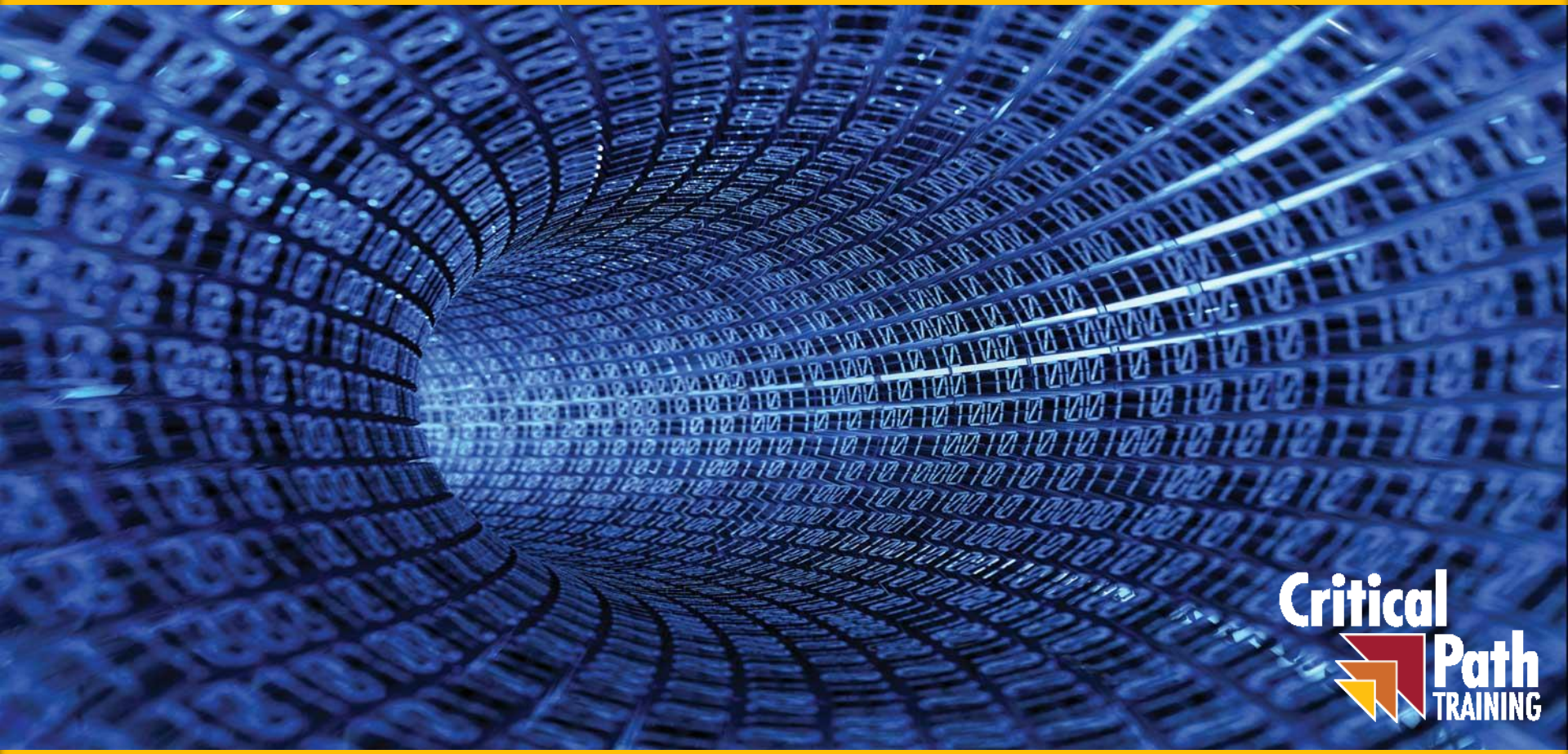
Data Modeling with Power BI Desktop



Agenda

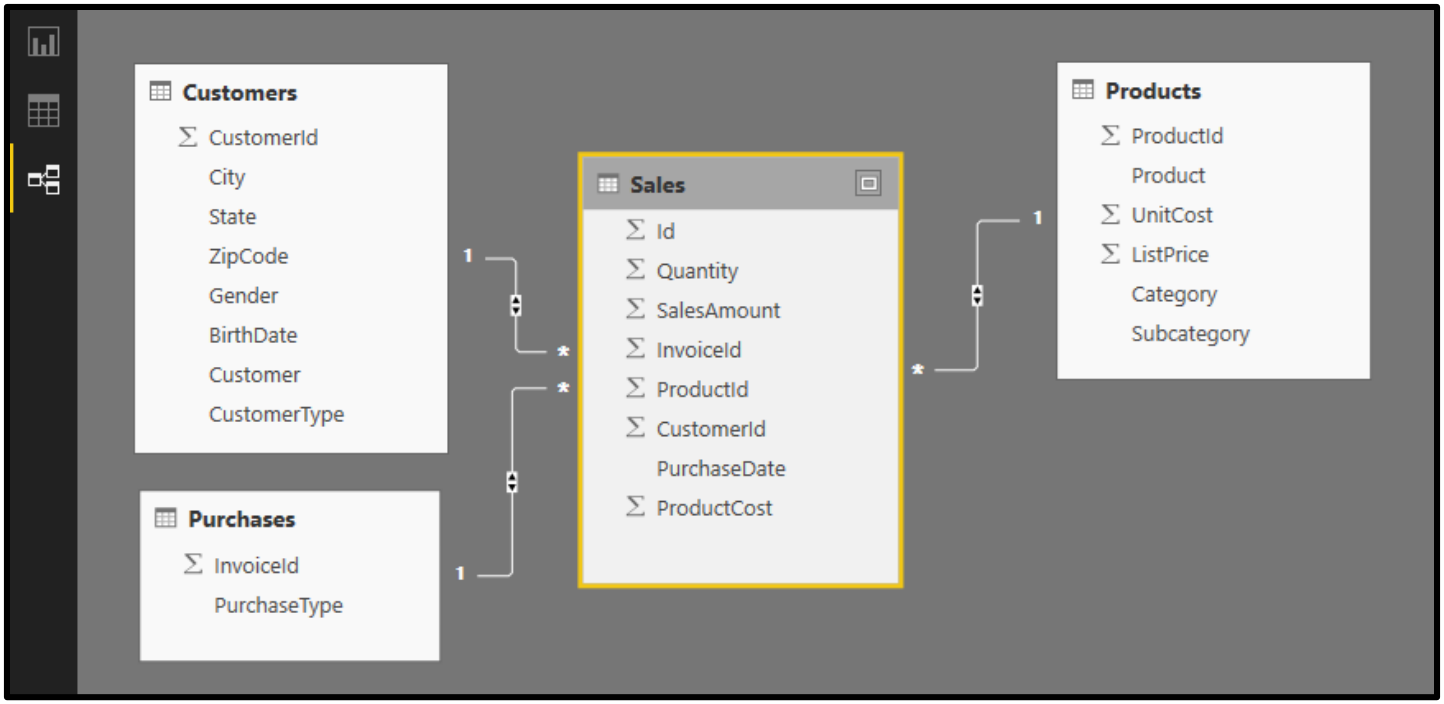
- Data Modeling with Power BI Desktop
- Understanding the DAX Evaluation Context
- Creating a Dynamic Calendar Table
- Designing Interactive Reports
- Understanding Row-level Security (RLS)
- Publishing PBIX Projects to PowerBI.com

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)

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



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>
```

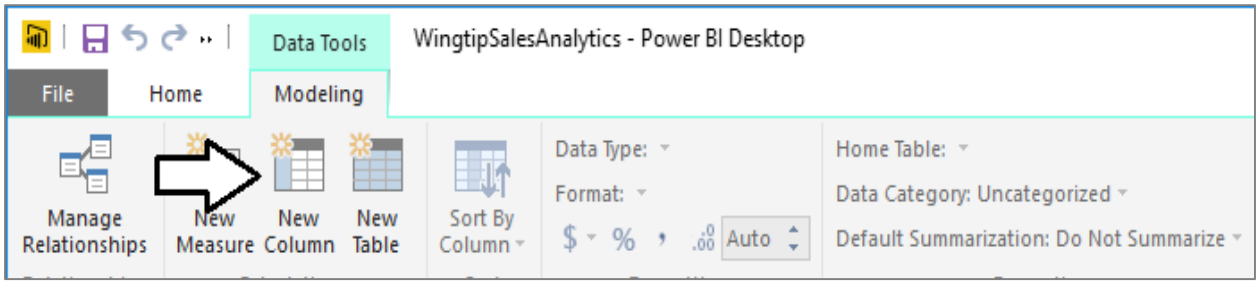
When to Create Calculated Columns

- 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

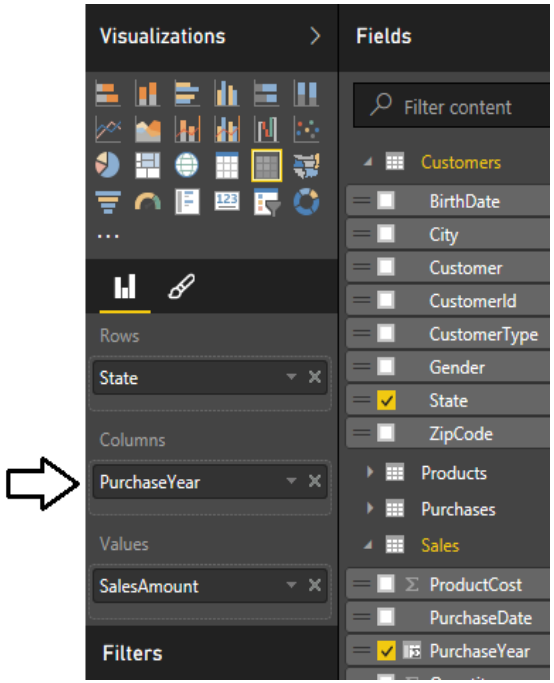



```
PurchaseYear = YEAR(Sales[PurchaseDate])
```

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



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

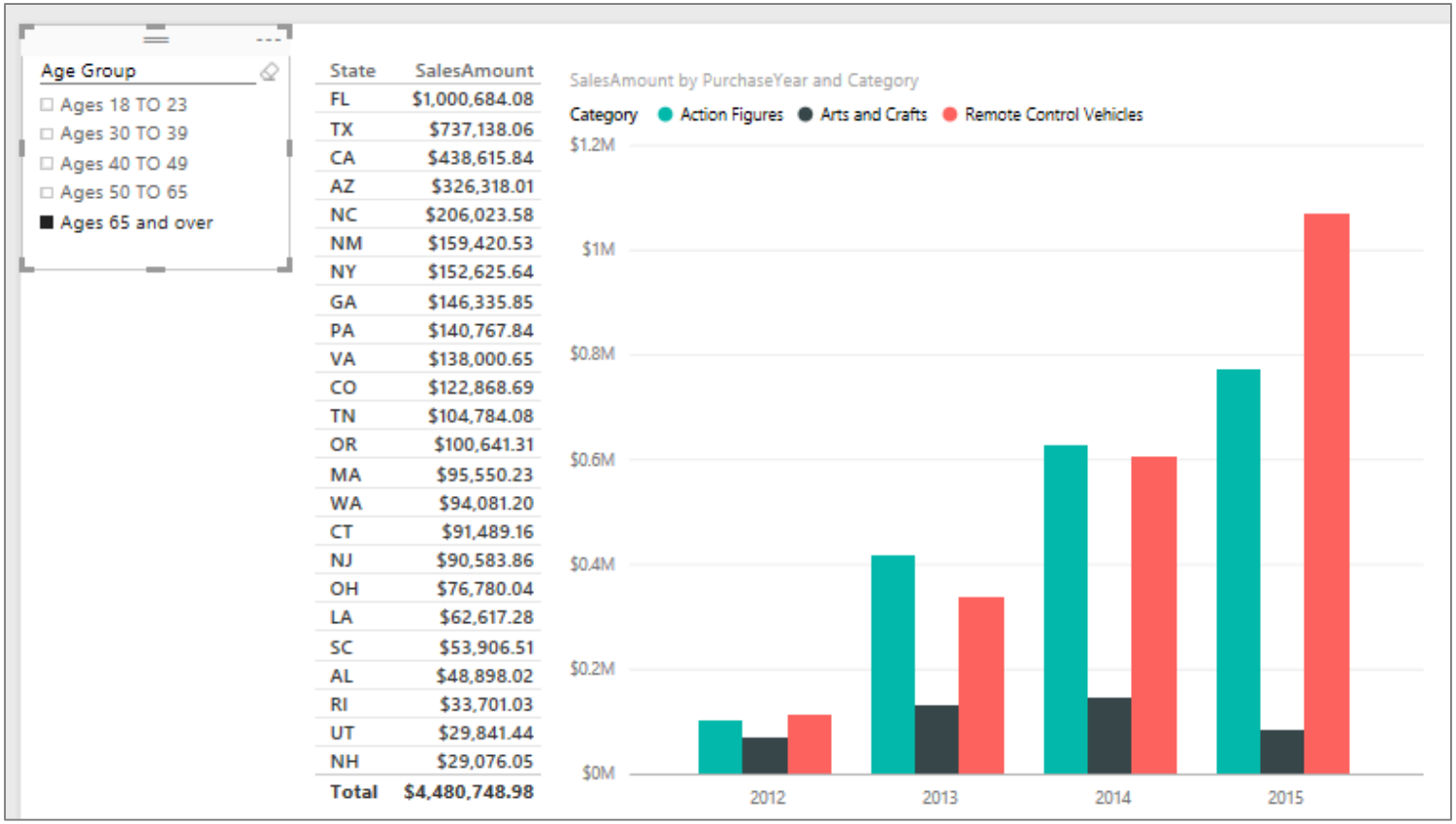
2. Calculate age groups using calculated column

```
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 used in a Slicer

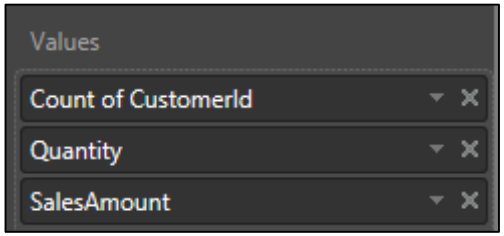
- Calculated column can populate slicer values



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**

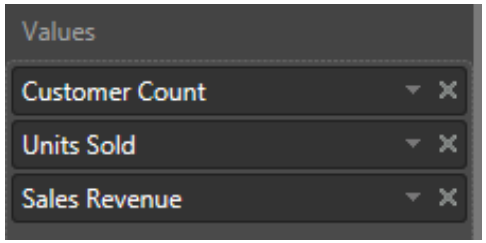
Benefits of Measures over Calculated Columns

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



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

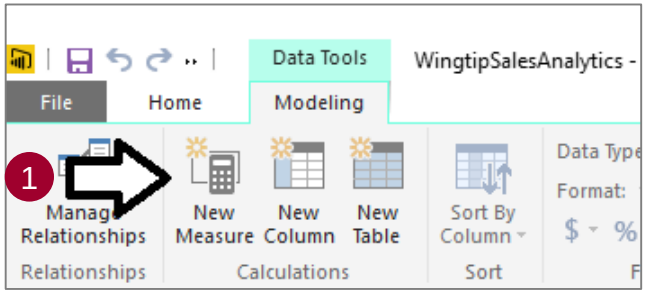


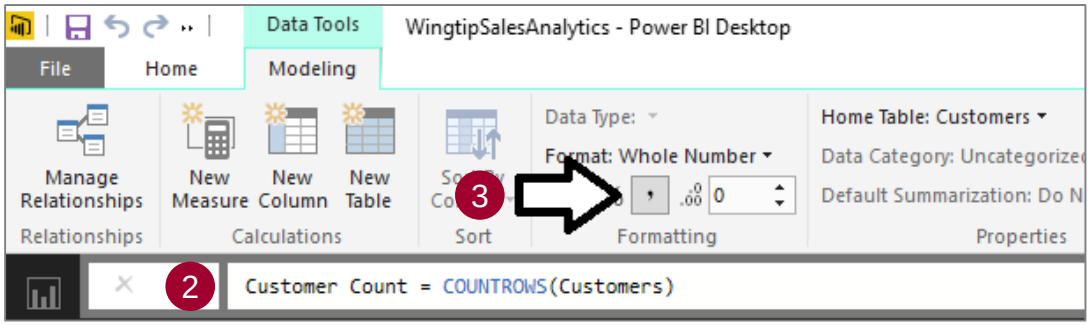
Age Group	Customer Count	Units Sold	Sales Revenue
Ages 50 TO 65	7,974	1,143,644	$4,904,343
Ages 65 and over	7,569	1,050,879	$4,480,749
Ages 40 TO 49	5,103	713,453	$3,083,964
Ages 30 TO 39	4,547	646,121	$2,798,053
Ages 18 TO 23	3,278	478,405	$1,985,991
Total	**28,471**	**4,032,502**	**$17,253,100**

Creating Measures

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

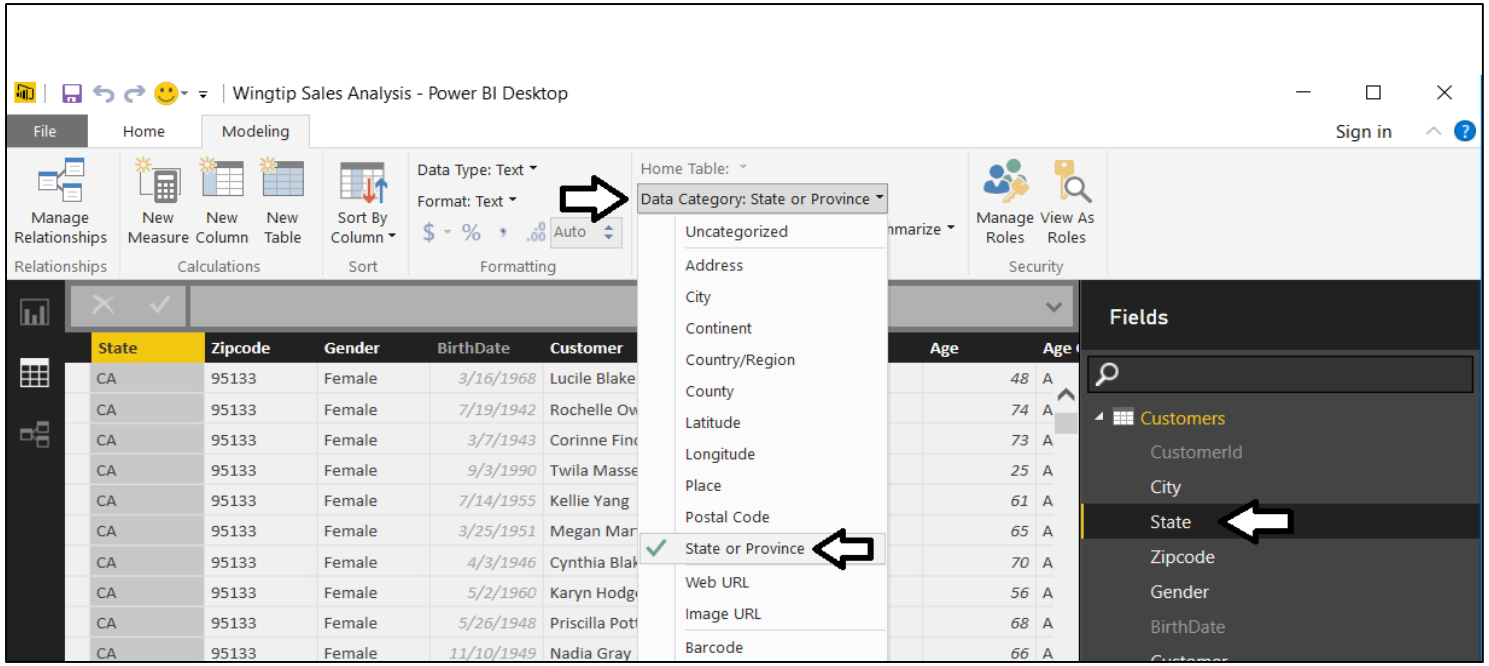
- Creating a measure with Power BI Desktop
  1. Click New Measure button
  2. Give measure a name and write DAX expressions
  3. Configure formatting





Geographic Field Metadata

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



Eliminate Geographic Ambiguity

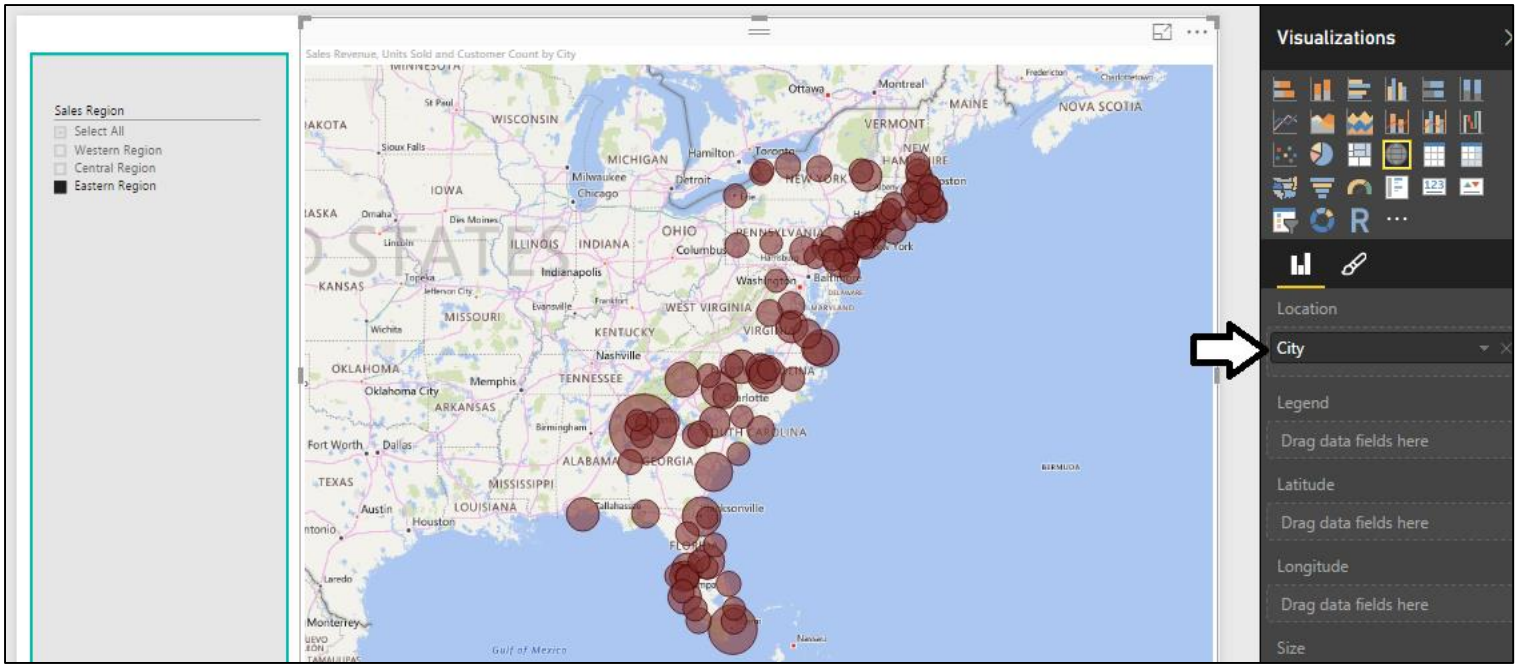
- City name alone is ambiguous
  - "Athens" defaults to Greece not Georgia
  - Concatenate city name with state to disambiguate

```
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

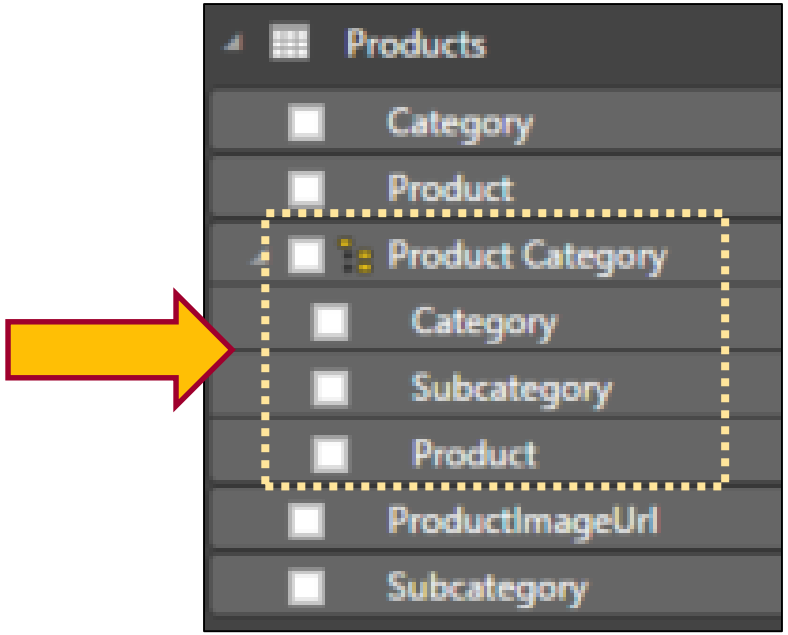
Using Map Visual with a Geographic Field

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



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



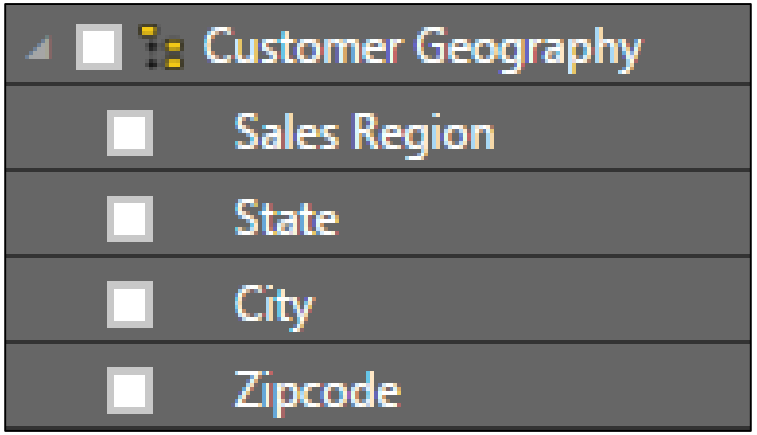
Pulling Columns for Hierarchy into Single Table

- 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



Agenda

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- ➢ Understanding the DAX Evaluation Context
- Creating a Dynamic Calendar Table
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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	$74,611	$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] )
    )
)
```

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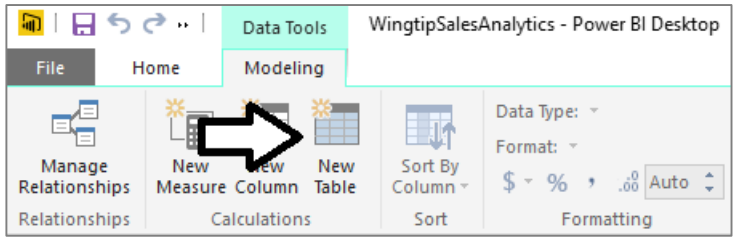
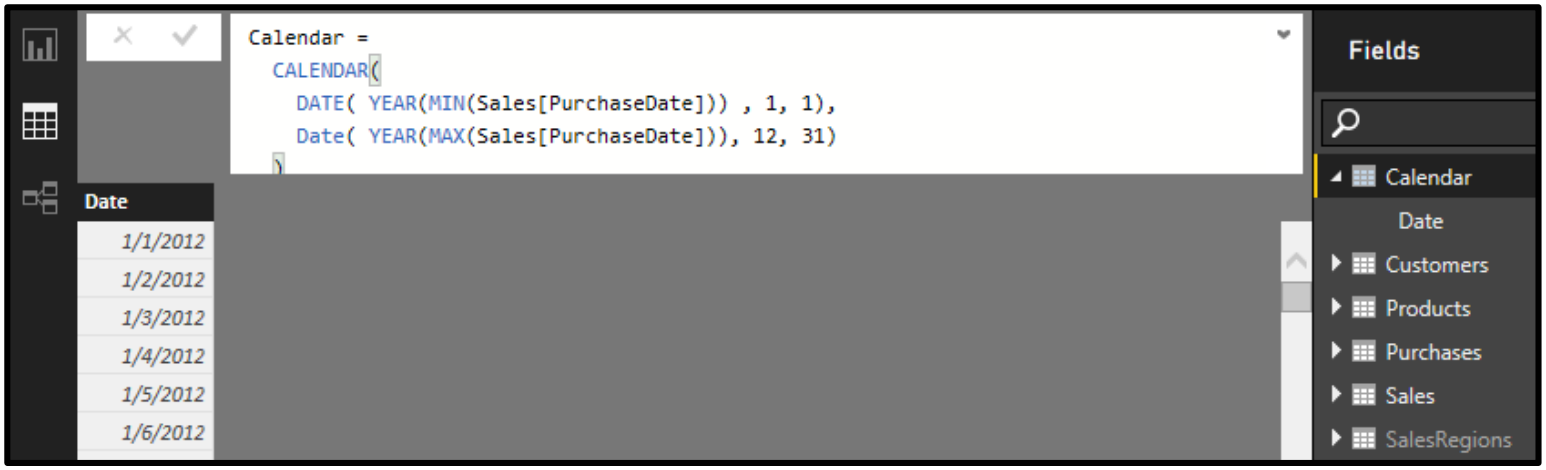
Creating Calendar Table as Calculated Table

- 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

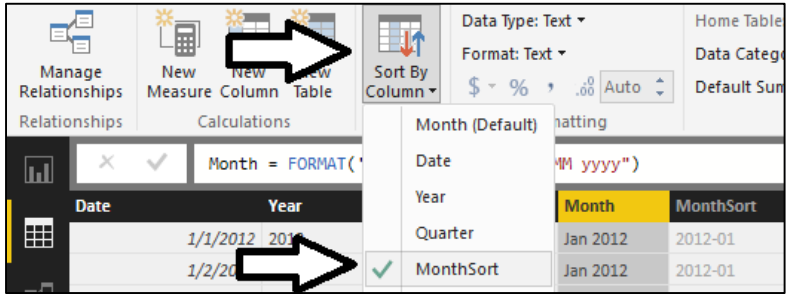
- Month column will not sort in desired fashion by default
  - For example, April will sort before January, February and March

- 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

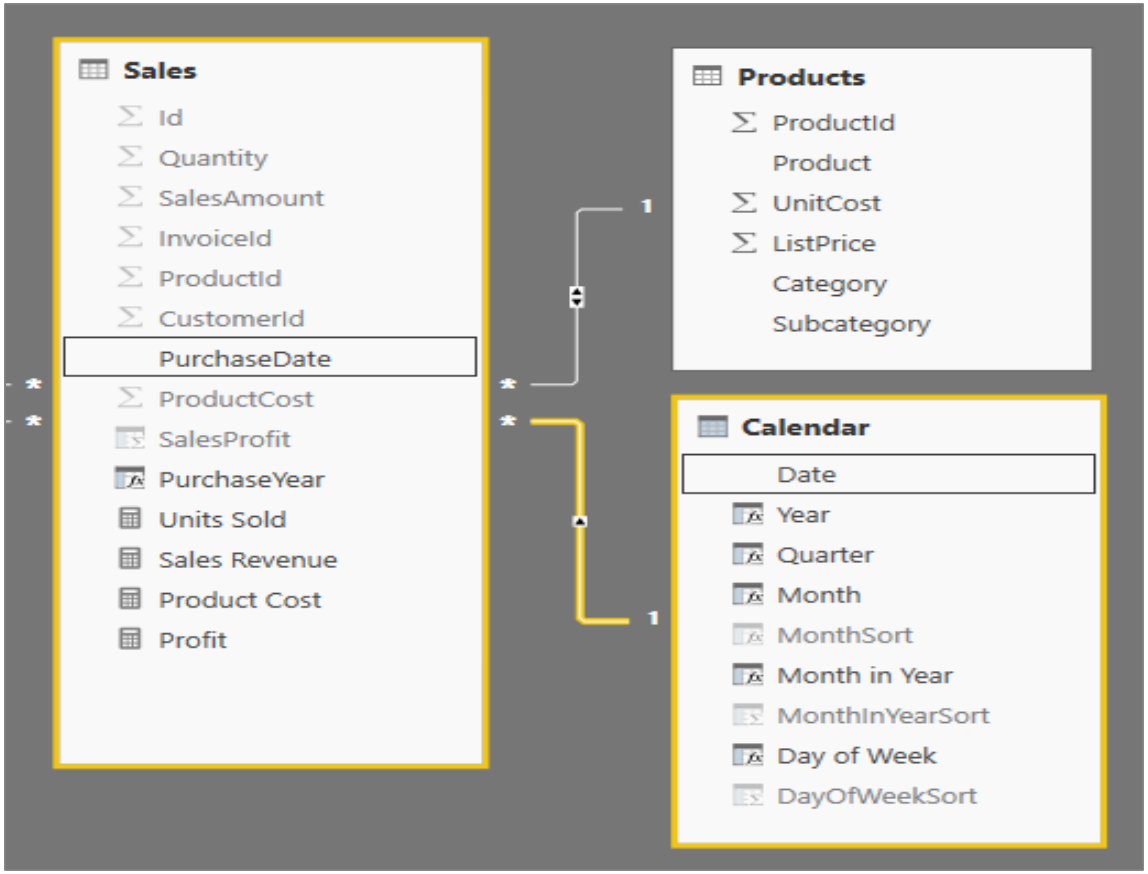
- Creating the **DayOfWeekSort** column

```
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

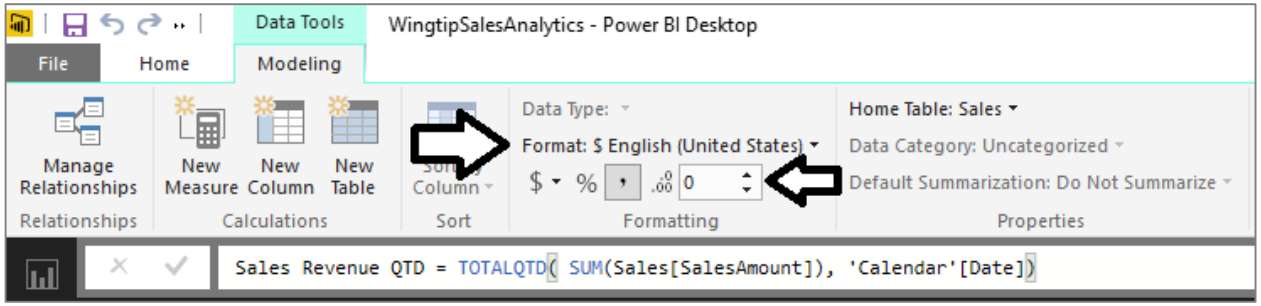
Integrating Calendar Table into Data Model

- Calendar table needs relationship to one or more tables

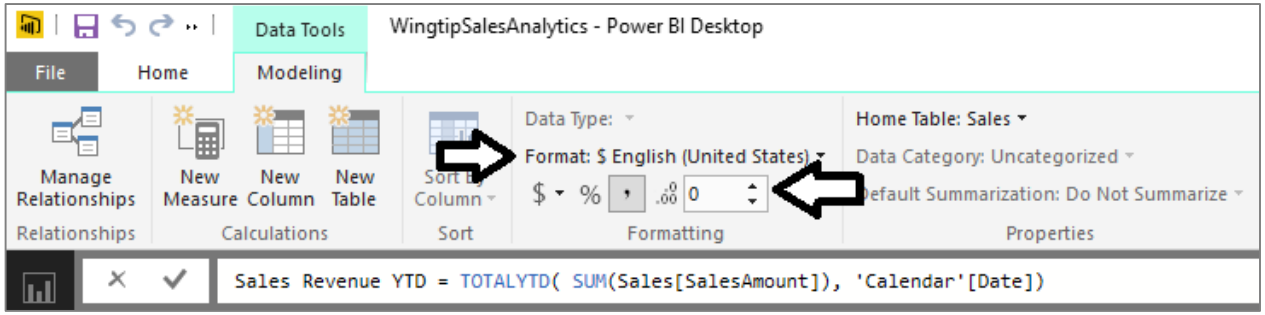


Calculated Fields for QTD and YTD Sales

- TOTALQTD function calculates quarter-to-date totals

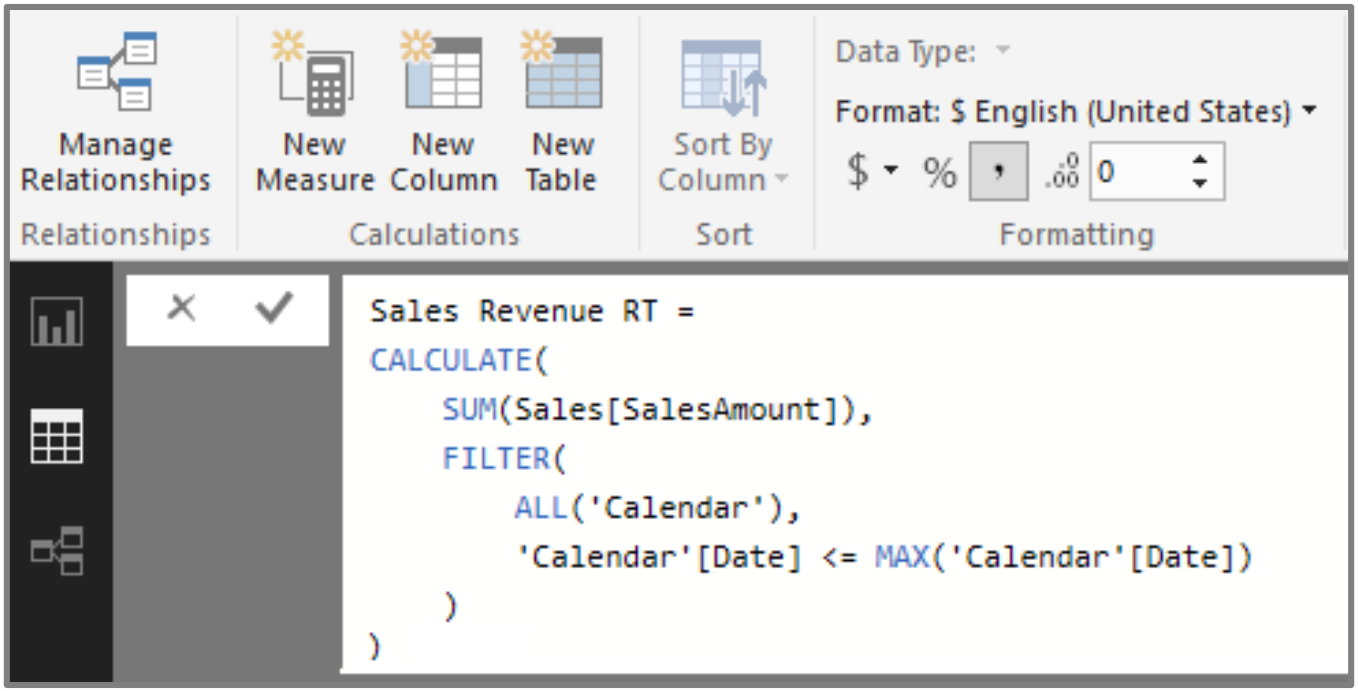


- TOTALYTD function calculates year-to-date totals



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 %

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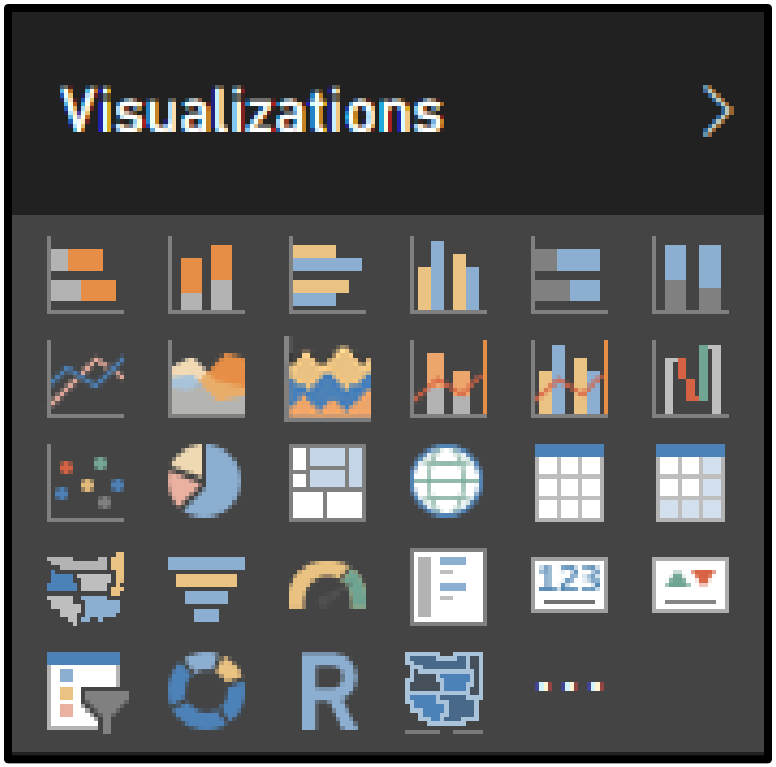
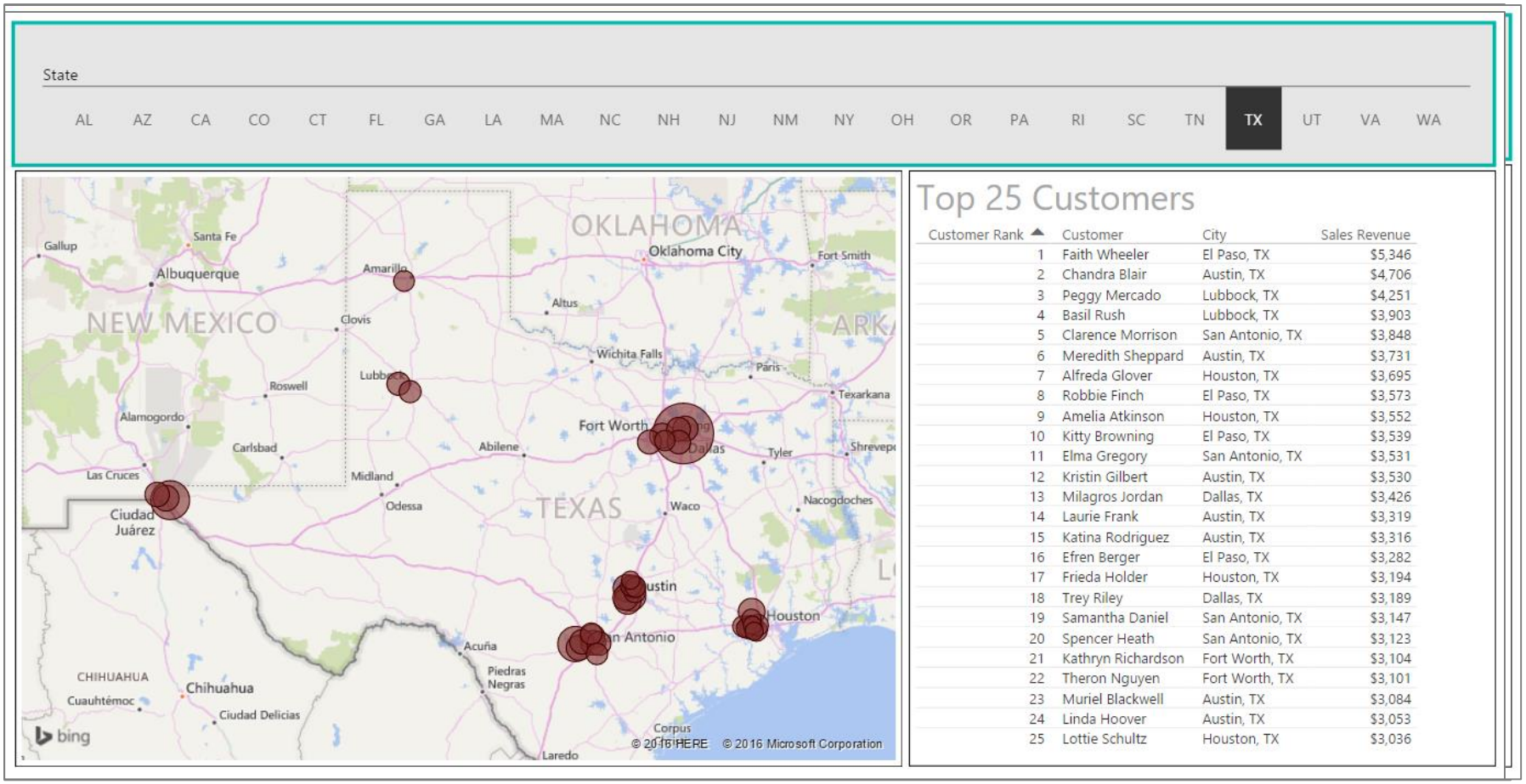
Built-in Visualization Types

- Table and Matrix
- Bar charts and Column charts
- Pie charts and Doughnut chart
- Line chart and Area chart
- Scatter chart and Combo charts
- Card and Multi-row Card
- Treemap
- Waterfall charts
- Funnel charts
- Gauge charts
- Map and Filled Map
- Slicer
- R script visual
- Shape map (in preview)



User Interaction with Slicers & Highlighting

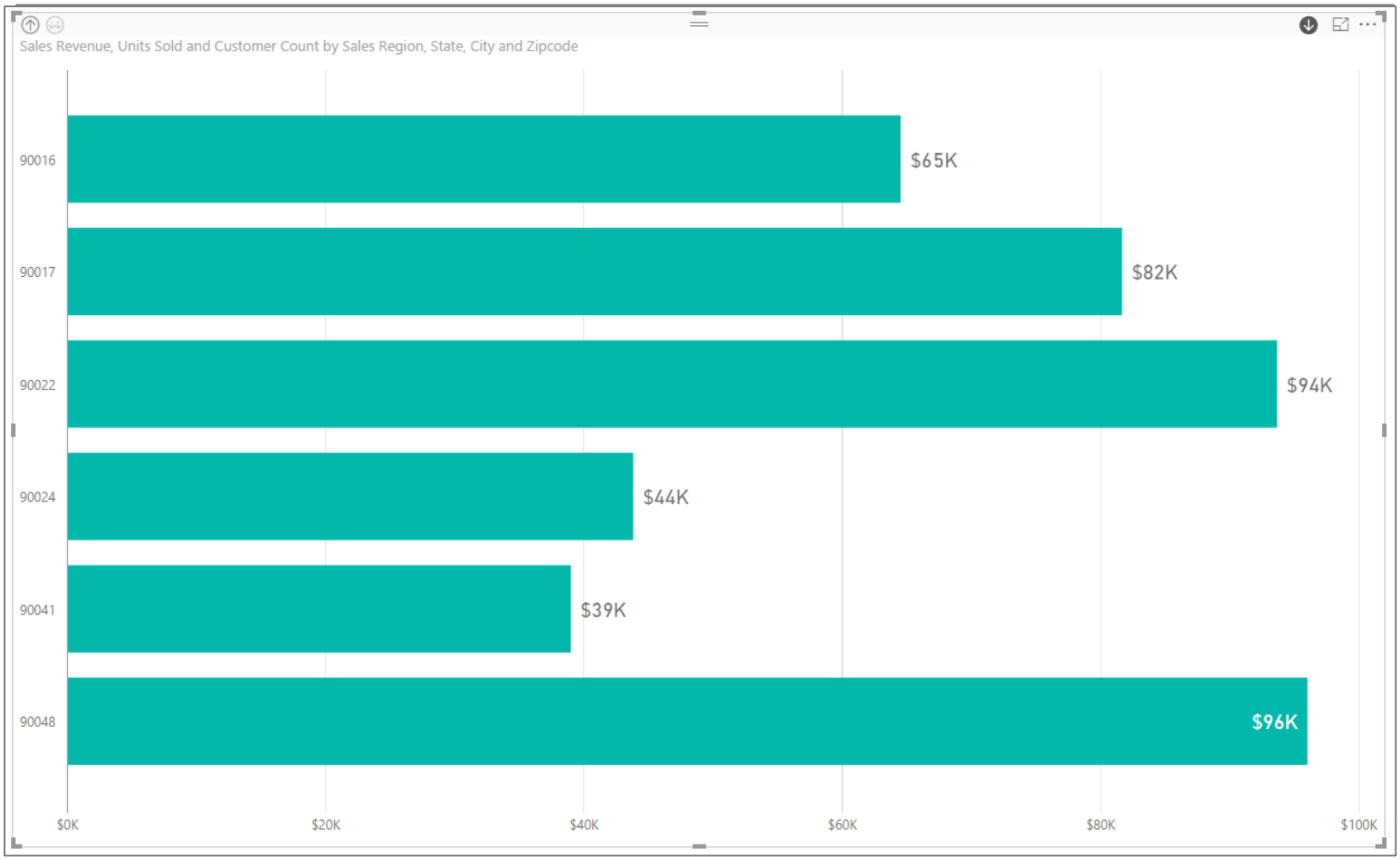
- Provides user with interactive filtering control



Customer Rank	Customer	City	Sales Revenue
1	Faith Wheeler	El Paso, TX	$5,346
2	Chandra Blair	Austin, TX	$4,706
3	Peggy Mercado	Lubbock, TX	$4,251
4	Basil Rush	Lubbock, TX	$3,903
5	Clarence Morrison	San Antonio, TX	$3,848
6	Meredith Sheppard	Austin, TX	$3,731
7	Alfreda Glover	Houston, TX	$3,695
8	Robbie Finch	El Paso, TX	$3,573
9	Amelia Atkinson	Houston, TX	$3,552
10	Kitty Browning	El Paso, TX	$3,539
11	Elma Gregory	San Antonio, TX	$3,531
12	Kristin Gilbert	Austin, TX	$3,530
13	Milagros Jordan	Dallas, TX	$3,426
14	Laurie Frank	Austin, TX	$3,319
15	Katina Rodriguez	Austin, TX	$3,316
16	Efren Berger	El Paso, TX	$3,282
17	Frieda Holder	Houston, TX	$3,194
18	Trey Riley	Dallas, TX	$3,189
19	Samantha Daniel	San Antonio, TX	$3,147
20	Spencer Heath	San Antonio, TX	$3,123
21	Kathryn Richardson	Fort Worth, TX	$3,104
22	Theron Nguyen	Fort Worth, TX	$3,101
23	Muriel Blackwell	Austin, TX	$3,084
24	Linda Hoover	Austin, TX	$3,053
25	Lottie Schultz	Houston, TX	$3,036

User Interaction using Drill Actions

- Drill Actions supported when using hierarchies
  - You must enabled drilldown mode in visual



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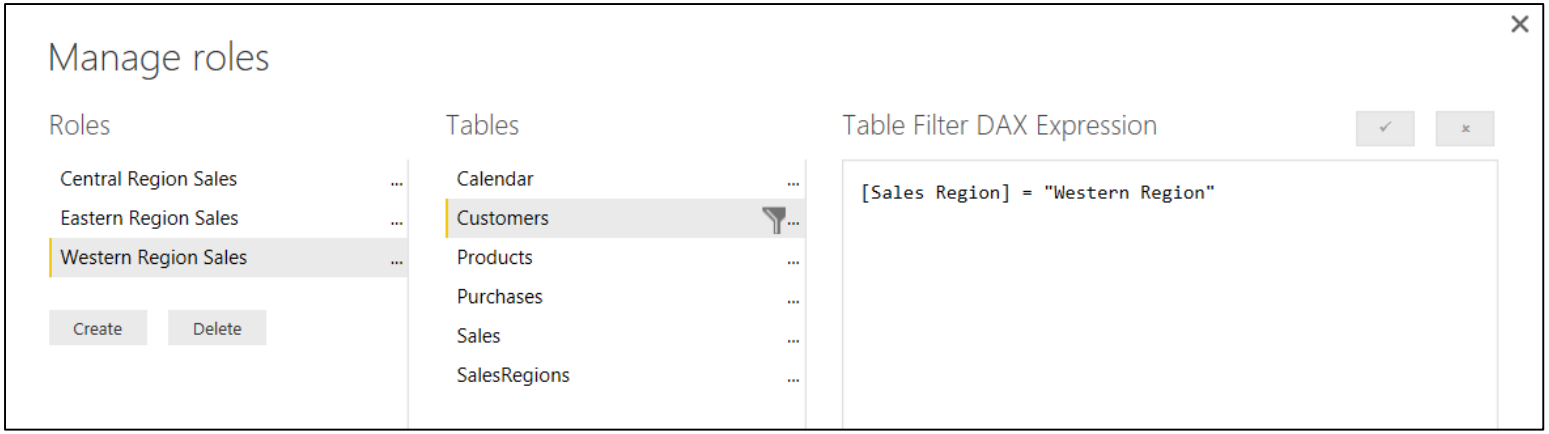
What Is Row-level Security (RLS)

- Security features for restricting user access
  - Introduced into preview in February of 2016
  - RLS feature set changed in summer of 2016
  - Configuring RLS now requires Power BI Desktop
  - RLS requires all users to have Power BI Pro license
  - This course covers RLS in Module 6 and Module 7



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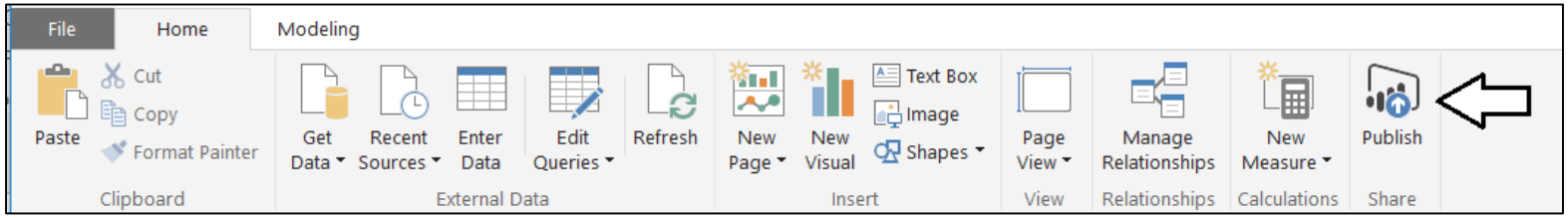
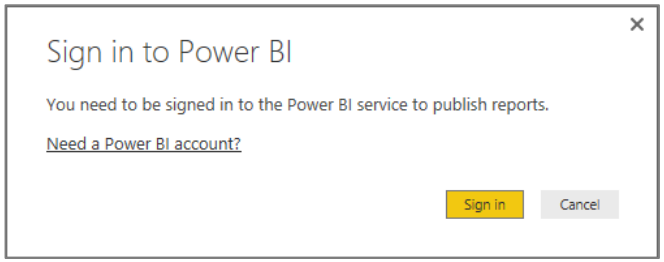
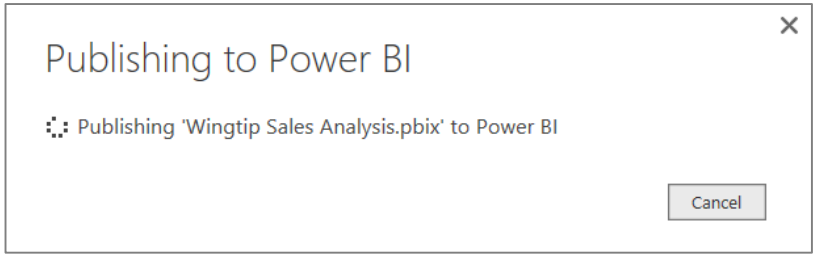
Publishing a Power BI Desktop Project

- Power BI Desktop provides **Publish** command
  - Used to publish project to Power BI service



  - Requires logging into your Office 365 account

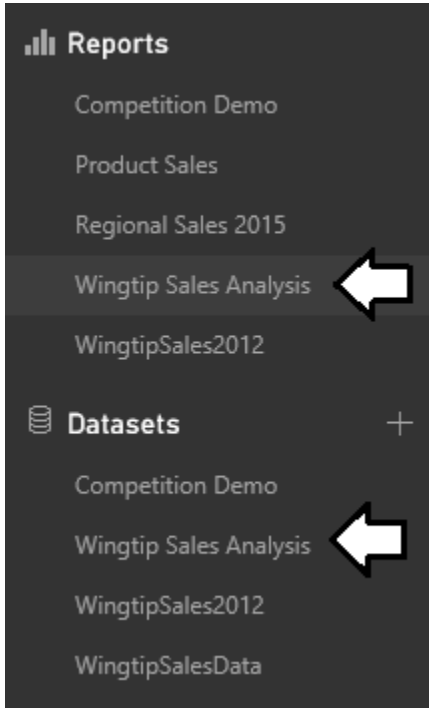




  - Published articles added to a specific workspace

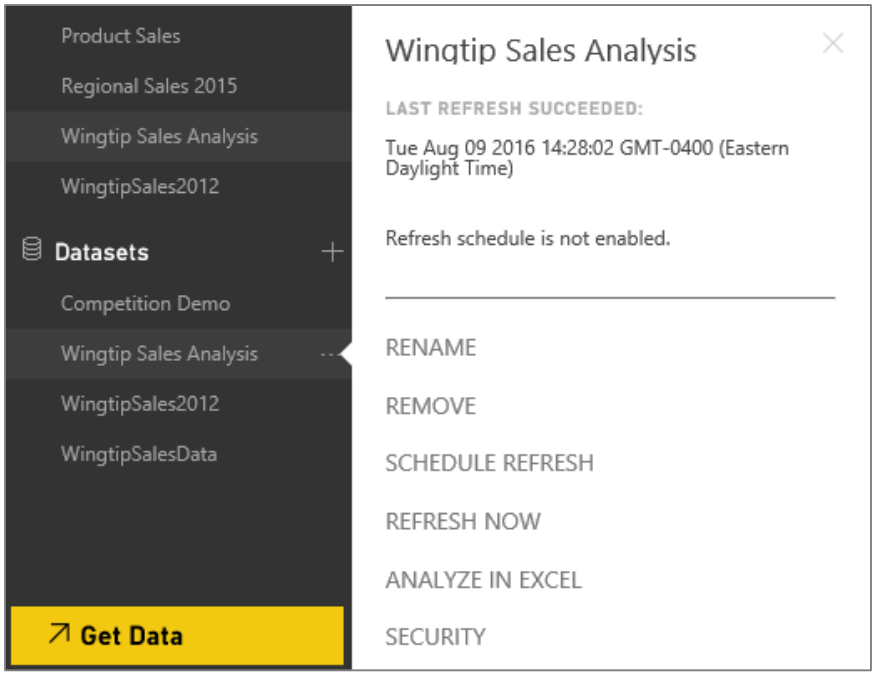
Examining What's Been Published

- What does project publishing add to workspace?
  - One dataset with same name as project
  - One report with same name as project



Dataset Configuration

- You can configure Dataset after its been published
  - Configure data source credentials
  - Configure refresh schedule
  - Configure Row-level Security



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