

# Designing a Data Model with Power BI Desktop



# Agenda

- Designing a Data model
- Creating Calculated Columns
- Creating Measures
- Adding Geographic Fields to a Data Model
- Creating Dimensional Hierarchies
- Understanding the Evaluation Context



# 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
  - Configure column data categories
  - 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

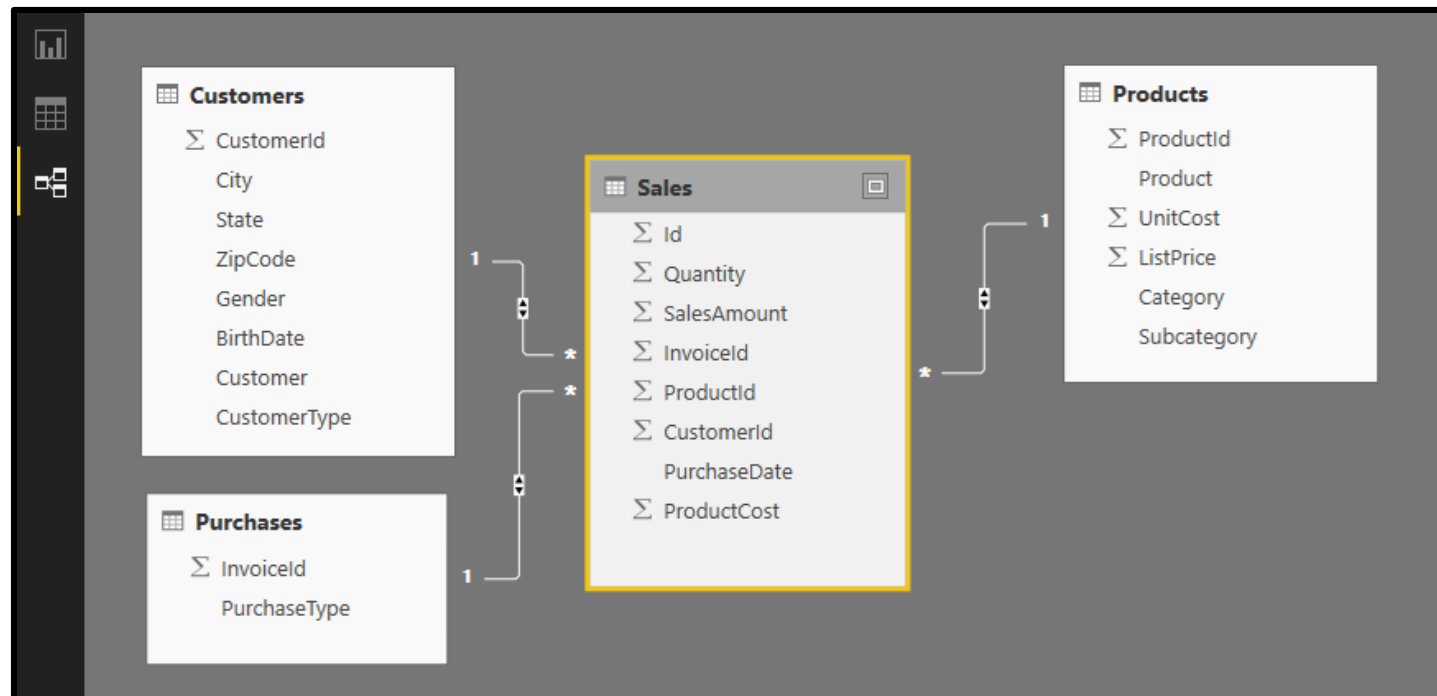
The screenshot shows the Power BI Desktop interface with the 'Modeling' ribbon selected. The ribbon includes options for 'Manage Relationships', 'New Measure', 'New Column', 'New Table', and 'Sort & Column'. The 'Sort & Column' option is highlighted with a black arrow. The ribbon also displays settings for 'Data Type' (Fixed Decimal Number), 'Format' (\$ English (United States)), 'Home Table', 'Data Category' (Uncategorized), and 'Default Summarization' (Sum). Below the ribbon, a data table is visible with columns: Id, Quantity, SalesAmount, InvoiceId, ProductId, CustomerId, PurchaseDate, and ProductCost. The 'SalesAmount' column is highlighted in yellow. To the right of the table is the 'Fields' pane, which lists the data sources: Customers, Products, Purchases, and Sales.

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



# 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



# Working with DAX

- DAX is the language used to create data model
  - DAX stands for "Data Analysis Expression 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





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# 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>`



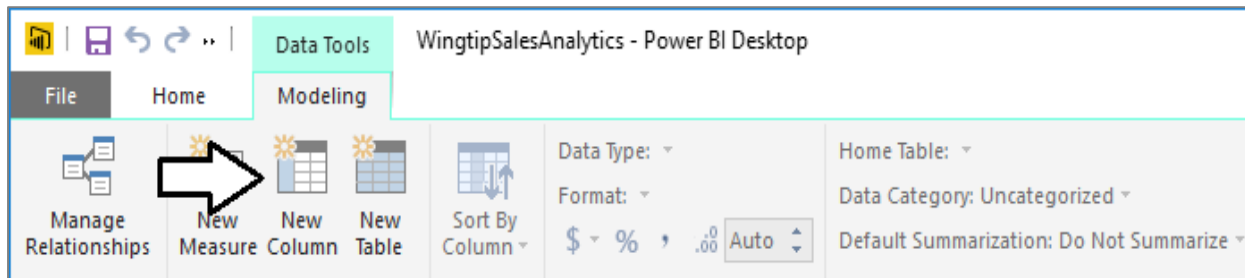
# When to Create Calculated Columns

- 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

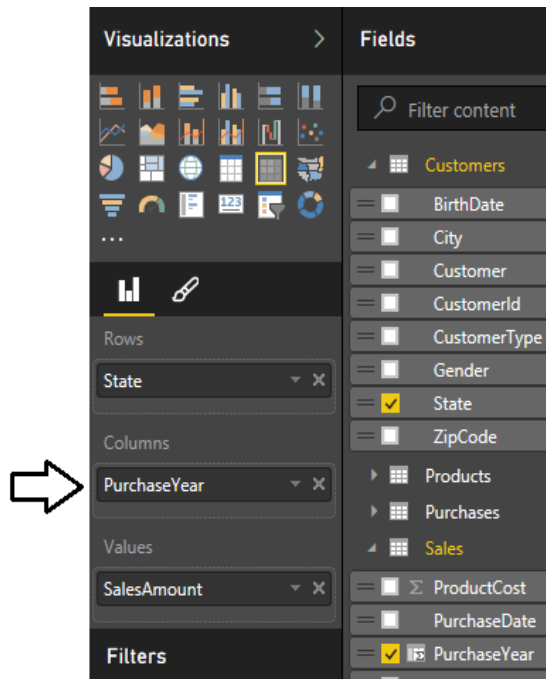


PurchaseYear = YEAR(Sales[PurchaseDate])									
Id	Quantity	SalesAmount	InvoiceId	ProductId	CustomerId	PurchaseDate	ProductCost	SalesProfit	PurchaseYear
2899	100	\$100.00	1457	14	888	6/21/12	\$8.00	\$92.00	2012
3824	100	\$100.00	1901	14	1137	7/21/12	\$8.00	\$92.00	2012
3968	100	\$100.00	1969	14	1173	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



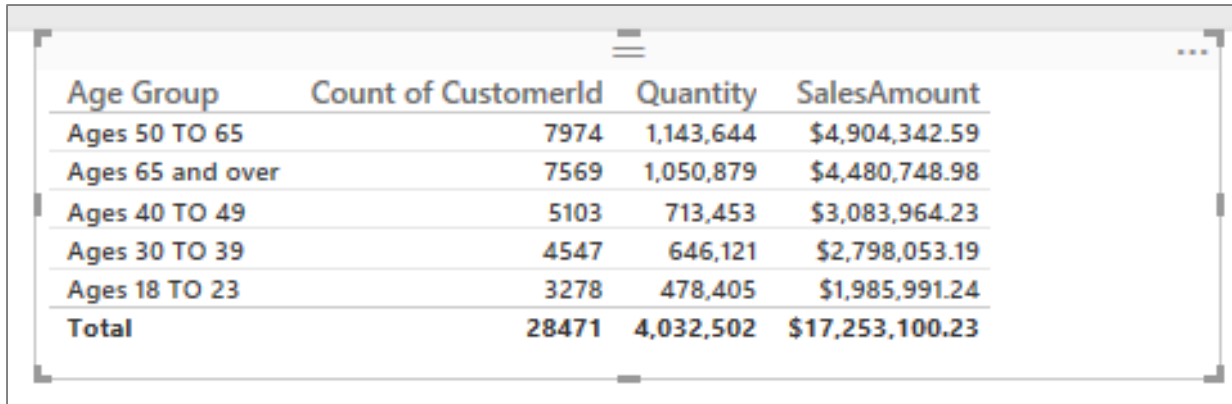
State	2012	2013	2014	2015	Total
CA	\$270,926.32	\$550,160.02	\$737,878.53	\$770,402.11	\$2,329,366.98
TX	\$212,085.08	\$490,643.98	\$683,079.11	\$919,030.36	\$2,304,838.53
FL	\$51,730.85	\$300,866.87	\$535,693.94	\$891,344.92	\$1,779,636.58
NC	\$11,018.02	\$164,804.24	\$315,139.92	\$448,638.72	\$939,600.90
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 as a Row Label

- Age Group can now be used as row label



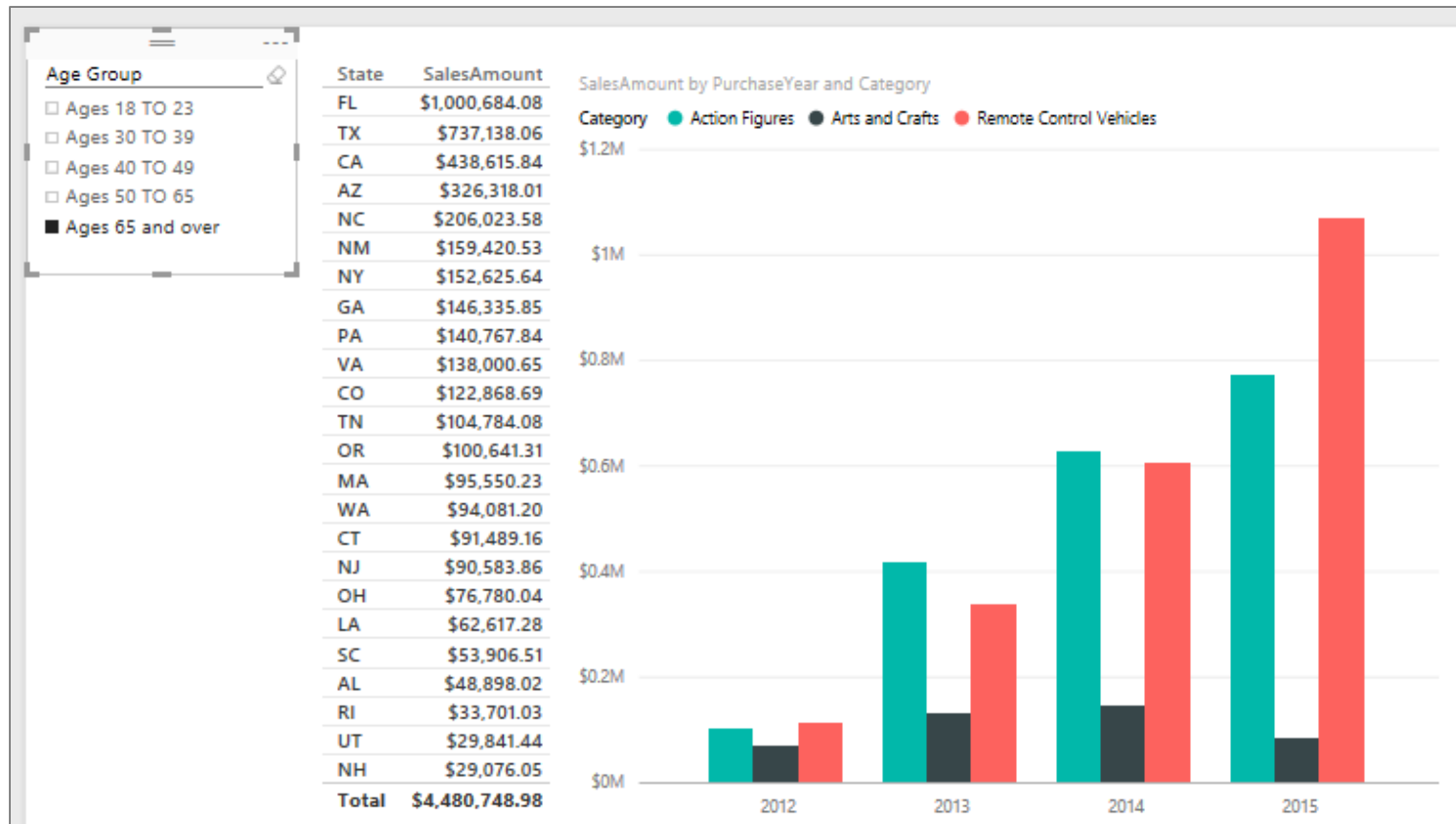
Age Group	Count of CustomerId	Quantity	SalesAmount
Ages 50 TO 65	7974	1,143,644	\$4,904,342.59
Ages 65 and over	7569	1,050,879	\$4,480,748.98
Ages 40 TO 49	5103	713,453	\$3,083,964.23
Ages 30 TO 39	4547	646,121	\$2,798,053.19
Ages 18 TO 23	3278	478,405	\$1,985,991.24
Total	28471	4,032,502	\$17,253,100.23





# Calculated Column used in a Slicer

- Calculated column can populate slicer values



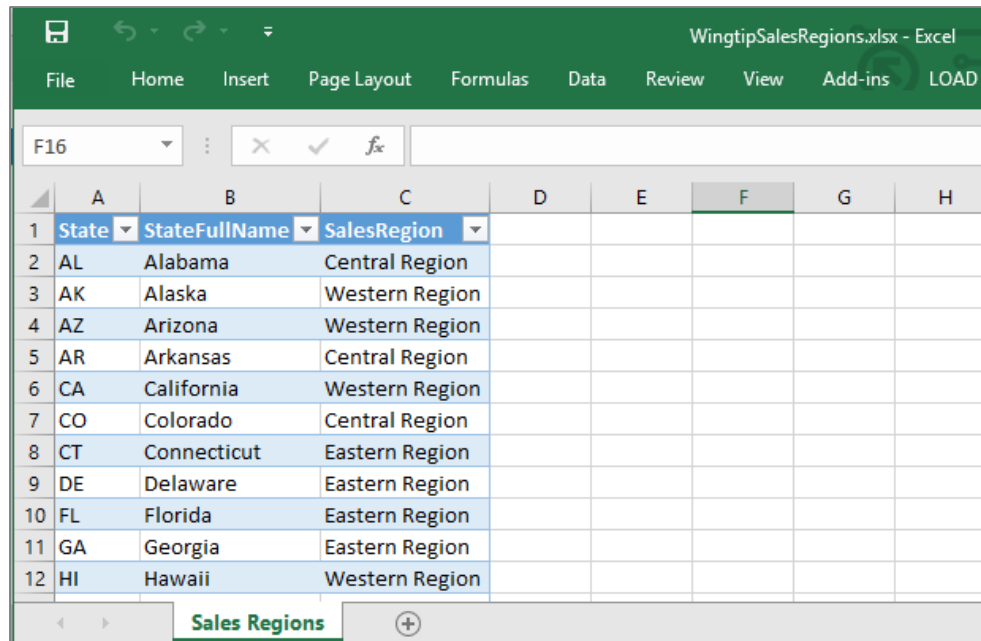


**DEMO**

## **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



The screenshot shows an Excel spreadsheet with the following data:

	A	B	C	D	E	F	G	H
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					

The spreadsheet is titled 'WingtipSalesRegions.xlsx - Excel'. The active sheet is 'Sales Regions'. The formula bar shows 'F16'.



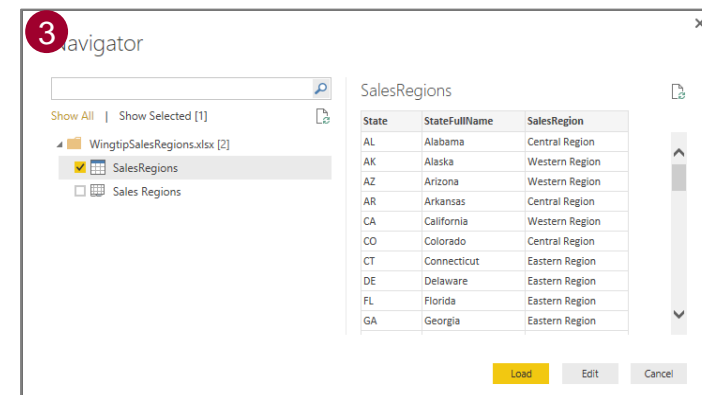
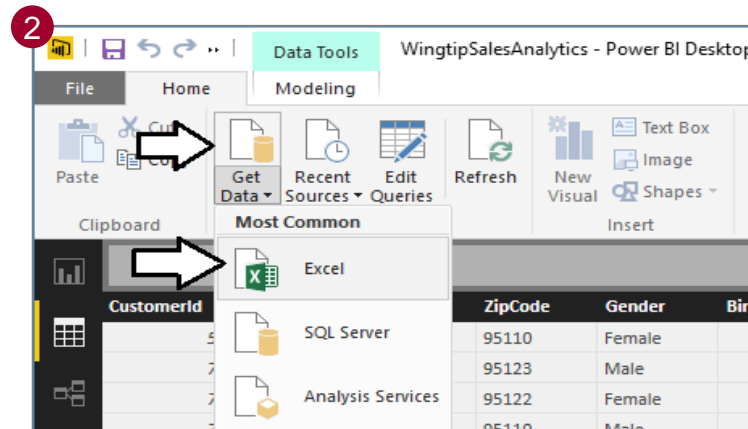


# Importing the SalesRegions Table from Excel

- Import table from Excel using Power Query

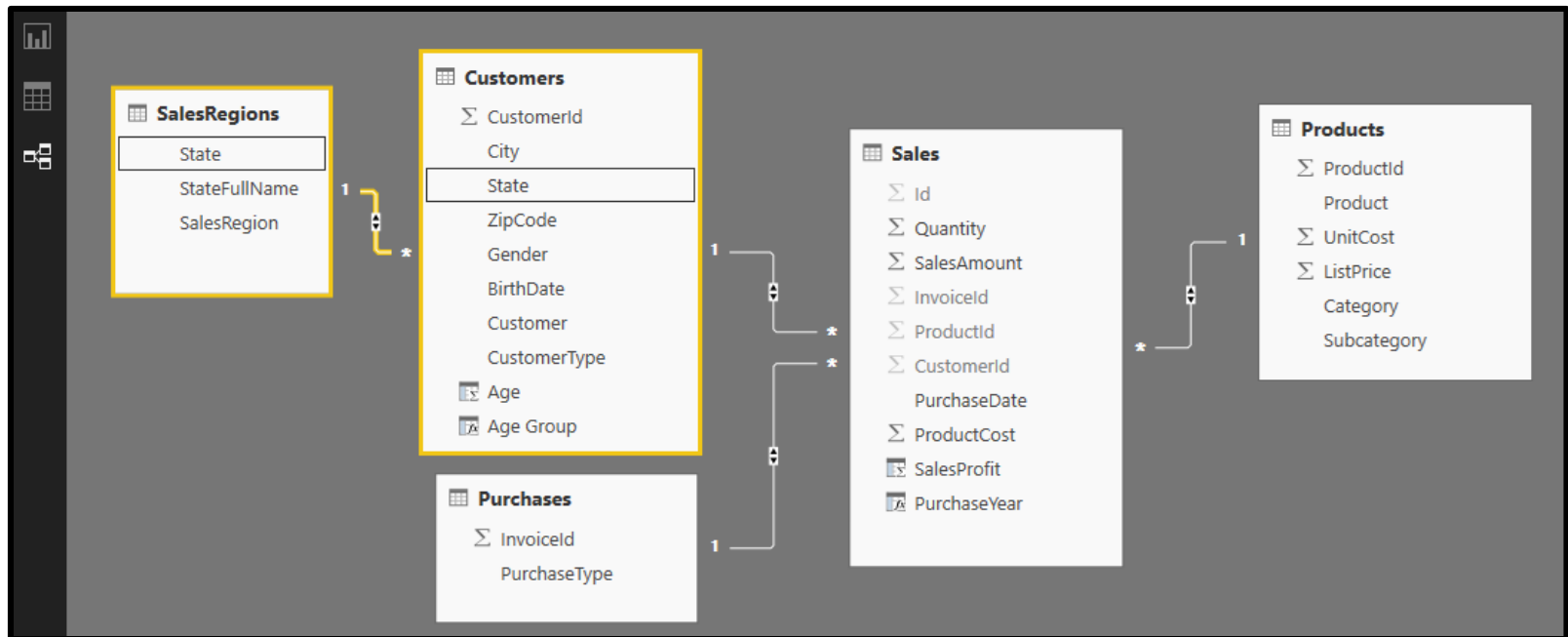
1

	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



# 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

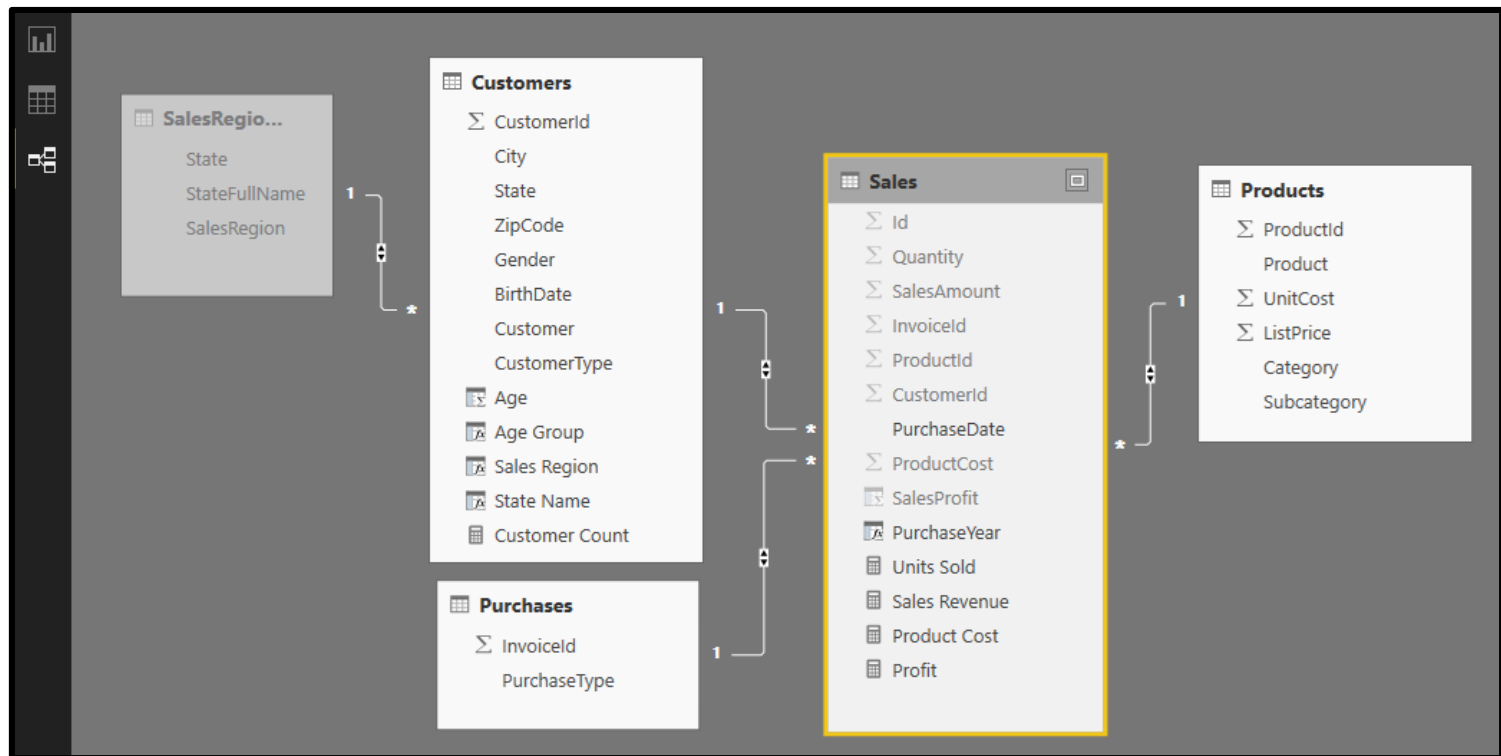
Sales Region = RELATED(SalesRegions[SalesRegion])										
CustomerId	City	State	ZipCode	Gender	BirthDate	Customer	CustomerType	Age	Age Group	Sales Region
55	San Jose	CA	95110	Female	3/10/49	Jewell Ryan	Repeat Customer	66	Ages 65 and over	Western Region
73	San Jose	CA	95123	Male	5/9/85	Granville Perry	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

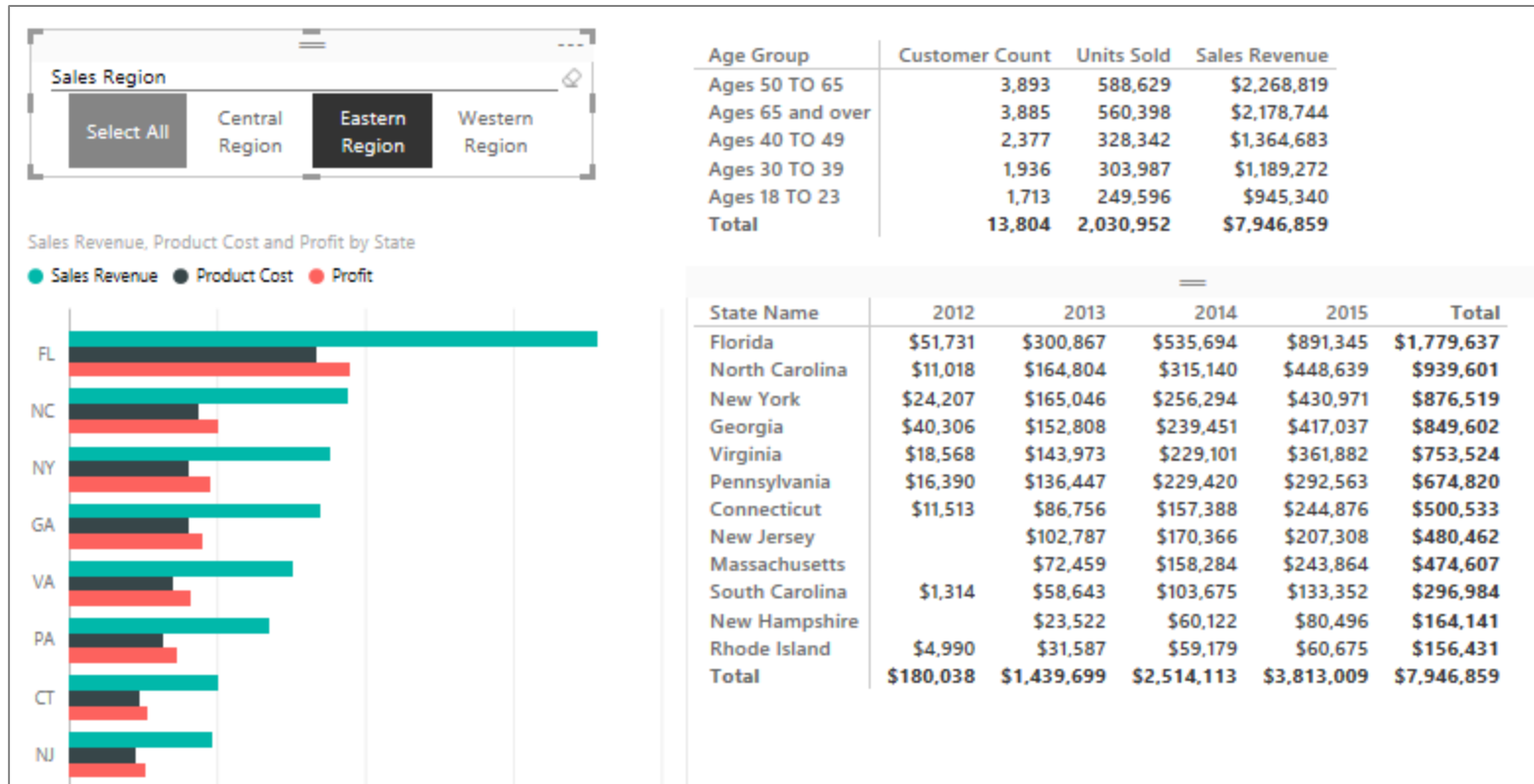
- Lookup table can often be hidden
  - simplifies reporting for data model consumers





# Filtering on Sales Region

- Calculated column used to calculate slicer values



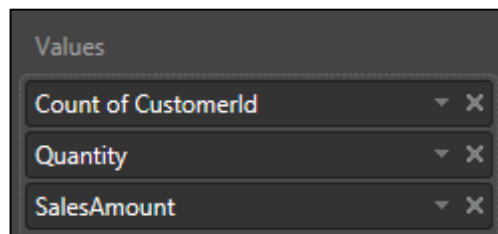
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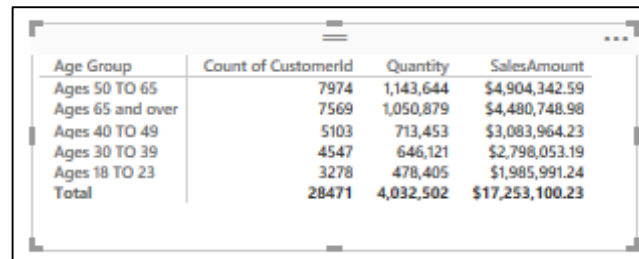


# Benefits of Measures over Calculated Columns

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

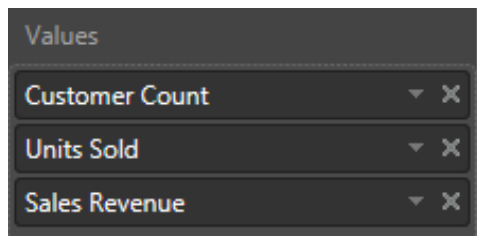


Values
Count of CustomerId
Quantity
SalesAmount

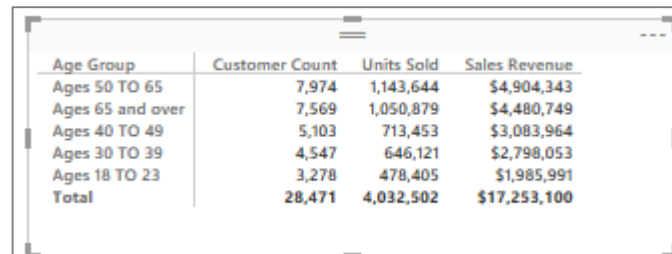


Age Group	Count of CustomerId	Quantity	SalesAmount
Ages 50 TO 65	7974	1,143,644	\$4,904,342.59
Ages 65 and over	7569	1,050,879	\$4,480,748.98
Ages 40 TO 49	5103	713,453	\$3,083,964.23
Ages 30 TO 39	4547	646,121	\$2,798,053.19
Ages 18 TO 23	3278	478,405	\$1,985,991.24
Total	28471	4,032,502	\$17,253,100.23

- 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



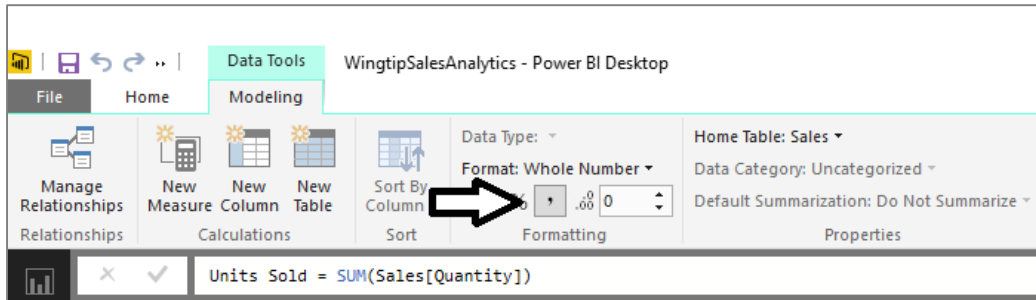
# Creating Measures

- 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



# Formatting Measures

- Format as whole number



- Format as currency







**DEMO**

## Creating Measures

# Agenda

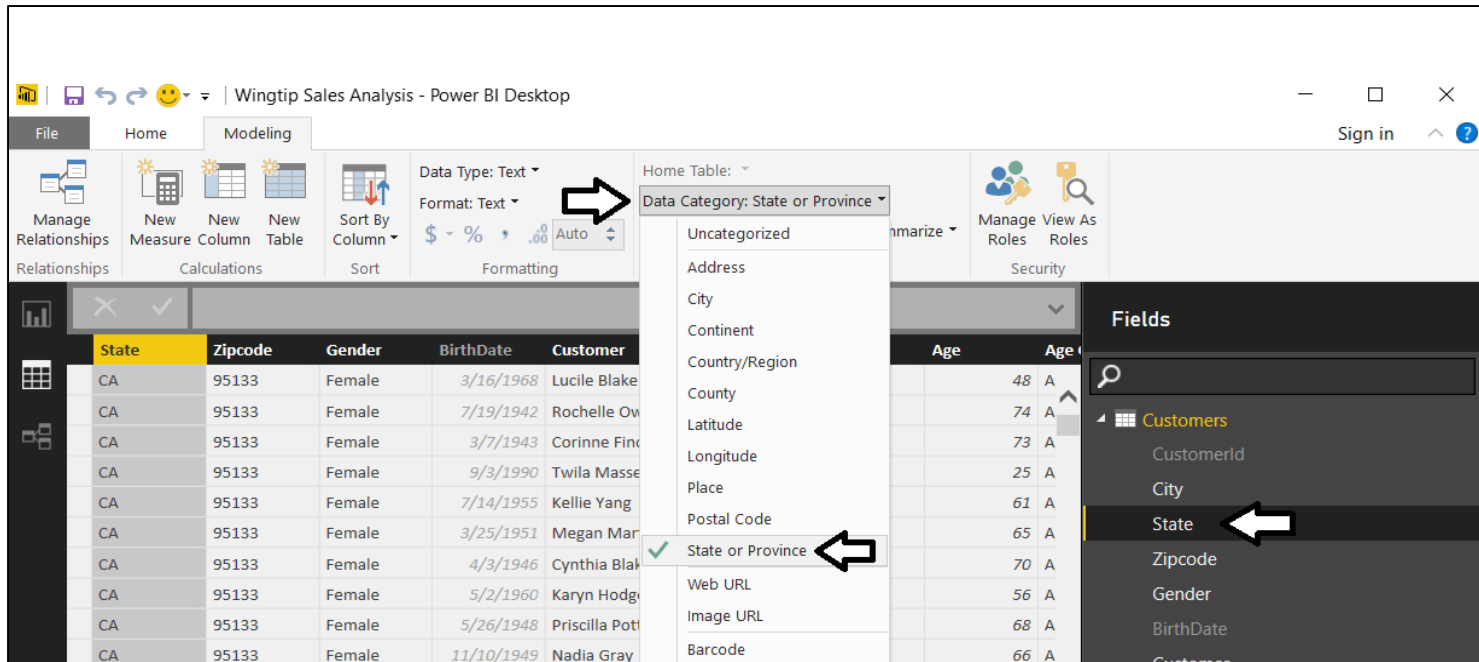
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# Geographic Field Metadata

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



# Eliminate Geographic Ambiguity

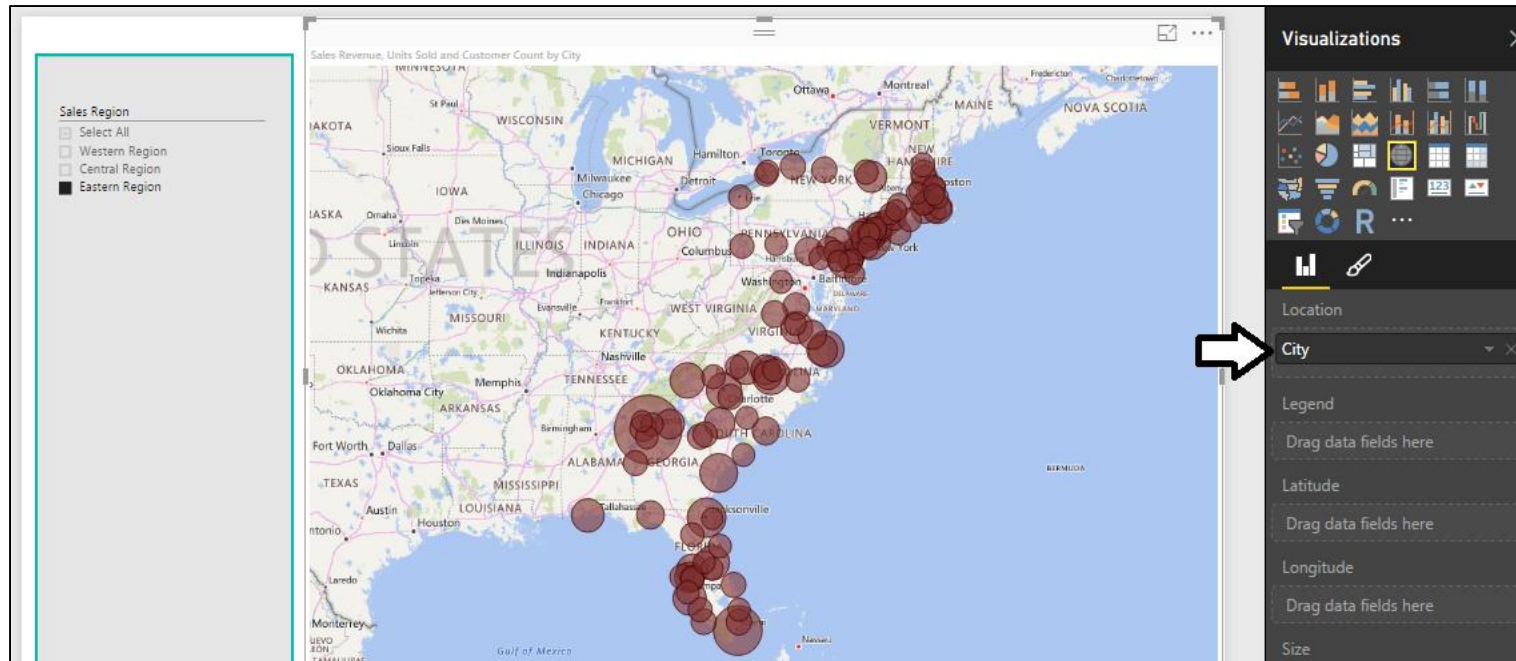
- City name alone is ambiguous
  - "Athens" defaults to Greece not Georgia
  - Concatenate city name with state to disambiguate

 		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



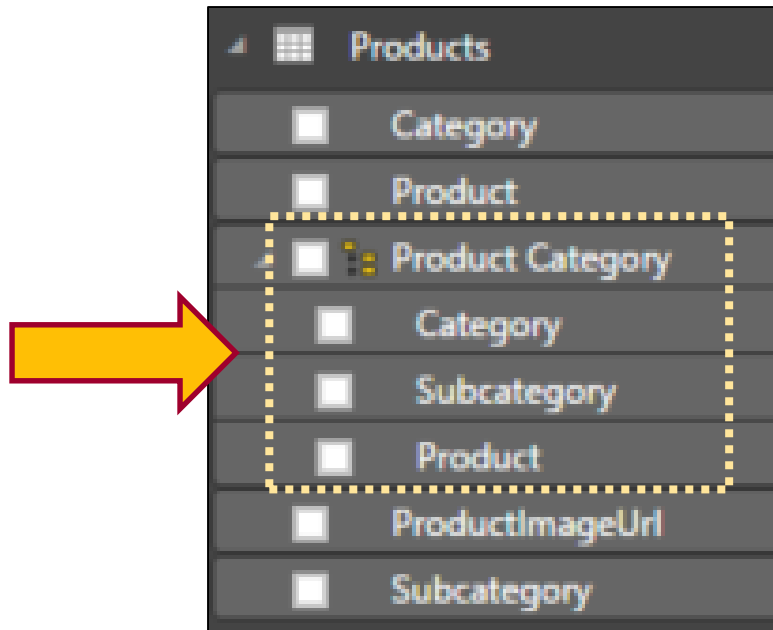
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# Dimensional Hierarchies

- 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



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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 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	\$613,971	\$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

	Month in Year	2012	2013	2014	2015	Total
<b>Sales Region</b>	January	\$425	\$50,169	\$61,295	\$76,614	\$188,503
<input type="checkbox"/> Select All	February	\$13,891	\$40,133	\$63,670	\$101,542	\$219,236
<input type="checkbox"/> Central Region	March	\$19,121	\$58,411	\$73,839	\$84,180	\$235,551
<input type="checkbox"/> Eastern Region	April	\$19,128	\$53,711	\$67,919	\$91,762	\$232,520
<input checked="" type="checkbox"/> Western Region	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
<b>Customer Type</b>	September	\$39,415	\$68,653	\$82,697	\$94,805	\$285,570
<input type="checkbox"/> One-time customer	October	\$51,994	\$69,122	\$99,344	\$84,177	\$304,637
<input checked="" type="checkbox"/> Repeat Customer	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] )  
    )  
)
```



# Summary

- ✓ Designing a Data model
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