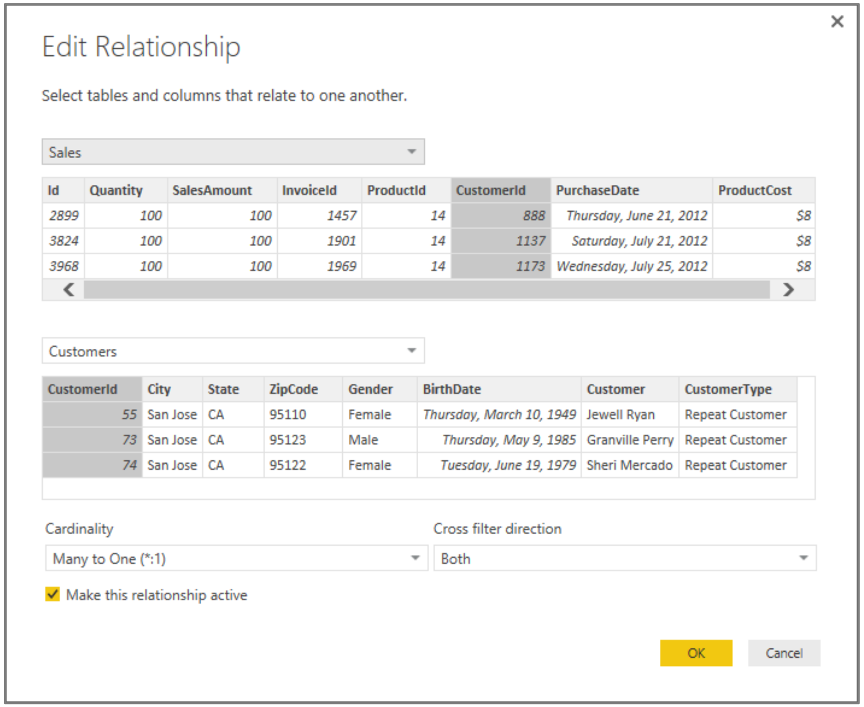


Cross filter direction

Both

Single

Both



Edit Relationship

Select tables and columns that relate to one another.

Sales

Id	Quantity	SalesAmount	InvoiceId	ProductId	CustomerId	PurchaseDate	ProductCost
2899	100	100	1457	14	888	Thursday, June 21, 2012	$8
3824	100	100	1901	14	1137	Saturday, July 21, 2012	$8
3968	100	100	1969	14	1173	Wednesday, July 25, 2012	$8

Customers

CustomerId	City	State	ZipCode	Gender	BirthDate	Customer	CustomerType
55	San Jose	CA	95110	Female	Thursday, March 10, 1949	Jewell Ryan	Repeat Customer
73	San Jose	CA	95123	Male	Thursday, May 9, 1985	Granville Perry	Repeat Customer
74	San Jose	CA	95122	Female	Tuesday, June 19, 1979	Sheri Mercado	Repeat Customer

Cardinality: Many to One (*:1)

Cross filter direction: Both

☑ Make this relationship active

Agenda

- ✓ Modeling Data in Power BI Desktop
- ✓ Understanding Table Relationships
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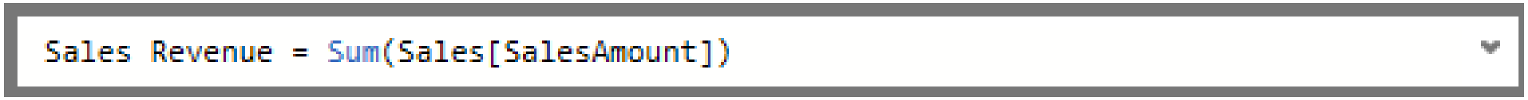
Working with DAX

- DAX is the language used to create data model
  - 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])
```

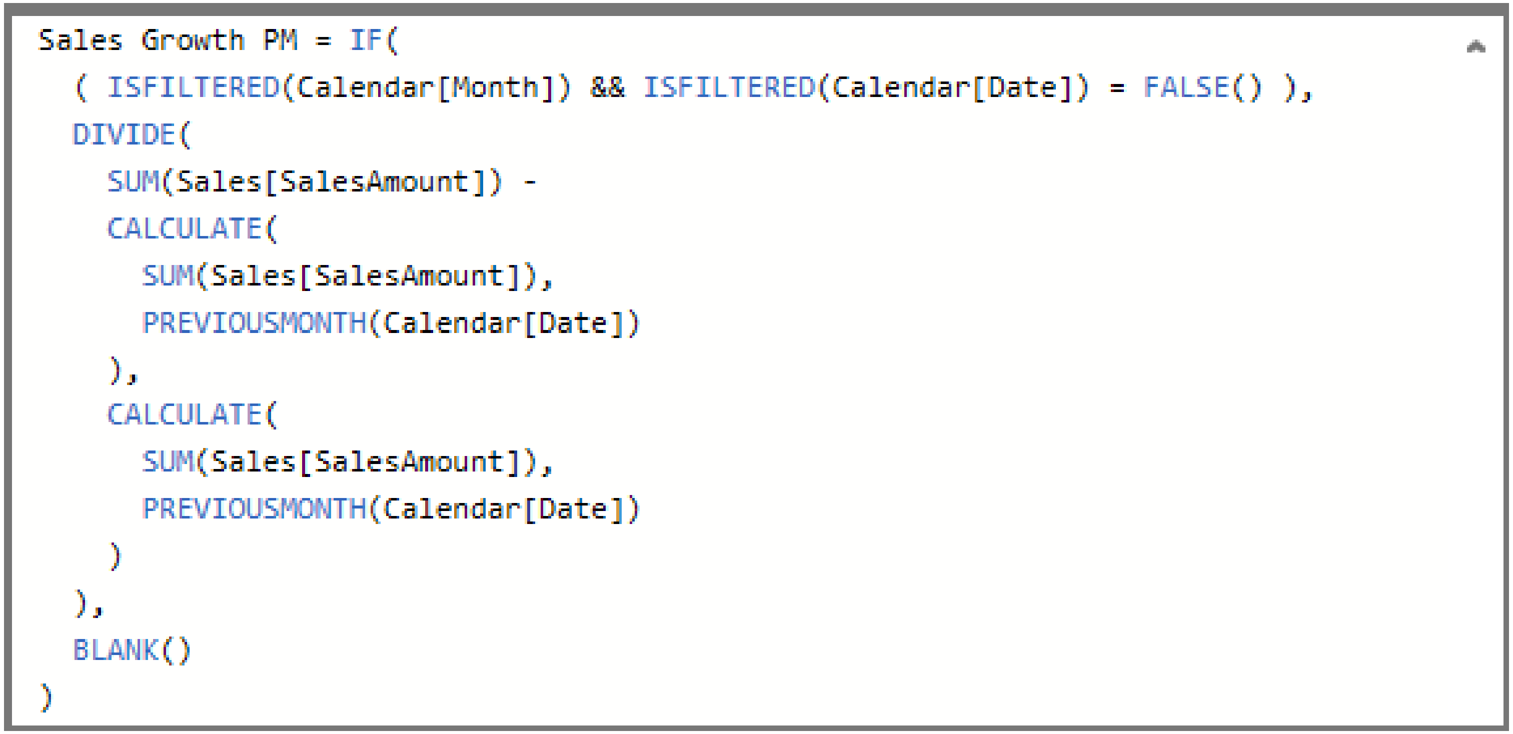
Writing DAX Expressions

- Some DAX expressions are simple



```
Sales Revenue = Sum(Sales[SalesAmount])
```

- Some DAX expressions are far more complex



```
Sales Growth PM = IF(
  ( ISFILTERED(Calendar[Month]) && ISFILTERED(Calendar[Date]) = FALSE() ),
  DIVIDE(
    SUM(Sales[SalesAmount]) -
    CALCULATE(
      SUM(Sales[SalesAmount]),
      PREVIOUSMONTH(Calendar[Date])
    ),
    CALCULATE(
      SUM(Sales[SalesAmount]),
      PREVIOUSMONTH(Calendar[Date])
    )
  ),
  BLANK()
)
```

Types of DAX Functions

- Date and Time Functions
- Information Functions
- Logical Functions
- Mathematical and Trigonometric Functions
- Statistical Functions
- Filter Functions
- Text Functions
- Time Intelligence Functions

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>
```

Agenda

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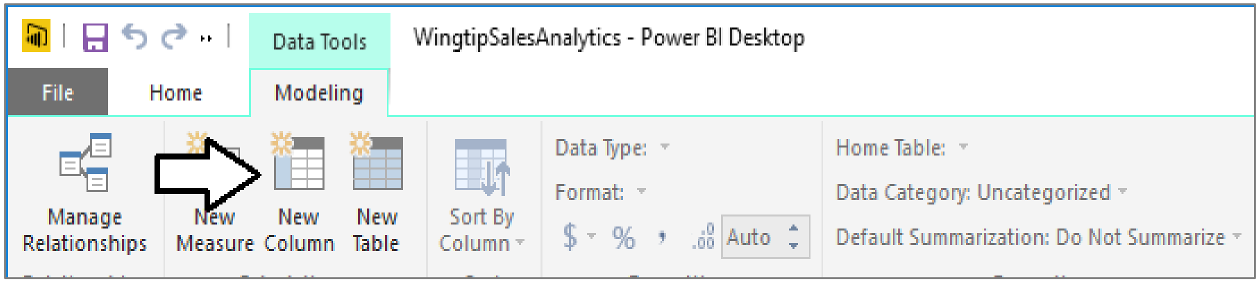
When to Create Calculated Columns

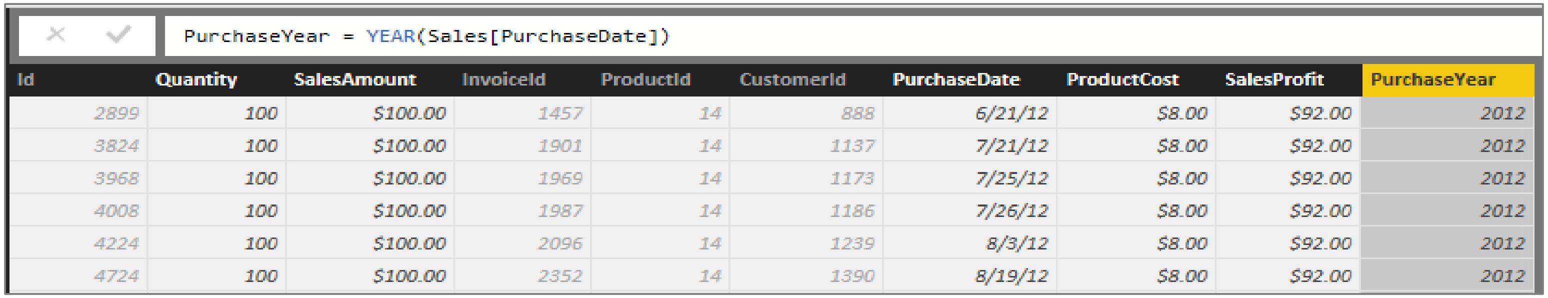
- Measures often better choice than calculate columns
  - Don't create calculated column when you need a measure
  - Prefer to create calculated columns only in specific scenarios

- When should you create calculated columns?
  - To create headers for row labels or column labels
  - To place calculated results in a slicer for filtering
  - Define an expression strictly bound to current row
  - Categories text or numbers (e.g. customer age groups)

Creating Calculated Columns

- Edited in formula bar of Power Pivot data view
  - Start with name and then equals (=) sign
  - Enter a valid DAX expression
  - Clicking on column adds it into expression



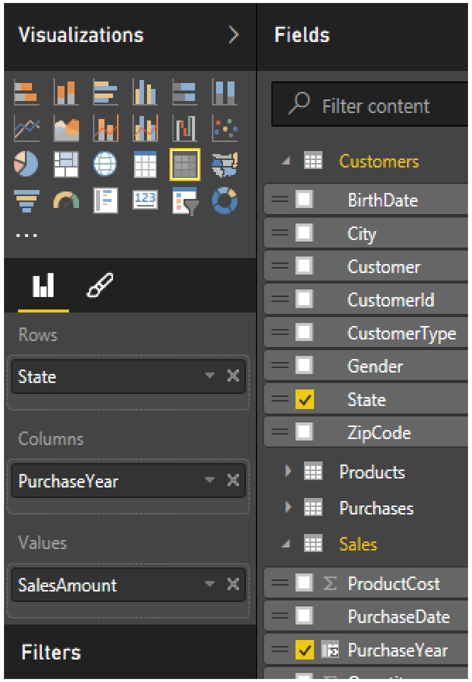


```
PurchaseYear = YEAR(Sales[PurchaseDate])
```

Id	Quantity	SalesAmount	InvoiceId	ProductId	CustomerId	PurchaseDate	ProductCost	SalesProfit	PurchaseYear
2899	100	$100.00	1457	14	888	6/21/12	$8.00	$92.00	2012
3824	100	$100.00	1901	14	1137	7/21/12	$8.00	$92.00	2012
3968	100	$100.00	1969	14	1173	7/25/12	$8.00	$92.00	2012
4008	100	$100.00	1987	14	1186	7/26/12	$8.00	$92.00	2012
4224	100	$100.00	2096	14	1239	8/3/12	$8.00	$92.00	2012
4724	100	$100.00	2352	14	1390	8/19/12	$8.00	$92.00	2012

Calculated Column as a Column Label

- Calculate column can serve as...
  - Row labels
  - Column labels



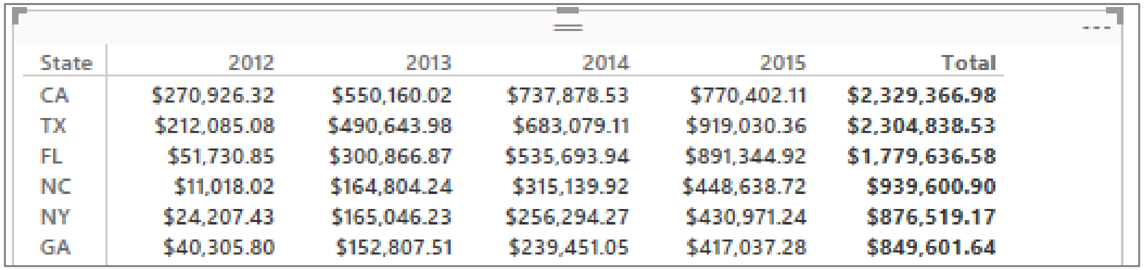
Rows: State

Columns: PurchaseYear

Values: SalesAmount

☑ State

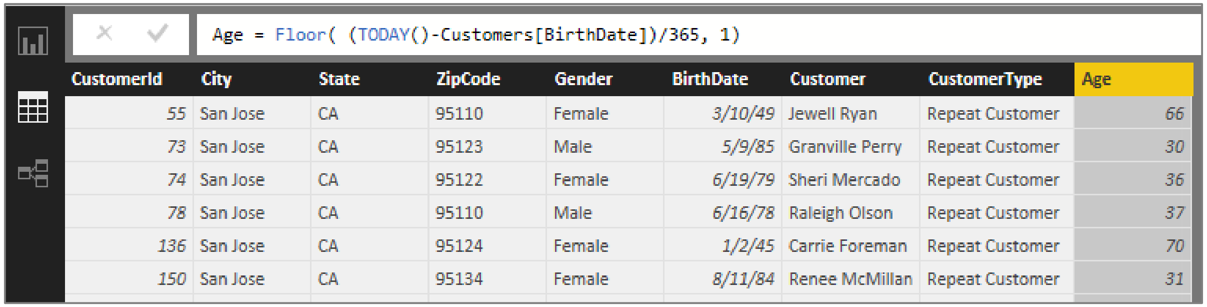
☑ PurchaseYear



State	2012	2013	2014	2015	Total
CA	$270,926.32	$550,160.02	$737,878.53	$770,402.11	$2,329,366.98
TX	$212,085.08	$490,643.98	$683,079.11	$919,030.36	$2,304,838.53
FL	$51,730.85	$300,866.87	$535,693.94	$891,344.92	$1,779,636.58
NC	$11,018.02	$164,804.24	$315,139.92	$448,638.72	$939,600.90
NY	$24,207.43	$165,046.23	$256,294.27	$430,971.24	$876,519.17
GA	$40,305.80	$152,807.51	$239,451.05	$417,037.28	$849,601.64

Calculated Column for Customer Age Group

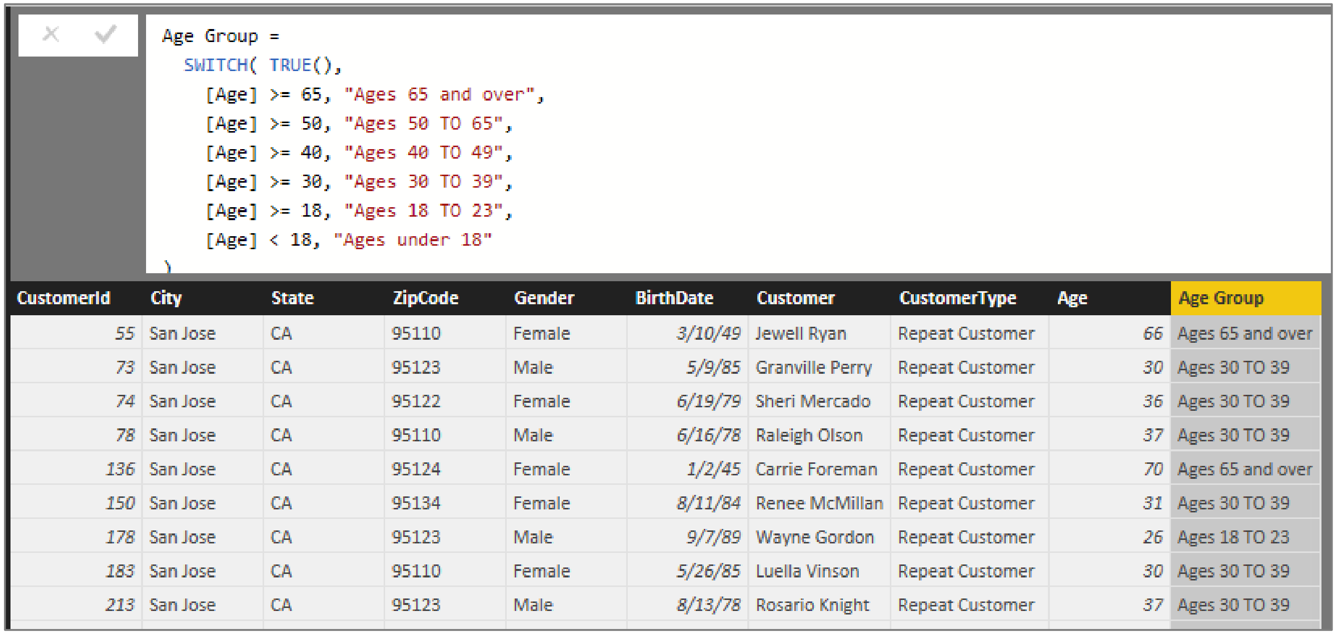
1. Calculate customer age from birthdate



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

CustomerId	City	State	ZipCode	Gender	BirthDate	Customer	CustomerType	Age
55	San Jose	CA	95110	Female	3/10/49	Jewell Ryan	Repeat Customer	66
73	San Jose	CA	95123	Male	5/9/85	Granville Perry	Repeat Customer	30
74	San Jose	CA	95122	Female	6/19/79	Sheri Mercado	Repeat Customer	36
78	San Jose	CA	95110	Male	6/16/78	Raleigh Olson	Repeat Customer	37
136	San Jose	CA	95124	Female	1/2/45	Carrie Foreman	Repeat Customer	70
150	San Jose	CA	95134	Female	8/11/84	Renee McMillan	Repeat Customer	31

2. Calculate age groups using calculated column

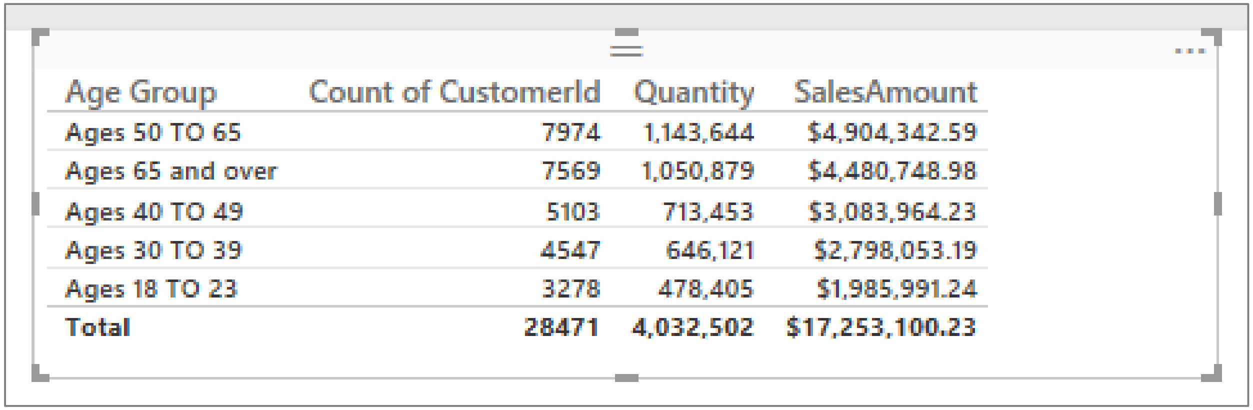


```
Age Group =
  SWITCH( TRUE(),
    [Age] >= 65, "Ages 65 and over",
    [Age] >= 50, "Ages 50 TO 65",
    [Age] >= 40, "Ages 40 TO 49",
    [Age] >= 30, "Ages 30 TO 39",
    [Age] >= 18, "Ages 18 TO 23",
    [Age] < 18, "Ages under 18"
)
```

CustomerId	City	State	ZipCode	Gender	BirthDate	Customer	CustomerType	Age	Age Group
55	San Jose	CA	95110	Female	3/10/49	Jewell Ryan	Repeat Customer	66	Ages 65 and over
73	San Jose	CA	95123	Male	5/9/85	Granville Perry	Repeat Customer	30	Ages 30 TO 39
74	San Jose	CA	95122	Female	6/19/79	Sheri Mercado	Repeat Customer	36	Ages 30 TO 39
78	San Jose	CA	95110	Male	6/16/78	Raleigh Olson	Repeat Customer	37	Ages 30 TO 39
136	San Jose	CA	95124	Female	1/2/45	Carrie Foreman	Repeat Customer	70	Ages 65 and over
150	San Jose	CA	95134	Female	8/11/84	Renee McMillan	Repeat Customer	31	Ages 30 TO 39
178	San Jose	CA	95123	Male	9/7/89	Wayne Gordon	Repeat Customer	26	Ages 18 TO 23
183	San Jose	CA	95110	Female	5/26/85	Luella Vinson	Repeat Customer	30	Ages 30 TO 39
213	San Jose	CA	95123	Male	8/13/78	Rosario Knight	Repeat Customer	37	Ages 30 TO 39

Calculated Column as a Row Label

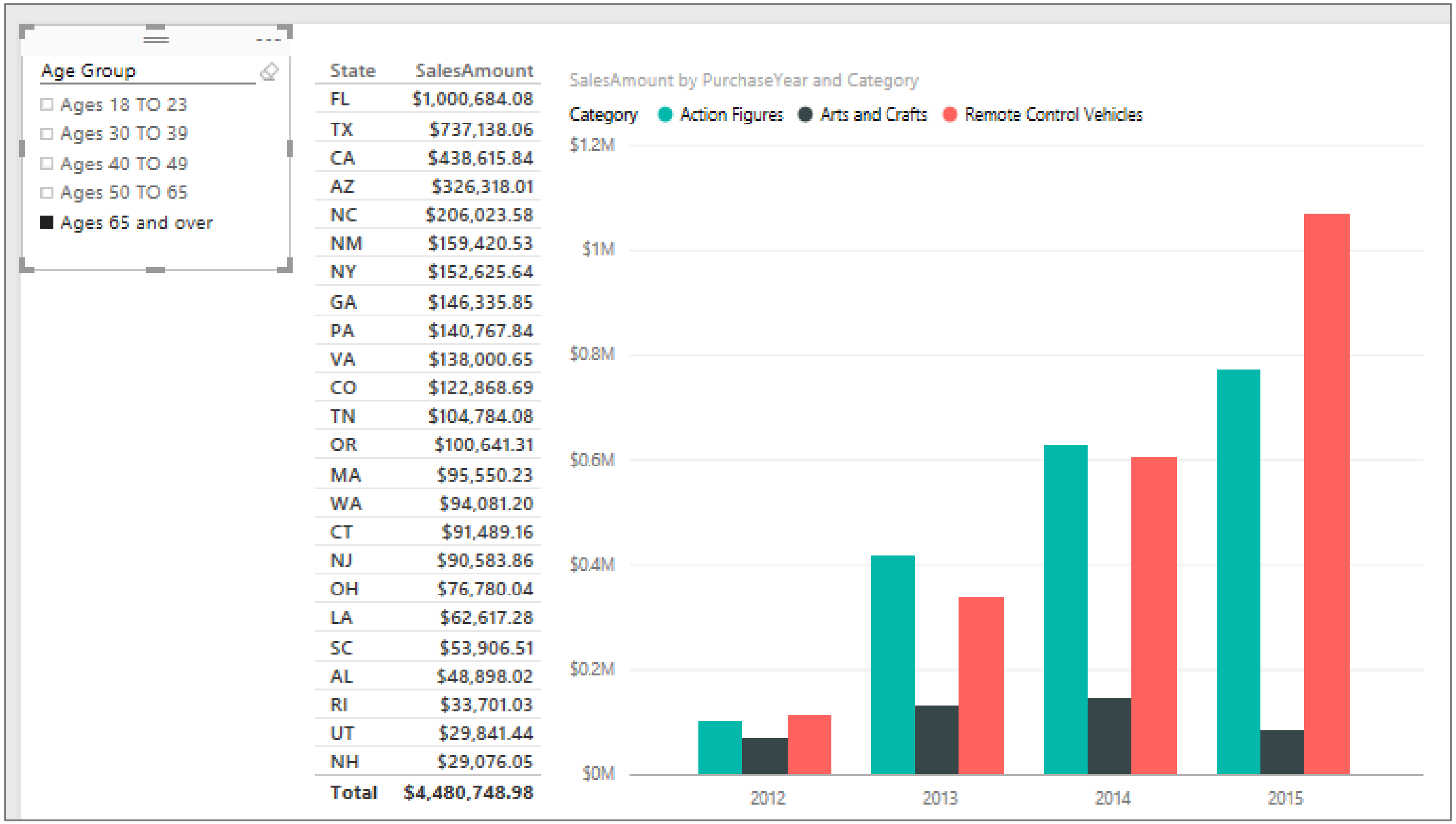
- Age Group can now be used as row label



Age Group	Count of CustomerId	Quantity	SalesAmount
Ages 50 TO 65	7974	1,143,644	$4,904,342.59
Ages 65 and over	7569	1,050,879	$4,480,748.98
Ages 40 TO 49	5103	713,453	$3,083,964.23
Ages 30 TO 39	4547	646,121	$2,798,053.19
Ages 18 TO 23	3278	478,405	$1,985,991.24
Total	**28471**	**4,032,502**	**$17,253,100.23**

Calculated Column used in a Slicer

- Calculated column can populate slicer values



Age Group

☐ Ages 18 TO 23
☐ Ages 30 TO 39
☐ Ages 40 TO 49
☐ Ages 50 TO 65
■ Ages 65 and over

State	SalesAmount
FL	$1,000,684.08
TX	$737,138.06
CA	$438,615.84
AZ	$326,318.01
NC	$206,023.58
NM	$159,420.53
NY	$152,625.64
GA	$146,335.85
PA	$140,767.84
VA	$138,000.65
CO	$122,868.69
TN	$104,784.08
OR	$100,641.31
MA	$95,550.23
WA	$94,081.20
CT	$91,489.16
NJ	$90,583.86
OH	$76,780.04
LA	$62,617.28
SC	$53,906.51
AL	$48,898.02
RI	$33,701.03
UT	$29,841.44
NH	$29,076.05
Total	**$4,480,748.98**

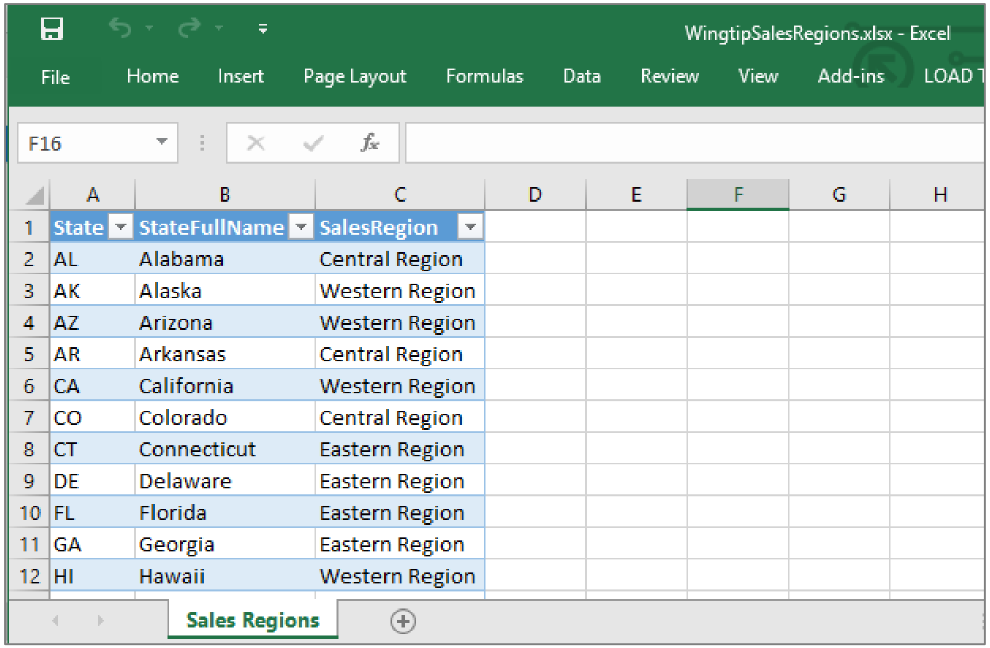
SalesAmount by PurchaseYear and Category
Category ● Action Figures ● Arts and Crafts ● Remote Control Vehicles
$1.2M
$1M
$0.8M
$0.6M
$0.4M
$0.2M
$0M
2012
2013
2014
2015

DEMO

Creating Calculated Columns

Adding Lookup Tables to the Data Model

- Data modeling might required adding lookup tables
  - Lookup tables inject extra related data into data model
- Example: Sales Regions table
  - Assign each state to specific sales region
  - Include full state name it required in reporting

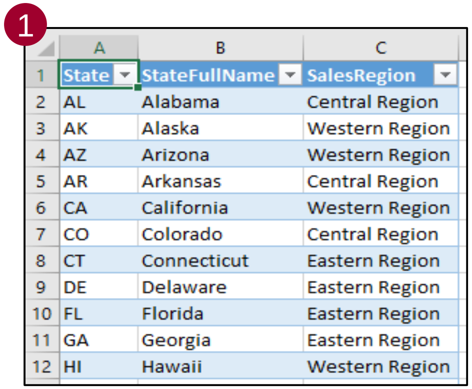


State	StateFullName	SalesRegion
AL	Alabama	Central Region
AK	Alaska	Western Region
AZ	Arizona	Western Region
AR	Arkansas	Central Region
CA	California	Western Region
CO	Colorado	Central Region
CT	Connecticut	Eastern Region
DE	Delaware	Eastern Region
FL	Florida	Eastern Region
GA	Georgia	Eastern Region
HI	Hawaii	Western Region

Importing the SalesRegions Table from Excel

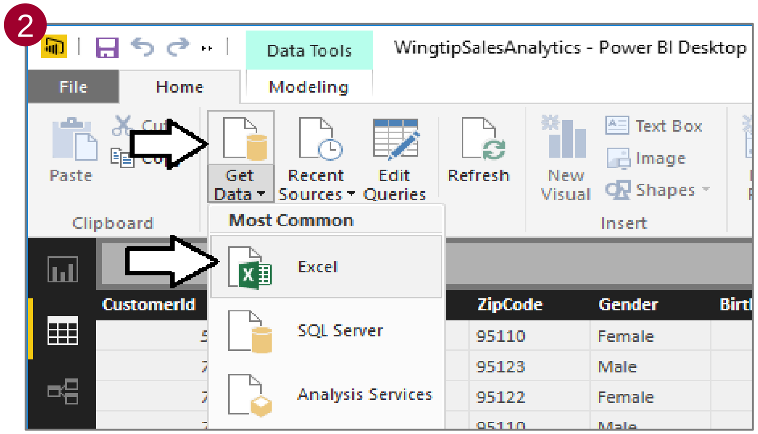
- Import table from Excel using Power Query

1



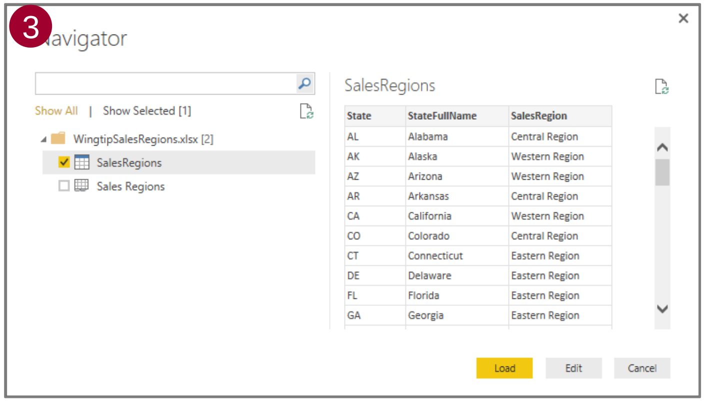
	A	B	C
1	State	StateFullName	SalesRegion
2	AL	Alabama	Central Region
3	AK	Alaska	Western Region
4	AZ	Arizona	Western Region
5	AR	Arkansas	Central Region
6	CA	California	Western Region
7	CO	Colorado	Central Region
8	CT	Connecticut	Eastern Region
9	DE	Delaware	Eastern Region
10	FL	Florida	Eastern Region
11	GA	Georgia	Eastern Region
12	HI	Hawaii	Western Region

2



CustomerId	ZipCode	Gender	Birt
	95110	Female	
	95123	Male	
	95122	Female	
	95110	Male	

3

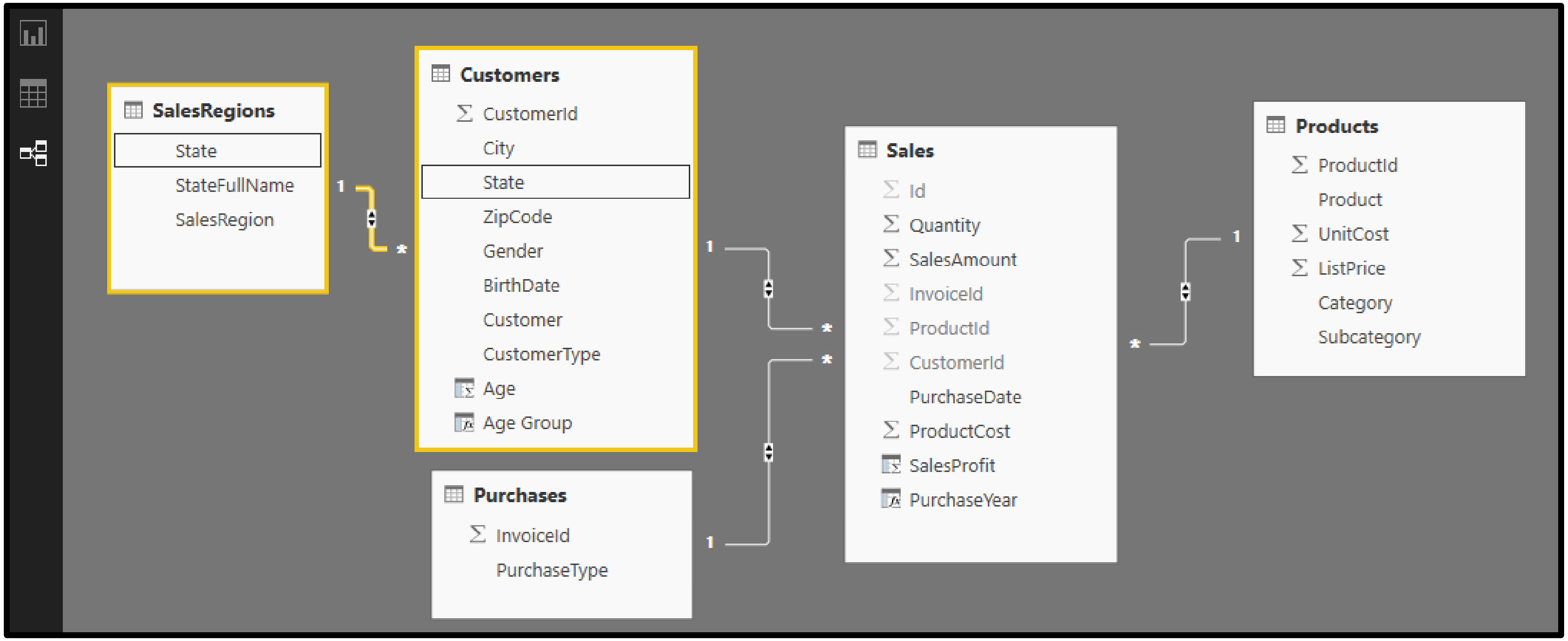


SalesRegions

State	StateFullName	SalesRegion
AL	Alabama	Central Region
AK	Alaska	Western Region
AZ	Arizona	Western Region
AR	Arkansas	Central Region
CA	California	Western Region
CO	Colorado	Central Region
CT	Connecticut	Eastern Region
DE	Delaware	Eastern Region
FL	Florida	Eastern Region
GA	Georgia	Eastern Region

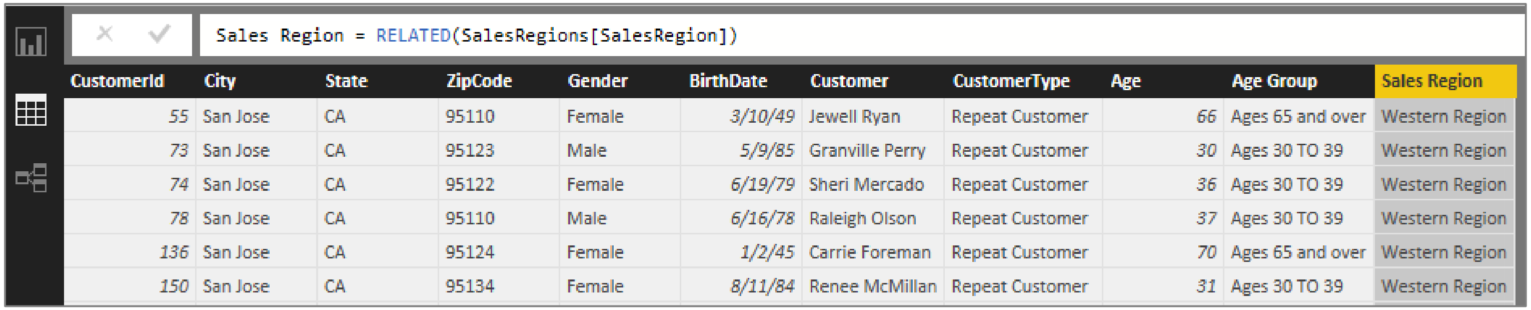
Integrating the Lookup Table into the Data Model

- Lookup table must be integrated into data model
  - Accomplished by creating relationship to one or more tables



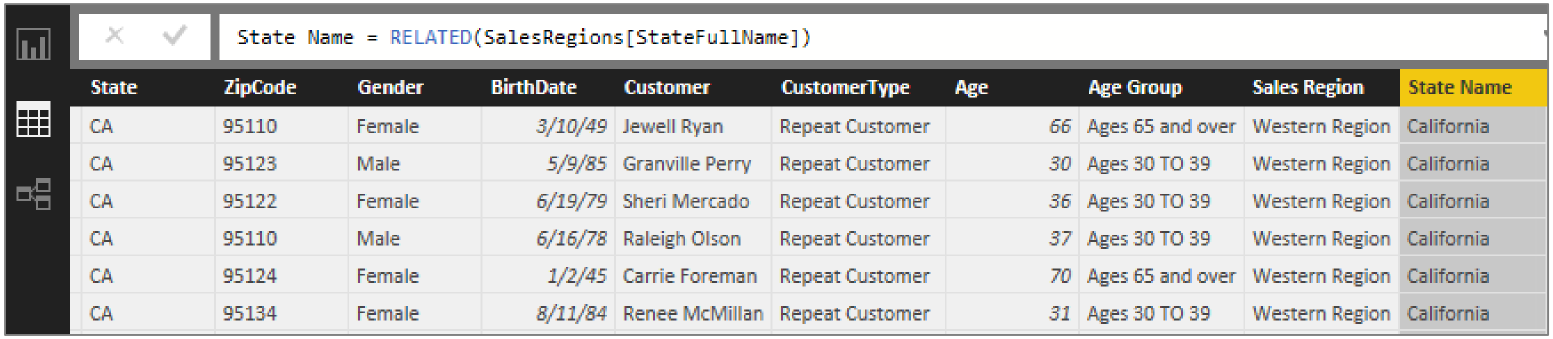
The RELATED Function

- RELATED function performs cross-table lookup
  - Effectively replaces older VLOOKUP function
  - Used in many-side table to look up value from one-side
  - Used to pull data from lookup table into primary table



```
Sales Region = RELATED(SalesRegions[SalesRegion])
```

CustomerId	City	State	ZipCode	Gender	BirthDate	Customer	CustomerType	Age	Age Group	Sales Region
55	San Jose	CA	95110	Female	3/10/49	Jewell Ryan	Repeat Customer	66	Ages 65 and over	Western Region
73	San Jose	CA	95123	Male	5/9/85	Granville Perry	Repeat Customer	30	Ages 30 TO 39	Western Region
74	San Jose	CA	95122	Female	6/19/79	Sheri Mercado	Repeat Customer	36	Ages 30 TO 39	Western Region
78	San Jose	CA	95110	Male	6/16/78	Raleigh Olson	Repeat Customer	37	Ages 30 TO 39	Western Region
136	San Jose	CA	95124	Female	1/2/45	Carrie Foreman	Repeat Customer	70	Ages 65 and over	Western Region
150	San Jose	CA	95134	Female	8/11/84	Renee McMillan	Repeat Customer	31	Ages 30 TO 39	Western Region

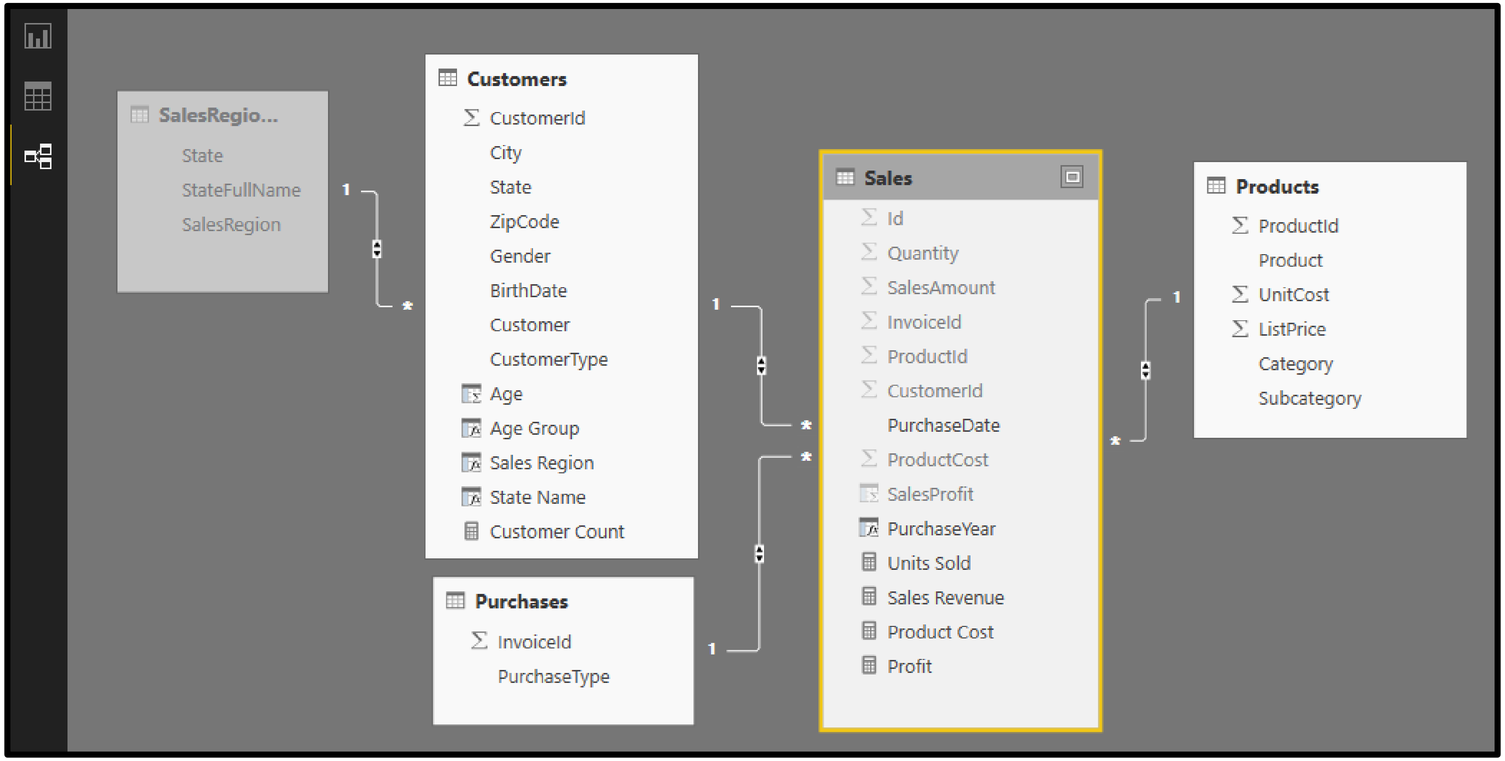


```
State Name = RELATED(SalesRegions[StateFullName])
```

State	ZipCode	Gender	BirthDate	Customer	CustomerType	Age	Age Group	Sales Region	State Name
CA	95110	Female	3/10/49	Jewell Ryan	Repeat Customer	66	Ages 65 and over	Western Region	California
CA	95123	Male	5/9/85	Granville Perry	Repeat Customer	30	Ages 30 TO 39	Western Region	California
CA	95122	Female	6/19/79	Sheri Mercado	Repeat Customer	36	Ages 30 TO 39	Western Region	California
CA	95110	Male	6/16/78	Raleigh Olson	Repeat Customer	37	Ages 30 TO 39	Western Region	California
CA	95124	Female	1/2/45	Carrie Foreman	Repeat Customer	70	Ages 65 and over	Western Region	California
CA	95134	Female	8/11/84	Renee McMillan	Repeat Customer	31	Ages 30 TO 39	Western Region	California

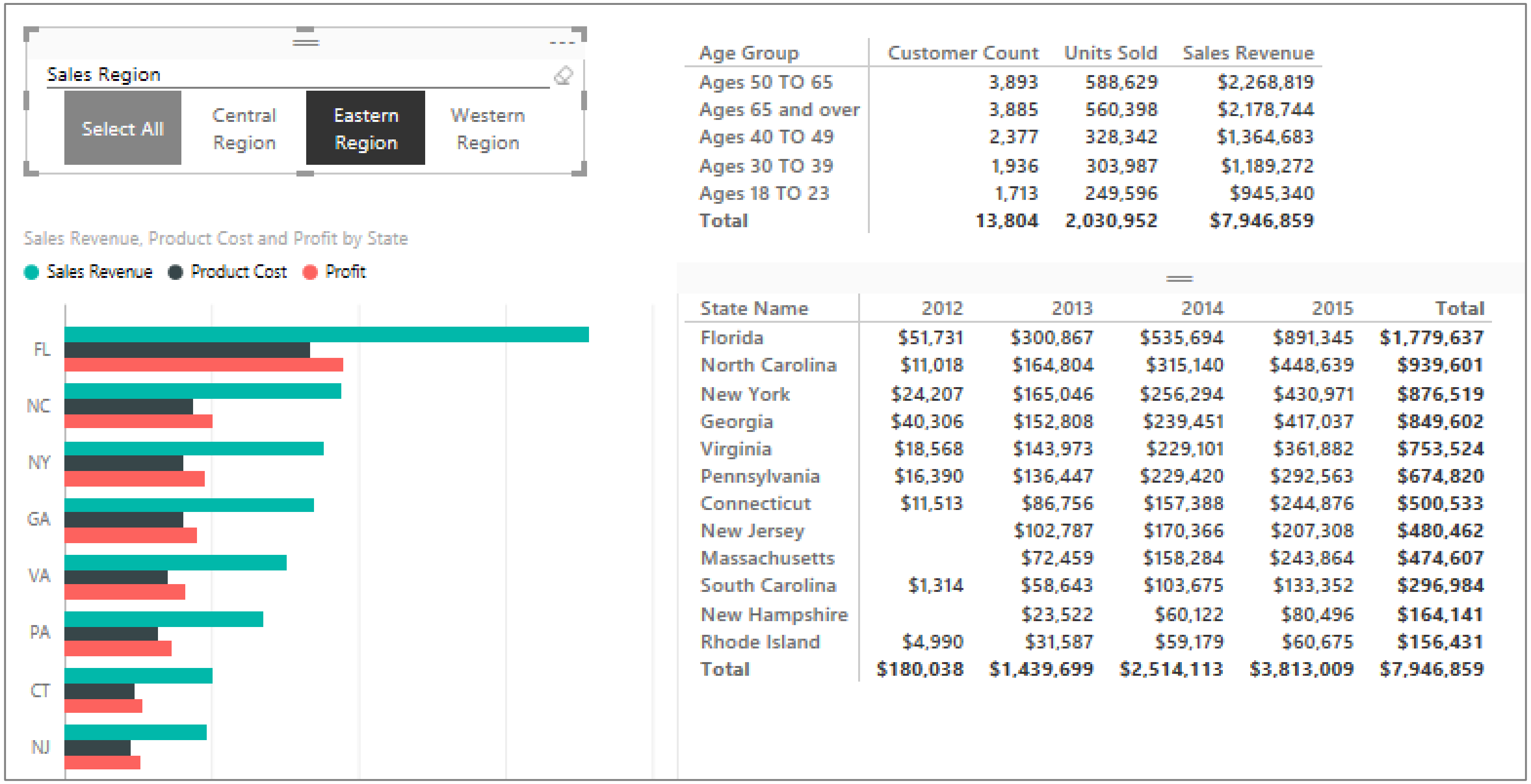
Hiding the Lookup Table

- Lookup table can often be hidden
  - simplifies reporting for data model consumers



Filtering on Sales Region

- Calculated column used to calculate slicer values


Sales Region
Select All
Central Region
Eastern Region
Western Region
Sales Revenue, Product Cost and Profit by State
● Sales Revenue ● Product Cost ● Profit
FL
NC
NY
GA
VA
PA
CT
NJ

Age Group	Customer Count	Units Sold	Sales Revenue
Ages 50 TO 65	3,893	588,629	$2,268,819
Ages 65 and over	3,885	560,398	$2,178,744
Ages 40 TO 49	2,377	328,342	$1,364,683
Ages 30 TO 39	1,936	303,987	$1,189,272
Ages 18 TO 23	1,713	249,596	$945,340
Total	13,804	2,030,952	$7,946,859

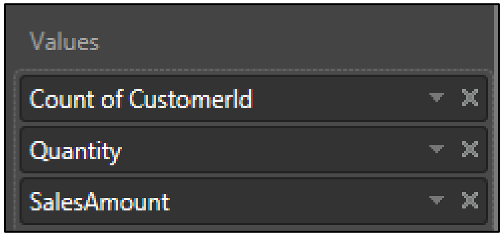
State Name	2012	2013	2014	2015	Total
Florida	$51,731	$300,867	$535,694	$891,345	$1,779,637
North Carolina	$11,018	$164,804	$315,140	$448,639	$939,601
New York	$24,207	$165,046	$256,294	$430,971	$876,519
Georgia	$40,306	$152,808	$239,451	$417,037	$849,602
Virginia	$18,568	$143,973	$229,101	$361,882	$753,524
Pennsylvania	$16,390	$136,447	$229,420	$292,563	$674,820
Connecticut	$11,513	$86,756	$157,388	$244,876	$500,533
New Jersey		$102,787	$170,366	$207,308	$480,462
Massachusetts		$72,459	$158,284	$243,864	$474,607
South Carolina	$1,314	$58,643	$103,675	$133,352	$296,984
New Hampshire		$23,522	$60,122	$80,496	$164,141
Rhode Island	$4,990	$31,587	$59,179	$60,675	$156,431
Total	$180,038	$1,439,699	$2,514,113	$3,813,009	$7,946,859

Agenda

- ✓ Modeling Data in Power BI Desktop
- ✓ Understanding Table Relationships
- ✓ Writing DAX Expressions
- ✓ Creating Calculated Columns
- ➢ Creating Measures to Aggregate Data
- Adding Geographic Fields to a Data Model

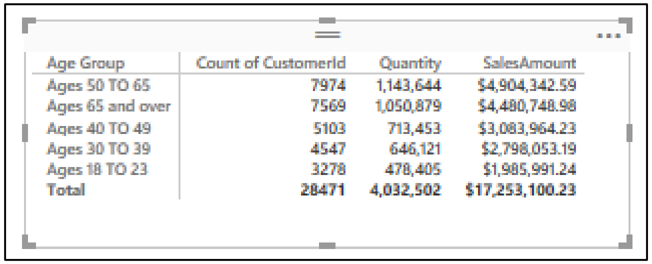
Benefits of Measures over Calculated Columns

- Calculated columns can be aggregated in visual
  - However, aggregation details are stored in visual
  - Visual doesn't offer control over name and formatting



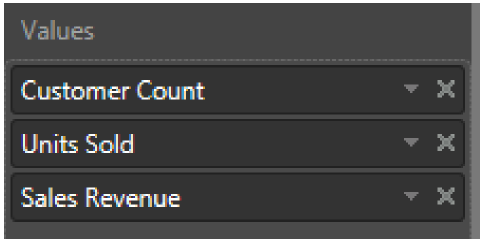
Values

- Count of CustomerId
- Quantity
- SalesAmount



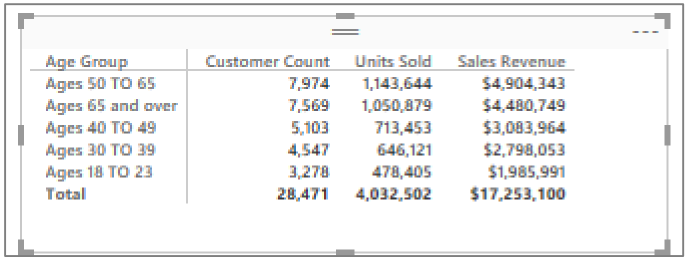
Age Group	Count of CustomerId	Quantity	SalesAmount
Ages 50 TO 65	7974	1,143,644	$4,904,342.59
Ages 65 and over	7569	1,050,879	$4,480,748.98
Ages 40 TO 49	5103	713,453	$3,083,964.23
Ages 30 TO 39	4547	646,121	$2,798,053.19
Ages 18 TO 23	3278	478,405	$1,985,991.24
Total	28471	4,032,502	$17,253,100.23

- Measure defines name, aggregation and formatting
  - Work is done once and reused across many visuals
  - Makes data model more fool-proof for report designers



Values

- Customer Count
- Units Sold
- Sales Revenue

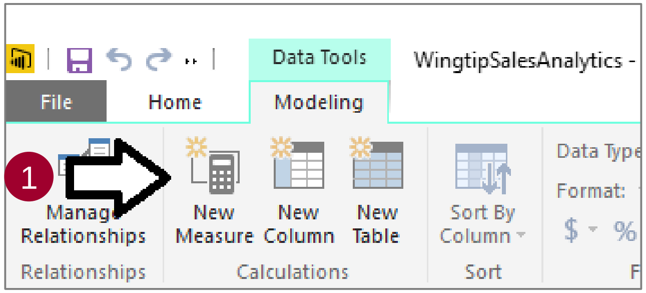


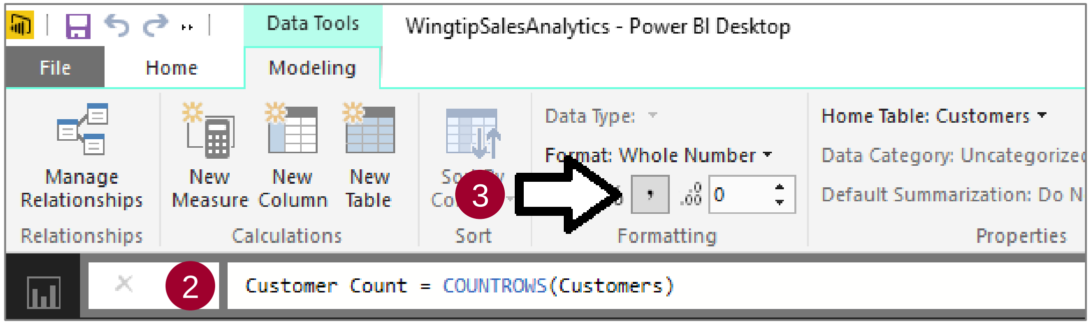
Age Group	Customer Count	Units Sold	Sales Revenue
Ages 50 TO 65	7,974	1,143,644	$4,904,343
Ages 65 and over	7,569	1,050,879	$4,480,749
Ages 40 TO 49	5,103	713,453	$3,083,964
Ages 30 TO 39	4,547	646,121	$2,798,053
Ages 18 TO 23	3,278	478,405	$1,985,991
Total	28,471	4,032,502	$17,253,100

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



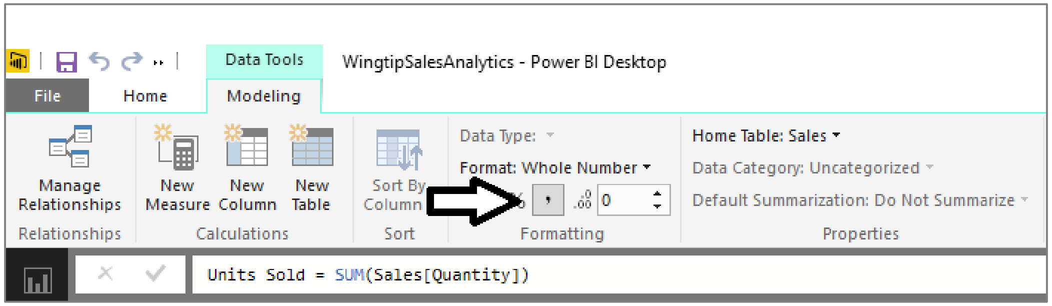


Data Type:
Format: Whole Number
0
Home Table: Customers
Data Category: Uncategorized
Default Summarization: Do N

```
Customer Count = COUNTROWS(Customers)
```

Formatting Measures

- Format as whole number



Data Type:

Format: Whole Number

0

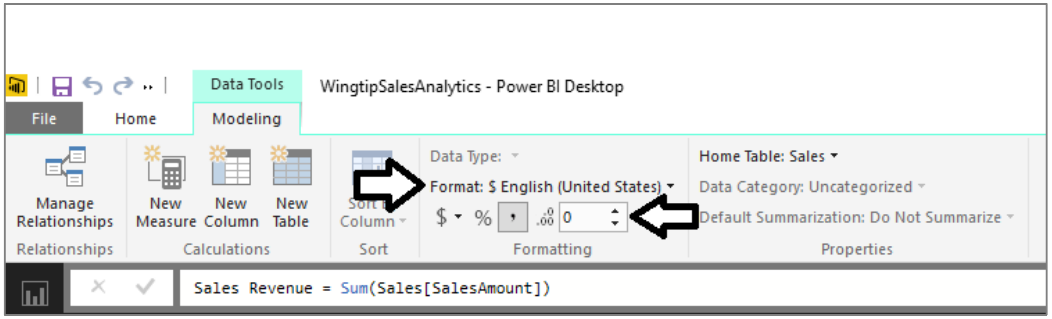
Home Table: Sales

Data Category: Uncategorized

Default Summarization: Do Not Summarize

```
Units Sold = SUM(Sales[Quantity])
```

- Format as currency



Data Type:

Format: $ English (United States)

$ % 0

Home Table: Sales

Data Category: Uncategorized

Default Summarization: Do Not Summarize

```
Sales Revenue = Sum(Sales[SalesAmount])
```

DEMO

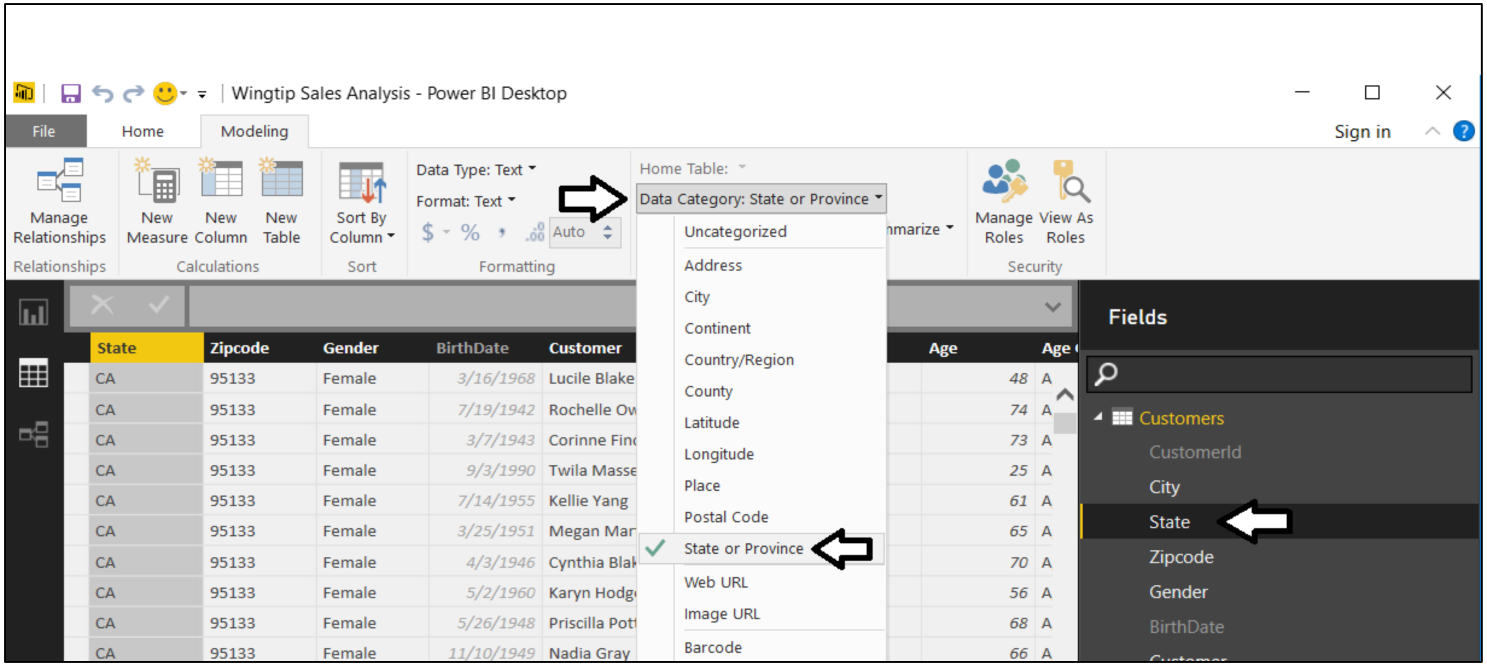
Creating Measures

Agenda

- ✓ Modeling Data in Power BI Desktop
- ✓ Understanding Table Relationships
- ✓ Writing DAX Expressions
- ✓ Creating Calculated Columns
- ✓ Creating Measures to Aggregate Data
- ➢ Adding Geographic Fields to a Data Model

Geographic Field Metadata

- Fields in data model have metadata properties
  - Metadata used by visuals and reporting tools
  - Used as hints to Bing Mapping service



Data Type: Text

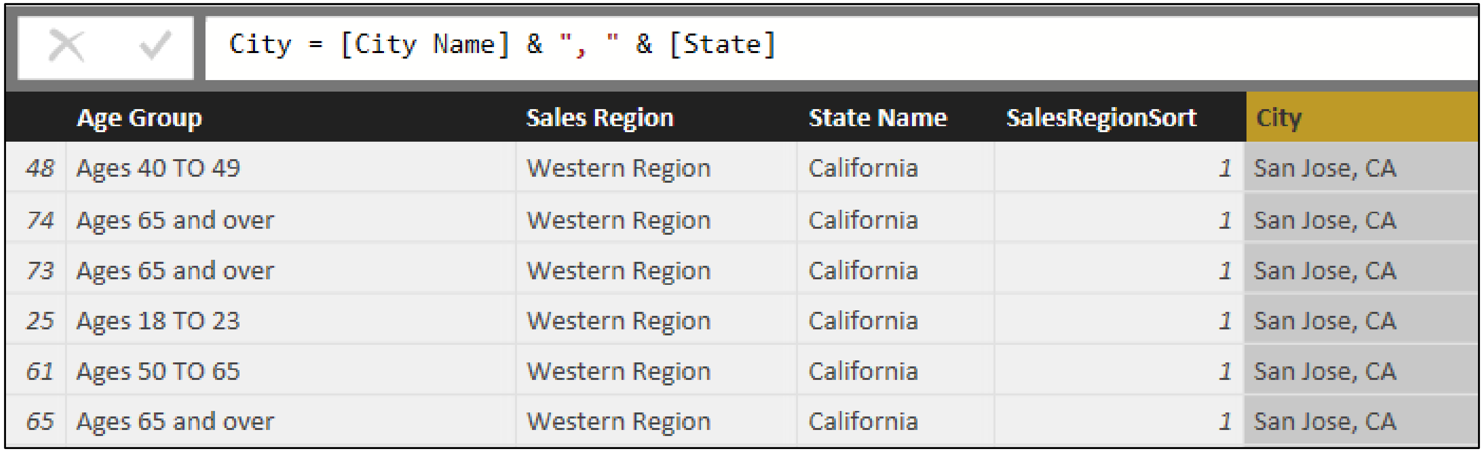
Format: Text

Data Category: State or Province

State	Zipcode	Gender	BirthDate	Customer	Age	Age
CA	95133	Female	3/16/1968	Lucile Blake	48	A
CA	95133	Female	7/19/1942	Rochelle Ow	74	A
CA	95133	Female	3/7/1943	Corinne Finc	73	A
CA	95133	Female	9/3/1990	Twila Masse	25	A
CA	95133	Female	7/14/1955	Kellie Yang	61	A
CA	95133	Female	3/25/1951	Megan Mar	65	A
CA	95133	Female	4/3/1946	Cynthia Blak	70	A
CA	95133	Female	5/2/1960	Karyn Hodg	56	A
CA	95133	Female	5/26/1948	Priscilla Pott	68	A
CA	95133	Female	11/10/1949	Nadia Gray	66	A

Eliminate Geographic Ambiguity

- City name alone is ambiguous
  - "Athens" defaults to Greece not Georgia
  - Concatenate city name with state to disambiguate

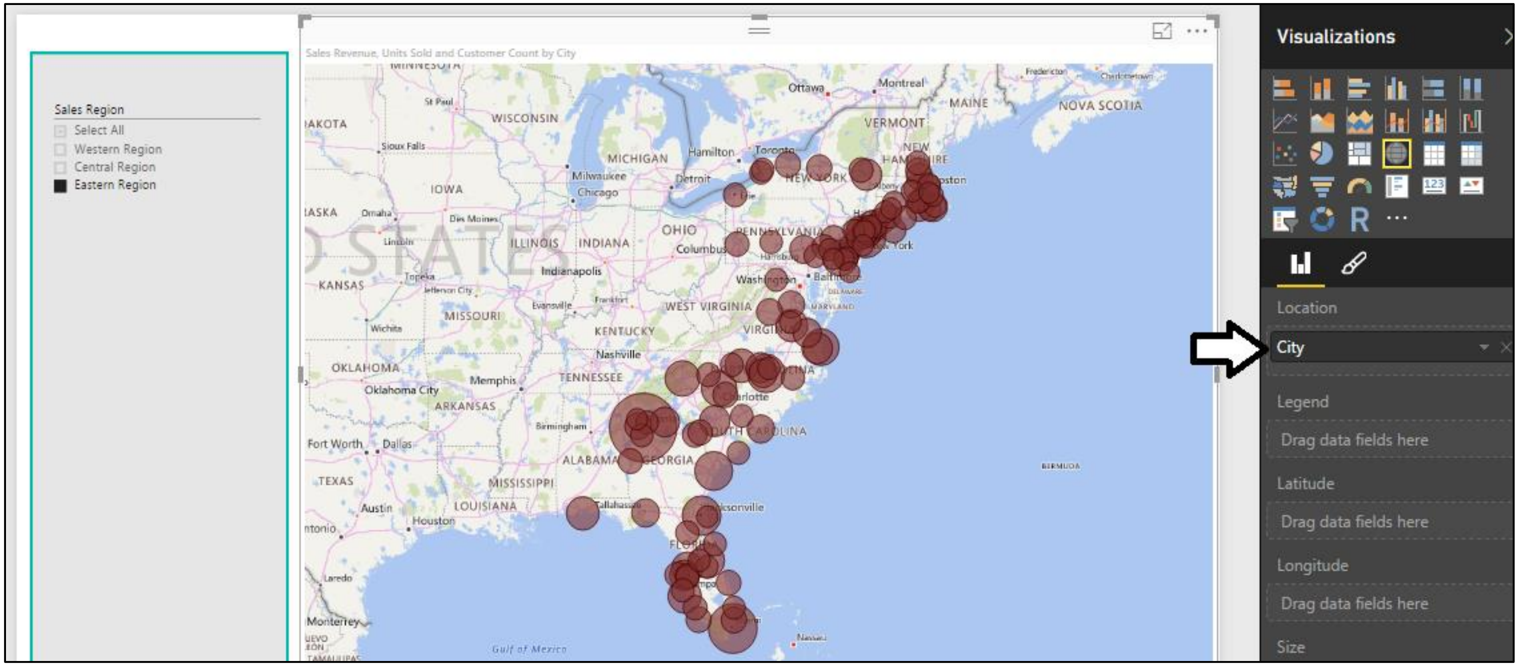


```
City = [City Name] & ", " & [State]
```

	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

Using Map Visual with a Geographic Field

- Map Visual shows distribution over geographic area
  - Visual automatically updates when filtered



Sales Region
- □ Select All
- □ Western Region
- □ Central Region
- ■ Eastern Region

Sales Revenue, Units Sold and Customer Count by City

Visualizations

Location
City

Legend
Drag data fields here

Latitude
Drag data fields here

Longitude
Drag data fields here

Size

Summary

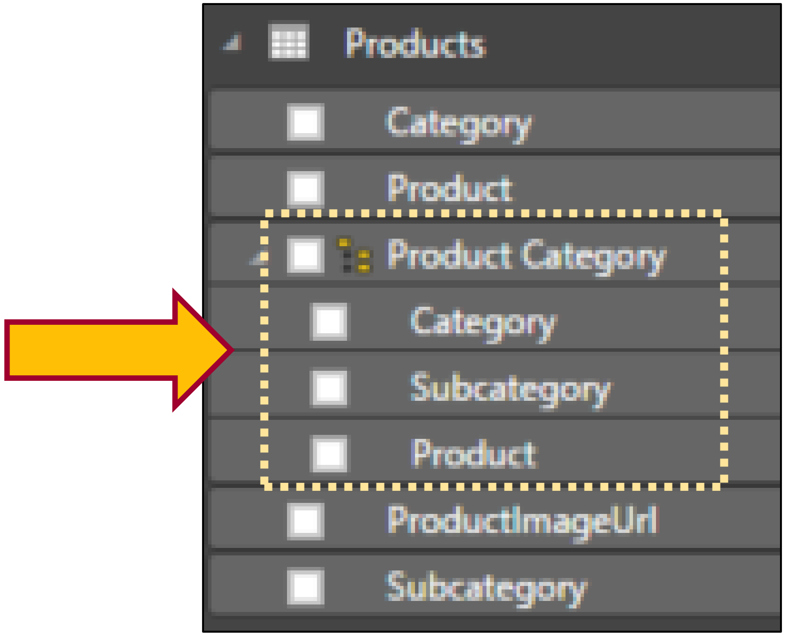
- ✓ Modeling Data in Power BI Desktop
- ✓ Understanding Table Relationships
- ✓ Writing DAX Expressions
- ✓ Creating Calculated Columns
- ✓ Creating Measures to Aggregate Data
- ✓ Adding Geographic Fields to a Data Model

Agenda

- Creating Dimensional Hierarchies
- Understanding the Evaluation Context
- Extending the Data Model using Calendar Tables
- Writing DAX Expressions with Time Intelligence
- Writing DAX Code with Contextual Awareness

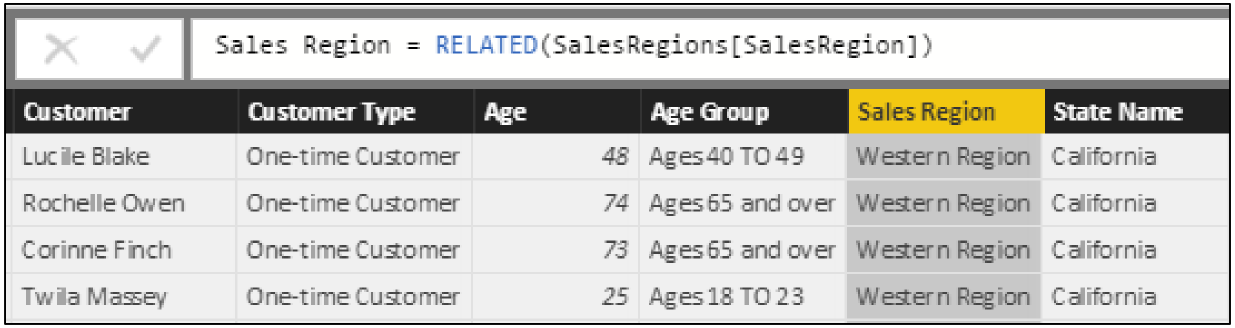
Dimensional Hierarchies

- 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



Pulling Columns for Hierarchy into Single Table

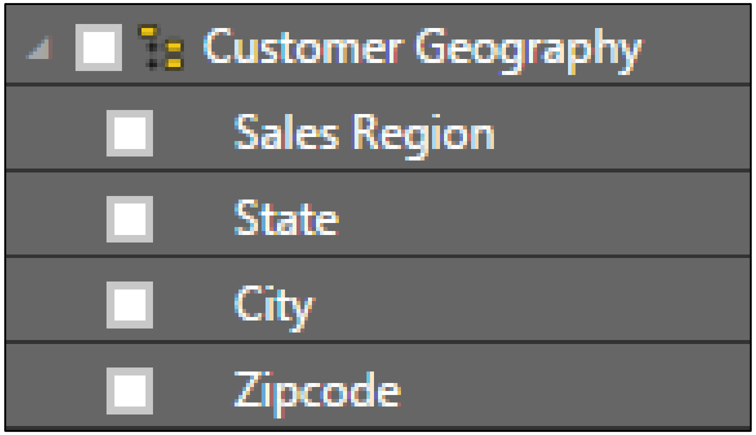
- Sometimes hierarchy columns are spread across tables
  - Use RELATED function from DAX to pull columns into single table



```
Sales Region = RELATED(SalesRegions[SalesRegion])
```

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
Twila Massey	One-time Customer	25	Ages 18 TO 23	Western Region	California

  - Then create hierarchy in the table with all the columns



□ Customer Geography
- □ Sales Region
- □ State
- □ City
- □ Zipcode

Agenda

✓ Creating Dimensional Hierarchies

➢ Understanding the Evaluation Context

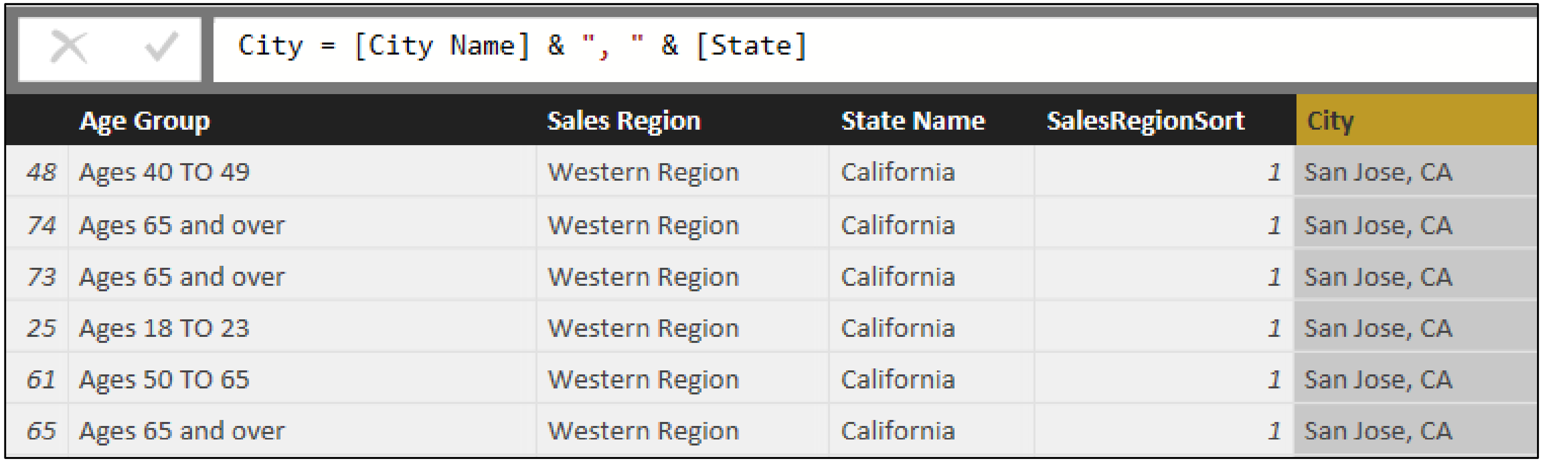
- Extending the Data Model using Calendar Tables
- Writing DAX Expressions with Time Intelligence
- Writing DAX Code with Contextual Awareness

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

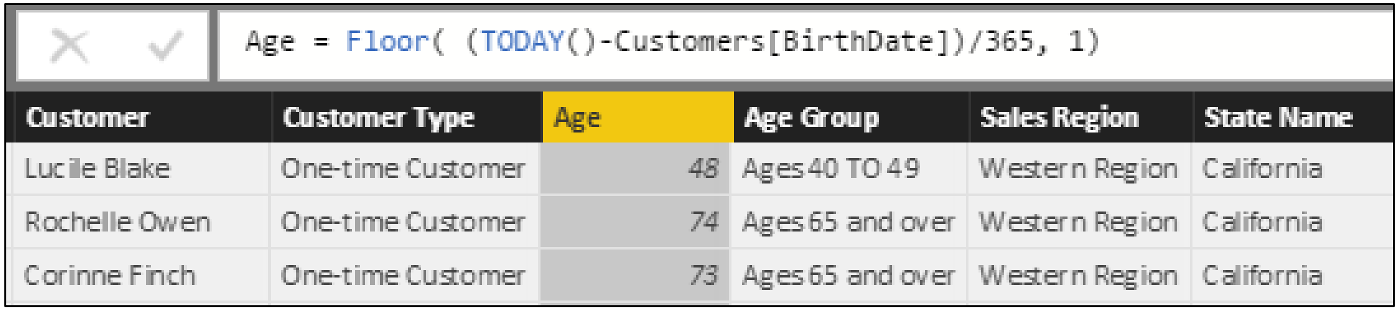
Understanding Row Context

- 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

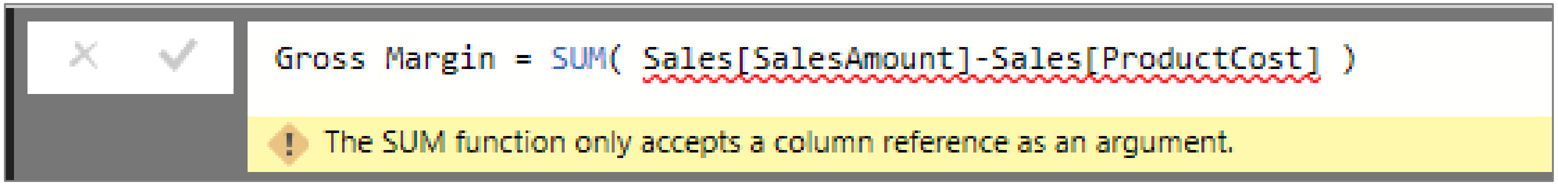


```
Age = Floor( (TODAY()-Customers[BirthDate])/365, 1)
```

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

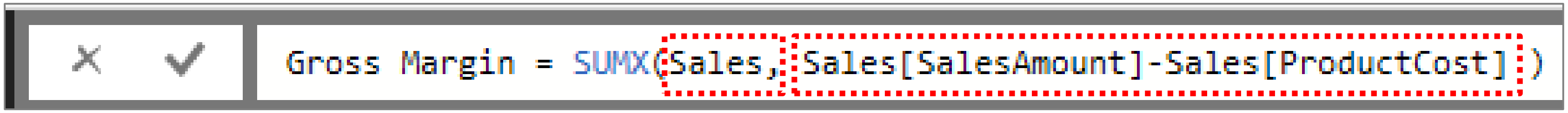
- Standard aggregation functions (e.g. SUM) have no row context
  - You can use SUM to sum values of a single column
  - You cannot use SUM to sum results of an expressions



```
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] )
```

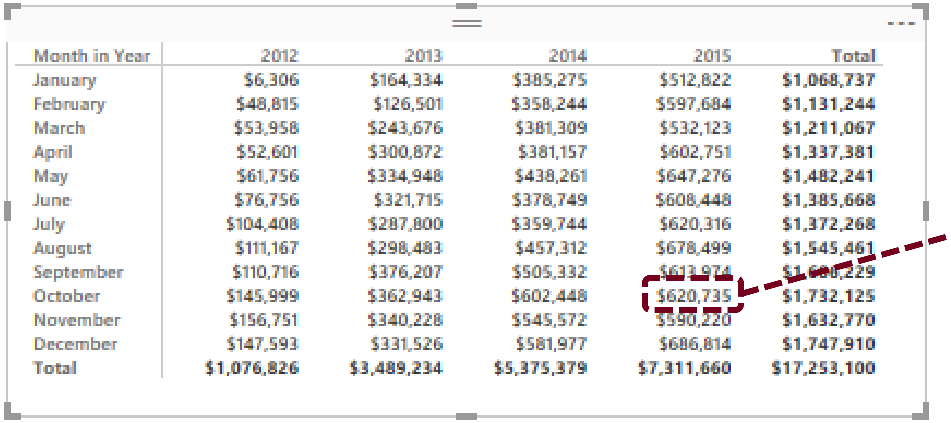
  - First argument accepts expressions that evaluates to table of rows
  - Second argument accepts expression that is evaluated for each row

DAX Table Iterator Functions

- The following DAX functions create row context
  - AVERAGEX
  - COUNTAX
  - COUNTX
  - MAXX
  - MINX
  - SUMX

Understanding Filter Context

- Visuals apply various filters in different evaluation contexts



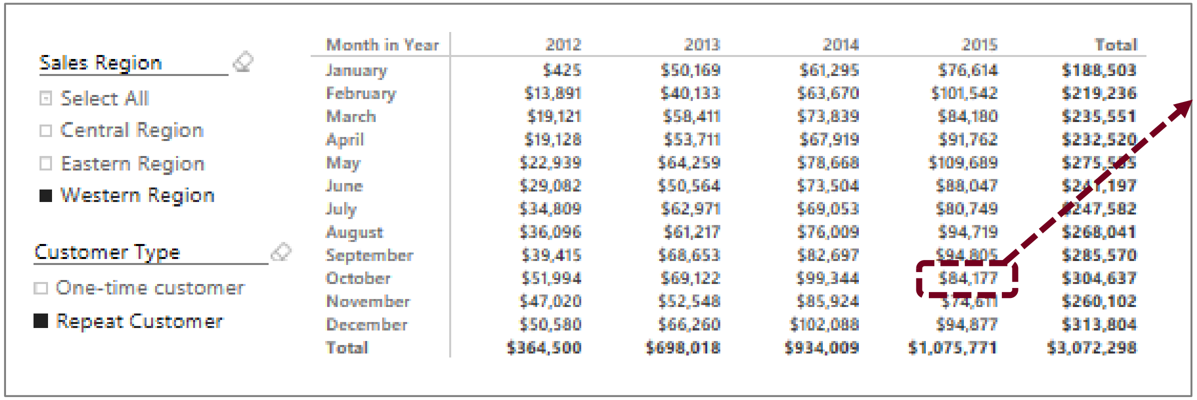
Month in Year	2012	2013	2014	2015	Total
January	$6,306	$164,334	$385,275	$512,822	$1,068,737
February	$48,815	$126,501	$358,244	$597,684	$1,131,244
March	$53,958	$243,676	$381,309	$532,123	$1,211,067
April	$52,601	$300,872	$381,157	$602,751	$1,337,381
May	$61,756	$334,948	$438,261	$647,276	$1,482,241
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	$74,610	$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

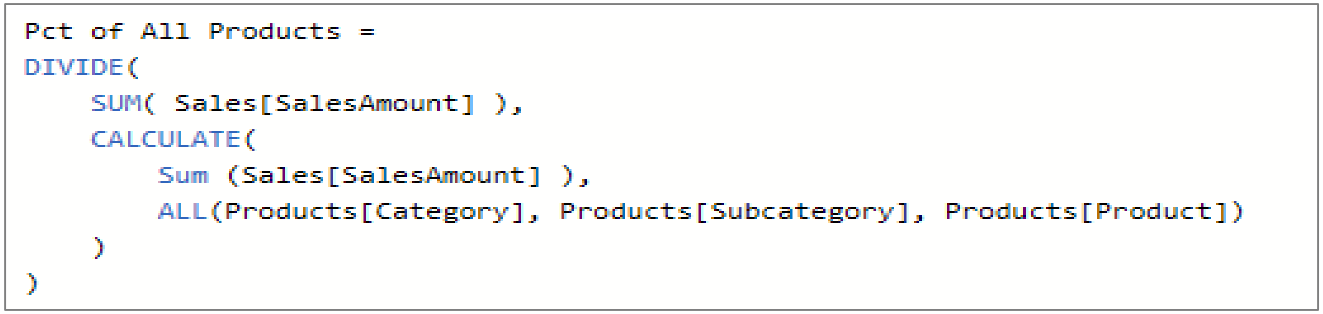
[Month in Year] = "October"

[Sales Region] = "Western Region"

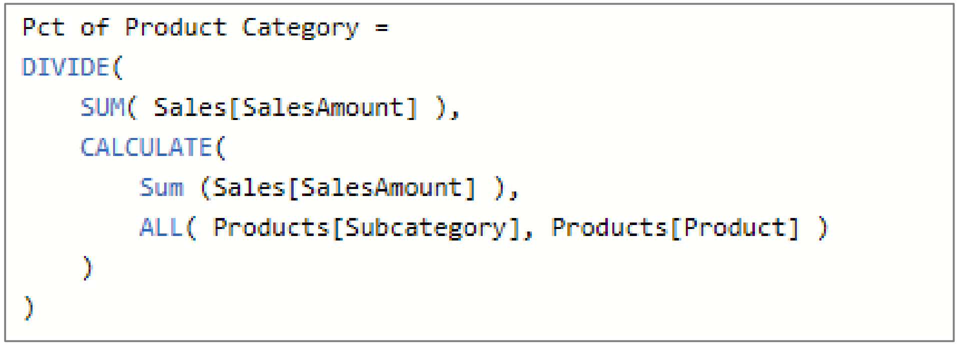
[Customer Type] = "Repeat Customer"

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] )
    )
)
```

DAX Functions that Return a Table

- ALL
- ALLEXCEPT
- CALCULATETABLE
- DISTINCT
- FILTER
- RELATEDTABLE
- VALUES

Agenda

- ✓ Creating Dimensional Hierarchies
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- ➢ Extending the Data Model using Calendar Tables
- Writing DAX Expressions with Time Intelligence
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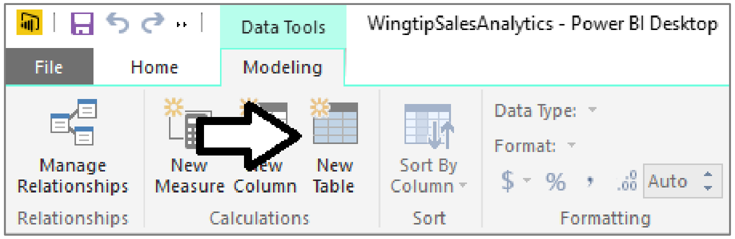
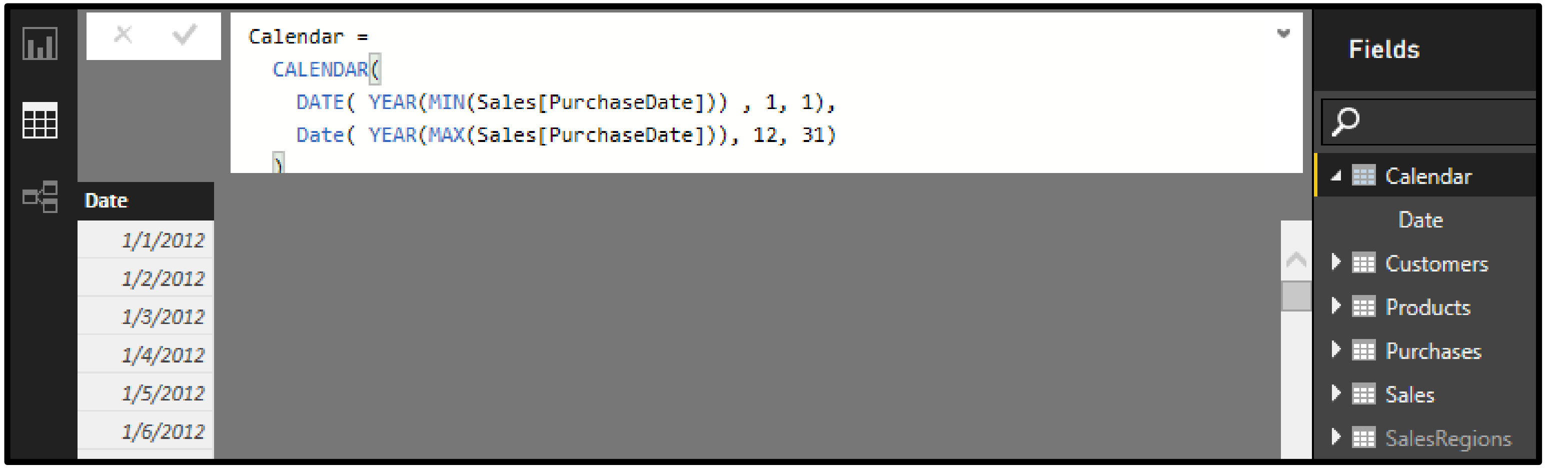
Creating Calendar Table as Calculated Table

- Use **New Table** command in ribbon



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

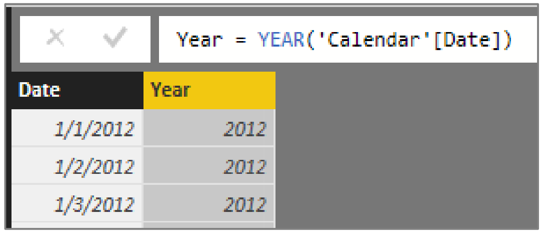


```
Calendar =
  CALENDAR(
    DATE( YEAR(MIN(Sales[PurchaseDate])) , 1, 1),
    Date( YEAR(MAX(Sales[PurchaseDate])), 12, 31)
  )
```

Date
1/1/2012
1/2/2012
1/3/2012
1/4/2012
1/5/2012
1/6/2012

Adding Columns to Calendar Table

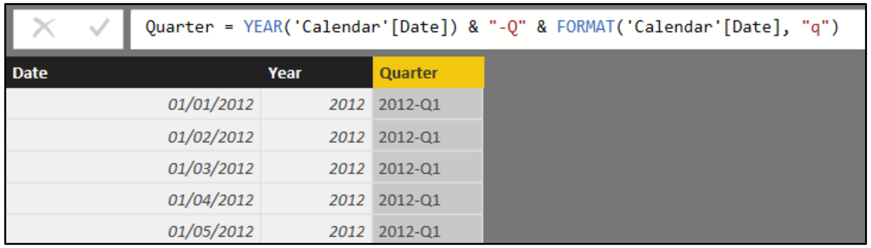
- Creating the **Year** column



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

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

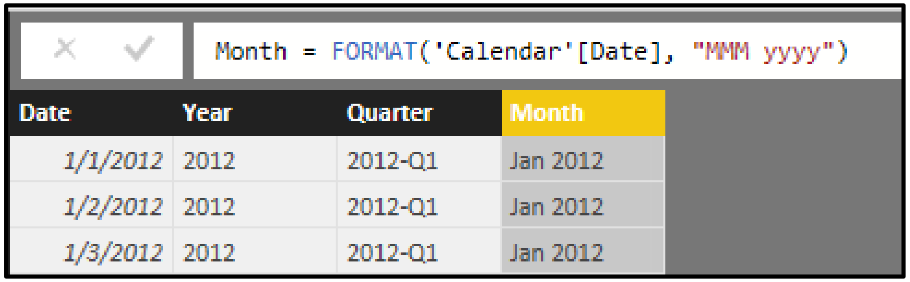
- Creating the **Quarter** column



```
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



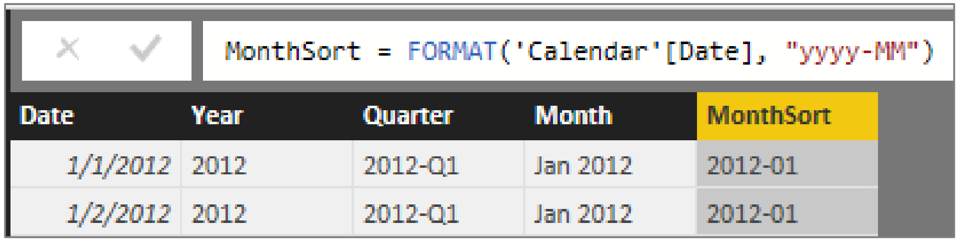
```
Month = FORMAT('Calendar'[Date], "MMM yyyy")
```

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

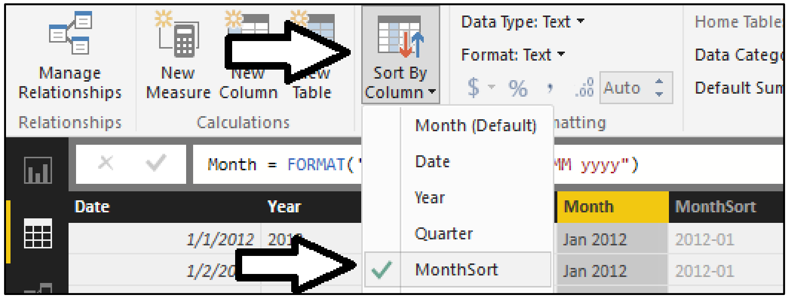
- Creating a sort column for the **Month** column
  - **MonthSort** sorts alphabetically & chronologically at same time



```
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



Data Type: Text

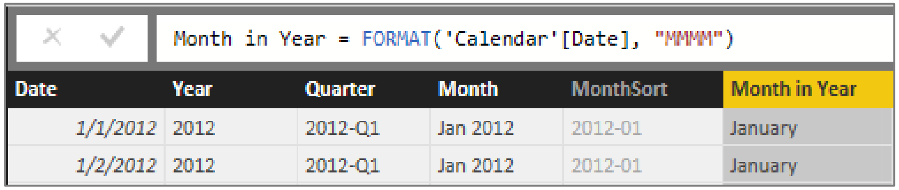
Format: Text

```
Month = FORMAT('                MM yyyy")
```

Date	Year	Month	MonthSort
1/1/2012	201	Jan 2012	2012-01
1/2/20		Jan 2012	2012-01

Columns for Month in Year and Day in week

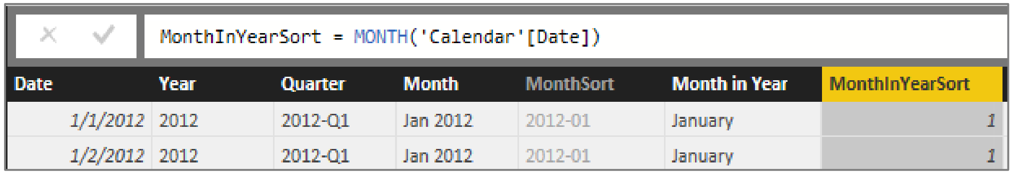
- Creating the **Month in Year** column



```
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

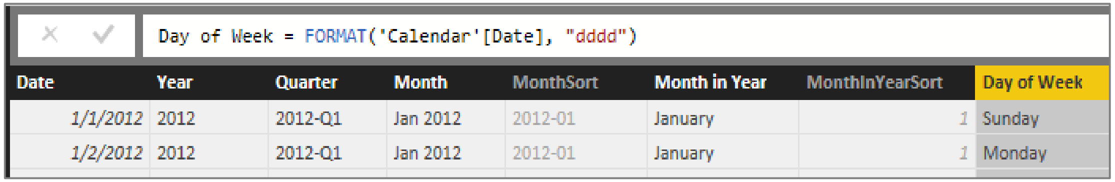
- Creating the **MonthInYearSort** column



```
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

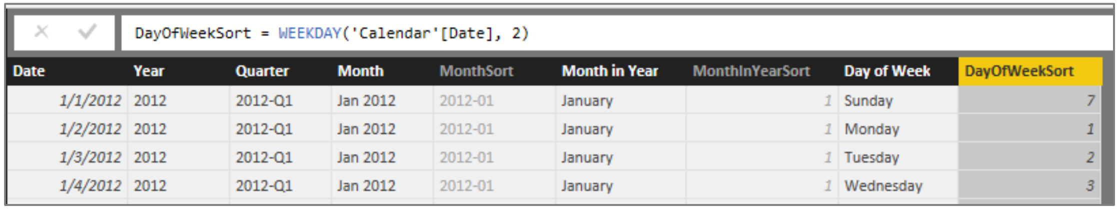
- Creating the **Day of Week** column



```
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

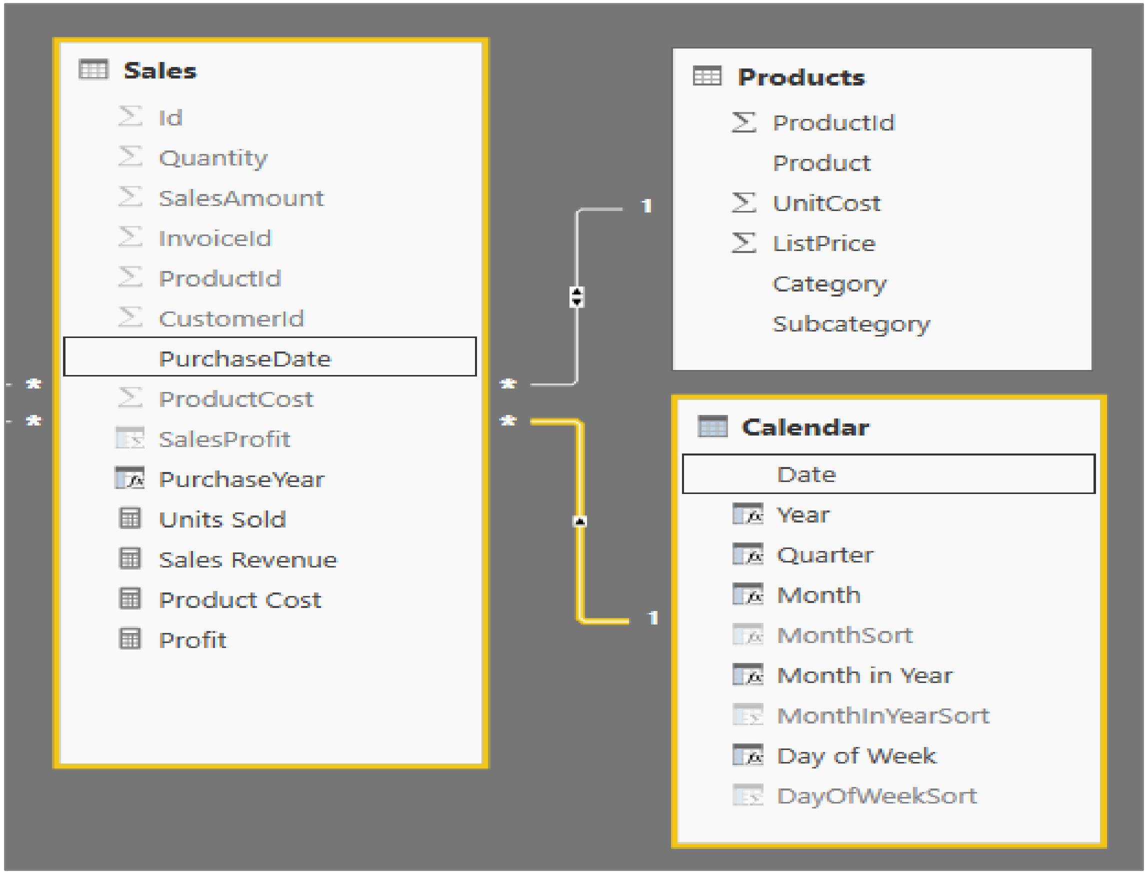


```
DayOfWeekSort = WEEKDAY('Calendar'[Date], 2)
```

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

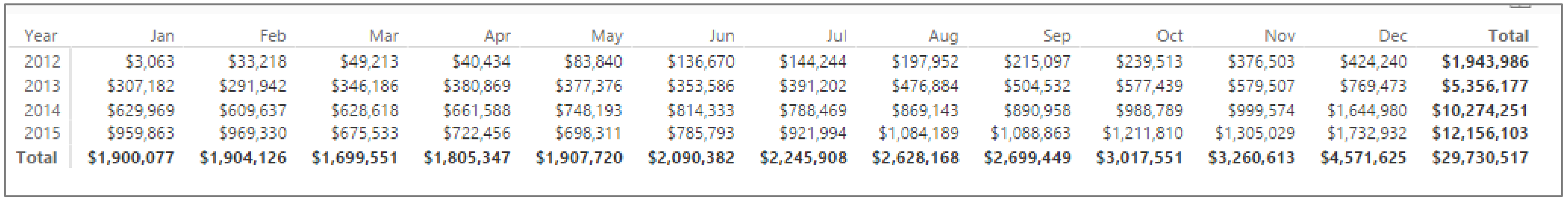
Integrating Calendar Table into Data Model

- Calendar table needs relationship to one or more tables



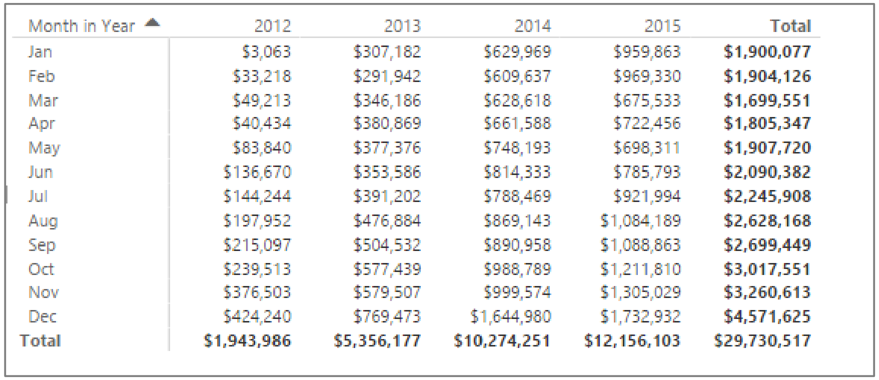
Creating Visuals with a Calendar Table

- **Year** for row labels and **Month in Year** as column labels



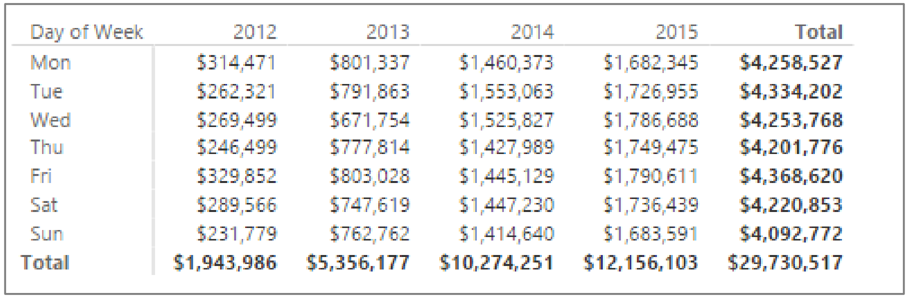
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2012	$3,063	$33,218	$49,213	$40,434	$83,840	$136,670	$144,244	$197,952	$215,097	$239,513	$376,503	$424,240	**$1,943,986**
2013	$307,182	$291,942	$346,186	$380,869	$377,376	$353,586	$391,202	$476,884	$504,532	$577,439	$579,507	$769,473	**$5,356,177**
2014	$629,969	$609,637	$628,618	$661,588	$748,193	$814,333	$788,469	$869,143	$890,958	$988,789	$999,574	$1,644,980	**$10,274,251**
2015	$959,863	$969,330	$675,533	$722,456	$698,311	$785,793	$921,994	$1,084,189	$1,088,863	$1,211,810	$1,305,029	$1,732,932	**$12,156,103**
Total	**$1,900,077**	**$1,904,126**	**$1,699,551**	**$1,805,347**	**$1,907,720**	**$2,090,382**	**$2,245,908**	**$2,628,168**	**$2,699,449**	**$3,017,551**	**$3,260,613**	**$4,571,625**	**$29,730,517**

- **Month in Year** for row labels and **Year** as column labels



Month in Year ▲	2012	2013	2014	2015	Total
Jan	$3,063	$307,182	$629,969	$959,863	**$1,900,077**
Feb	$33,218	$291,942	$609,637	$969,330	**$1,904,126**
Mar	$49,213	$346,186	$628,618	$675,533	**$1,699,551**
Apr	$40,434	$380,869	$661,588	$722,456	**$1,805,347**
May	$83,840	$377,376	$748,193	$698,311	**$1,907,720**
Jun	$136,670	$353,586	$814,333	$785,793	**$2,090,382**
Jul	$144,244	$391,202	$788,469	$921,994	**$2,245,908**
Aug	$197,952	$476,884	$869,143	$1,084,189	**$2,628,168**
Sep	$215,097	$504,532	$890,958	$1,088,863	**$2,699,449**
Oct	$239,513	$577,439	$988,789	$1,211,810	**$3,017,551**
Nov	$376,503	$579,507	$999,574	$1,305,029	**$3,260,613**
Dec	$424,240	$769,473	$1,644,980	$1,732,932	**$4,571,625**
Total	**$1,943,986**	**$5,356,177**	**$10,274,251**	**$12,156,103**	**$29,730,517**

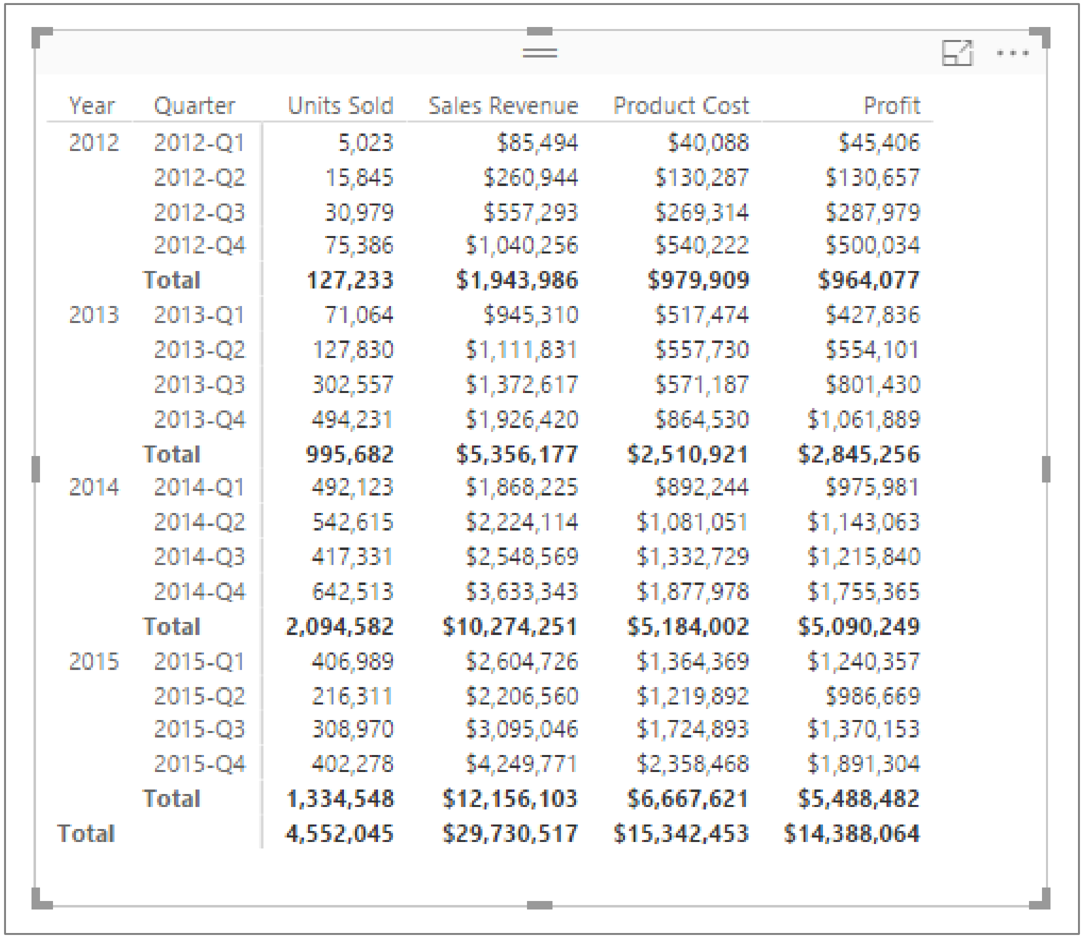
- **Month in Year** for row labels and **Year** as column labels



Day of Week	2012	2013	2014	2015	Total
Mon	$314,471	$801,337	$1,460,373	$1,682,345	**$4,258,527**
Tue	$262,321	$791,863	$1,553,063	$1,726,955	**$4,334,202**
Wed	$269,499	$671,754	$1,525,827	$1,786,688	**$4,253,768**
Thu	$246,499	$777,814	$1,427,989	$1,749,475	**$4,201,776**
Fri	$329,852	$803,028	$1,445,129	$1,790,611	**$4,368,620**
Sat	$289,566	$747,619	$1,447,230	$1,736,439	**$4,220,853**
Sun	$231,779	$762,762	$1,414,640	$1,683,591	**$4,092,772**
Total	**$1,943,986**	**$5,356,177**	**$10,274,251**	**$12,156,103**	**$29,730,517**

Hierarchical Row Labels in a Matrix

- Dimensional hierarchy can be visualized using matrix



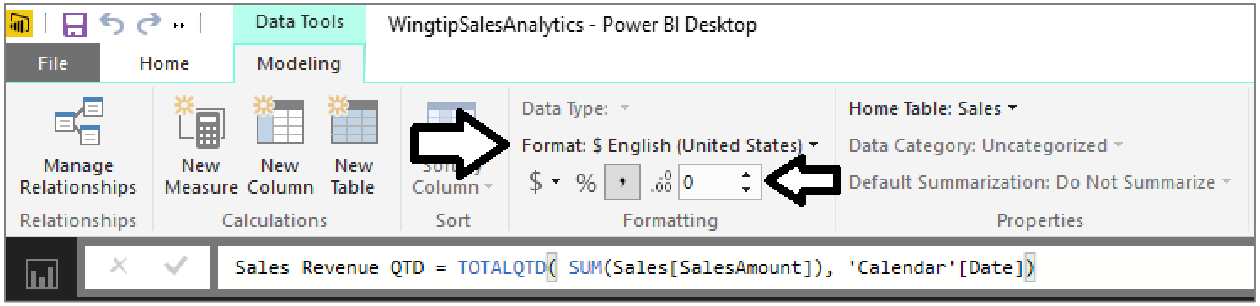
Year	Quarter	Units Sold	Sales Revenue	Product Cost	Profit
2012	2012-Q1	5,023	$85,494	$40,088	$45,406
	2012-Q2	15,845	$260,944	$130,287	$130,657
	2012-Q3	30,979	$557,293	$269,314	$287,979
	2012-Q4	75,386	$1,040,256	$540,222	$500,034
	Total	**127,233**	**$1,943,986**	**$979,909**	**$964,077**
2013	2013-Q1	71,064	$945,310	$517,474	$427,836
	2013-Q2	127,830	$1,111,831	$557,730	$554,101
	2013-Q3	302,557	$1,372,617	$571,187	$801,430
	2013-Q4	494,231	$1,926,420	$864,530	$1,061,889
	Total	**995,682**	**$5,356,177**	**$2,510,921**	**$2,845,256**
2014	2014-Q1	492,123	$1,868,225	$892,244	$975,981
	2014-Q2	542,615	$2,224,114	$1,081,051	$1,143,063
	2014-Q3	417,331	$2,548,569	$1,332,729	$1,215,840
	2014-Q4	642,513	$3,633,343	$1,877,978	$1,755,365
	Total	**2,094,582**	**$10,274,251**	**$5,184,002**	**$5,090,249**
2015	2015-Q1	406,989	$2,604,726	$1,364,369	$1,240,357
	2015-Q2	216,311	$2,206,560	$1,219,892	$986,669
	2015-Q3	308,970	$3,095,046	$1,724,893	$1,370,153
	2015-Q4	402,278	$4,249,771	$2,358,468	$1,891,304
	Total	**1,334,548**	**$12,156,103**	**$6,667,621**	**$5,488,482**
Total		**4,552,045**	**$29,730,517**	**$15,342,453**	**$14,388,064**

Agenda

- ✓ Creating Dimensional Hierarchies
- ✓ Understanding the Evaluation Context
- ✓ Extending the Data Model using Calendar Tables
- ➢ Writing DAX Expressions with Time Intelligence
- Writing DAX Code with Contextual Awareness

Calculated Fields for QTD and YTD Sales

- TOTALQTD function calculates quarter-to-date totals



Data Type:

Format: $ English (United States)

$ % , .00 0

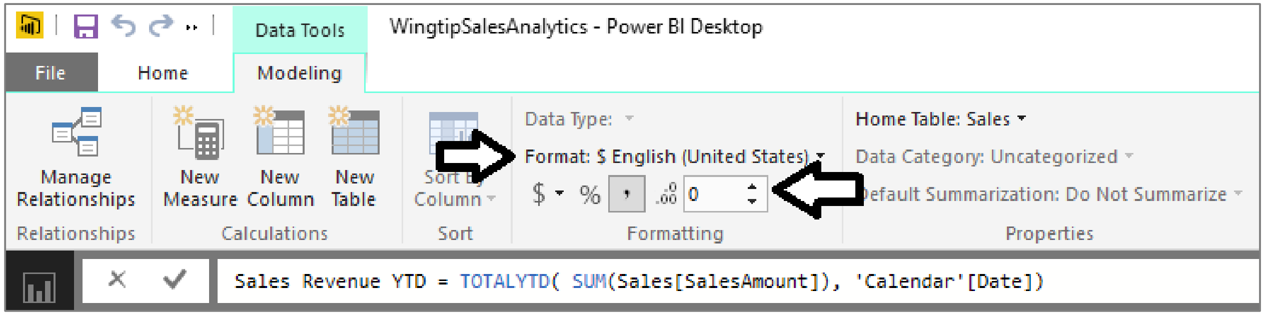
Home Table: Sales

Data Category: Uncategorized

Default Summarization: Do Not Summarize

```
Sales Revenue QTD = TOTALQTD( SUM(Sales[SalesAmount]), 'Calendar'[Date])
```

- TOTALYTD function calculates year-to-date totals



Data Type:

Format: $ English (United States)

$ % , .00 0

Home Table: Sales

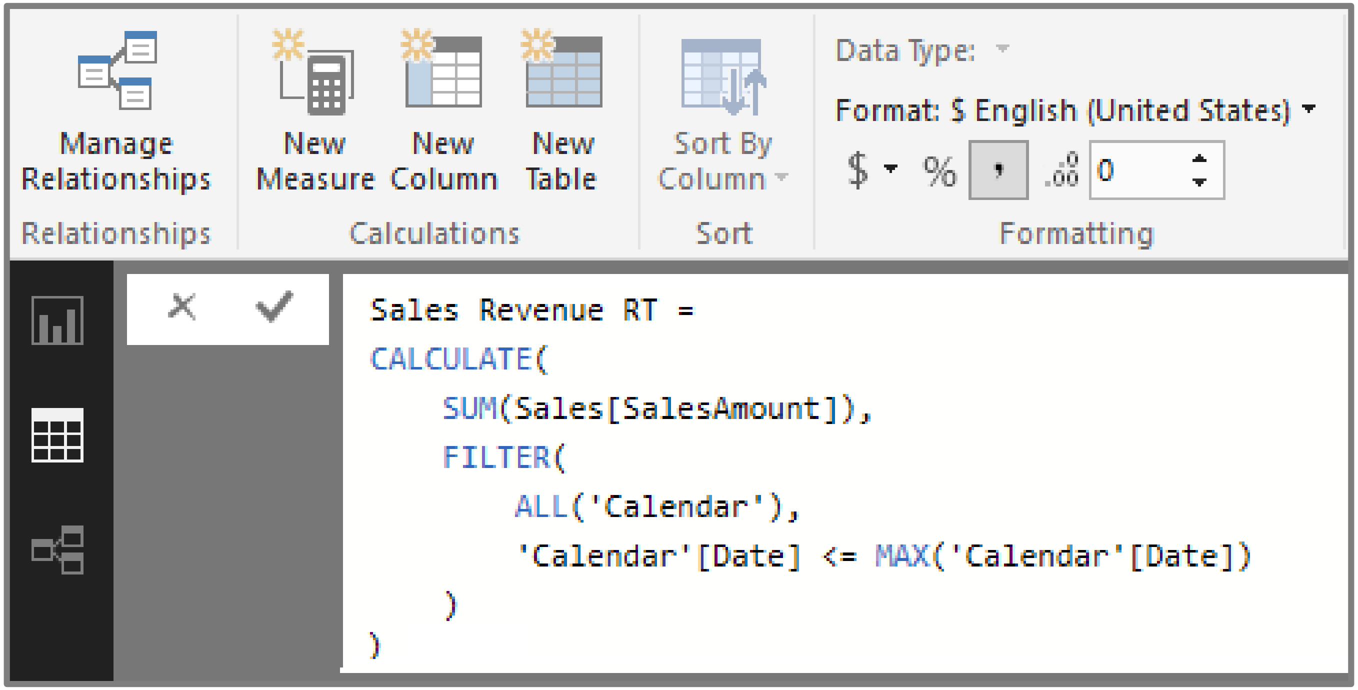
Data Category: Uncategorized

Default Summarization: Do Not Summarize

```
Sales Revenue YTD = TOTALYTD( SUM(Sales[SalesAmount]), 'Calendar'[Date])
```

Creating Running Total using CALCULATE

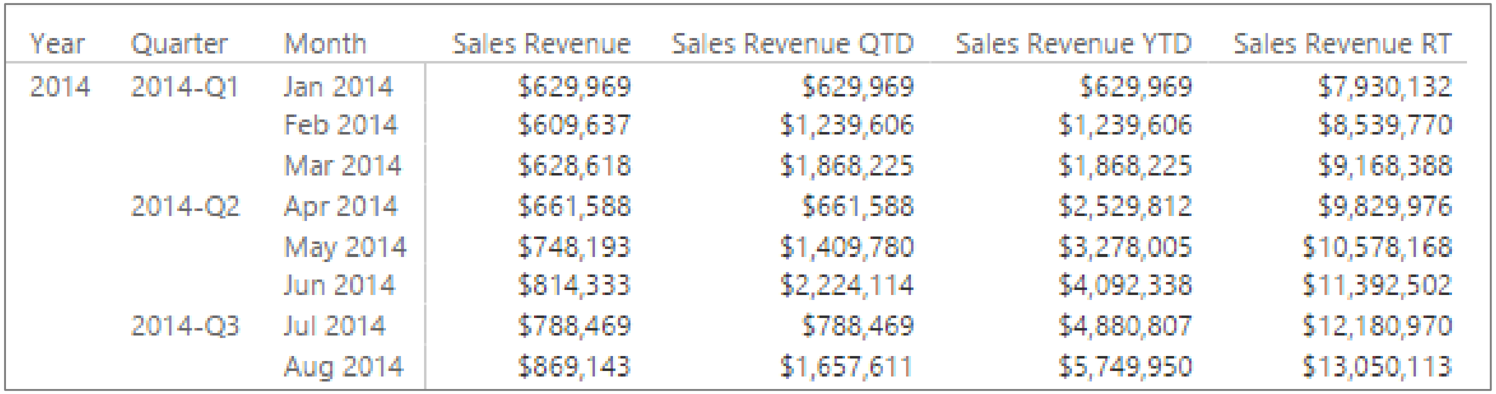
- Calculate a running total of sales revenue across years
  - This must be done using **CALCULATE** function



```
Sales Revenue RT =
CALCULATE(
    SUM(Sales[SalesAmount]),
    FILTER(
        ALL('Calendar'),
        'Calendar'[Date] <= MAX('Calendar'[Date])
    )
)
```

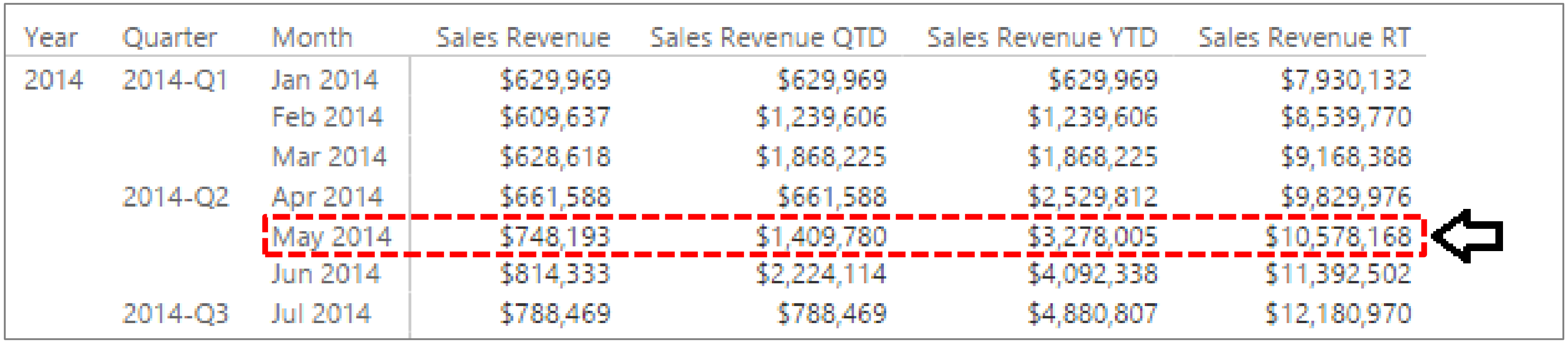
Matrix Visual with To-Date Running Totals

- Running totals calculated using DAX



Year	Quarter	Month	Sales Revenue	Sales Revenue QTD	Sales Revenue YTD	Sales Revenue RT
2014	2014-Q1	Jan 2014	$629,969	$629,969	$629,969	$7,930,132
		Feb 2014	$609,637	$1,239,606	$1,239,606	$8,539,770
		Mar 2014	$628,618	$1,868,225	$1,868,225	$9,168,388
	2014-Q2	Apr 2014	$661,588	$661,588	$2,529,812	$9,829,976
		May 2014	$748,193	$1,409,780	$3,278,005	$10,578,168
		Jun 2014	$814,333	$2,224,114	$4,092,338	$11,392,502
	2014-Q3	Jul 2014	$788,469	$788,469	$4,880,807	$12,180,970
		Aug 2014	$869,143	$1,657,611	$5,749,950	$13,050,113

- Question: when did Wingtip reach $10,000,000 in sales



Year	Quarter	Month	Sales Revenue	Sales Revenue QTD	Sales Revenue YTD	Sales Revenue RT
2014	2014-Q1	Jan 2014	$629,969	$629,969	$629,969	$7,930,132
		Feb 2014	$609,637	$1,239,606	$1,239,606	$8,539,770
		Mar 2014	$628,618	$1,868,225	$1,868,225	$9,168,388
	2014-Q2	Apr 2014	$661,588	$661,588	$2,529,812	$9,829,976
		May 2014	$748,193	$1,409,780	$3,278,005	$10,578,168
		Jun 2014	$814,333	$2,224,114	$4,092,338	$11,392,502
	2014-Q3	Jul 2014	$788,469	$788,469	$4,880,807	$12,180,970

Agenda

✓ Creating Dimensional Hierarchies

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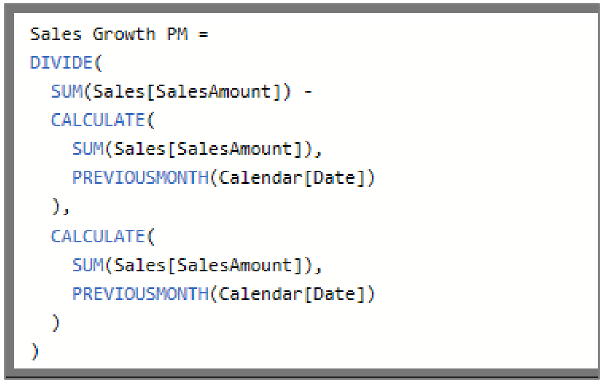
✓ Writing DAX Expressions with Time Intelligence

➢ Writing DAX Code with Contextual Awareness

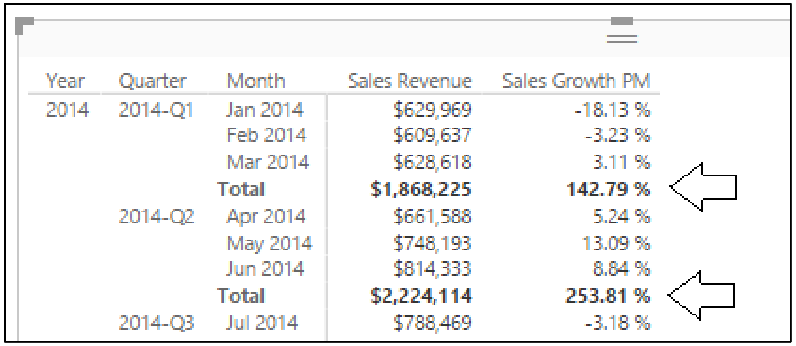
Sales Growth PM Measure - First Attempt

- 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])
  )
)
```

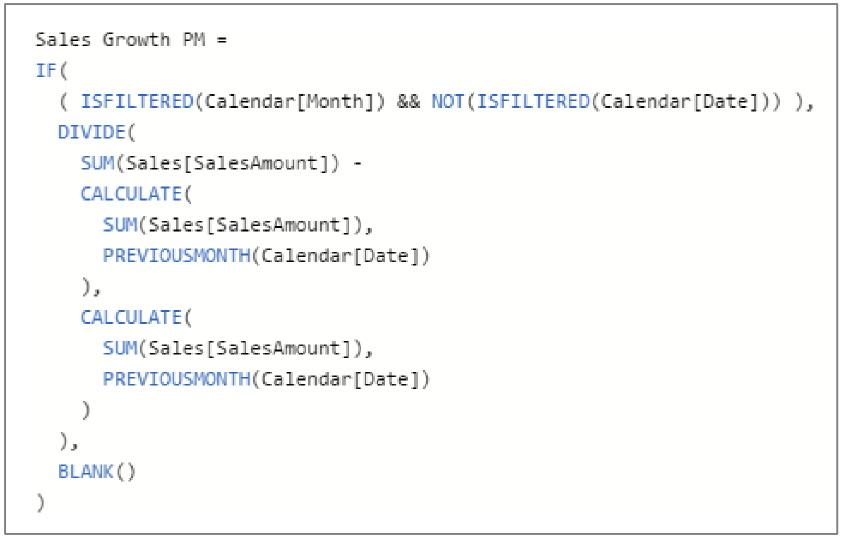
- Use measure in matrix evaluating month and quarter
  - Measure returns correct value when filtered by Month
  - Measure returns large, erroneous value when filtered by Quarter



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 %

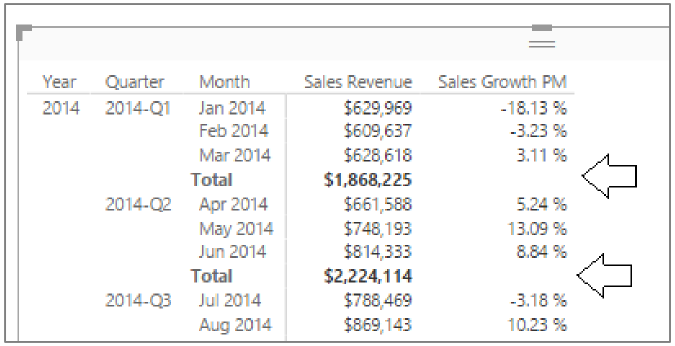
Using the ISFILTERED Function

- 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()
)
```

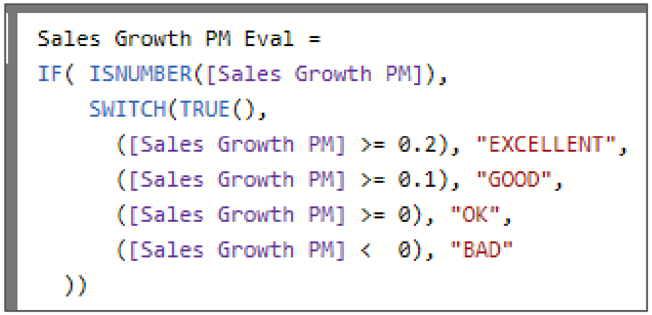
- Expression returns Blank value when evaluation context is invalid



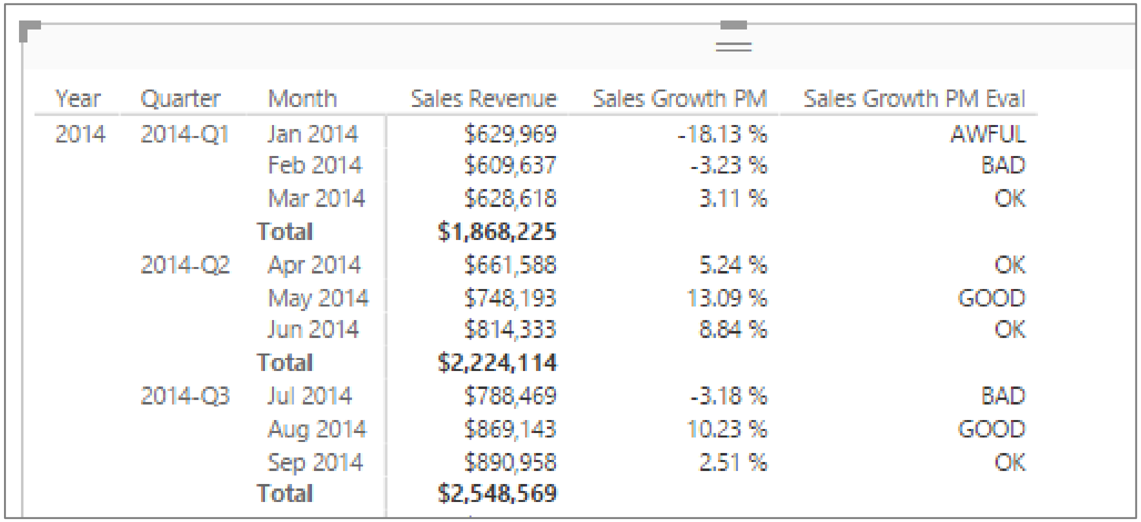
Year	Quarter	Month	Sales Revenue	Sales Growth PM
2014	2014-Q1	Jan 2014	$629,969	-18.13 %
		Feb 2014	$609,637	-3.23 %
		Mar 2014	$628,618	3.11 %
		Total	**$1,868,225**	
	2014-Q2	Apr 2014	$661,588	5.24 %
		May 2014	$748,193	13.09 %
		Jun 2014	$814,333	8.84 %
		Total	**$2,224,114**	
	2014-Q3	Jul 2014	$788,469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

Simulating KPIs with Power BI Desktop

- KPIs are not directly support in data model
  - But you can create something similar using measures



```
Sales Growth PM Eval =
IF( ISNUMBER([Sales Growth PM]),
    SWITCH(TRUE(),
      ([Sales Growth PM] >= 0.2), "EXCELLENT",
      ([Sales Growth PM] >= 0.1), "GOOD",
      ([Sales Growth PM] >= 0), "OK",
      ([Sales Growth PM] <  0), "BAD"
  ))
```



Year	Quarter	Month	Sales Revenue	Sales Growth PM	Sales Growth PM Eval
2014	2014-Q1	Jan 2014	$629,969	-18.13 %	AWFUL
		Feb 2014	$609,637	-3.23 %	BAD
		Mar 2014	$628,618	3.11 %	OK
		Total	**$1,868,225**		
	2014-Q2	Apr 2014	$661,588	5.24 %	OK
		May 2014	$748,193	13.09 %	GOOD
		Jun 2014	$814,333	8.84 %	OK
		Total	**$2,224,114**		
	2014-Q3	Jul 2014	$788,469	-3.18 %	BAD
		Aug 2014	$869,143	10.23 %	GOOD
		Sep 2014	$890,958	2.51 %	OK
		Total	**$2,548,569**		

Summary

- ✓ Creating Dimensional Hierarchies
- ✓ Understanding the Evaluation Context
- ✓ Extending the Data Model using Calendar Tables
- ✓ Writing DAX Expressions with Time Intelligence
- ✓ Writing DAX Code with Contextual Awareness