Example Title:	Histogram Service Example
Description:	This example provides a service to generate histogram data
Key Concepts:	Histogram, Infotable Services
Min TW Version:	ThingWorx 7.4
Extensions Required:	N/A
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Example Revision:	1.0 Initial version – August 2, 2017

This example provides the ability to generate a simple entity structure and some historical data for each entity. Historical data is run through a ThingWorx service to generate histogram data for display in a bar chart.

All entities used in the example are tagged with model tag Applications:MfgData

1. **Setup**
    a. Import the provided .twx or .xml entities file into your 7.4 or later ThingWorx platform
    b. On the MfgData.Services thing, run the GenerateInitialData service. The NumberOfPoints parameter will be used to generate historical data for 3 characteristics on 4 work cells. Using of the default value of 2,000 points will create 24,000 records in the MfgData.CharacteristicData stream. Running this service will first delete any existing data in the MfgData.CharacteristicData stream.
2. **Thing Model Entity Structure** – Instances from the provided MfgData.Line and MfgData.WorkCell thing templates were created to represent the following hierarchy:
    a. Line 1 (MfgData.Line1)
        i. Work Cell A (MfgData.Line1.WorkCellA)
        ii. Work Cell B (MfgData.Line1.WorkCellB)
    b. Line 2 (MfgData.Line2)
        i. Work Cell A (MfgData.Line2.WorkCellA)
        ii. Work Cell B (MfgData.Line2.WorkCellB)
    c. Line 2 (MfgData.Line2)
3. **Characteristic Data** – data for 3 characteristics for each of the above 4 work cells is stored in the stream – MfgData.CharacteristicData
4. **Data Shapes** – there are 6 data shapes used in this example:
    a. MfgData.Characteristic – simple one column data shape used to return a list of characteristics using the MfgData.Services GetCharacteristics service
    b. MfgData.CharacteristicData – a data shape that contains infotable columns that is used to return time series data, histogram data, and aggregate data from the MfgData.Services RetrieveCharacteristicData service
    c. MfgData.CharacteristicDataShape – the data shape used on the MfgData.CharacteristicData stream
    d. MfgData.TimeSeries – data shape used to return time series data of characteristics as well as assign specific data points to a histogram bin number.
    e. MfgData.WorkCellShape – data shape used to return work cell data from the MfgData.Services GetWorkCellsForLine service
    f. MfgData.Histogram – data shape used to return the histogram data
5. **How the Histogram Data is Calculated** – the MfgData.Services RetrieveCharacteristicData is used to retrieve both historical and histogram data for a specific Line, Work Cell and Characteristic for a specific number of records. The most recent records are retrieved. The following is a high level outline of the ThingWorx java script service code:
    a. Empty result infotable is created
    b. The MfgData.Services RetrieveCharacteristicTrendData service is called with the passed in parameters to grab the stream data out of the MfgData.CharacteristicData stream for the specific Line, Work Cell and Characteristic – this is returned in the TrendData infotable object

c. The TrendData object is aggregated to find the minimum and maximum data point values
d. The values are used to calculate the data range as well as the bin width to create a histogram with the passed in number of bins.
e. The TrendData object is the iterated to assign each data point to the proper histogram bin
f. Rows with bin assignments are added to the TrendDataWithBins infotable
g. After this iteration, the TrendDataWithBins is aggregated by the assigned BinNum
h. The TrendAggregatesByBin is the data to create a histogram
i. This data is iterated to get bin labels, etc. into an infotable called HistogramData
j. However, there could be empty bins which are not present in the infotable yet
k. The HistogramData is iterated to add any missing empty bins as well as to finally sort by BinNum
l. The overall service result is created to have:
    i. Time Series Trend Data
    ii. Histogram Data
    iii. Minimum Data Point
    iv. Maximum Data Point
    v. Average Value of Data Points
m. Note: The service will likely have issues with a negative or zero value of bins. The numeric entry widget for Number of Bins will constrain the entry

6. View the Data in a Mashup

a. Open the MfgData.Mashup mashup to view the trend and histogram data. Select different lines, work cells, and characteristics with different number of point and number of bins values to test the services and view the results.