Lab 4. Starting an Adventure with Calculations and Parameters

The first half of this lab focuses on laying a foundation, while the second half provides quite a few practical examples. The topics we will study here are as follows:

- Overview of the four main types of calculations
- Creating and editing calculations
- Row-level calculation examples
- Aggregate calculation examples
- Parameters
- Practical examples
- Performance considerations

We'll start with an introduction to the types of calculations in Tableau and then delve into some examples.

Introduction to calculations

A calculation is often referred to as a **Calculated Field** in Tableau because, in most cases, when you create a calculation, it will show up as either a new measure or dimension in the data pane. Calculations consist of code that's made up of functions, operations, and references to other fields, parameters, constants, groups, or sets. This code returns a value. Sometimes, this result is per row of data, and sometimes it is done at an aggregate level. We'll consider the difference between Tableau's major calculation types next.

Let's see how calculation types are created and edited.

Creating and editing calculations

There are multiple ways to create a calculated field in Tableau:

1. Select **Analysis** | **Create Calculated Field...** from the menu.

2. Use the drop-down menu next to **Dimensions** in the **Data** pane:

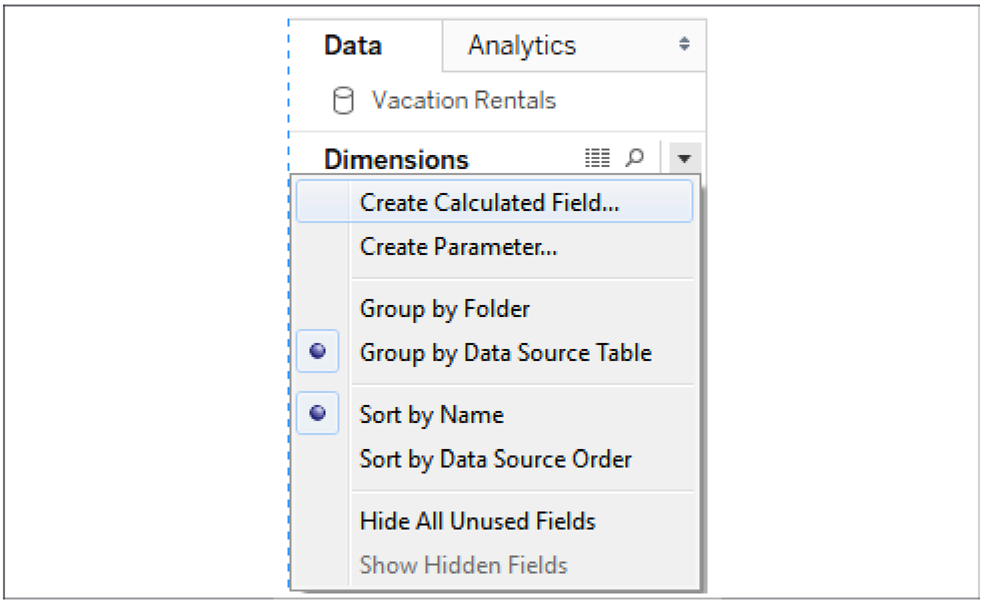


Figure 4.1: The Create Calculated Field... option

3. Right-click an empty area in the **Data** pane and select **Create Calculated Field...**.

4. Use the drop-down menu on a field, set, or parameter in the data pane and select **Create** | **Calculated Field...**. The calculation will begin as a reference to the field you selected.

5. Double-click an empty area on the **Rows**, **Columns**, or **Measure Values** shelves, or in the empty area on the **Marks** card to create an ad hoc calculation (though this will not show the full calculation editor).

6. When you create a calculated field, it will be part of the data source that is currently selected at the time you create it. You can edit an existing calculated field in the data pane by using the drop-down menu and selecting **Edit...**.

The interface for creating and editing calculations looks like this:

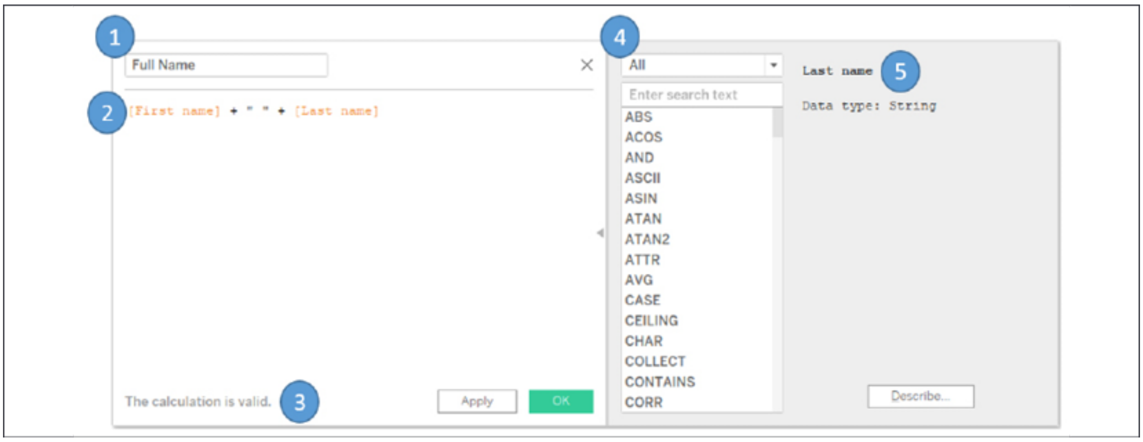


Figure 4.2: The creating and editing calculations interface

This window has several key features:

- **Calculated field name**: Enter the name of the calculated field here. Once created, the calculated field will show up as a field in the data pane with the name you entered in this text box.
- **Code editor**: Enter code in this text area to perform the calculation. The editor includes autocomplete for recognized fields and functions. Additionally, you may drag and drop fields and text snippets to and from the code editor and the data pane and view.
- An **indicator** at the bottom of the editor will alert you to errors in your code. Additionally, if the calculation is used in views or other calculated fields, you will see a drop-down indicator that will let you see the dependencies. Click the **Apply** button to apply changes to the calculation throughout the workbook while leaving the calculation editor open. The **OK** button will save the code changes and close the editor. If you wish to discard any changes you've made, click the **X** button in the upper-right corner to cancel the changes.
- The **functions list** contains all the functions that you can use in your code. Many of these functions will be used in examples or discussed in this lab. Tableau groups various functions according to their overall use:
  - **Number**: Mathematical functions, such as rounding, absolute value, trig functions, square roots, and exponents.
  - **String**: Functions that are useful for string manipulation, such as getting a substring, finding a match within a string, replacing parts of a string, and converting a string value to uppercase or lowercase.
  - **Date**: Functions that are useful for working with dates, such as finding the difference between two dates, adding an interval to a date, getting the current date, and transforming strings with non-

standard formats into dates.
- **Type Conversion**: Functions that are useful for converting one type of field to another, such as converting strings into integers, integers into floating-point decimals, or strings into dates. We'll cover the major Tableau data types in the next section.
- **Logical**: Decision-making functions, such as `if` `then` `else` logic or `case` statements.
- **Aggregate**: Functions that are used for aggregating such as summing, getting the minimum or maximum values, or calculating standard deviations or variances.
- **Pass Through** (only available when connected live to certain databases, such as SQL Server): These functions allow you to pass through raw SQL code to the underlying database and retrieve a returned value at either a row level or aggregate level.
- **User**: Functions that are used to obtain usernames and check whether the current user is a member of a group. These functions are often used in combination with logical functions to customize the user's experience or to implement user-based security when publishing to Tableau Server or Tableau Online.
- **Table calculation**: These functions are different from the others. They operate on the aggregated data *after* it is returned from the underlying data source and just prior to the rendering of the view.
- **Spatial**: These functions allow you to perform calculations with spatial data.

- Selecting a function in the list or clicking a field, parameter, or function in the code will reveal details about the selection on the right. This is helpful when nesting other calculated fields in your code, when you want to see the code for that particular calculated field, or when you want to understand the syntax for a function.

With a good understanding of the interface, let's briefly look at some foundational concepts for calculations.

Data types

Fundamental to the concept of calculations are **data types**, which describe the kind of information stored by a field, parameter, or returned by a function. Tableau distinguishes six types of data:

- **Number (decimal)**: These are numeric values that include places after the decimal. Values such as `0.02`, `100.377`, or `3.14159` are decimal values.
- **Number (whole)**: These are integer or whole numbers with no fractional values or places after the decimal. Values such as `5`, `157`, and `1,455,982` are whole numbers.
- **Date and Time**: These are dates along with times. Values such as `November 8`, `1980 12:04:33 PM` are date and time types.
- **Date**: These are dates without times. Values such as `July 17, 1979` are date types.
- **String**: These are a series of characters. A string may consist of a mixture of alphabetic characters, numeric characters, symbols, or special characters. They may even be blank (empty). Values such as `Hello World`, `password123`, and `%$@*!` are all strings. In code, strings will be surrounded by single or double quotes.
- **Boolean**: This is a true or false value. The values `TRUE`, `FALSE`, and the expressions `1=1` (which evaluates as true) and `1=2` (which evaluates as false) are all Boolean types.
- **Spatial:** A complex value that describes a location, line or shape as it relates to a spatial area.

Every field in Tableau has one of these data types and every function in Tableau returns one of these data types. Some functions expect input that matches some of these types and you'll receive errors if you try to pass in the wrong type.

Some types can be converted to other types. For example, using some of the type conversion functions mentioned above, you could convert the string `"2.81"` to the decimal value `2.81`. You could convert that decimal value to a whole number, but in that case, you'd lose the places after the decimal value and the whole number would simply be `2`.

A data type is different from the format displayed. For example, you may choose to format a decimal as a percentage (for example, `0.2` could be shown as `20%`), as currency (for example, `144.56` could be formatted as `$144.56`), or even as a number with 0 decimals (for example, `2.81` would be rounded to `3`).

Pay attention to the data types of fields and functions as we continue.

Additional functions and operators

Tableau supports numerous functions and operators. In addition to the functions that are listed on the calculation screen, Tableau supports the following operators, keywords, and syntax conventions:

Operator / Keyword	Description
AND	Logical *and* between two Boolean (`true/false`) values or statements
OR	Logical *or* between two Boolean values or statements
NOT	Logical *not* to negate a Boolean value or statement
= or ==	Logical *equals to* to test the equality of two statements or values (single or double equal signs are equivalent in Tableau's syntax)
+	Addition of numeric or date values or the concatenation of strings
-	Subtraction of numeric or date values
*	Multiplication of numeric values
/	Division of numeric values
^	Raise to a power with numeric values
( )	Parentheses to define the order of operations or enclose function arguments
[ ]	Square brackets to enclose field names
{ }	Curly braces to enclose the level of detail calculations
//	Double slash to start a comment

Note:

Field names that are a single word may optionally be enclosed in brackets when used in calculations. Field names with spaces, special characters, or from secondary data sources must be enclosed in brackets.

You'll see these operators and functions throughout the next few labs, so familiarize yourself with their uses. Now, let's consider the data that will guide us through some practical examples.

Example data

Before we get started with some examples, let's consider a sample dataset that will be used for the examples in this lab. It's simple and small, which means we will be able to easily see how the calculations are being done.

This dataset is included as `Vacation Rentals.csv` in the `tableau-fundamentals\Lab 04` directory of this book's resources, and is also included in the `Chapter 4` workbook as a data source named `Vacation Rentals`:

Rental Property	First	Last	Start	End	Discount	Rent	Tax per Night
112-Asbury Atoll	Mary	Slessor	Dec 2	Dec 9	150	1,500	15
112-Asbury Atoll	Amy	Carmichael	Dec 9	Dec 15	0	1,500	15
155-Beach Breeze	Charles	Ryrie	Dec 2	Dec 9	260	1,300	10
155-Beach Breeze	Dwight	Pentecost	Dec 16	Dec 23	280	1,400	10
207-Beach Breeze	Lewis	Chafer	Dec 9	Dec 23	280	2,800	10
207-Beach Breeze	John	Walvoord	Dec 2	Dec 9	60	1,500	10

The dataset describes several vacation rental properties, the renters, the start and end dates of the rental period, the discount, rent, and tax per night. We'll use it throughout the rest of the lab as we see some examples of calculations. Let's start with row-level calculations.

Row-level calculations

We'll walk through several examples of row-level calculations in this section. You'll find the completed calculations in the `Complete` workbook, but you might prefer to start from scratch in the `Starter` workbook. We won't necessarily cover creating a visualization for every example, but try building some of your own as you work through the examples.

Simple example

We'll start with a very simple example and then build up in complexity. In the `Chapter 04` workbook, create a new calculated field called `Full Name` with the following code:

```
[First] + " " + [Last]
```

This code concatenates the strings of `First` and `Last` with a space in-between them. Your calculation editor should look something like the following:

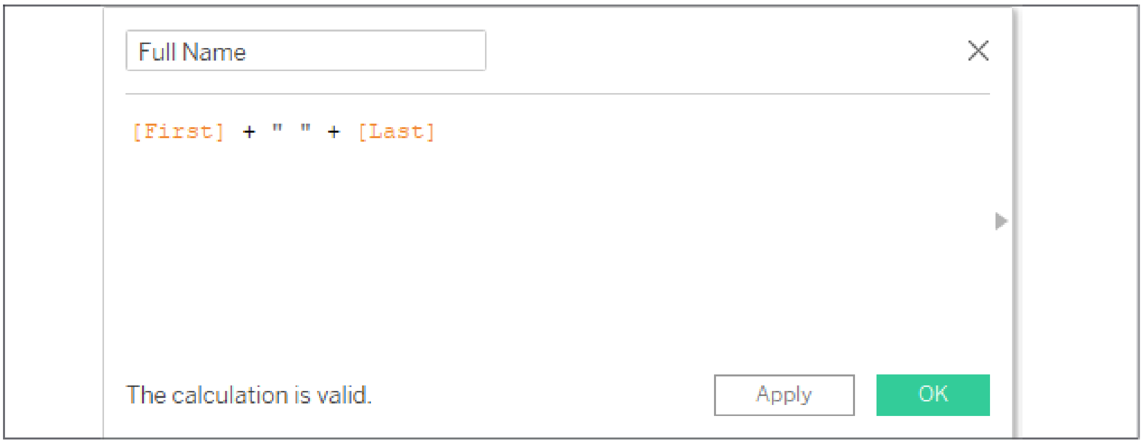


Figure 4.3: Creating the Full Name calculation in the editor

After clicking **OK**, you should notice a new **Full Name** field in the data pane. The value for that field is calculated per row of data. That is, every row of data contains the full name of the renter.

More complex examples

Note that the `Rental Property` field contains values such as `112-Asbury Atoll` or `207-Beach Breeze`. Let's assume that the naming convention of the rental unit in the vacation rental data gives us the room number and the name of the building separated by a dash. For example, the unit named `207-Beach Breeze` is room 207 of the Beach Breeze building.

Name the first `Room` with the following code:

```
SPLIT([Rental Property], "-", 1)
```

Then, create another calculated field named `Building` with the following code:

```
SPLIT([Rental Property], "-", 2)
```

Both of these functions use the `Split()` function, which splits a string into multiple values and keeps one of those values. This function takes three arguments: the **string**, the **delimiter** (a character or set of characters that separate values), and the **token number** (which value to keep from the split, that is, first, second, third, and so on.) Using the `-` (dash) as the delimiter, `Room` is the first value and `Building` is the second.

Using the two calculated fields, create a bar chart of **Rent per Building & Room**, like this:

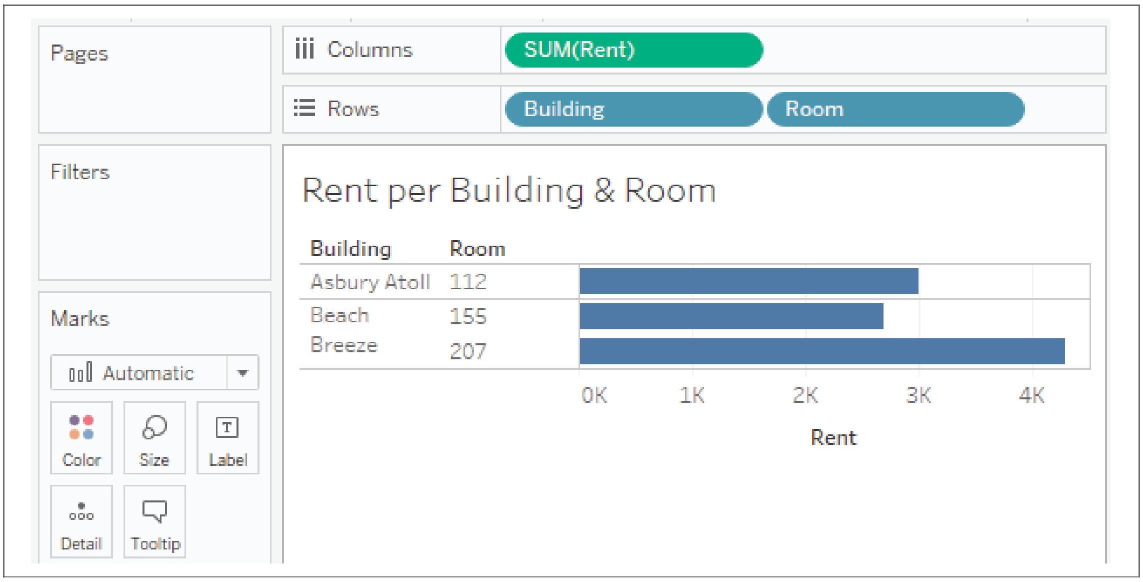


Figure 4.4: Using your calculated fields to build a view

The **Building** and **Room** fields show up in the data pane as dimensions. The calculated dimensions can be used just like any other dimension. They can slice the data, define the level of detail, and group measures.

Row-level calculations are calculated at the row level, but you can choose to aggregate the results. For example, you could aggregate to find the highest **Room** number `(MAX)` or count the distinct number of **Buildings** `(COUNTD)`. In fact, if the result of a row-level calculation is numeric, Tableau will often place the resulting field as a measure by default. But as we've seen, you can use a row-level field as either a dimension or measure in the view.

Note that Tableau adds a small equals sign to the icon of the fields in the data pane to indicate that they are calculated fields:

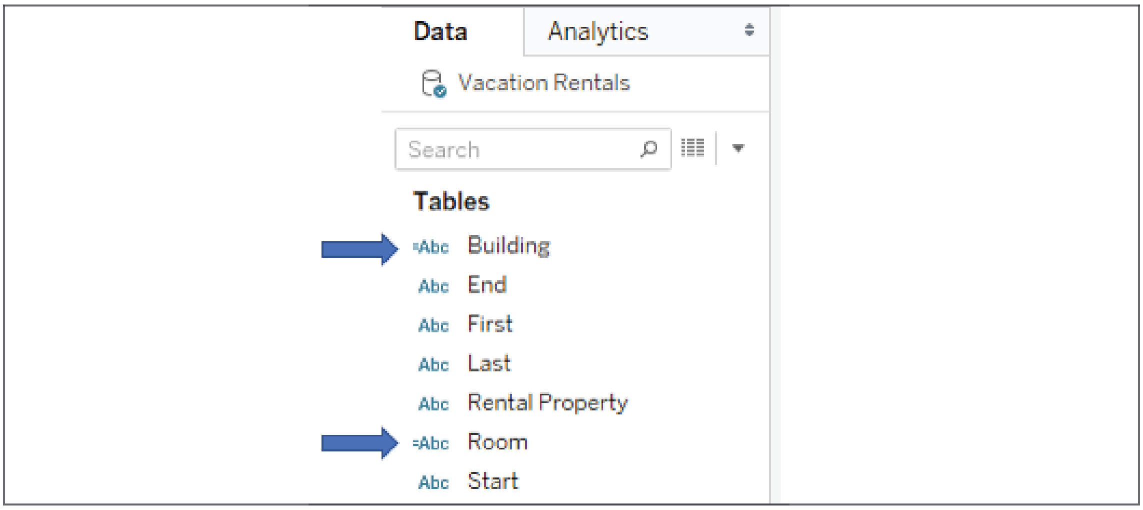
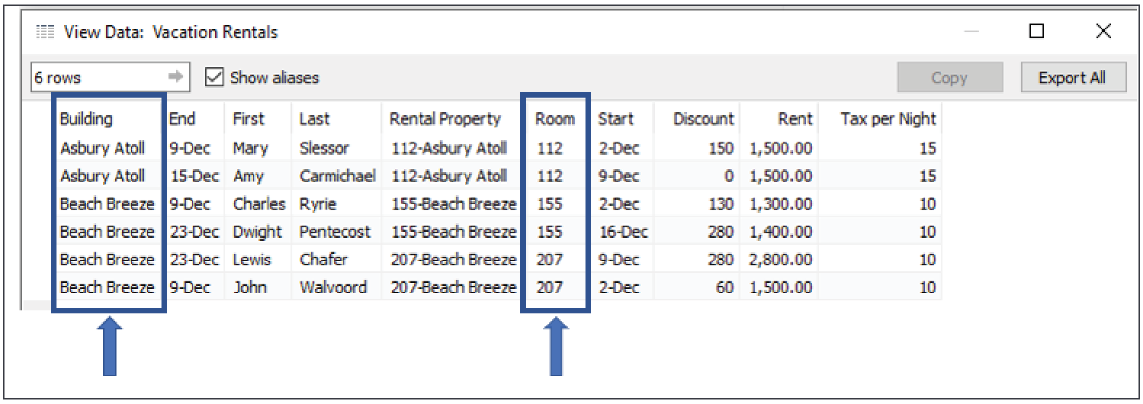


Figure 4.5: The small = sign indicates a field is a calculation

The code for both calculated fields is executed for every row of data and returns a row-level value. We can verify that the code is operating on the row level by examining the source data. Simply click on the **View Data** icon next to dimensions to see the row-level detail (it's next to the magnifying glass icon in the preceding screenshot). Here, the new fields of **Building** and **Unit**, along with the row-level values, can be clearly seen:



Building	End	First	Last	Rental Property	Room	Start	Discount	Rent	Tax per Night
Asbury Atoll	9-Dec	Mary	Slessor	112-Asbury Atoll	112	2-Dec	150	1,500.00	15
Asbury Atoll	15-Dec	Amy	Carmichael	112-Asbury Atoll	112	9-Dec	0	1,500.00	15
Beach Breeze	9-Dec	Charles	Ryrie	155-Beach Breeze	155	2-Dec	130	1,300.00	10
Beach Breeze	23-Dec	Dwight	Pentecost	155-Beach Breeze	155	16-Dec	280	1,400.00	10
Beach Breeze	23-Dec	Lewis	Chafer	207-Beach Breeze	207	9-Dec	280	2,800.00	10
Beach Breeze	9-Dec	John	Walvoord	207-Beach Breeze	207	2-Dec	60	1,500.00	10

Figure 4.6: Viewing the underlying data shows us the calculation is done per row of data

Tip:

Tableau provides a shortcut for splitting a field. You can use the drop-down menu on a field in the data pane and select **Transform** | **Split** or **Transform** | **Custom Split** (if you have a non-standard delimiter). The results are calculated fields similar to those you created previously, but with some additional logic around determining data types. Transform functionality, such as split, is also available for fields in the **Preview** or **Metadata** views on the **Data** source screen.

Extending the example

We'll extend the example a bit more and assume you know that the floor of a room is indicated by its number. Rooms 100 through 199 are on the first floor, and 200 through 299 are on the second. You'd like to have that information available for analysis.

We could potentially add this attribute to the source data, but there are times when this may not be an option or may not be feasible. You may not have permission to change the source data or the source might be a spreadsheet that is automatically generated every day, and any changes would be overwritten.

Instead, you can create a row-level calculation in Tableau to extend the data. To do so, create a calculated field named `Floor` with the following code:

```
IF LEFT([Room], 1) = "1"
THEN "First Floor"
ELSEIF LEFT([Room], 1) = "2"
THEN "Second Floor"
END
```

This code uses the `LEFT()` function to return the leftmost character of the room. Thus, `112` gives a result of `1`; `207` gives a result of `2`. The `IF THEN END` logic allows us to assign a result (either `First Floor` or `Second Floor`), depending on which case is true. Notice that you used the `Room` field in the calculation, which, in turn, was another calculation.

Note:

Using a reference to a calculated field within another calculation is referred to as **nesting.** The calculations that use other calculated fields are called **nested calculations**. There's no theoretical limit to how many levels of nesting you can use, but it may become hard to untangle the logic if you use too many levels of nesting.

Planning for data variations

As you write calculations, consider whether your calculation covers variations in the data that are not currently present.

Tip:

A few good questions to ask yourself whenever you write a calculation in Tableau are: *What happens if the data changes? Does the calculation handle unexpected or invalid values? Have I covered every case?*

For example, the preceding floor calculation only works if all the rooms are either 100- or 200-level rooms. What if there is a room, 306, on the third floor, or a room, 822, on the eighth floor?

To account for additional cases, we might simplify our calculation to the following:

```
LEFT([Room], 1)
```

This code simply returns the leftmost character of the room number. We'll get `3` for `306` and `8` for `822`. But what if we have room numbers such as 1056 on the tenth floor, and 1617 on the sixteenth? We'd have to consider other options, such as the following:

```
MID([Room], 0, LEN([Room]) - 2)
```

Although this is more complicated, the string functions return a substring that starts at the beginning of the string and ends just before the last two characters. That gives us floor `10` for `1025`, and floor `18` for `1856`.

We've now considered some row-level calculation examples. Let's move on to the next major type of calculation in Tableau: aggregate-level calculations.

Aggregate calculations

We've already considered aggregations such as `sum`, `min`, and `max` in Tableau. Often, you'll use fields as simple aggregations in the view. But sometimes, you'll want to use aggregations in more complex calculations.

For example, you might be curious to explore the percentage of the rent that was discounted. There is no such field in the data. It could not really be stored in the source, because the value changes based on the level of detail present in the view (for example, the percent discounted for an individual unit will be different to the percent discounted per floor or per building). Rather, it must be calculated as an aggregate and recalculated as the level of detail changes.

Let's create a calculation named `Discount %` with the following code:

```
SUM([Discount]) / SUM([Rent])
```

This code indicates that the sum of `Discount` should be divided by the sum of `Rent`. This means that all the values of `Discount` will be added, and all the values of `Rent` will be added. Only after the sums are calculated will the division occur.

Note:

Once you've created the calculation, you'll notice that Tableau treats the new field as a **Measure** in the data pane. Tableau will treat any calculation with a numeric result as a measure by default, but you can change *row-level calculations* to dimensions if desired. In this case, though, you are not even able to redefine the new field as a dimension. The reason for this is that Tableau will treat every *aggregate calculation* as a measure, no matter what data type is returned. This is because an aggregate calculation depends on dimensions to define the level of detail at which the calculation is performed. So, an aggregate calculation cannot be a dimension itself.

As the value of your calculation is a percentage, you will also likely want to define the format as a percentage. To do this, right-click the `Discount %` field, select **Default Properties** | **Number Format**, and select **Percentage**. You may adjust the number of decimal places that are displayed if desired.

Now, create a couple of views to see how the calculation returns different results, depending on the level of detail in the view. First, we'll build a view to look at each individual rental period:

1. Place **Building**, **Room**, **Full Name**, **Start**, and **End** on **Rows**.
2. In the data pane, under **Measures**, double-click each of the following fields: **Rent**, **Discount**, and **Discount %**. Tableau will place each of these measures in the view by using **Measure Names** and **Measure Values**.
3. Rearrange the fields on the **Measure Values** shelf so that the order is **Rent**, **Discount**, and **Discount %**:

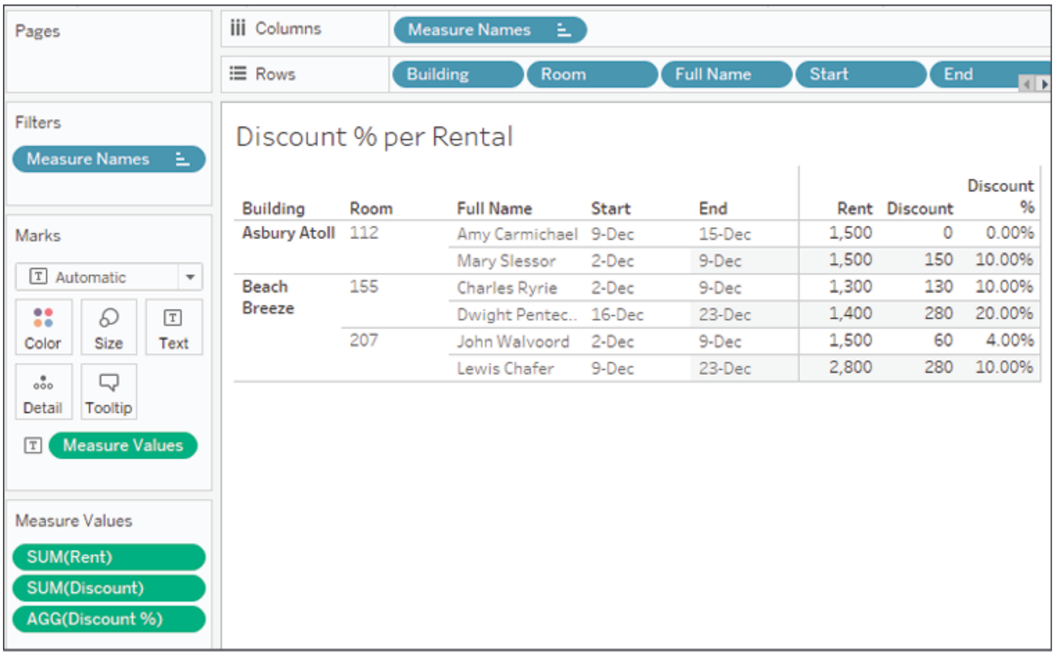


Figure 4.7: Illustrates the Discount % calculated at the level of Building, Room, Full Name, Start, and End

You can see the percentage given by way of discount for each rental period. However, notice how the values change when you remove all fields except **Building** and **Room**:

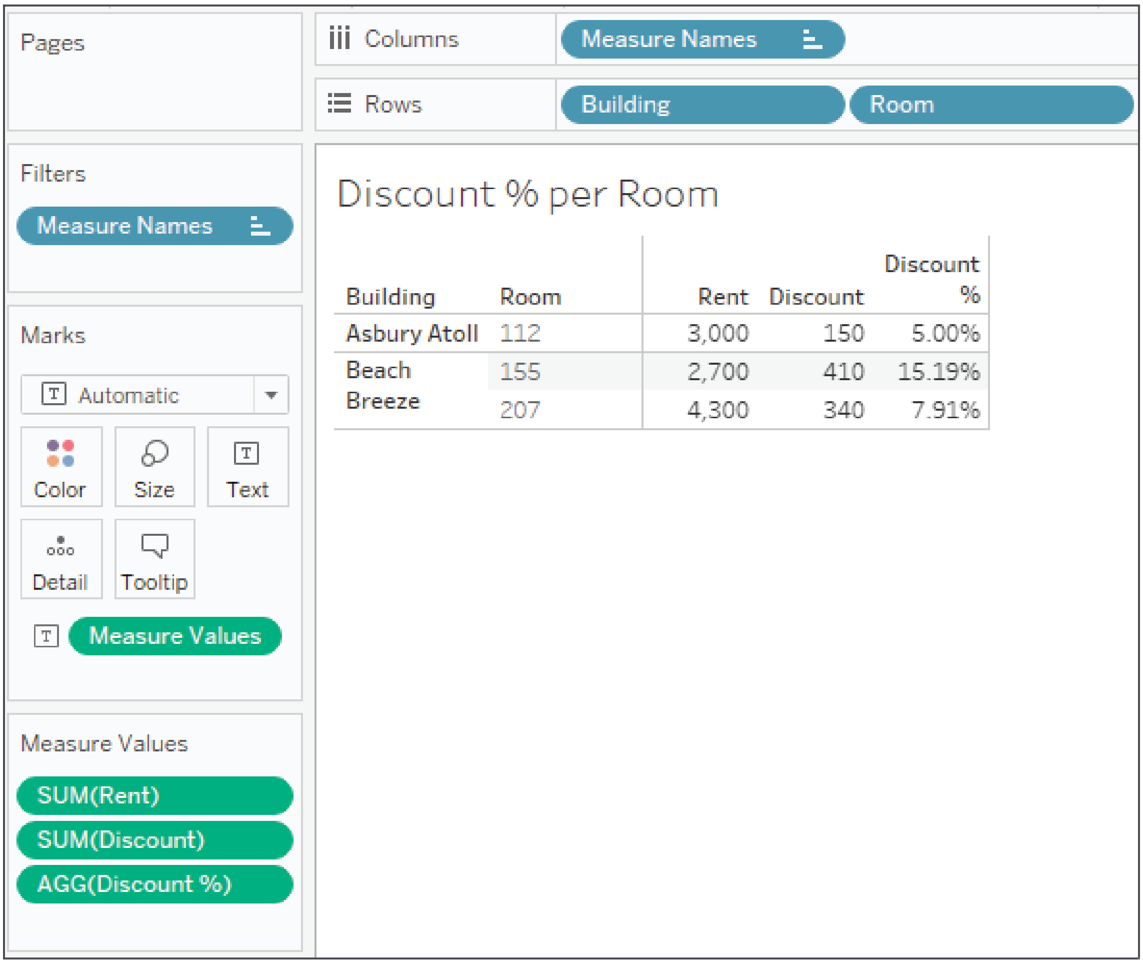


Figure 4.8: Illustrates the Discount % calculated at the level of Building and Room

Why did the values change? Because aggregations depend on what dimensions are defining the level of detail of the view. In the first case, **Building** and **Room**, **Full Name**, **Start**, and **End** defined the level of detail in the view. So, the calculation added up all the rent for each rental period and all the discounts for the rental period and then divided them. In the second case, **Building** and **Room** redefine the level of detail. So, the calculation added up all the prices for each building and room and all the discounts for each building and room and then divided them.

Note:

You may have noticed that as you double-clicked each measure, it was added to the pane of the view in a special way. **Measure Names** and **Measure Values** are special fields that appear in every data connection (toward the bottom of the **Data** pane). These serve as placeholders for multiple measures that share the same space in the view.

In the view you just created, for example, three measures all shared space in the pane. **Measure Values** on **Text** indicated that all values of measures on the **Measure Values** shelf should be displayed as text. The **Measure Names** field on **Columns** created a column for each measure, with the value of the name of that measure.

Notice that the values change again, as expected, if you look at the overall dataset without slicing by any dimensions:

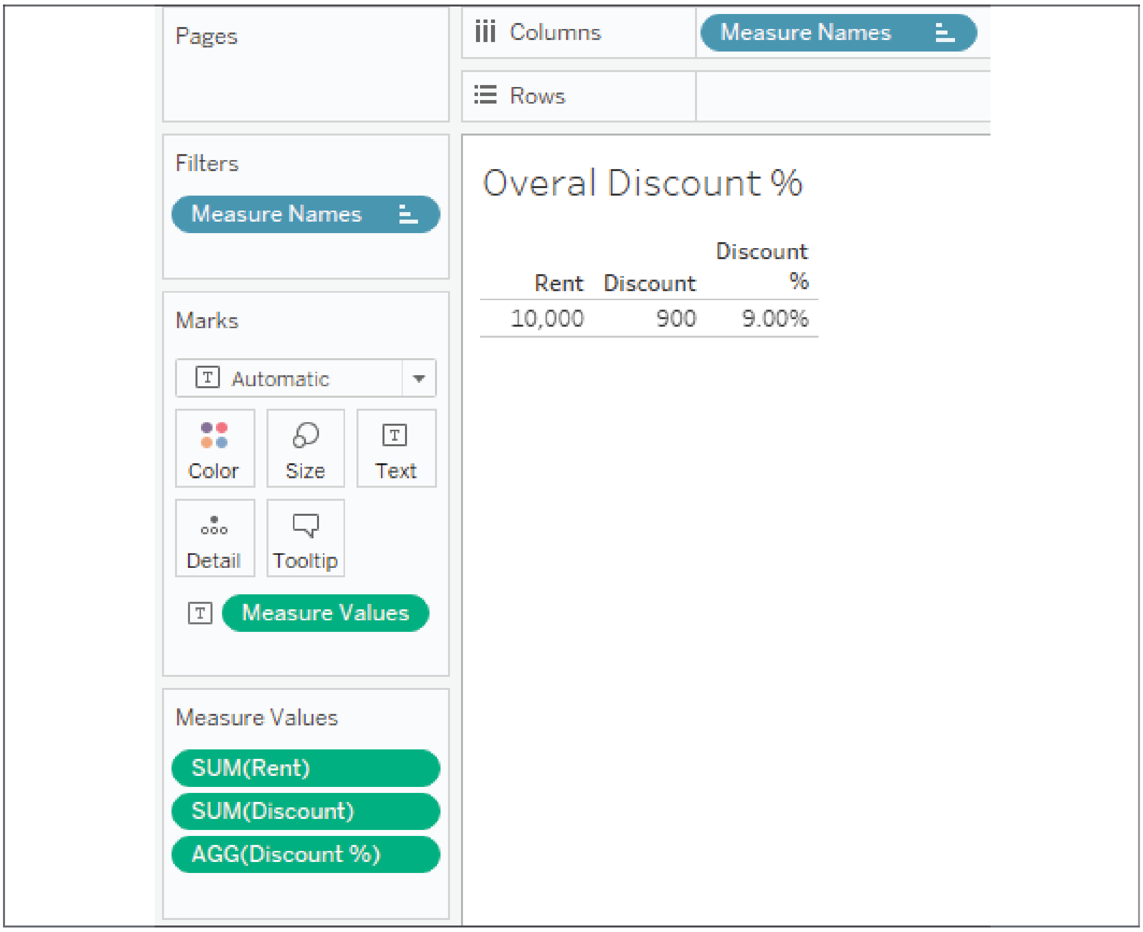


Figure 4.9: Illustrates the Discount % calculated at the highest possible level: the entire dataset

Tip:

An easy way to get Tableau to implement **Measure Names** / **Measure Values** is to remember that they are used whenever you want to use *two or more measures in the same space* in a view. So, if you want to use two or more measures in the pane, drag the first to the pane and then the second. If you want to use two or more measures on the same axis, drag the first to the axis, and then drag and drop the second on the same spot.

Now that you have a basic understanding of row-level and aggregate calculations, let's consider why the distinction is important.

Why the row level versus aggregate difference matters

Let's say you created a `Discount % (row level)` calculation with the following code:

```
[Discount]/[Rent]
```

The code differs from the aggregate calculation you created previously, which had the following code:

```
SUM([Discount])/SUM([Rent])
```

Here is the dramatic difference in results:

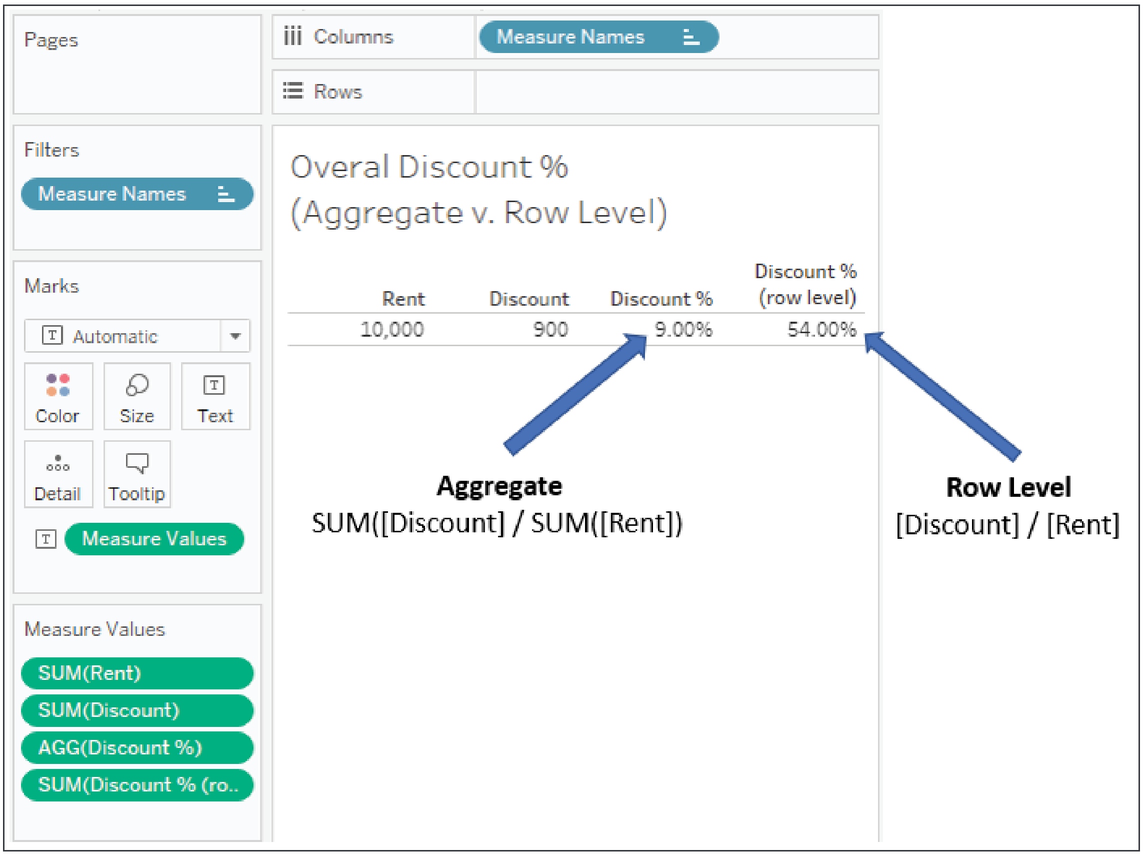


Figure 4.10: Illustrates the Discount % calculated as a row-level value and as an aggregate

Why is there such a difference in the results? It's a result of the way the calculations were performed.

Notice that `Discount % (row level)` appears on the **Measure Values** shelf as a `SUM`. That's because the calculation is a row-level calculation, so it gets calculated row by row and then aggregated as a measure after all row-level values have been determined. The `54.00%` value you see is actually a sum of percentages that were calculated in each record of underlying data.

In fact, the row-level calculation and the final aggregation is performed like this:

Rental Property	First	Discount	Rent	Discount %
112-Asbury Atoll	Mary	150	$1,500	10%
112-Asbury Atoll	Amy	0	$1,500	0%
155-Beach Breeze	Charles	130	$1,300	10%
155-Beach Breeze	Dwight	280	$1,400	20%
207-Beach Breeze	Lewis	280	$2,800	10%
207-Beach Breeze	John	60	$1,500	4%
				54%

Row Level
[Discount] / [Rent]
Results calculated for each row

Final Aggregation
Sum of row level results

Figure 4.11: If each Discount % result is calculated at a row level and then aggregated, the result is wrong

Contrast that with the way the aggregate calculation is performed. Notice that the aggregation that's listed in the active field on the **Measure Values** shelf in the view is `AGG`, and not `SUM`. This indicates that you have defined the aggregation in the calculation. Tableau is not aggregating the results further. Here is how the aggregate calculation is performed:

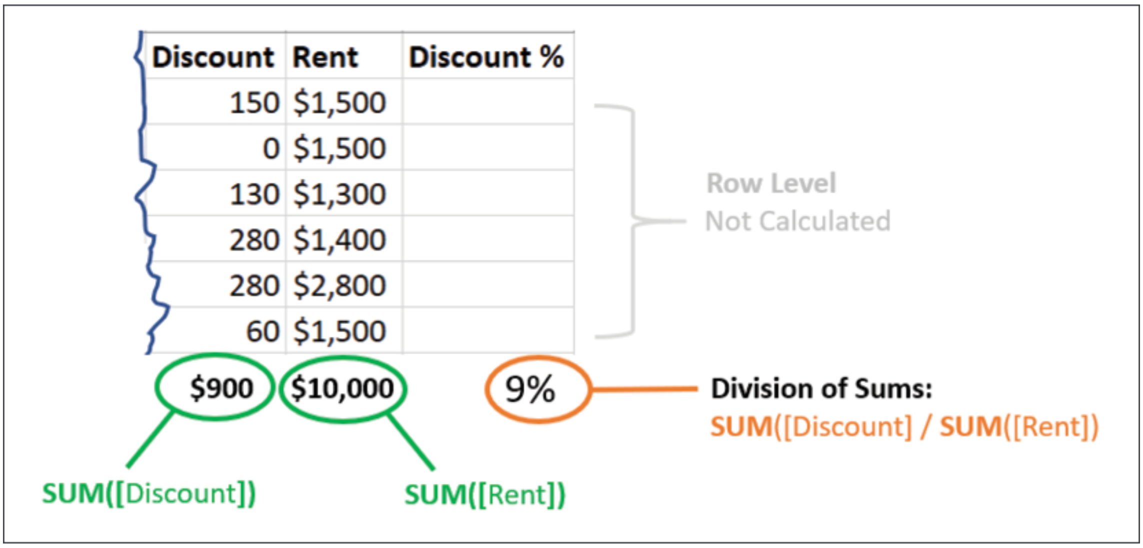


Figure 4.12: If the numerator and denominator are aggregated first, then the Discount % calculation is correct

It is vital to understand the difference between row-level and aggregate calculations to ensure you are getting the results you expect and need. In general, use row-level calculations when you are certain that you will use either the value as a dimension or that an aggregation of the row-level values will make sense. Use aggregate calculations if aggregations must be performed prior to other operations.

One of the most common error messages that's encountered while writing Tableau calculations is *Cannot mix aggregate and non-aggregate arguments with this function*. When you encounter this message, check your code to make sure you are not improperly mixing row-level fields and calculations with aggregate fields and calculations. For example, you cannot have something like `[Discount] / SUM([Rent])`.

This mixture of a row-level value `(Discount)` and the aggregation (`SUM` of `Rent`) is invalid.

With the distinction between row-level and aggregate calculations clear, let's take an interlude and discuss parameters before building additional examples.

Parameters

Before moving to some additional examples of row-level and aggregate calculations, let's take a little side trip to examine parameters, given that they can be used in incredible ways in calculations.

A **parameter** in Tableau is a placeholder for a single, global value such as a number, date, or string. Parameters may be shown as controls (such as sliders, drop-down lists, or type-in text boxes) to end users of dashboards or views, giving them the ability to change the current value of the parameter. Parameter values may even be changed with actions, as you'll see in *Lab 8*, *Telling a Data Story with Dashboards*.

The value of a parameter is global so that if the value is changed, every view and calculation in the workbook that references the parameter will use the new value. Parameters provide another way to provide rich interactivity to the end users of your dashboards and visualizations.

Parameters can be used to allow anyone interacting with your view or dashboard to dynamically do many things, including the following:

- Alter the results of a calculation
- Change the size of bins
- Change the number of top or bottom items in a top *n* filter or top *n* set
- Set the value of a reference line or band
- Change the size of bins
- Pass values to a custom SQL statement that's used in a data source

Some of these are options we'll consider in later labs.

Since parameters can be used in calculations, and since calculated fields can be used to define any aspect of a visualization (from filters to colors to rows and columns), the change in a parameter value can have dramatic results. We'll see some examples of this in the following sections.

Creating parameters

Creating a parameter is similar to creating a calculated field.

There are multiple ways to create a parameter in Tableau:

- Use the drop-down menu next to **Dimensions** in the data pane and select **Create Parameter**.
- Right-click an empty area in the data pane and select **Create Parameter**.
- Use the drop-down menu on a field, set, or parameter already in the data pane and select **Create | Parameter...**.

In the last case, Tableau will create a parameter with a list of potential values based on the **domain** (distinct values) of the field. For fields in the data pane that are **discrete** (blue) by default, Tableau will create a parameter with a list of values matching the discrete values of the field. For fields in the data pane that are **continuous** (green), Tableau will create a parameter with a range set to the minimum and maximum values of the field that's present in the data.

When you first create a parameter (or subsequently edit an existing parameter), Tableau will present an interface like this:

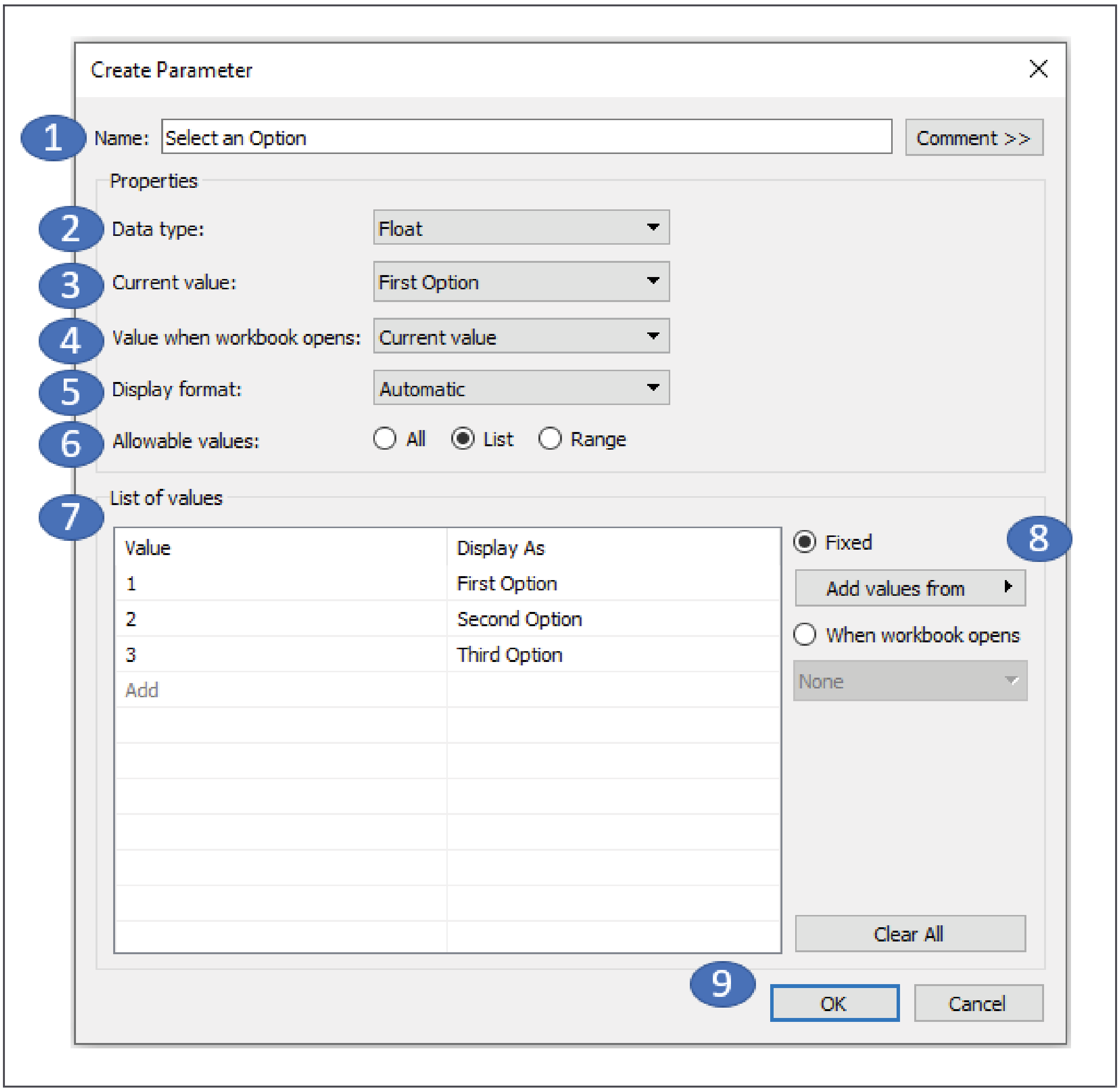


Figure 4.13: The Create Parameter interface numbered with corresponding descriptions below

The interface contains the following features:

1. **Name** will show as the default title for parameter controls and will also be the reference in calculations. You can also add a **Comment** to describe the use of the parameter.
2. **Data type** defines what type of data is allowed for the value of the parameter. Options include integer, float (floating-point decimal), string, Boolean, date, or date with time.
3. **Current value** defines what the initial default value of the parameter will be. Changing this value on this screen or on a dashboard or visualization where the parameter control is shown will change the current value.
4. **Value when workbook opens** allows you to optionally change the default value of the parameter when the workbook opens based on a calculated value.
5. **Display format** defines how the values will be displayed. For example, you might want to show an integer value as a dollar amount, a decimal as a percentage, or display a date in a specific format.
6. The **Allowable values** option gives us the ability to restrict the scope of values that are permissible. There are three options for **Allowable values**:
    - **All** allows any input from the user that matches the data type of the parameter.

   - **List** allows us to define a list of values from which the user must select a single option. The list can be entered manually, pasted from the clipboard, or loaded from a dimension of the same data type.
   - **Range** allows us to define a range of possible values, including an optional upper and lower limit, as well as a step size. This can also be set from a field or another parameter.

7. In the example of the preceding screenshot, since we've selected **List** for **Allowable values**, we are given options to enter the list of possible values. In this example, a list of three items has been entered. Notice that the value must match the data type, but the display value can be any string value. You can drag and drop values in the list to reorder the list. If **Range** had been selected, the screen would instead show options for setting the **Minimum**, **Maximum**, and **Step Size** for the range.
8. Also specific to **List** are a couple of additional options for populating the list:
   - **Fixed**: You may manually enter the values, paste from the clipboard, or set them from the existing values of a field in the data. In any case, the list will be a static list and will not change even if the data is updated.
   - **When the workbook opens** allows you to specify a field that will dynamically update the list based on the available values for that field when the workbook is first opened.

Click **OK** to save changes to the parameter or **Cancel** to revert.

When the parameter is created, it appears in the data pane in the **Parameters** section. The drop-down menu for a parameter reveals an option, **Show Parameter Control**, which adds the parameter control to the view. The little drop-down caret in the upper right of the parameter control reveals a menu for customizing the appearance and behavior of the parameter control. Here is the parameter control, shown as a single value list, for the parameter we created earlier:

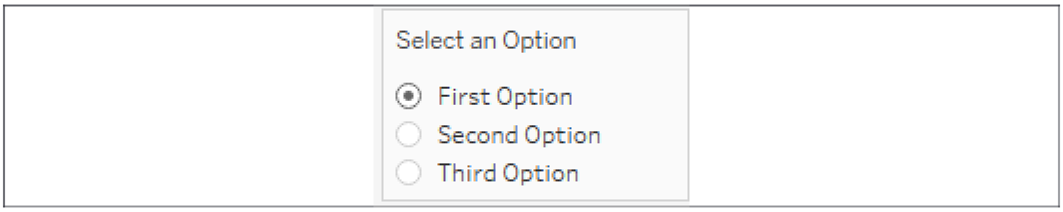


Figure 4.14: The parameter control shown as a single select radio button list

This control can be shown on any sheet or dashboard and allows the end user to select a single value. When the value is changed, any calculations, filters, sets, or bins that use the parameter will be re-evaluated, and any views that are affected will be redrawn.

Next, we'll consider some practical examples that use parameters in calculations.

Practical examples of calculations and parameters

Let's turn our attention to some practical examples of row-level and aggregate calculations. The goal is to learn and understand some of what is possible with calculations. You will be able to build on these examples as you embark on your analysis and visualization journey.

Note:

A great place to find help and suggestions for calculations is the official Tableau forums at [https://community.tableau.com/s/explore-forums].

Fixing data issues

Often, data is not entirely clean. That is, it has problems that need to be corrected before meaningful analysis can be accomplished. For example, dates may be incorrectly formatted, or fields may contain a mix of numeric values and character codes that need to be separated into multiple fields. Calculated fields can often be used to fix these kinds of issues.

Tip:

We'll consider using Tableau Prep---a tool designed to shape and cleanse data---in *Lab 14*, *Structuring Messy Data to Work Well in Tableau*. Tableau Prep's calculation syntax is nearly identical, so many of the examples in this lab will also be applicable in that context. Knowing how to address data issues in either Tableau Desktop or Tableau Prep will help you greatly.

We'll continue working with the `Vacation Rentals` data. You'll recall that the start and end dates looked something like this:

Start	End
Dec 2	Dec 9
Dec 9	Dec 15
Dec 16	Dec 23

Without the year, Tableau does not recognize the `Start` or `End` fields as *dates*. Instead, Tableau recognizes them as *strings*. You might try using the drop-down menu on the fields in the data pane to change the data type to date, but without the year, Tableau will almost certainly parse them incorrectly, or at least incompletely. This is a case where we'll need to use a calculation to fix the issue.

Assuming, in this case, that you are confident the year should always be 2020, you might create calculated fields named `Start Date` and `End Date`.

Here is the code for getting the start date:

```
DATE([Start] + ", 2020")
```

And here is the code for getting the end date:

```
DATE([End] + ", 2020")
```

What these calculated fields do is concatenate the month and day with the year and then use the `DATE()` function to convert the string into a date value. Indeed, Tableau recognizes the resulting fields as dates (with all the features of a date field, such as built-in hierarchies). A quick check in Tableau reveals the expected results:

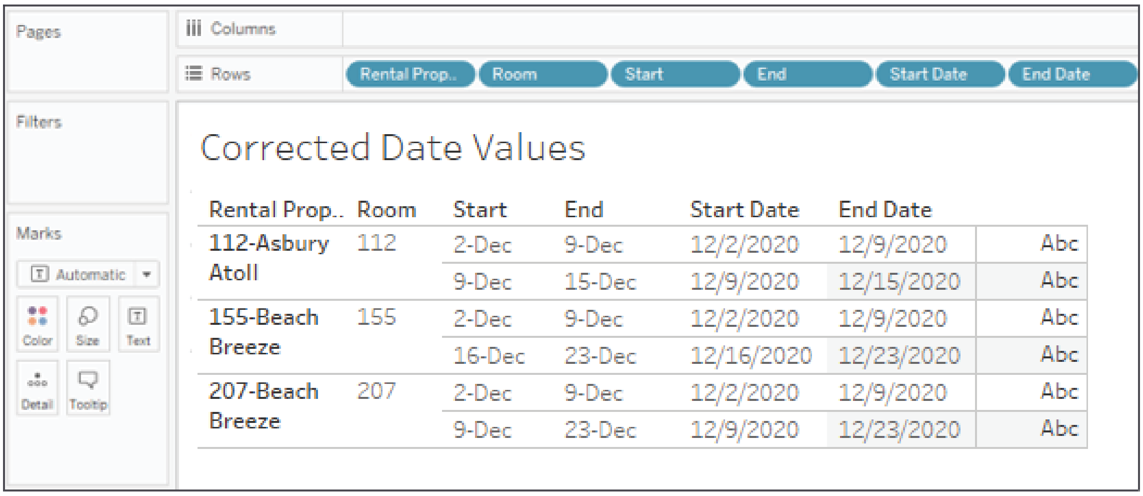


Figure 4.15: The corrected dates appear next to the string versions. All fields are discrete dimensions on Rows (the dates are exact dates)

Not only are we able to fix problems in the data, but we can also extend the data and our analysis using calculations. We'll consider this next.

Extending the data

Often, there will be dimensions or measures you'd like to have in your data, but which are not present in the source. Many times, you will be able to extend your dataset using calculated fields. We already considered an example of creating a field for the full name of the guest where we only had first and last name fields.

Another piece of data that might unlock some truly interesting analysis would be the length of each rental. We have the start and end dates, but not the length of time between those two dates. Fortunately, this is easy to calculate.

Create a calculated field named `Nights Rented` with the following code:

```
DATEDIFF('day', [Start Date], [End Date])
```

Note:

Tableau employs intelligent code completion. It will offer suggestions for functions and field names as you type in the code editor. Pressing the [Tab] key will autocomplete what you have started to type based on the current suggestion.

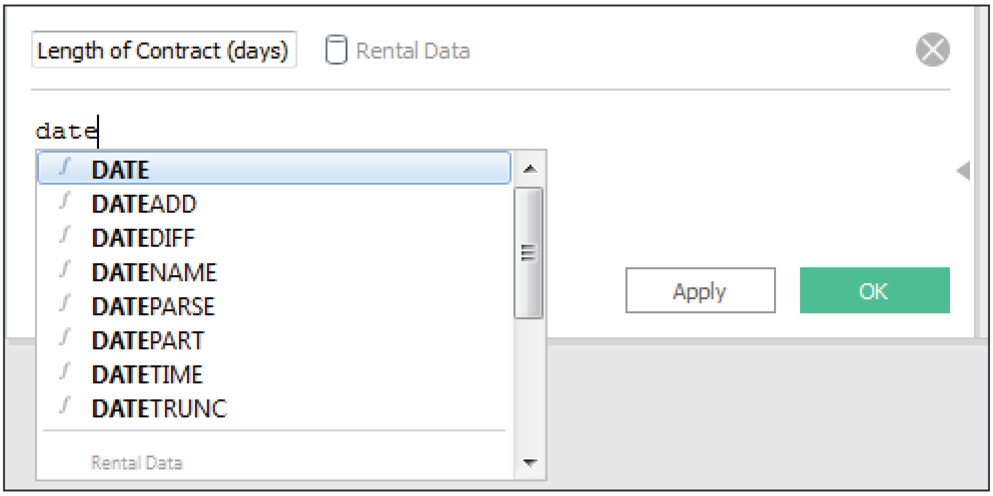


Figure 4.16: The intelligent code completion will suggest possible field names and functions as you type.

The `DATEDIFF()` function takes a date part description, a start and an end date, and returns a numeric value for the difference between the two dates. We now have a new measure, which wasn't available previously. We can use this new measure in our visualizations, such as the Gantt chart of rentals, as follows:

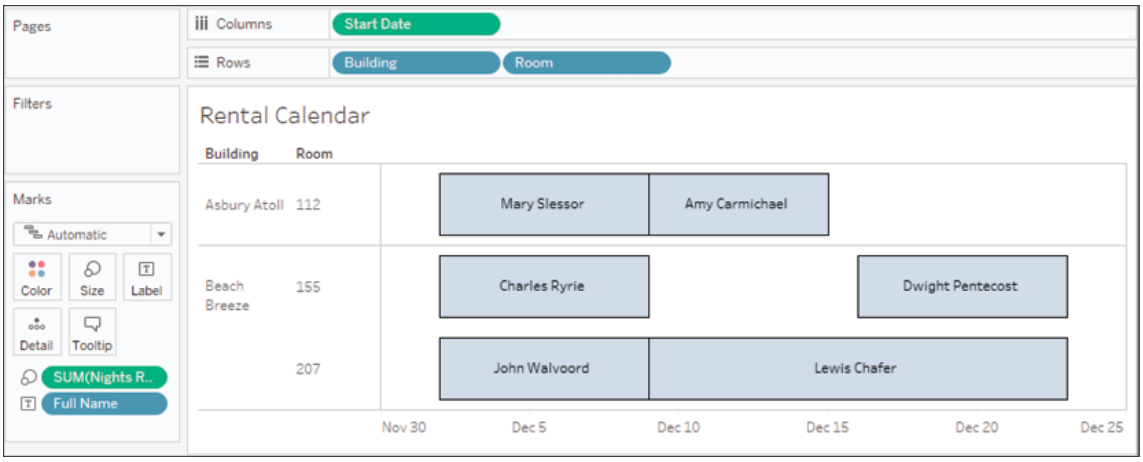


Figure 4.17: The calculated field allows us to create the Gantt chart

You'll find many ways to extend your data with calculations as you continue your journey in Tableau. And that will enable you to accomplish some amazing analysis and visualizations. We'll consider some examples next.

Enhancing user experience, analysis, and visualizations

Calculations and parameters can greatly enhance the user experience, the analysis, and the visualizations.

Let's say we want to give the vacation condo manager the ability to do some what-if analysis. Every year, she offers a free night during the month of December. She wants to be able to see which renters would have received the free night, depending on which night she chooses.

To accomplish this, follow these steps:

1. If you have not done so, create a Gantt chart similar to what was shown earlier (following the field placement of the screenshot).

2. Create a parameter called **Free Night** with a data type of **Date** and a starting value of `12/12/2020`. This will allow the manager to set and adjust the starting date for the promotional month. Show the parameter control by selecting **Show Parameter Control** from the drop-down menu on the **Free Night** parameter in the data pane.

3. Now, add a reference line to the view to show the free night. Do this by switching to the **Analytics** tab in the left sidebar. Drag **Reference Line** to the view and drop it on **Table**:

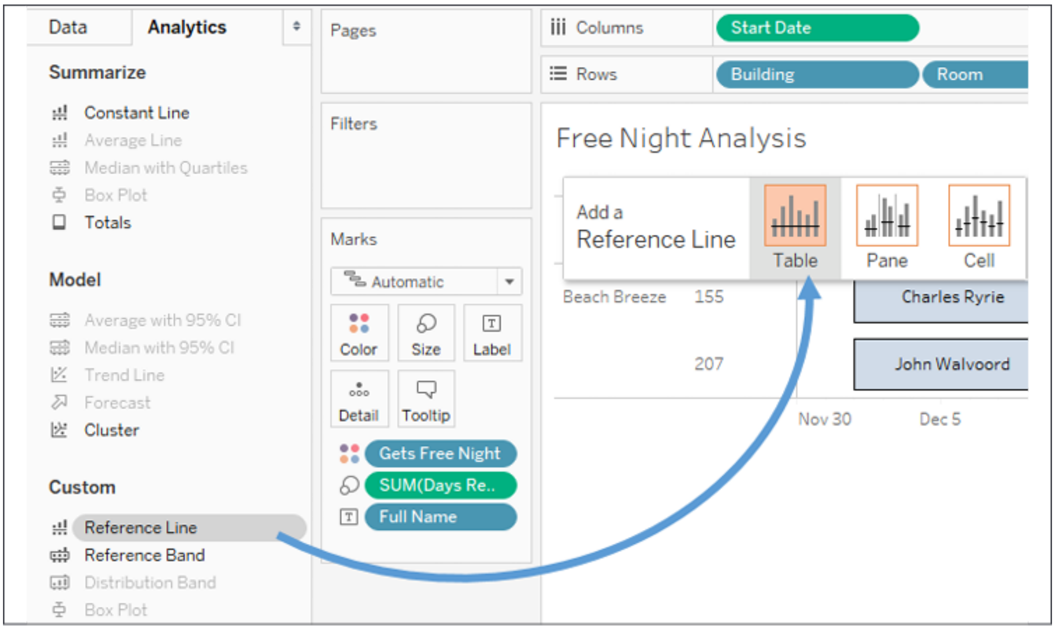


Figure 4.18: Add a reference line by switching to the Analytics pane and dragging the reference line onto the canvas

4. In the resulting dialog box, set **Line** Value to **Free Night**. You may wish to set the **Label** to **None**, or **Custom** with the text `Free Night`. You may also wish to adjust the formatting of the line:

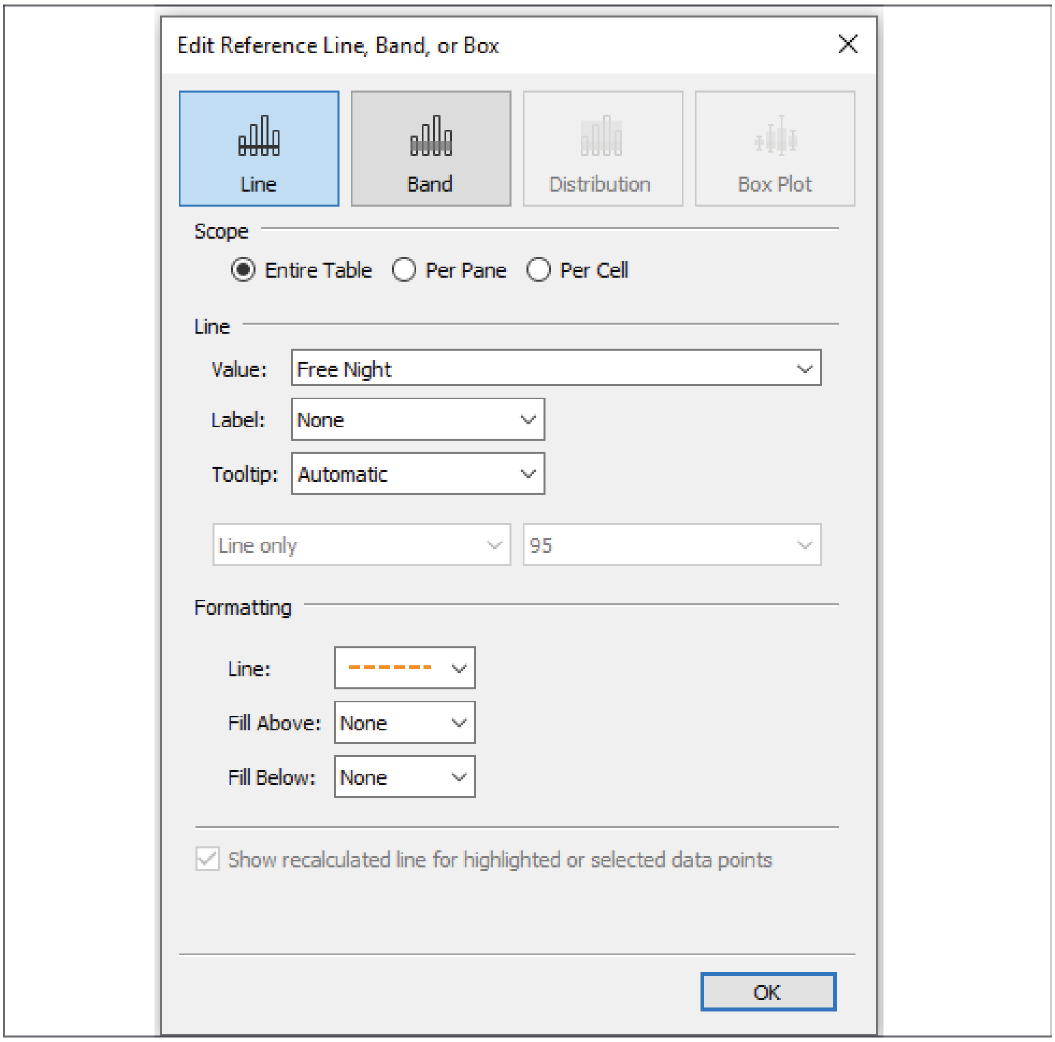


Figure 4.19: Use the Edit Reference Line dialog to adjust formatting, labels, and tooltips

5. Create a calculated field called **Gets Free Night** that returns a `true` or `false` value, depending on whether the free night falls within the rental period:

```
[Free Night] >= [Start Date]
AND
[Free Night] <= [End Date]
```

1. Place this new calculated field on the **Color** shelf.

We now have a view that allows the apartment manager to change the date and see a dynamically changing view that makes it obvious which renters would have fallen within a given promotional period. Experiment by changing the value of the **Free Night** parameter to see how the view updates:

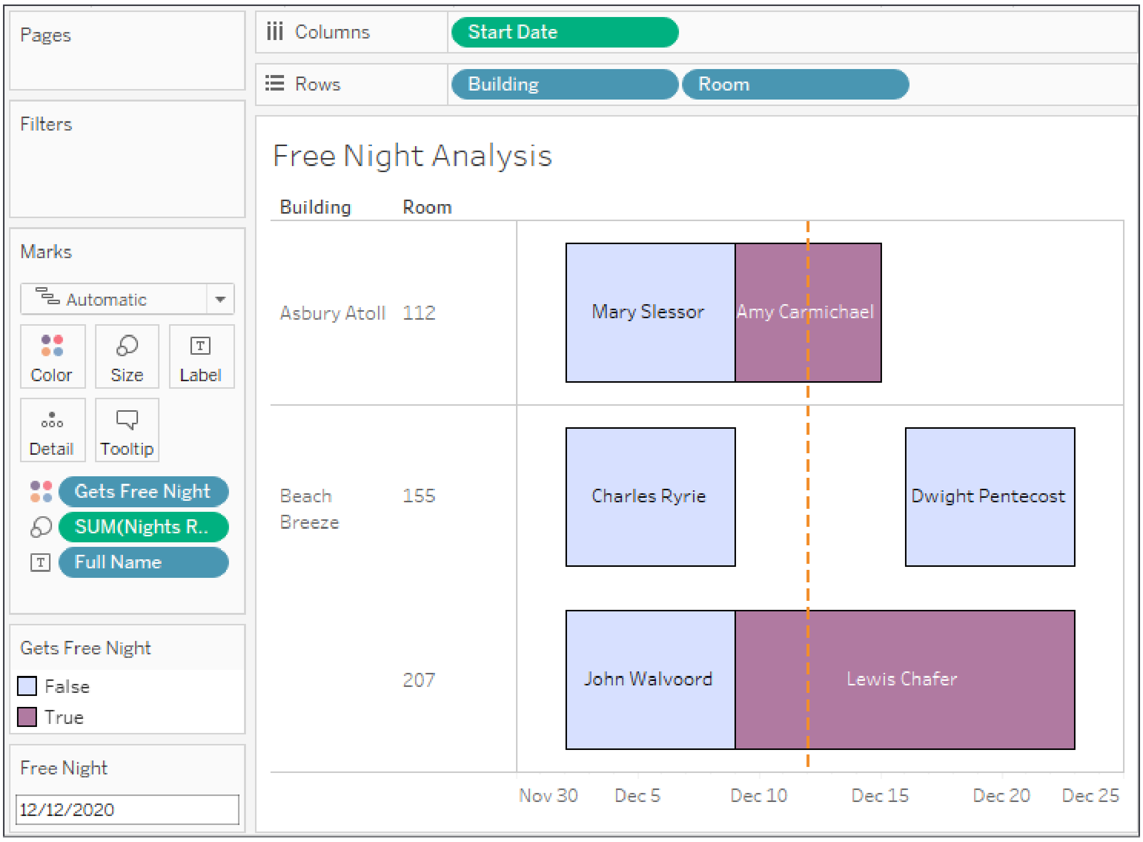


Figure 4.20: The reference line will move, and the affected individuals will be recalculated every time you change the Free Night parameter value

The preceding view shows the proposed free night as a dashed line and highlights which rental periods would receive a free night. The line and colors will change as the apartment manager adjusts the **Free Night** parameter value.

In addition to extending your analysis, visualization, and user experience, you might also use calculations to add required business logic. We'll consider that next.

Meeting business requirements

Sometimes, data doesn't exactly match what your organization wants. For example, the measures in the data may not be the exact metrics required to make key business decisions. Or dimension values may need to be grouped according to a certain set of rules. Although this kind of business logic is often applied as data is transformed or modeled prior to connecting to it with Tableau, you may find cases where you need to implement business logic on the fly.

In this example, consider that the measure `Rent` is simply the base rent and does not include the discount or taxes. Those are separate fields in the data. If you needed to analyze the total `Revenue`, you'd need to calculate it. That calculation might look something like this:

```
[Rent] - [Discount] + ([Tax per Night] * [Nights Rented])
```

This formula takes the base `Rent`, subtracts the `Discount`, and then adds the `Tax per Night` multiplied by the `Nights Rented`. The parentheses aid readability but are not required because the multiplication operator, `*`, has higher precedence and is evaluated before the addition, `+`.

Up until now, we've created calculated fields that extend the data source. Sometimes you just need a quick calculation to help in a single view. We'll conclude by looking at these quick ad hoc calculations.

Ad hoc calculations

Ad hoc calculations allow you to add calculated fields to shelves in a single view without adding fields to the data pane.

Let's say you have a simple view that shows the **Revenue per Guest**, like this:

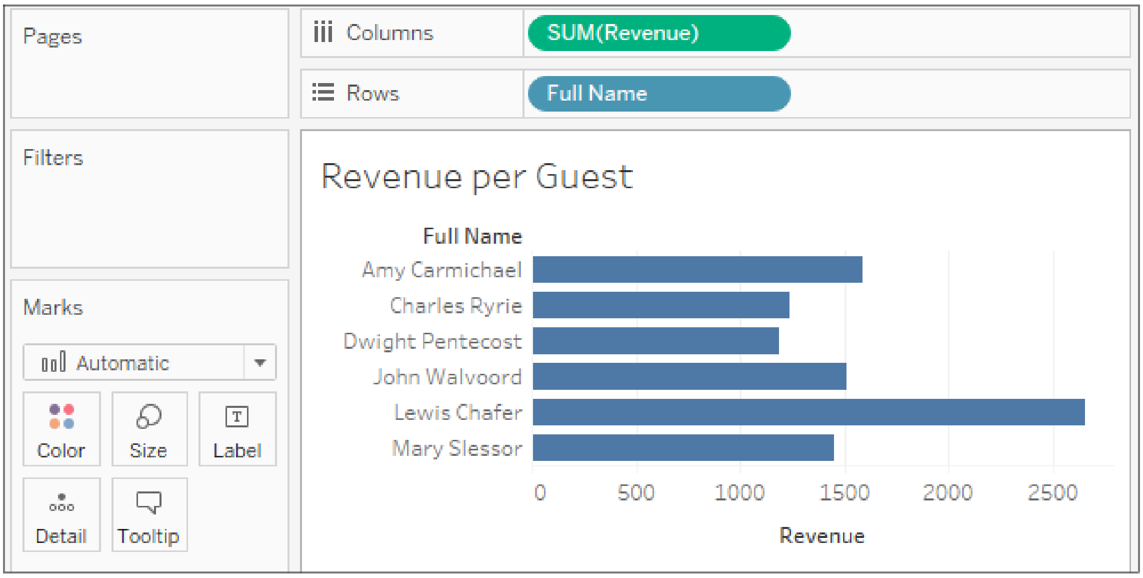


Figure 4.21: The revenue generated from each individual's stay

What if you wanted to quickly highlight any renters who had paid less than $1,500? One option would be to create an ad hoc calculation. To do so, simply double-click on an empty area of the **Columns**, **Rows**, or **Measure Values** cards, or on the empty space of the **Marks** shelf, and then start typing the code for a calculation. In this example, we've double-clicked the empty space on the **Marks** shelf:

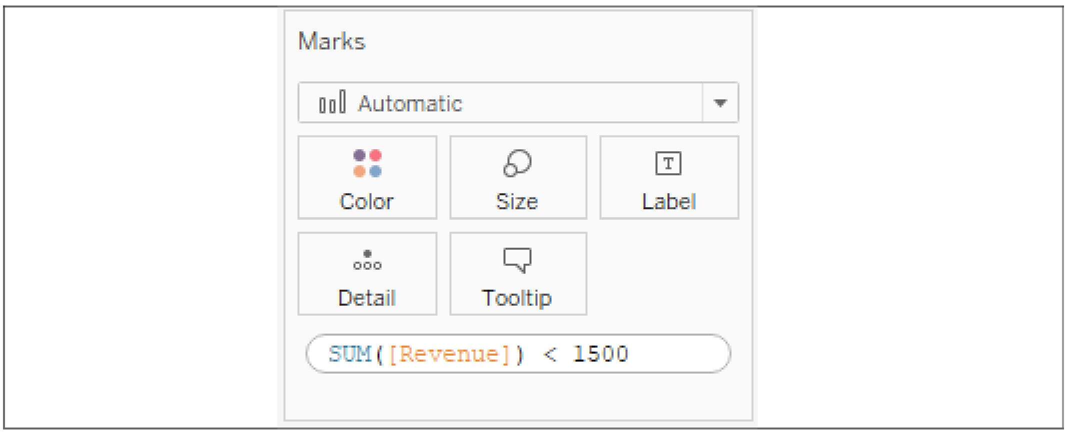


Figure 4.22: Creating an ad hoc calculation on the Marks card

Here, we've entered code that will return `True` if the sum of `Rent` is less than $1,500 and `False` otherwise. Pressing *Enter* or clicking outside the text box will reveal a new ad hoc field that can be dragged and dropped anywhere within the view. Here, we've moved it to the **Color** shelf:

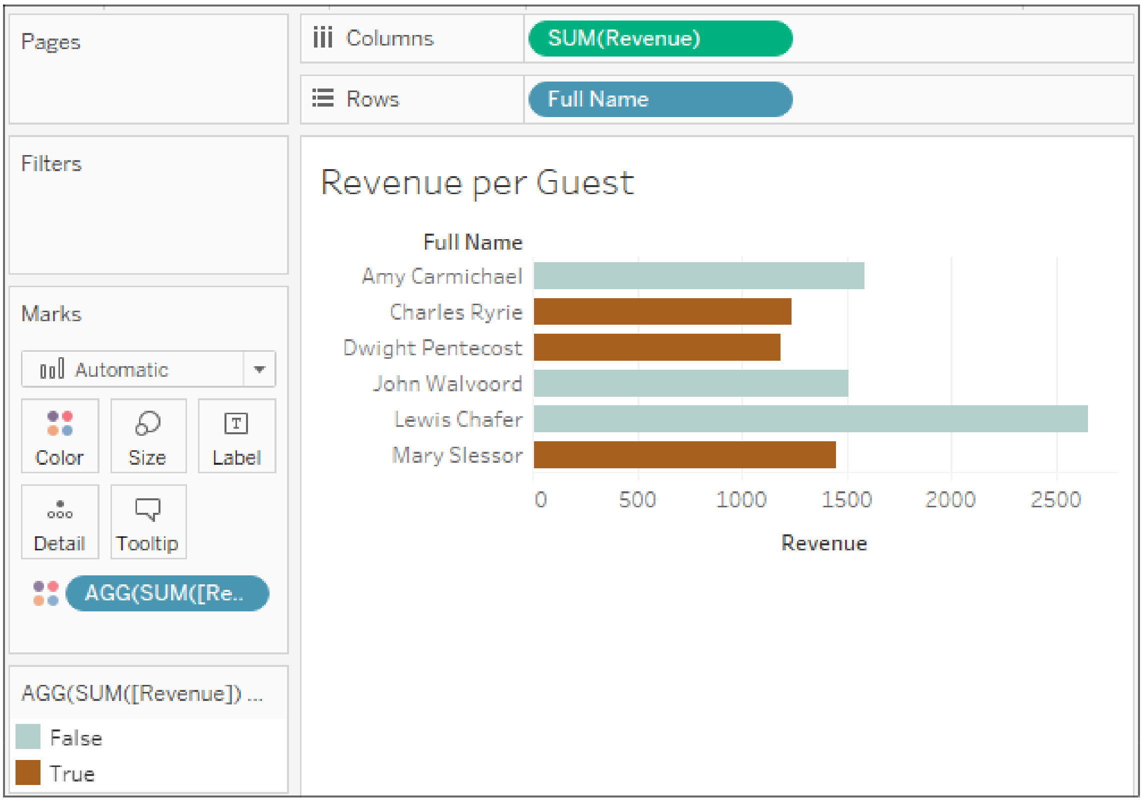


Figure 4.23: Using the ad hoc calculation on Color

The ad hoc field is only available within the view and does not show up in the data pane. You can double-click the field to edit the code.

Tip:

Dragging and dropping an ad hoc field into the data pane transforms it into a regular calculated field that will be available for other views that are using that data source.

Having seen a number of practical examples, let's conclude by considering some ways to ensure good performance when using calculations.

Performance considerations

When working with a small dataset and an efficient database, you often won't notice inefficient calculations. With larger datasets, the efficiency of your calculations can start to make a difference to the speed at which a view is rendered.

Here are some tips for making your calculations as efficient as possible:

- Boolean and numeric calculations are much faster than string calculations. If possible, avoid string manipulation and use aliasing or formatting to provide user-friendly labels. For example, don't write the following code: ``IF [value] == 1`` THEN "Yes" ELSE "No" END``. Instead, simply write `[value] == 1`, and then edit the aliases of the field and set `True` to `Yes` and `False` to `No`.

- Look for ways to increase the efficiency of a calculation. If you find yourself writing a long `IF ELSEIF` statement with lots of conditions, see whether there are one or two conditions that you can check first to eliminate the checks of all the other conditions. For example, let's consider simplifying the following code:

  ```
  //This is potentially less efficient...
  IF [Type] = "Dog" AND [Age] < 1 THEN "Puppy"
  ELSEIF [Type] = "Cat" AND [Age] < 1 THEN "Kitten"
  END
  //...than this code:
  IF [Age] < 1 THEN
      IF [Type] = "Dog" THEN "Puppy"
      ELSEIF [Type] = "Cat" THEN "Kitten"
      END
  END
  ```

  Notice how the check of type doesn't have to be done for any records where the age was less than `1`. That could be a very high percentage of records in the dataset.

- Row-level calculations have to be performed for every row of data. Try to minimize the complexity of row-level calculations. However, if that is not possible or doesn't solve a performance issue, consider the final option.

- When you create a data extract, certain row-level calculations are materialized. This means that the calculation is performed once when the extract is created, and the results are then stored in the extract. This means that the data engine does not have to execute the calculation over and over. Instead, the value is simply read from the extract. Calculations that use any user functions, parameters, or `TODAY()` or `NOW()`, will not be materialized in an extract as the value necessarily changes according to the current user, parameter selection, and system time. Tableau's optimizer may also determine whether to materialize certain calculations that are more efficiently performed in memory rather than having to read the stored value.

Tip:

When you use an extract to materialize row-level calculations, only the calculations that were created at the time of the extract are materialized. If you edit calculated fields or create new ones after creating the extract, you will need to optimize the extract (use the drop-down menu on the data source or select it from the **Data** menu and then select **Extract** | **Optimize** or **Extract** | **Compute Calculations Now**).

As you continue to work with calculations, pay special attention to situations where you notice performance issues, and consider whether you can optimize your calculations for better results.

Summary

The key to using calculated fields is understanding the four main types of calculations in Tableau. Row-level calculations are performed for every row of source data. These calculated fields can be used as dimensions or they can be aggregated as measures. Aggregate calculations are performed at the level of detail that's defined by the dimensions that are present in a view. They are especially helpful, and even necessary, when you must first aggregate components of the calculation before performing additional operations.

In the next lab, we'll explore the third of the four main types of calculations: **Level of Detail calculations**. This will greatly extend your ability to work with data and solve all kinds of interesting problems.