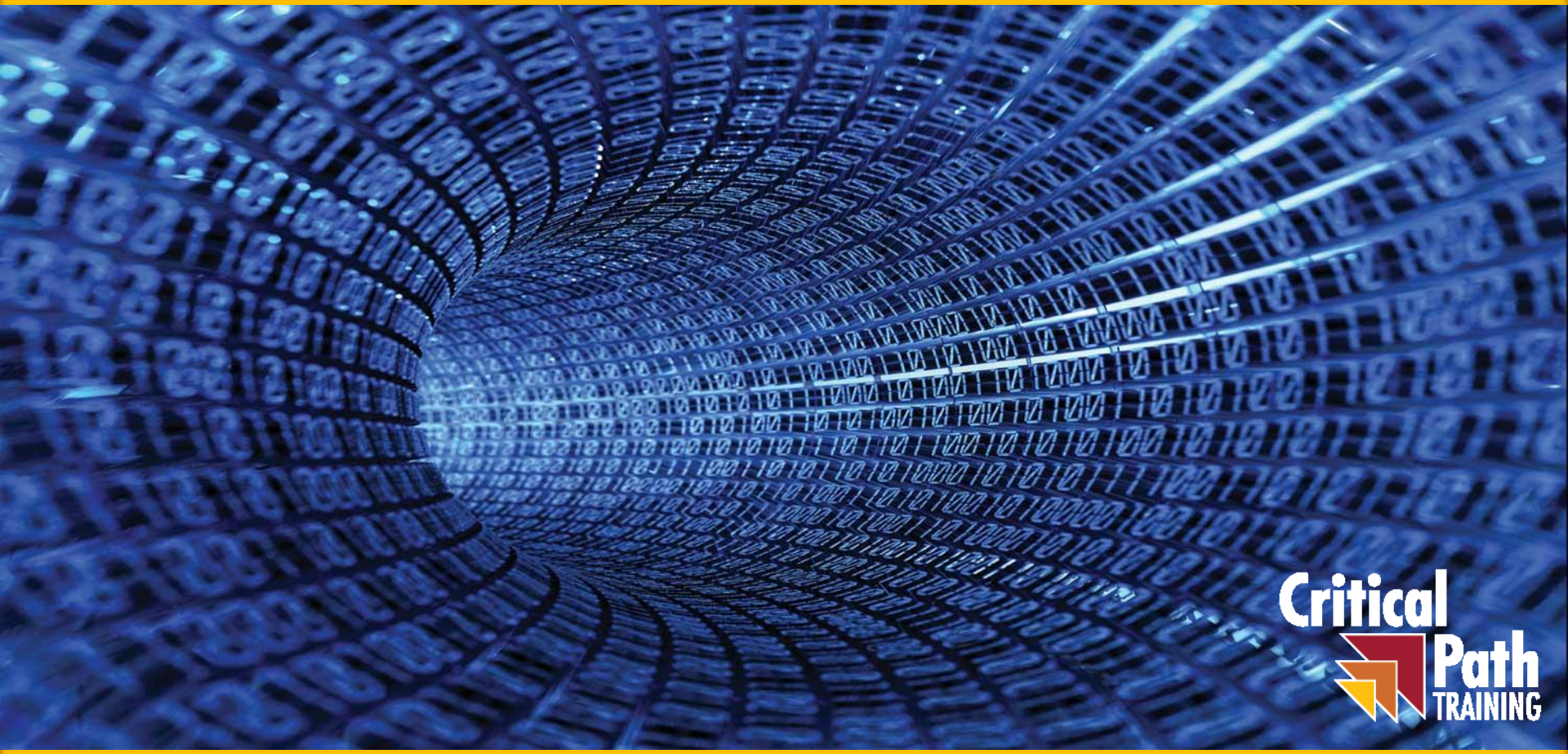
Designing a Data Model with Power BI Desktop



Agenda

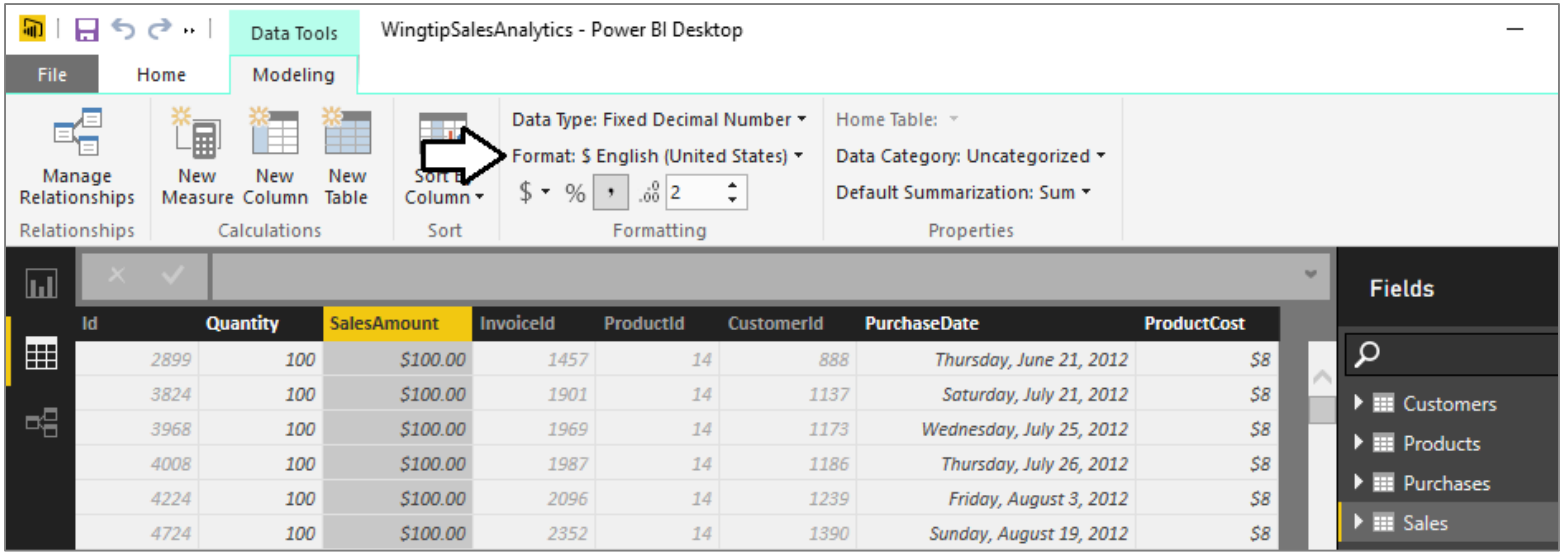
- Designing a Data model
- Creating Calculated Columns
- Creating Measures
- Adding Geographic Fields to a Data Model
- Creating Dimensional Hierarchies
- Understanding the Evaluation Context

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

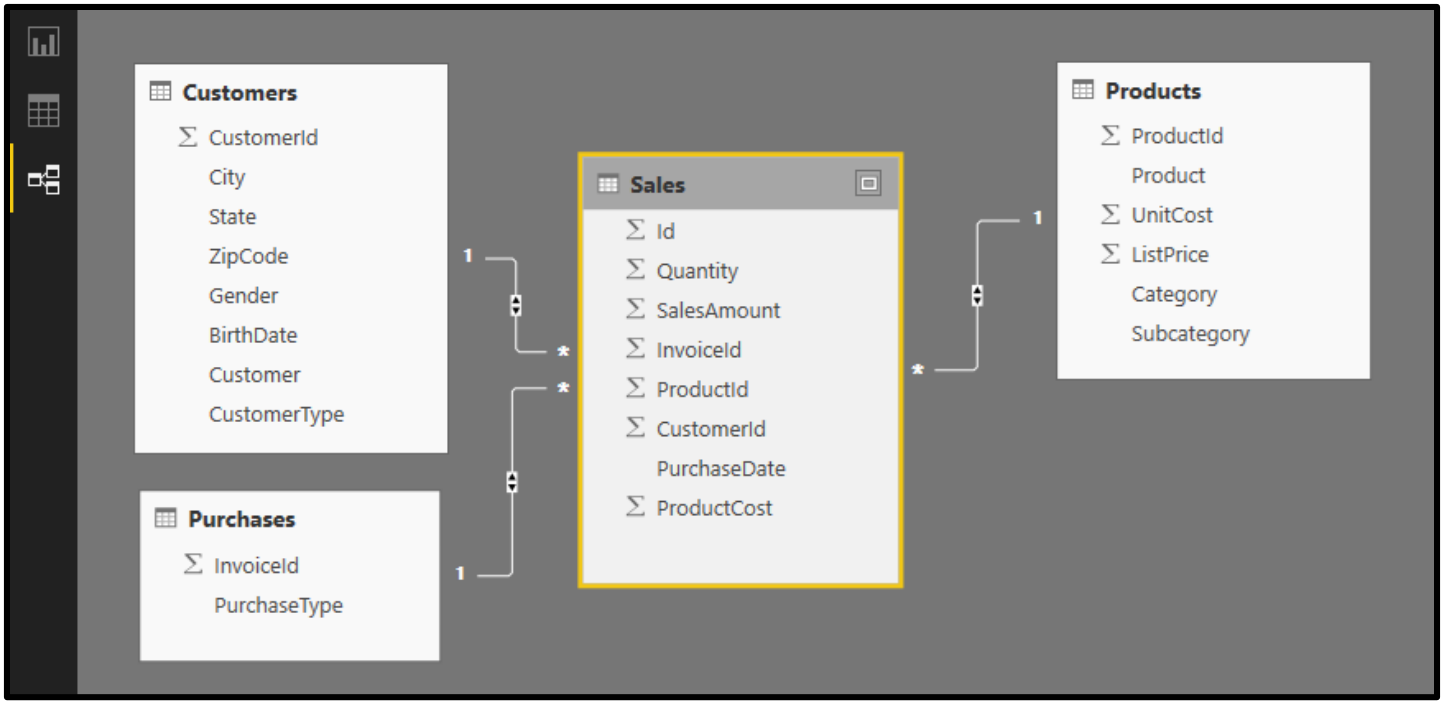
- Each column has its own formatting properties
  - Formatting propagated to reports and visuals
  - Makes it easier on data model consumers



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 "**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

Agenda

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

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>
```

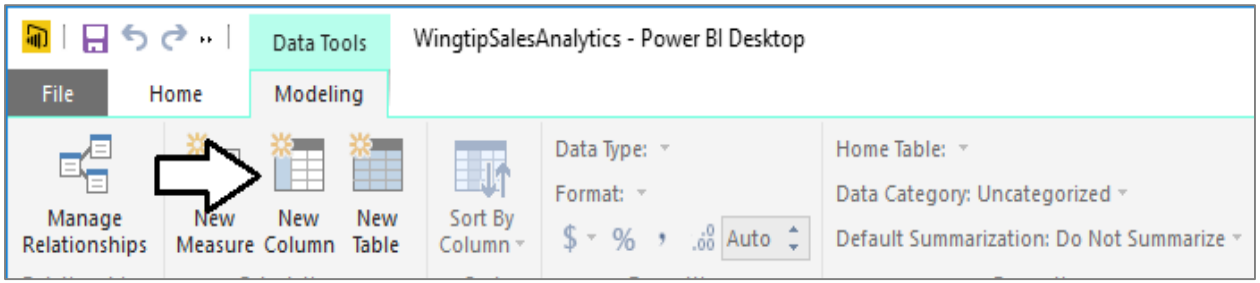
When to Create Calculated Columns

- 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

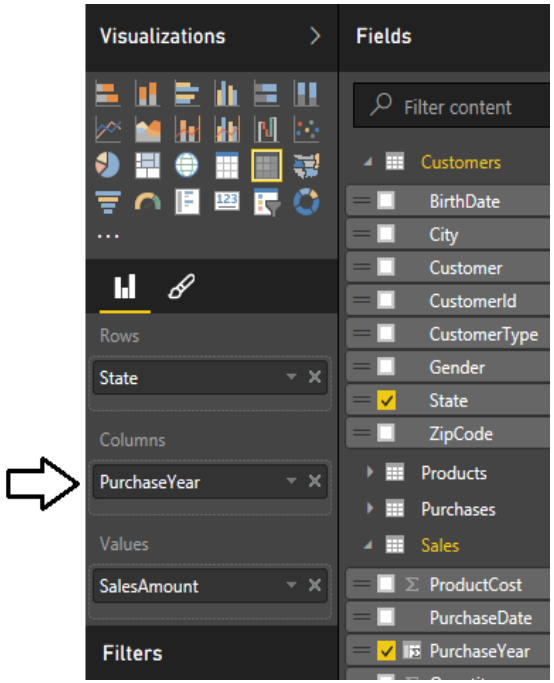



```
PurchaseYear = YEAR(Sales[PurchaseDate])
```

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

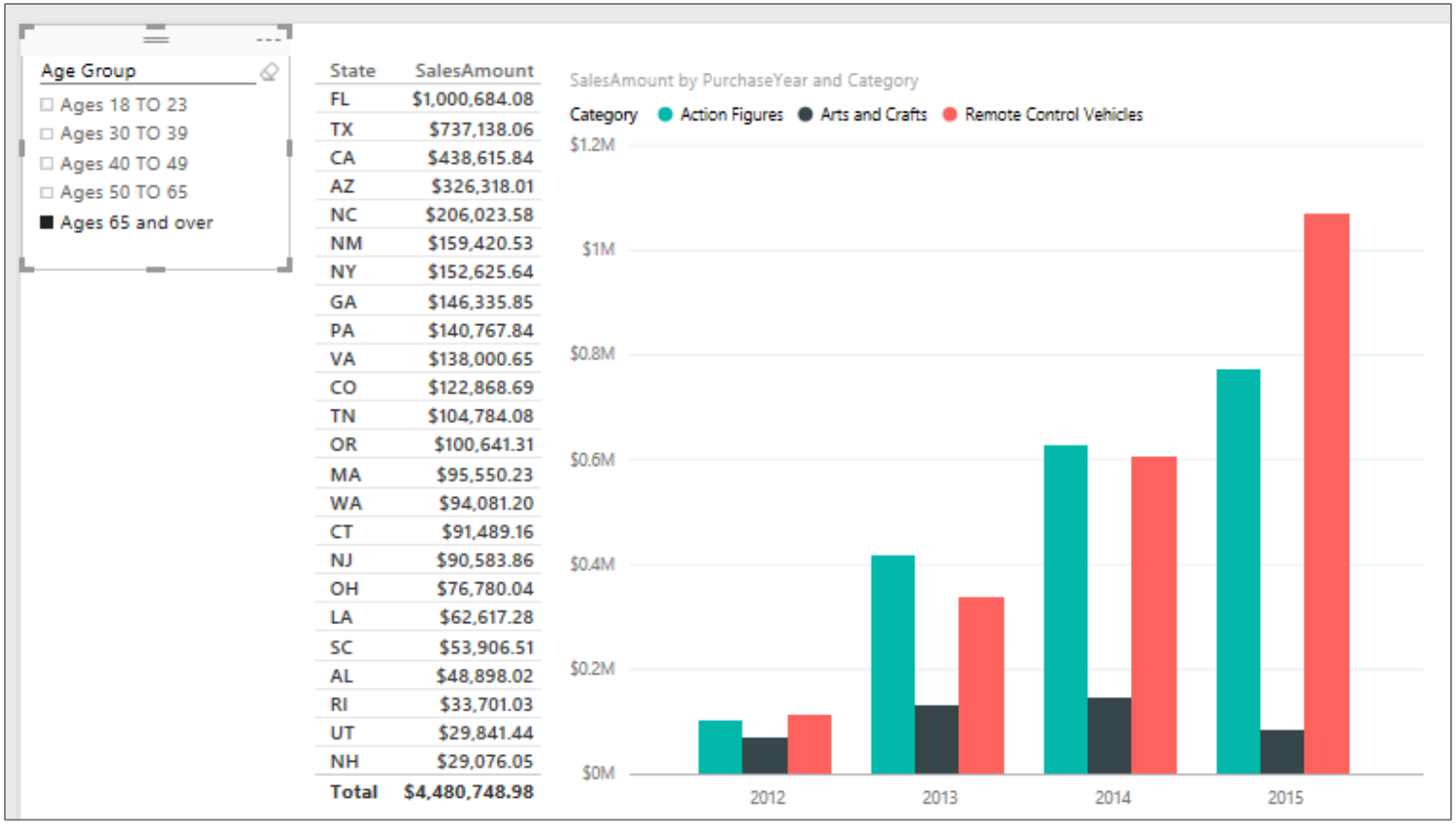
Calculated Column as a Row Label

- 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



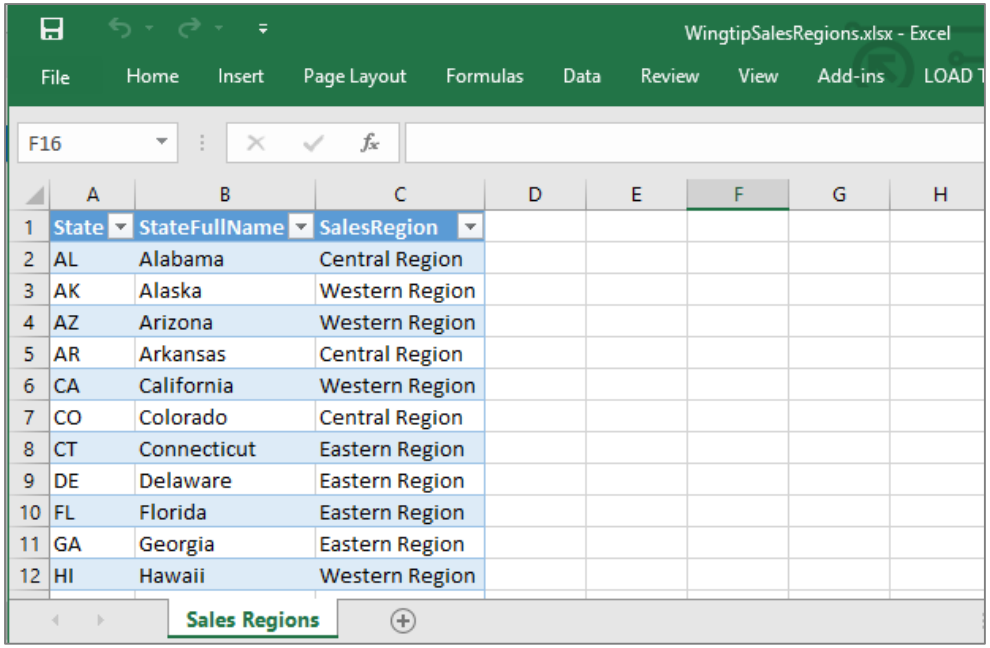
State	SalesAmount
FL	$1,000,684.08
TX	$737,138.06
CA	$438,615.84
AZ	$326,318.01
NC	$206,023.58
NM	$159,420.53
NY	$152,625.64
GA	$146,335.85
PA	$140,767.84
VA	$138,000.65
CO	$122,868.69
TN	$104,784.08
OR	$100,641.31
MA	$95,550.23
WA	$94,081.20
CT	$91,489.16
NJ	$90,583.86
OH	$76,780.04
LA	$62,617.28
SC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

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
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

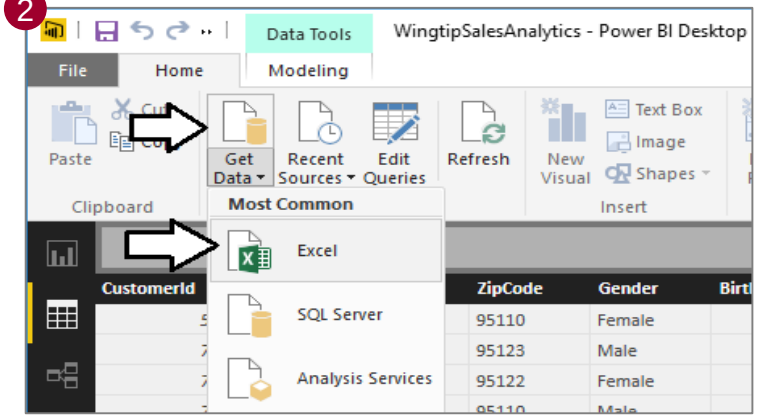
Importing the SalesRegions Table from Excel

- 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



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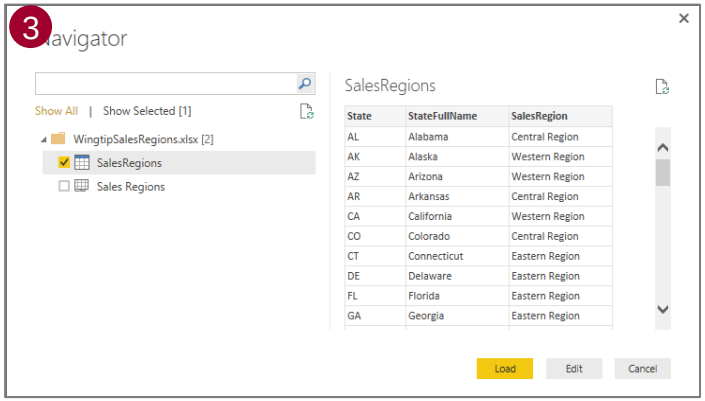
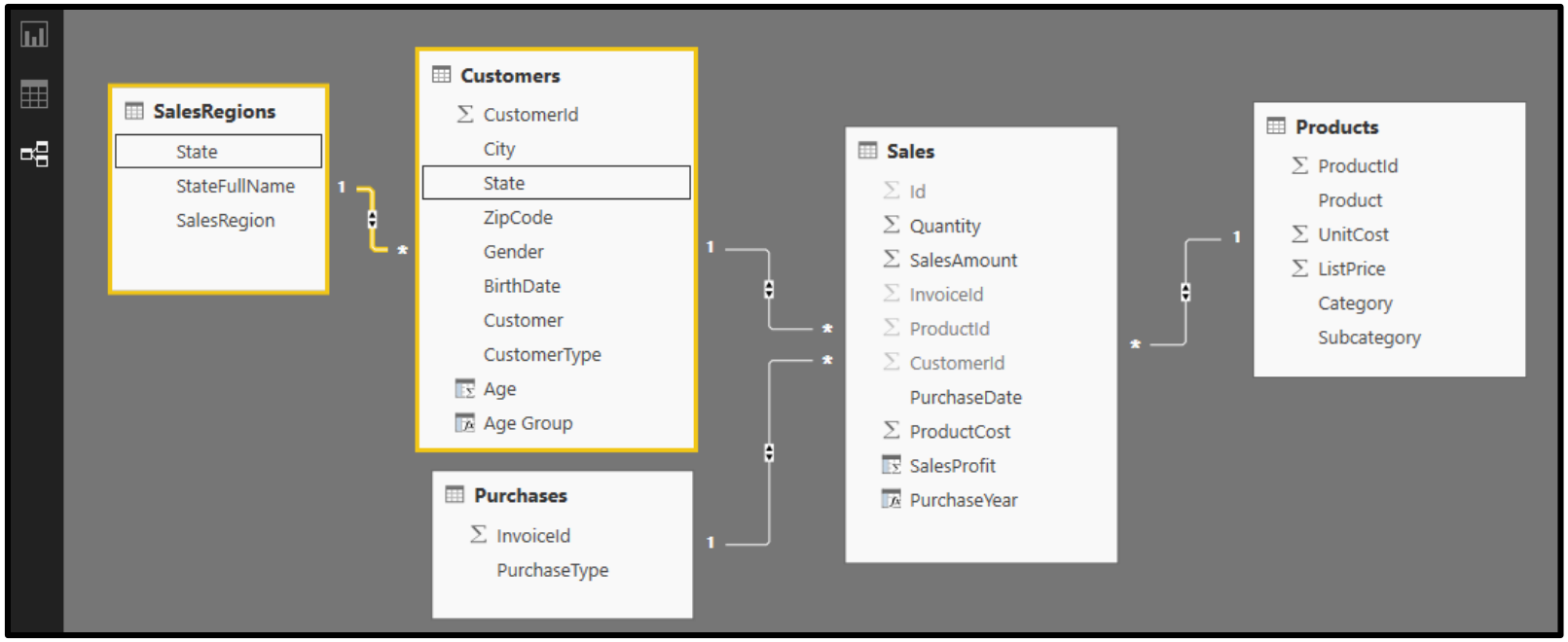


Integrating the Lookup Table into the Data Model

- 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])
```

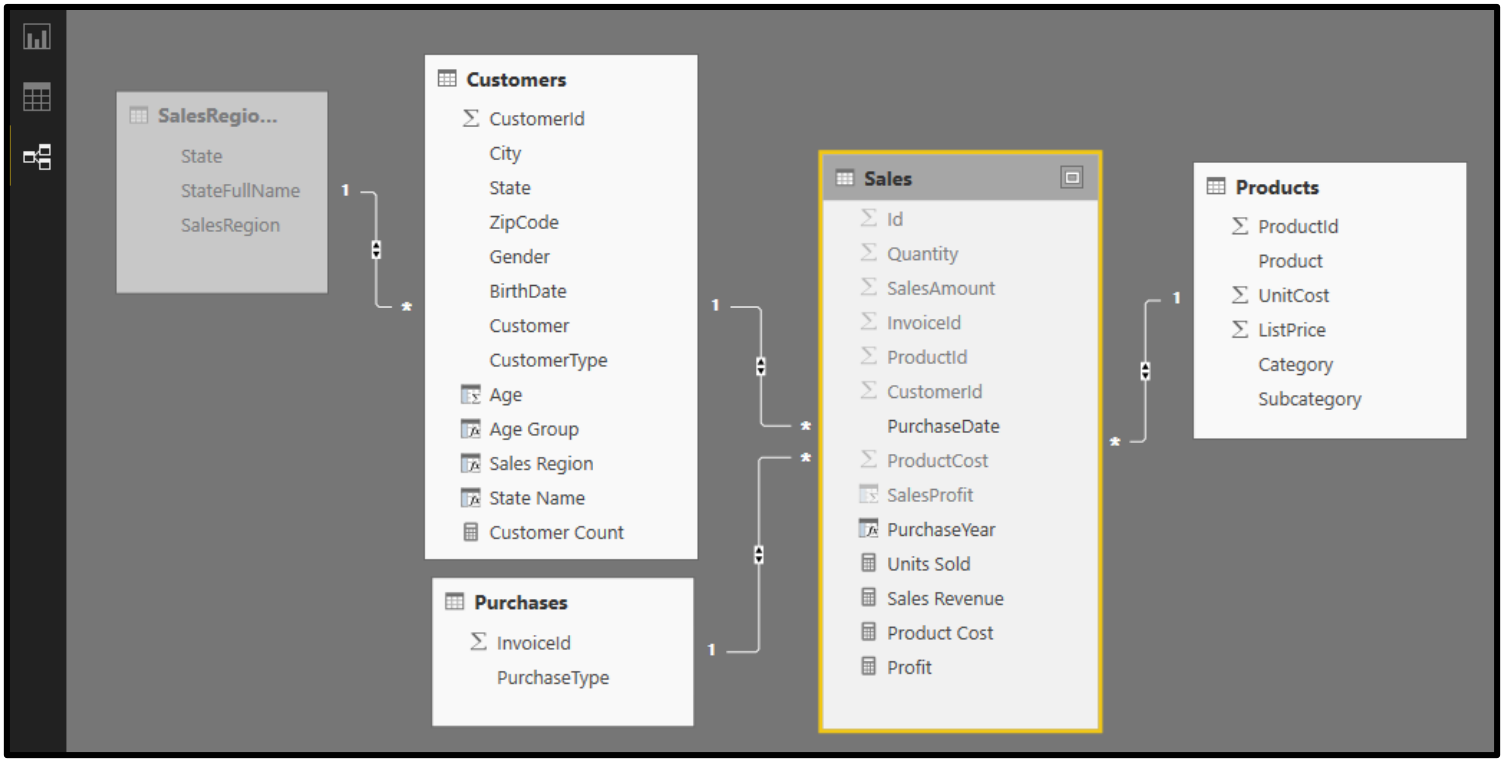
CustomerId	City	State	ZipCode	Gender	BirthDate	Customer	CustomerType	Age	Age Group	Sales Region
55	San Jose	CA	95110	Female	3/10/49	Jewell Ryan	Repeat Customer	66	Ages 65 and over	Western Region
73	San Jose	CA	95123	Male	5/9/85	Granville Perry	Repeat Customer	30	Ages 30 TO 39	Western Region
74	San Jose	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

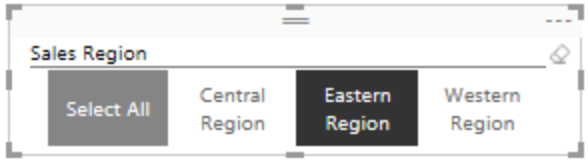
Hiding the Lookup Table

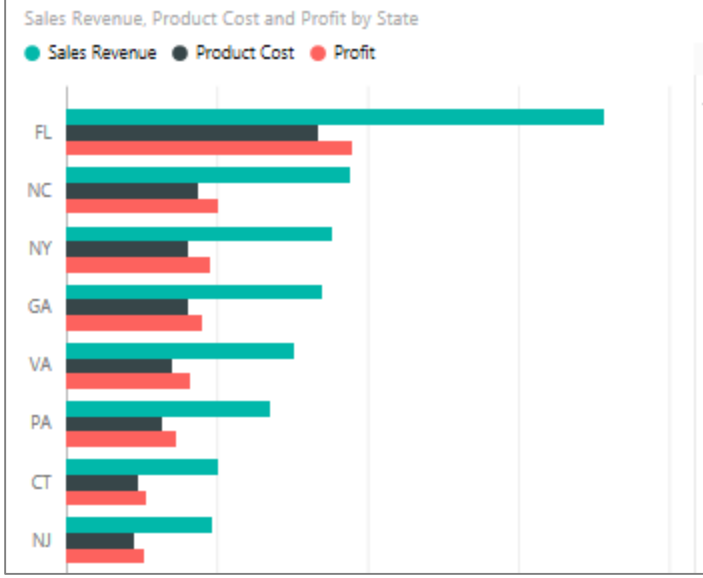
- Lookup table can often be hidden
  - simplifies reporting for data model consumers



Filtering on Sales Region

- Calculated column used to calculate slicer values





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**

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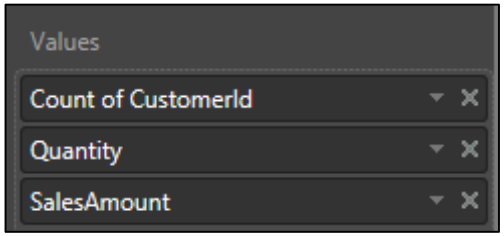
Benefits of Measures over Calculated Columns

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



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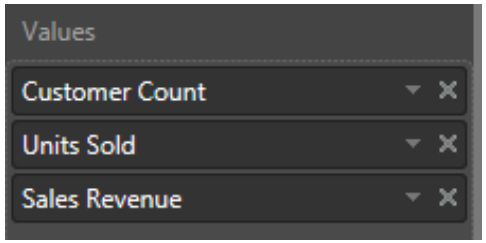
Ages 65 and over	7569	1,050,879	$4,480,748.98
Ages 40 TO 49	5103	713,453	$3,083,964.23
Ages 30 TO 39	4547	646,121	$2,798,053.19
Ages 18 TO 23	3278	478,405	$1,985,991.24
Total	**28471**	**4,032,502**	**$17,253,100.23**

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

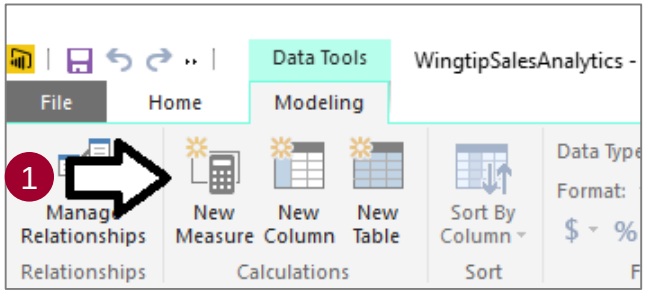


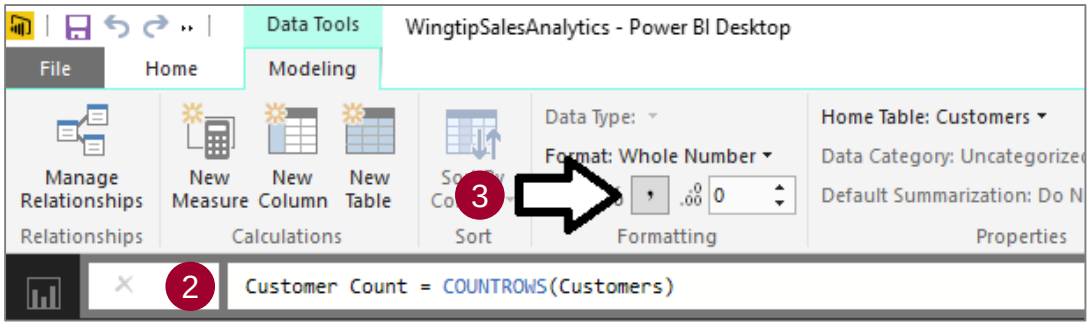
Age Group	Customer Count	Units Sold	Sales Revenue
Ages 50 TO 65	7,974	1,143,644	$4,904,343
Ages 65 and over	7,569	1,050,879	$4,480,749
Ages 40 TO 49	5,103	713,453	$3,083,964
Ages 30 TO 39	4,547	646,121	$2,798,053
Ages 18 TO 23	3,278	478,405	$1,985,991
Total	**28,471**	**4,032,502**	**$17,253,100**

Creating Measures

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

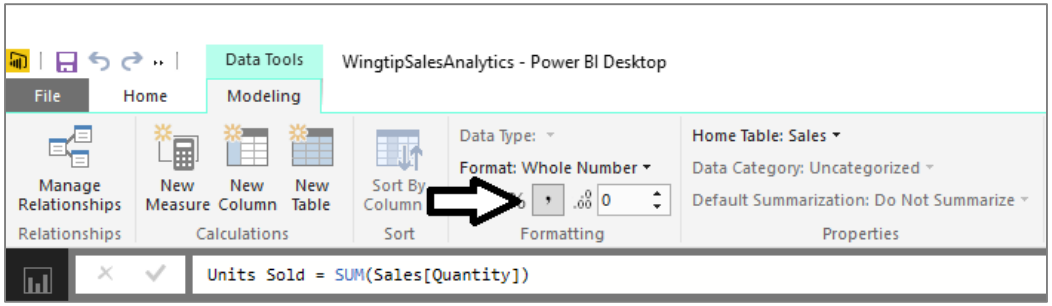
- Creating a measure with Power BI Desktop
  1. Click New Measure button
  2. Give measure a name and write DAX expressions
  3. Configure formatting



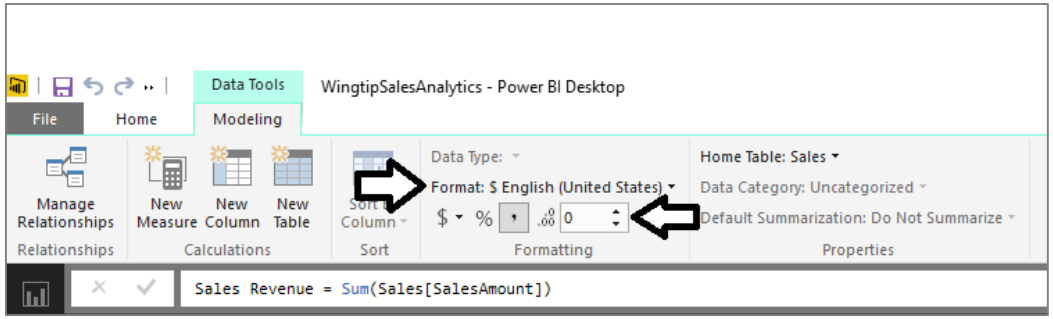


Formatting Measures

- Format as whole number



- Format as currency



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Creating Measures

Agenda

- ✓ Designing a Data model
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- ➢ Adding Geographic Fields to a Data Model
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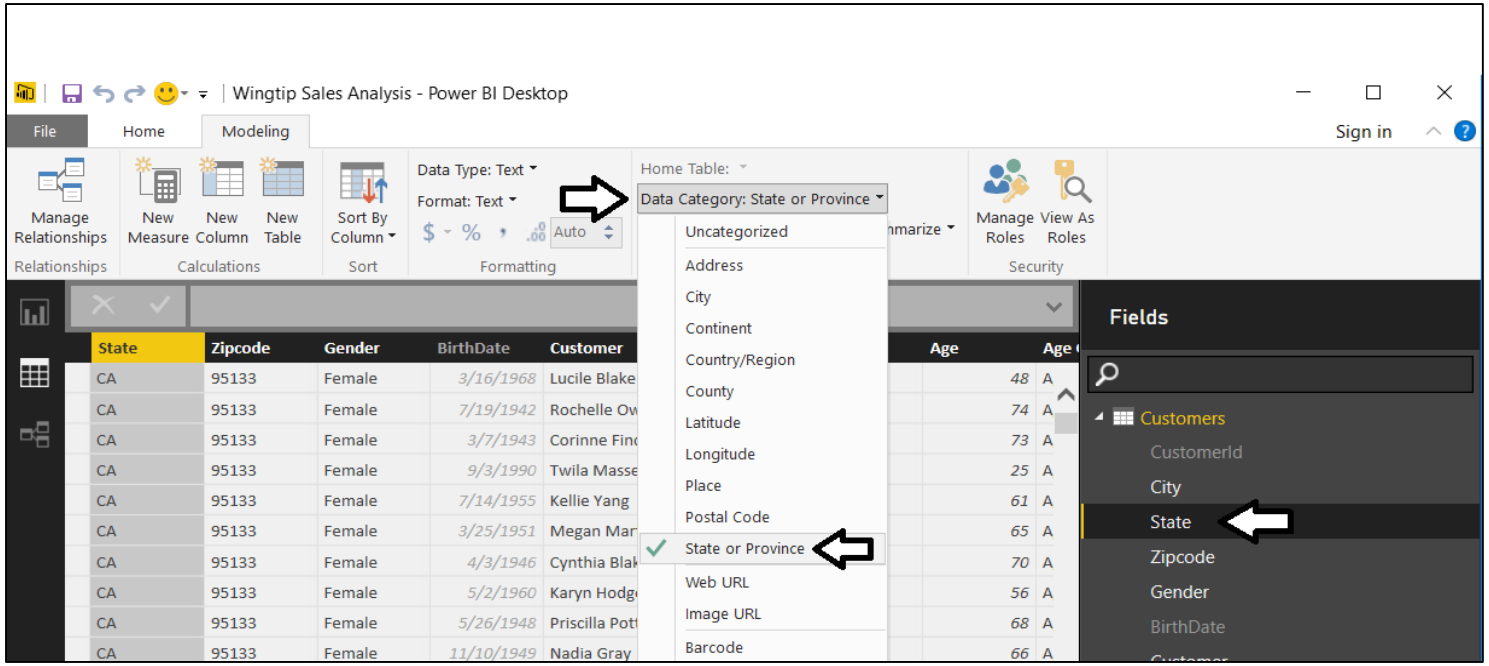
Geographic Field Metadata

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



Eliminate Geographic Ambiguity

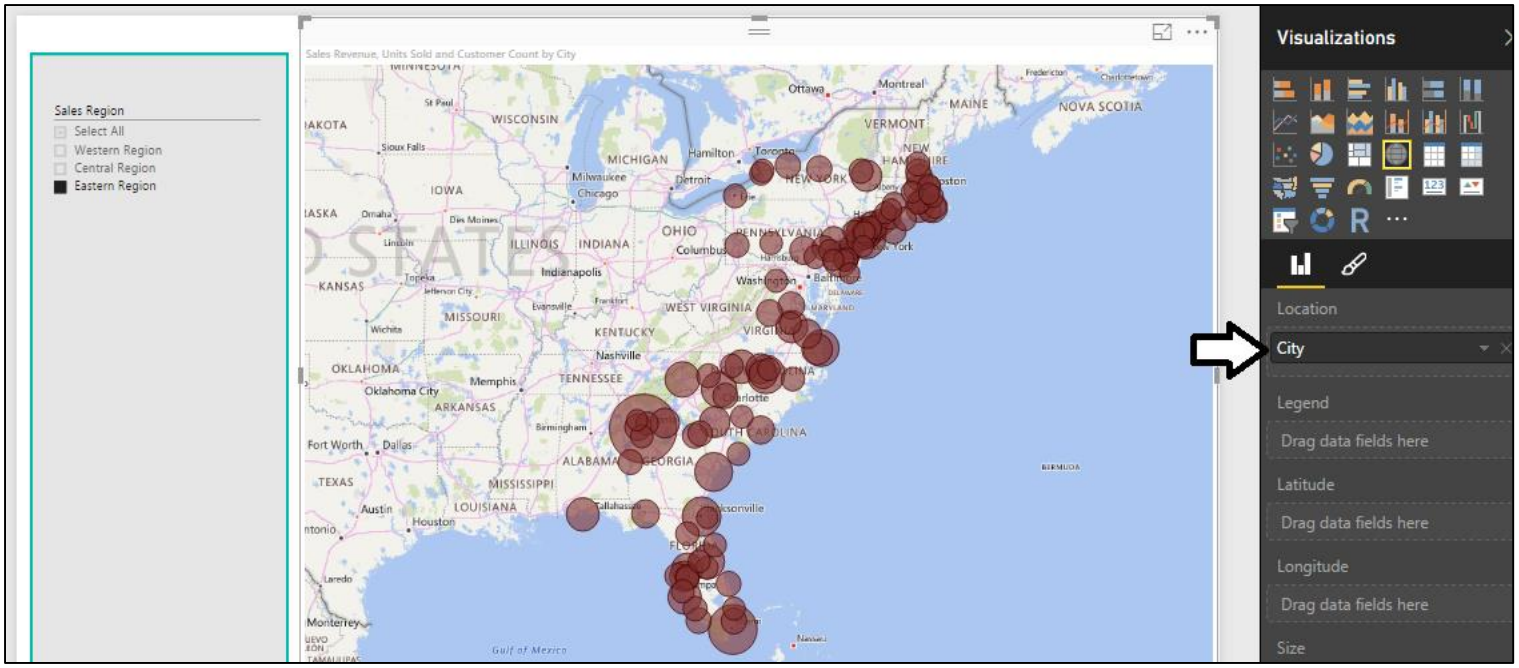
- City name alone is ambiguous
  - "Athens" defaults to Greece not Georgia
  - Concatenate city name with state to disambiguate

```
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

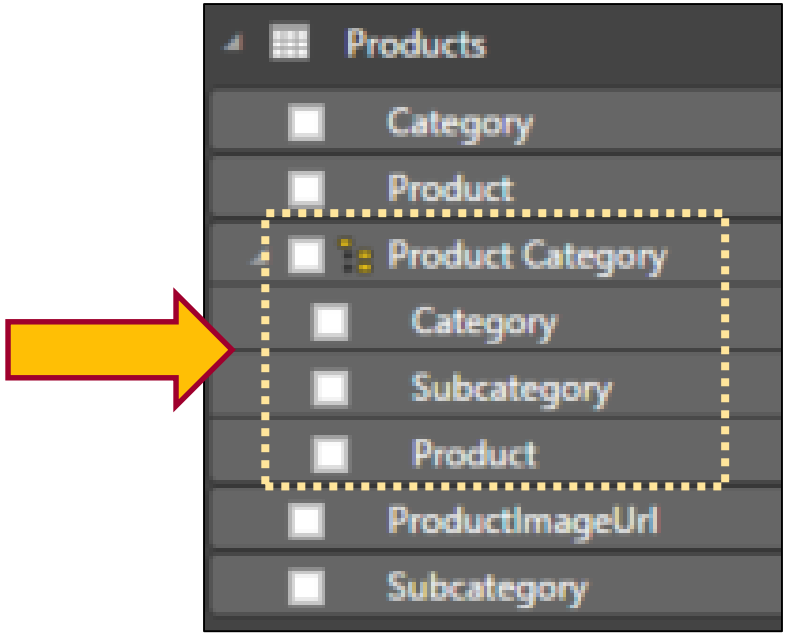


Agenda

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

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



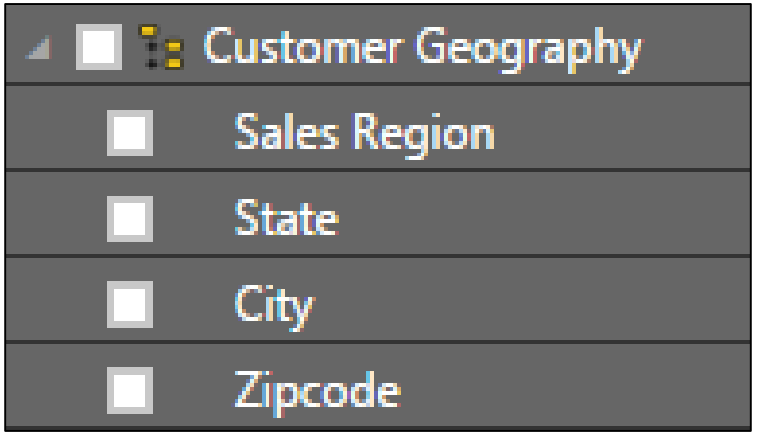
Pulling Columns for Hierarchy into Single Table

- 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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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	$613,974	$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] )
    )
)
```

Summary

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