



Microsoft Machine Learning in a Day Workshop

Student Guide

September 2018

Information in this document, including URL and other Internet Web site references, is subject to change without notice. Unless otherwise noted, the example companies, organizations, products, domain names, e-mail addresses, logos, people, places, and events depicted herein are fictitious, and no association with any real company, organization, product, domain name, e-mail address, logo, person, place or event is intended or should be inferred. Complying with all applicable copyright laws is the responsibility of the user. Without limiting the rights under copyright, no part of this document may be reproduced, stored in or introduced into a retrieval system, or transmitted in any form or by any means (electronic, mechanical, photocopying, recording, or otherwise), or for any purpose, without the express written permission of Microsoft Corporation.

Microsoft may have patents, patent applications, trademarks, copyrights, or other intellectual property rights covering subject matter in this document. Except as expressly provided in any written license agreement from Microsoft, the furnishing of this document does not give you any license to these patents, trademarks, copyrights, or other intellectual property.

The names of manufacturers, products, or URLs are provided for informational purposes only and Microsoft makes no representations and warranties, either expressed, implied, or statutory, regarding these manufacturers or the use of the products with any Microsoft technologies. The inclusion of a manufacturer or product does not imply endorsement of Microsoft of the manufacturer or product. Links may be provided to third party sites. Such sites are not under the control of Microsoft and Microsoft is not responsible for the contents of any linked site or any link contained in a linked site, or any changes or updates to such sites. Microsoft is not responsible for webcasting or any other form of transmission received from any linked site. Microsoft is providing these links to you only as a convenience, and the inclusion of any link does not imply endorsement of Microsoft of the site or the products contained therein.

© 2018 Microsoft Corporation. All rights reserved.

Microsoft and the trademarks listed at <https://www.microsoft.com/en-us/legal/intellectualproperty/Trademarks/Usage/General.aspx> are trademarks of the Microsoft group of companies. All other trademarks are property of their respective owners.

Contents

Machine Learning in a Day student guide.....	1
Abstract and learning objectives.....	1
Architecture	2
Section 1: Set up a Data Science Virtual Machine (DSVM) on Azure Portal.....	3
Section 2: Download Telco dataset and create Blob Storage Account and Container access	9
Section 3A: Upload CSV file to Blob Storage Container Manually	14
Section 3B (Optional): Upload CSV file to Blob Storage Container with Azure Data Factory V2.	17
Section 4: Build a clustering unsupervised model in Azure Machine Learning Studio	37
Section 5: Set up a Spark Cluster on Databricks and connect to Azure Blob Storage Account.....	51
Section 6: Implement Feature Engineering Techniques to Enhance data for Machine Learning	59
Section 7: Apply Classification Supervised Model with Logistic Regression on Azure Databricks	68
Section 8: Export predicted DataFrame from Spark on Azure Databricks to Power BI for visualizations.....	71

Machine Learning in a Day student guide

Abstract and learning objectives

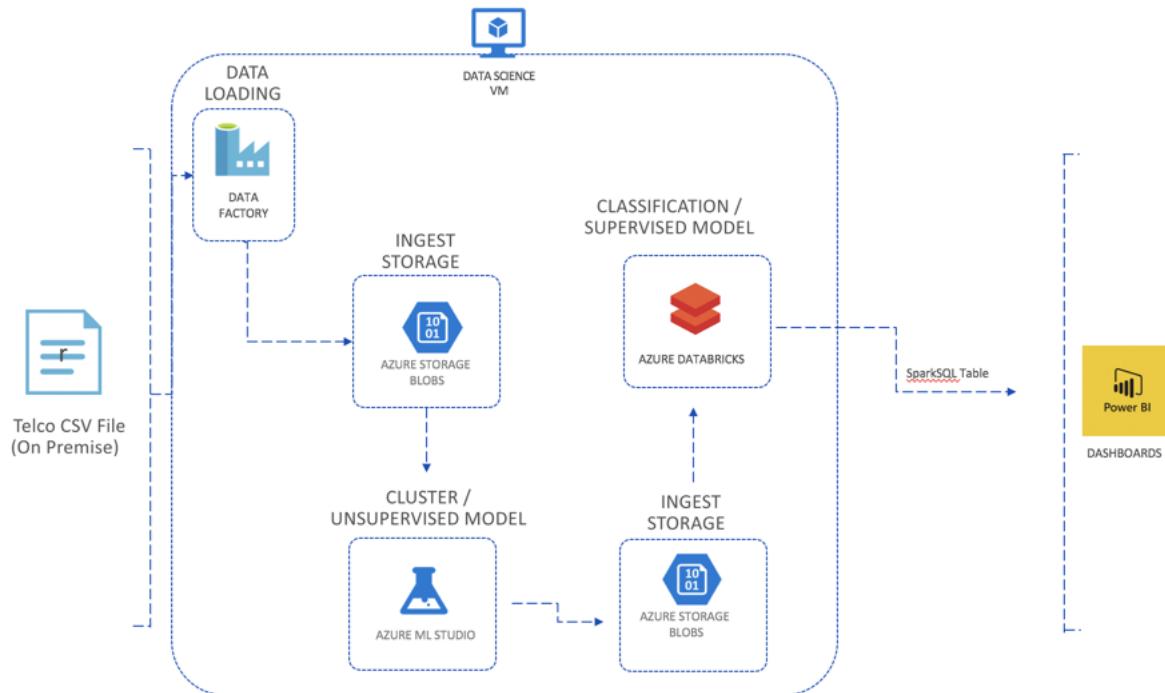
In this workshop, you will complete will build a Machine Learning model that will be used to predict whether customers remain with business or move onto other services based on their behavior, demographics, and spending. You will leverage several Microsoft products and services on Microsoft Azure to deliver the Machine Learning Model.

The dataset that will be used in the workshop contains the following information

1. Customers who left within the last month – the column is called **Churn**
2. Services that each customer has signed up for
 - a. Phone
 - b. Multiple lines
 - c. Internet
 - d. Online security
 - e. Online backup
 - f. Device protection
 - g. Tech support
 - h. Streaming TV and movies
3. Customer account information
 - a. How long they've been a customer
 - b. Contract
 - c. Payment method
 - d. Paperless billing
 - e. Monthly charges
 - f. Total charges
4. Demographic information about customers
 - a. Gender
 - b. Age range
 - c. If they have partners and dependents

Architecture

MACHINE LEARNING IN A DAY WORKSHOP



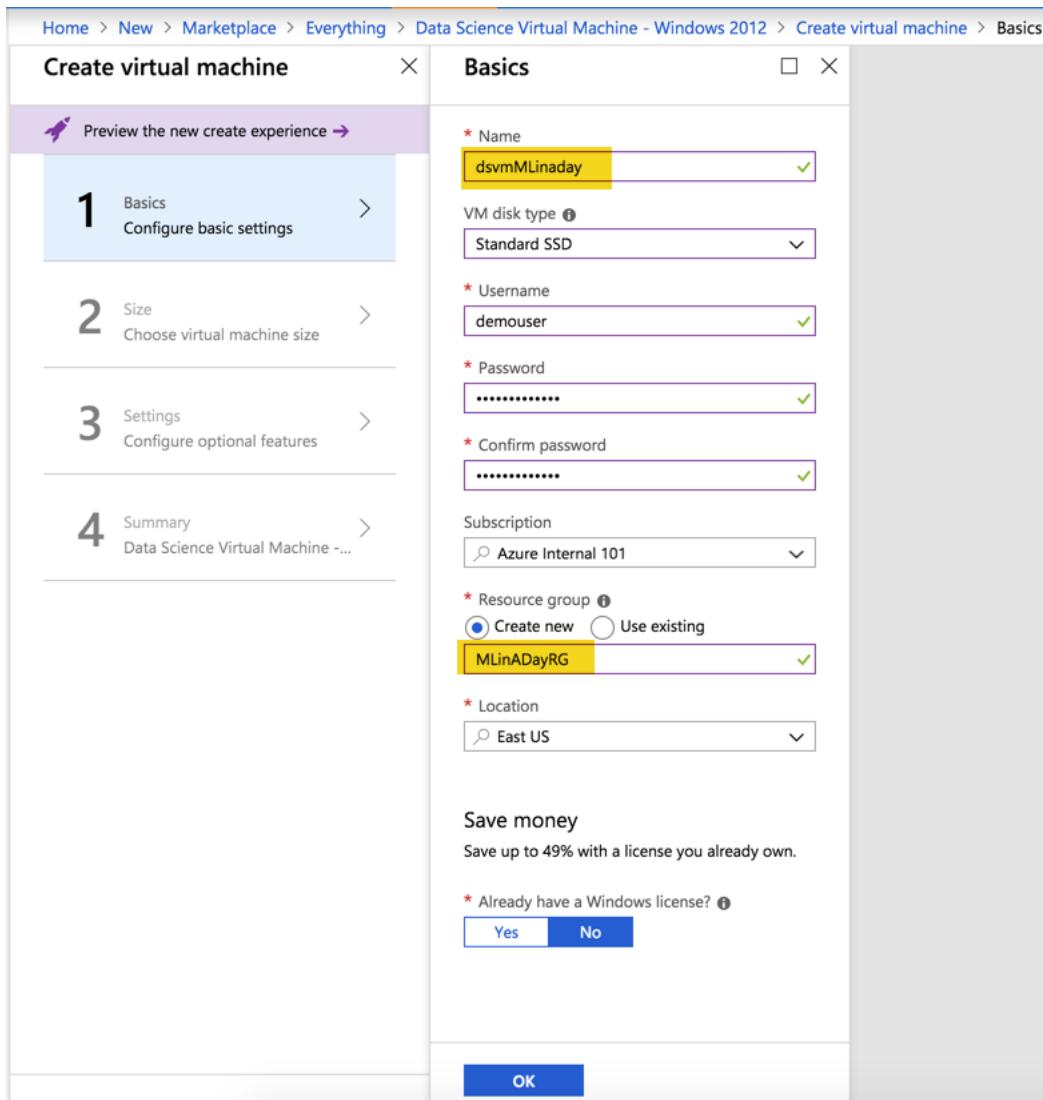
Section 1: Set up a Data Science Virtual Machine (DSVM) on Azure Portal

1. The use of this documentation requires the subscription of a Microsoft Azure account either from a personal email account or a work email account.
2. Visit portal.azure.com and click on **Create a resource** on the left-hand side and type in **Data Science Virtual Machine – Windows 2012** and select the **Create** button as seen in the following screenshot:

The screenshot shows the Azure portal interface. On the left, there's a sidebar with various service icons and a 'Create a resource' button highlighted with a yellow box. The main area has a search bar with 'data science virtual machine' typed in. Below it is a table with columns 'NAME', 'PUBLISHER', and 'CATEGORY'. The first row, 'Data Science Virtual Machine - Windows 2012', is also highlighted with a yellow box and has a red arrow pointing to it from the search bar. The right side of the screen displays detailed information about the selected DSVM, including its description, useful links, and deployment options.

NAME	PUBLISHER	CATEGORY
Data Science Virtual Machine - Windows 2012	Microsoft	Virtual Machine Images
(CSP)Data Science Virtual Machine - Windows 2012	Microsoft	Virtual Machine Images
Data Science Virtual Machine for Linux (Ubuntu)	Microsoft	Virtual Machine Images
Data Science Virtual Machine - Windows 2016	Microsoft	Virtual Machine Images
Data Science Virtual Machine for Linux (CentOS)	Microsoft	Virtual Machine Images
Data Science Virtual Machine for Linux (Ubuntu)	Microsoft	Virtual Machine Images
Data Science Virtual Machine - Windows 2016	Microsoft	Virtual Machine Images
Geo AI Data Science VM with ArcGIS	Microsoft	Solution Templates
Signal Sciences -BYOL	Signal Sciences	Virtual Machine Images
Deep Learning Virtual Machine	Microsoft	Solution Templates
Microsoft Machine Learning Server 9.3.0 on Ubuntu 16.04	Microsoft	Recommended
Microsoft Machine Learning Server 9.3.0 on Red Hat Enterprise Linux 7.2	Microsoft	Recommended
Microsoft Machine Learning Server 9.3.0 on Windows Server 2016	Microsoft	Recommended
Microsoft Machine Learning Server 9.3.0 on CentOS Linux 7.2	Microsoft	Recommended

3. Assign the following basic configuration settings for your Data Science Virtual Machine and the select the **OK** button as seen in the following screenshot:



Please note that you can keep your Names and passwords different from this document as long as you remember what you used for future use. In this section, we will assign a username of **demouser** and a password of **#MLinaDay2018** (Please keep track of both the Username and Password as you will need both of them several times as we go through future sections of this workshop).

4. Choose the following size VM (**D2S_v3**) for the purposes of this workshop as seen in the following screenshot:

Choose a size

SKU	Type	vCPUs	RAM	Data Disks	Max IOPS	Local SSD	Premium	Additions	USD/Month
B1s	Standard	1	2	800	4 GB	Yes			\$10.42
B1ms	Standard	1	2	1600	4 GB	Yes			\$18.30
B2s	Standard	2	4	3200	8 GB	Yes			\$43.15
B2ms	Standard	2	8	4800	16 GB	Yes			\$73.66
B4ms	Standard	4	16	7200	32 GB	Yes			\$146.57
B8ms	Standard	8	32	10800	64 GB	Yes			\$293.14
D2s_v3	Standard	2	4	3200	16 GB	Yes			\$139.87
D4s_v3	Standard	4	16	6400	32 GB	Yes			\$279.74
D8s_v3	Standard	8	32	12800	64 GB	Yes			\$559.49
D16s_v3	Standard	16	64	25600	128 GB	Yes			\$1,118.98
D32s_v3	Standard	32	128	51200	256 GB	Yes			\$2,237.95
D64s_v3	Standard	64	256	80000	512 GB	Yes			\$4,475.90
E2s_v3	Standard	2	16	3200	32 GB	Yes			\$167.40

Prices presented are estimates in your local currency that include Azure infrastructure applicable software costs, as well as any discounts for the subscription and location. Recommended sizes are determined by the publisher of the selected image based on hardware and software requirements.

Select

5. For settings, the only configuration that is truly needed is to enable on **auto-shutdown** every evening at **7pm EST** (your manager will thank you later on !!!!) and then select **OK** as seen in the following screenshot:

Settings

Network Security Group

Extensions

Auto-shutdown

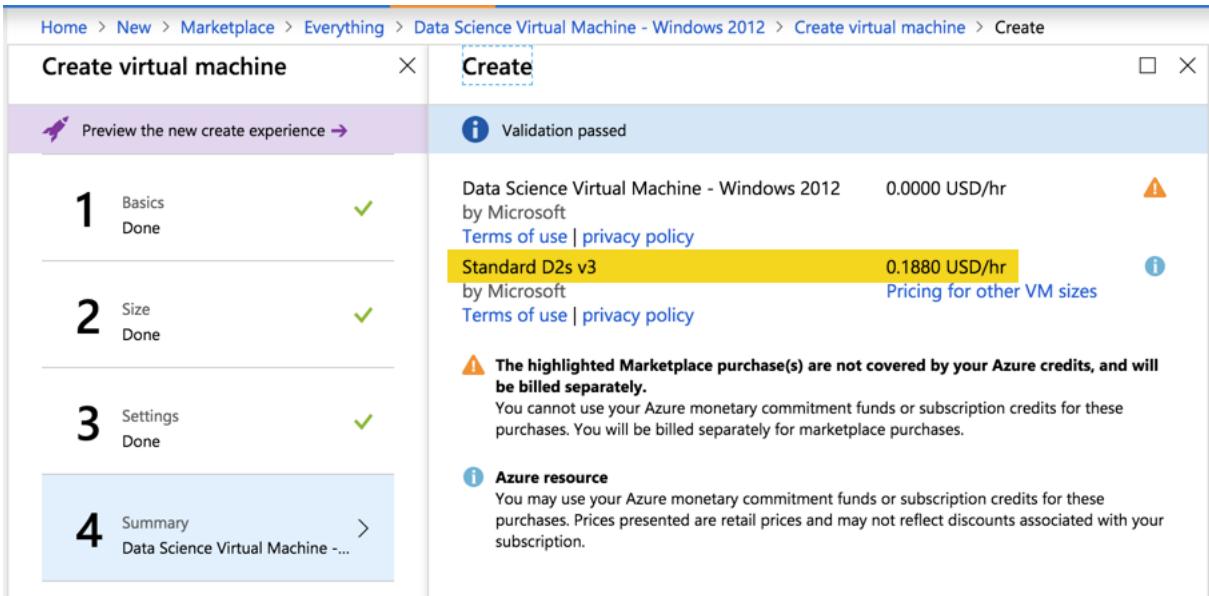
Enable auto-shutdown

Shutdown time

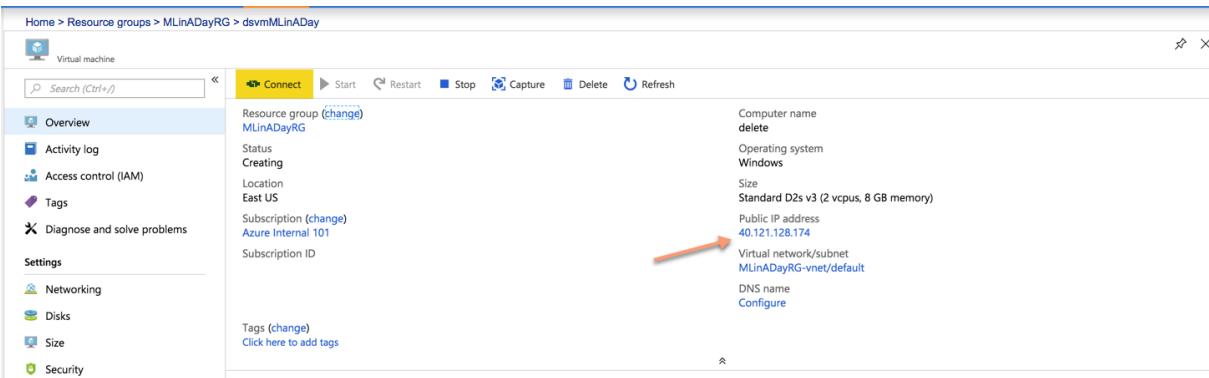
Time zone

Notification before shutdown

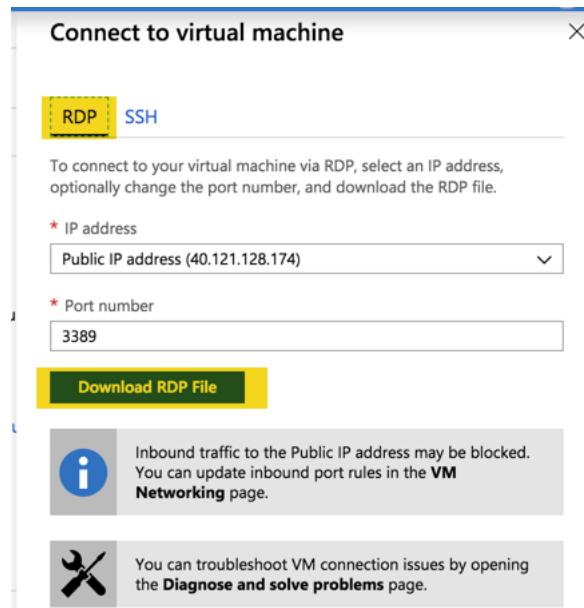
6. Click **OK** on the summary section and confirm everything that was selected is accurate and let the provisioning process of the DSVM begin by clicking on **Create** as seen in the following screenshot:



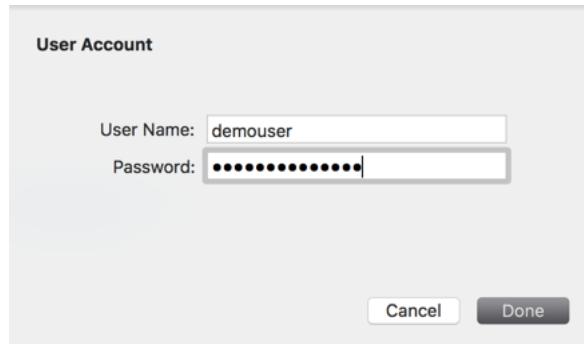
- Once the provisioning is complete, you can go to your resource and view your DSVM overview and obtain your **Public IP address** as seen in the following screenshot:



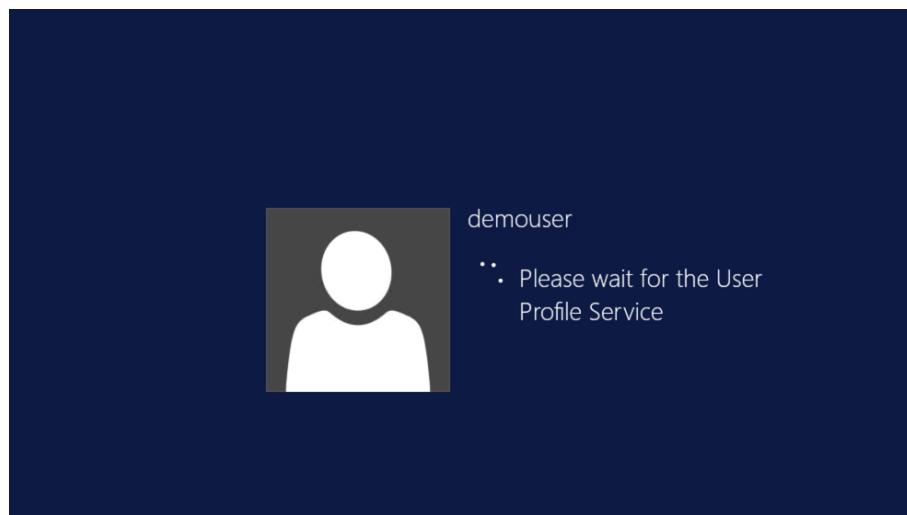
- Make sure that your DSVM is currently running and click on the **Connect** button to enter your virtual machine using RDP as seen in the following screenshot:



9. Enter your login credentials that were created back in Step # 3 as seen in the following screenshot:



10. It may take a few extra moments while your profile is being created and you will see the following window:

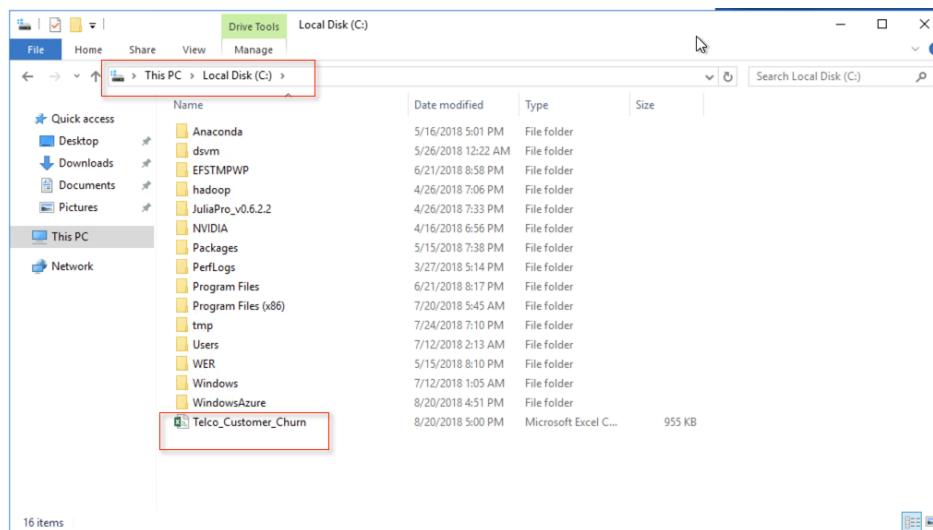


11. Once you log in using your credentials using the RDP approach, you should see the following remote server for the data science virtual machine as seen in the following screenshot:

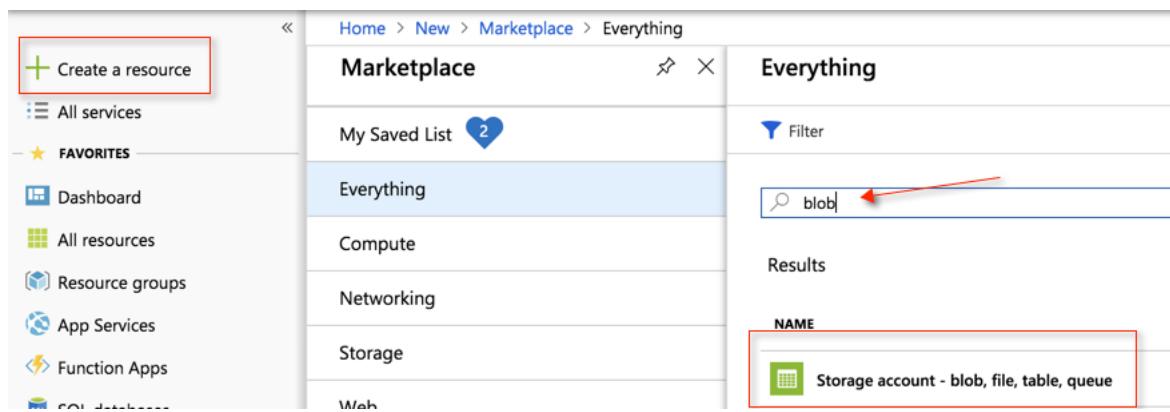


Section 2: Download Telco dataset and create Blob Storage Account and Container access

1. The Telco Churn Dataset ([TELCO_CUSTOMER_CHURN.csv](https://raw.githubusercontent.com/asherif844/MachineLearningInADay/master/Files/Telco_Customer_Churn.csv)) can be downloaded from the following link:
https://raw.githubusercontent.com/asherif844/MachineLearningInADay/master/Files/Telco_Customer_Churn.csv
2. For now, the dataset can be saved in the C:\ drive as seen in the following screenshot:



3. Next, we will return to our Azure portal (<https://portal.azure.com>) and create a Blob storage account to house our data. We can do this by selecting **Create A Resource**, typing **Blob** in the search, and then selecting **Storage Account – blob, file, table, queue** as seen in the following screenshot:



4. Once you create a **Blob** account, you can name and customize the properties of the account as the following, for optimal performance in this workshop (Please note than any existing resource that is created from this point forward in the workshop should ideally use the same existing **Resource Group** that we created in Section 1):

Create storage account

Basics Advanced Tags Review + create

Azure Storage is a Microsoft-managed service providing cloud storage that is highly available, secure, durable, scalable, and redundant. Azure Storage includes Azure Blobs (objects), Azure Data Lake Storage Gen2, Azure Files, Azure Queues, and Azure Tables. The cost of your storage account depends on the usage and the options you choose below. [Learn more](#)

PROJECT DETAILS

Select the subscription to manage deployed resources and costs. Use resource groups like folders to organize and manage all your resources.

* Subscription: Azure Internal 101
 * Resource group: MLinADayRG
[Create new](#)

INSTANCE DETAILS

The default deployment model is Resource Manager, which supports the latest Azure features. You may choose to deploy using the classic deployment model instead. [Choose classic deployment model](#)

* Storage account name: blobmlinaday
 * Location: East US
 Performance: Standard (selected)
 Account kind: StorageV2 (general purpose v2)
 Replication: Locally-redundant storage (LRS)
 Access tier (default): Cool (selected)

Review + create Previous Next : Advanced >

5. Ensure that the Basics setting includes **Standard** Performance, **StorageV2** Account Kind, and **Cool** Access Tier.
6. Continue on to the Advanced Section of the settings and ensure that **secure transfer required** has been disabled as seen in the following screenshot:

Dashboard > New > Marketplace > Everything > Storage account - blob, file, table, queue > Create storage account

Create storage account

Basics Advanced Tags Review + create

SECURITY

Secure transfer required: Disabled (selected) Enabled

VIRTUAL NETWORKS

Allow access from: All networks Selected network
All networks will be able to access this storage account. [Learn more](#)

DATA LAKE STORAGE GEN2 (PREVIEW)

Hierarchical namespace: Disabled Enabled

7. Next, we can just click on **Review and Create** and ensure that our validation has passed as seen in the following screenshot:

Dashboard > New > Marketplace > Everything > Storage account - blob, file, table, queue > Create storage account

Create storage account

Validation passed

Basics Advanced Tags Review + create

BASICS

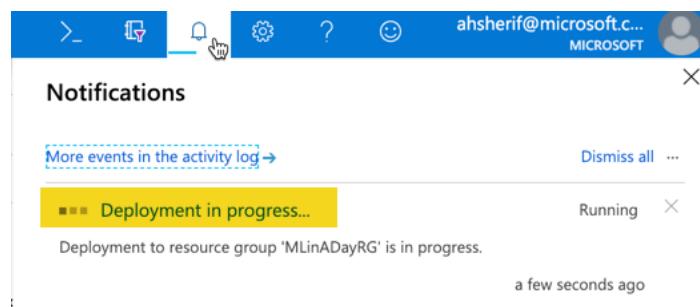
Subscription	Azure Internal 101
Resource group	MLinADayRG
Location	East US
Storage account name	blobmlinaday
Deployment model	Resource manager
Account kind	StorageV2 (general purpose v2)
Replication	Locally-redundant storage (LRS)
Performance	Standard
Access tier (default)	Cool

ADVANCED

Secure transfer required	Disabled
Allow access from	All networks
Hierarchical namespace	Disabled

Create Previous Next Download a template for automation

8. We can then just click on **Create** and begin the deployment process of the blob storage.
9. While the deployment is underway, we can check the progress as seen in the following screenshot:



10. Once the Blob account has been successfully deployed, we can go to the storage account by clicking on **Go to Resource**, as seen in the following screenshot:

The screenshot shows a 'Notifications' page with a single item: 'Deployment succeeded' at 1:27 PM. Below the message are two buttons: 'Go to resource' and 'Pin to dashboard'. A red arrow points from the text 'Once inside the resource, select Blobs under the Services section as seen in the following screenshot:' to the 'Go to resource' button.

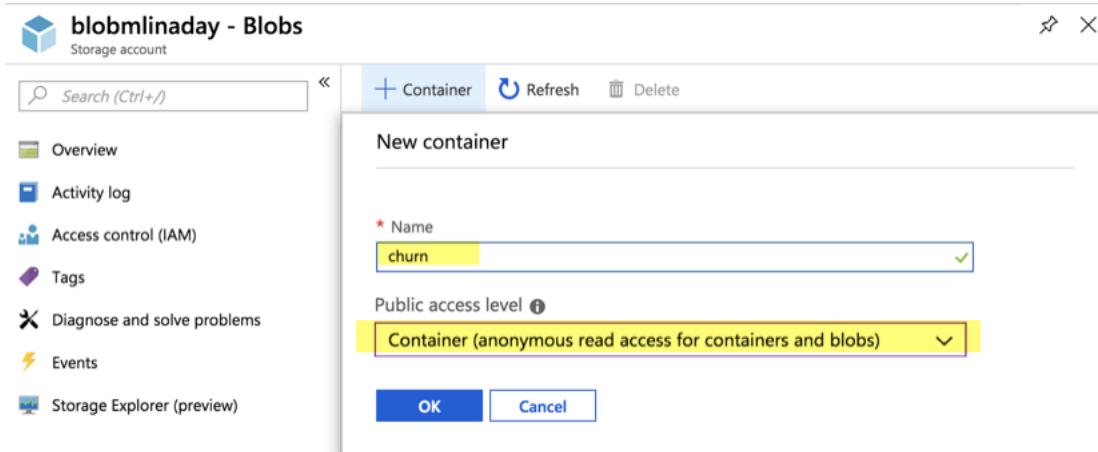
11. Once inside the resource, select **Blobs** under the **Services** section as seen in the following screenshot:

The screenshot shows the 'blobmlinaday' storage account overview page. In the 'Services' section, the 'Blobs' service is highlighted with a red arrow. The 'Blobs' service is described as 'REST-based object storage for unstructured data'.

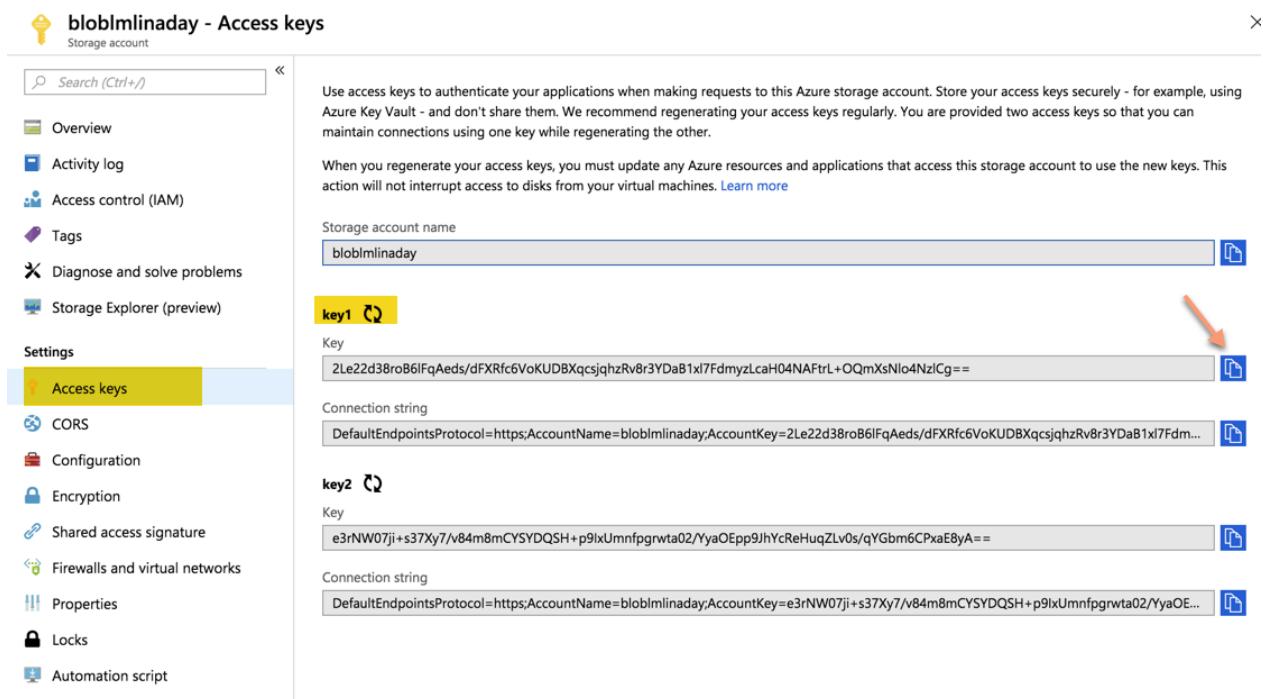
12. ****Important Step ***** Ensure that your blob account has the following setting configured to ensure that **Secure Transfer Required** is **Disabled** by selecting Configuration as seen in the following screenshot:

The screenshot shows the 'blobmlinaday - Configuration' page. In the 'Configuration' section, the 'Secure transfer required' setting is highlighted with a yellow box and a red arrow. The setting is currently set to 'Disabled'.

13. We should now be in the Containers section; however, if this is the first time, we are entering the Container, we should see a message that says **You don't have any containers yet. Click '+ Container' to get started.**
14. Go ahead and create a new Container called **Churn** and set **Public access level to Container (anonymous read access for containers and blobs)**, as seen in the following screenshot:



15. The only thing that we will need right now is an **Access Keys** that will be used in future sections of this workshop. We can copy **key1** and paste it somewhere handy in a notepad editor as seen in the following screenshot:



16. Once the container has been successfully created, we can move onto the next section of adding data to the container using a couple of different options.

Section 3A: Upload CSV file to Blob Storage Container Manually

- ***This section will manually upload our CSV file to blob storage without using an ETL tool like Azure Data Factory V2. If you wish to use ADF V2 instead, skip this section and move onto Section 3B. Otherwise, continue on with this section.***
- Access your blob storage container once again by selecting **Storage Accounts** on the left-hand side of the Portal menu, selecting your Blob account, and finally selecting **Blobs** under **Blob Service** as seen in the following screenshot:

The screenshot shows the Microsoft Azure portal interface. On the left, the navigation menu is open, with 'Storage accounts' selected. In the main content area, the 'blobmlinaday' storage account is displayed. Under the 'Blob service' section, the 'Blobs' item is highlighted with a yellow box. The right pane provides detailed information about the storage account, including its resource group (MLinADayRG), status (Primary: Available), location (East US), and account kind (Locally-redundant storage (LRS)). It also lists services like Files, Tables, and Queues.

- Select your **container** which should be called churn as seen in the following screenshot:

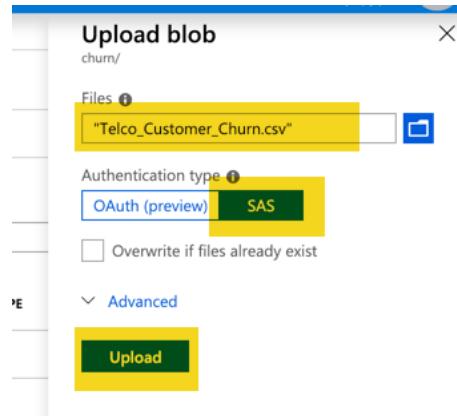
The screenshot shows the 'blobmlinaday - Blobs' blade. The 'churn' container is selected and highlighted with a yellow box. The blade displays a list of blobs with columns for NAME, LAST MODIFIED, PUBLIC ACCESS ..., and LEASE STATE. The 'LAST MODIFIED' column shows the date and time of the last modification, and the 'PUBLIC ACCESS ...' column indicates if it is available.

NAME	LAST MODIFIED	PUBLIC ACCESS ...	LEASE STATE
churn	11/25/2018, 11:20:31 AM	Container	Available

- Once inside your container, select the upload icon to begin the uploading of your csv spreadsheet as seen in the following screenshot:

The screenshot shows the Azure Storage interface for a container named 'churn'. On the left, there's a sidebar with options like Overview, Access Control (IAM), Settings, Access policy, Properties, Metadata, and Editor (preview). The main area shows a search bar and a table with columns: NAME, MODIFIED, ACCESS TIER, and BLOB TYPE. A message says 'No blobs found.' At the top, there are buttons for Upload, Refresh, Delete, Acquire lease, Break lease, View snapshots, and Create snapshot. The 'Upload' button is highlighted with a yellow box.

- Select your file from your local hard drive and use **SAS authentication type**. Next select Upload as seen in the following screenshot:



- You should now see your CSV file in your container as seen in the following screenshot:

The screenshot shows the same storage container 'churn' after upload. The table now lists one item: 'Telco_Customer_Churn.csv'. The table includes columns: NAME, MODIFIED, ACCESS TIER, BLOB TYPE, SIZE, and LEASE STATE. The file details are: Modified on 11/25/2018, 11:28:06 AM, Cool (Inferred) access tier, Block blob type, 954.59 kB size, and Available lease state. The file name is highlighted with a yellow box.

- Your file should be ~ 955 kB. If you click on your CSV file and select **Edit Blob**, you can preview your actual data that is in the CSV file within the **Blob** container as seen in the following screenshot:

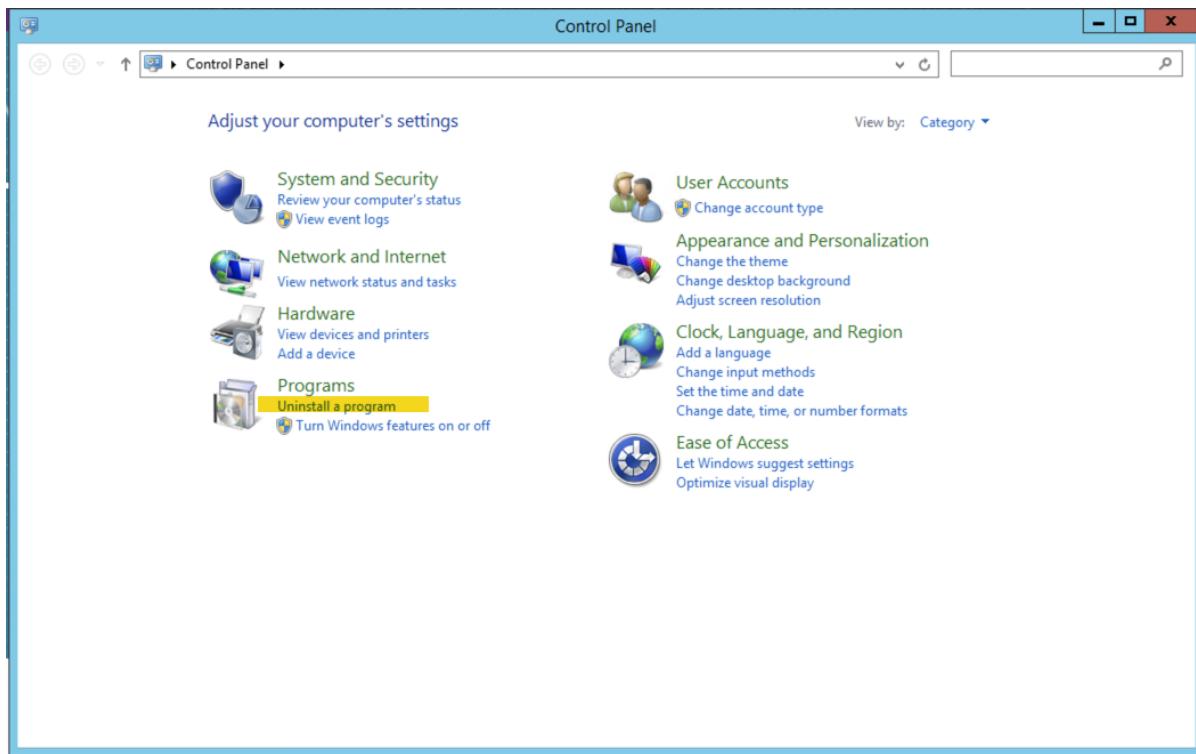
The screenshot shows the Azure Storage Blob service interface. On the left, there's a sidebar with 'Upload', 'Refresh', 'More', 'Save', 'Discard', 'Download', and 'Delete' buttons. Below these are sections for 'Location: churn' and 'NAME', where 'Telco_Customer_Churn.csv' is listed. The main area is titled 'Telco_Customer_Churn.csv' and shows a preview of the CSV file. The preview table has columns for row numbers (1 to 27) and data fields. The 'Edit blob' button is highlighted with a yellow box and an orange arrow. At the bottom right of the preview area, there are 'Csv' and 'Download' buttons.

	CustomerID	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	MultipleLines	InternetService	OnlineSecurity	OnlineBackup	TechSupport	StreamingTV	StreamingMovies	Contract	PaperlessBilling	PaymentMethod	MonthlyCharges	TotalCharges
1	7590-VHVEG	Female	0	Yes	No	1	No	No	phone service	DSL	No	Yes	No	No	No	Month-to-month	Yes	Electronic check	7590-VHVEG
2	5575-GNVDL	Male	0	No	No	34	Yes	No	DSL	Yes	No	Yes	No	No	No	One year	No	Mailed check	56.95
3	3668-QPYBK	Male	0	No	No	2	Yes	No	DSL	Yes	Yes	No	No	No	No	Month-to-month	Yes	Mailed check	53.85
4	7795-CFOCW	Male	0	No	No	45	Yes	No	DSL	Yes	Yes	No	Yes	No	No	One year	No	Bank transfer (automat	108.15
5	9237-HQITU	Female	0	No	No	2	Yes	No	Fiber optic	No	No	No	No	No	No	Month-to-month	Yes	Electronic check	70.7
6	9305-CDSKC	Female	0	No	No	8	Yes	Yes	Fiber optic	No	No	Yes	No	Yes	Yes	Month-to-month	Yes	Electronic check	1452-KIOVK
7	6713-OKOMC	Female	0	No	No	10	No	No	phone service	DSL	Yes	Yes	No	No	No	Month-to-month	No	Credit card (automat	29
8	7892-POOKP	Female	0	Yes	No	28	Yes	Yes	DSL	Yes	Yes	Yes	No	Yes	Yes	Month-to-month	Yes	Electronic check	6388-TABGU
9	9763-GRSKD	Male	0	Yes	Yes	13	Yes	No	DSL	Yes	No	No	No	No	No	Month-to-month	Yes	Mailed check	49.95
10	7469-LKBCI	Male	0	No	No	16	Yes	No	No	No	No	No	No	No	No	internet service	No	internet service	587.45
11	8091-TTVAZ	Male	0	Yes	No	58	Yes	Yes	Fiber optic	No	No	Yes	No	Yes	Yes	One year	No	Credit card (automatic)	0280-XJGEX
12	5129-JLPIS	Male	0	No	No	49	Yes	Yes	Fiber optic	No	Yes	Yes	No	Yes	Yes	Month-to-month	Yes	Bank transfer (auto	34
13	3655-SNYQZ	Female	0	Yes	Yes	69	Yes	Yes	Fiber optic	Yes	Yes	Yes	Yes	Yes	Yes	Two year	No	Credit card (auto	18191-XWSZG
14	9959-WOFGT	Male	0	No	Yes	71	Yes	Yes	Fiber optic	Yes	Yes	Yes	Yes	Yes	Yes	Two year	No	Bank transfer (automatic)	4190-MFLWU
15	4183-MYFRB	Female	0	No	No	21	Yes	No	Fiber optic	No	Yes	Yes	No	Yes	Yes	Month-to-month	Yes	Electronic check	8779-QRMV
16	1680-VDCWN	Male	0	Yes	No	12	Yes	No	No	No	No	No	No	No	No	internet service	No	internet service	59.93
17	1066-JKSGK	Male	0	No	No	1	Yes	No	No	No	No	No	No	No	No	internet service	No	internet service	6322-HRPFA
18	3638-WEABW	Female	0	Yes	No	58	Yes	Yes	DSL	No	Yes	No	No	No	No	Month-to-month	No	Credit card (automatic)	6865-JZNKO
19																			
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27																			

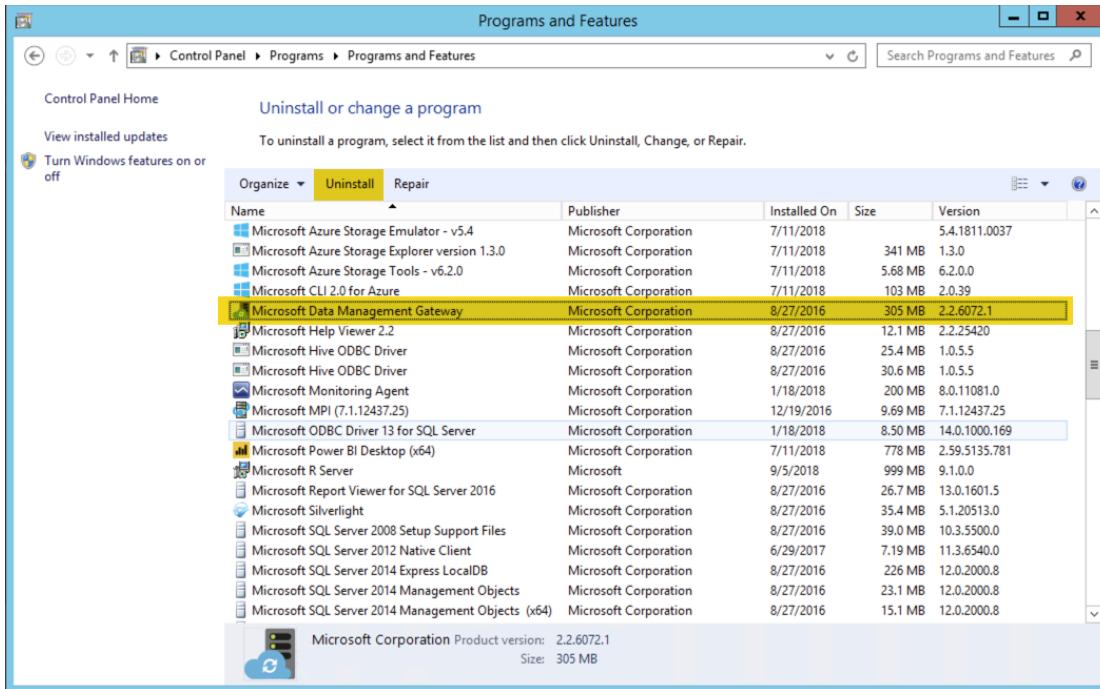
- We have now confirmed our file is in our Blob account and we can continue onto Section 4.

Section 3B (Optional): Upload CSV file to Blob Storage Container with Azure Data Factory V2.

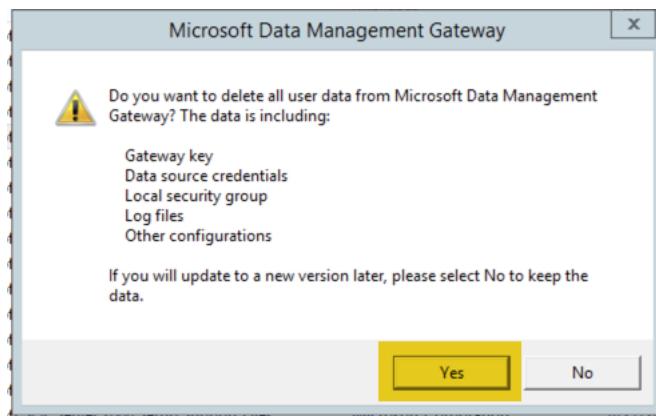
1. **Continue with this approach if you did not proceed with Section 3A. Otherwise, you can move onto Section 4.**
2. You have now completed the provisioning of a data science virtual machine on Windows Server 2012. One note to factor for this virtual machine is we will uninstall a product that is outdated and download later on in this section. First, we will go to the **Control Panel** in the DSVM and select to **Uninstall A Program** as seen in the following screenshot:



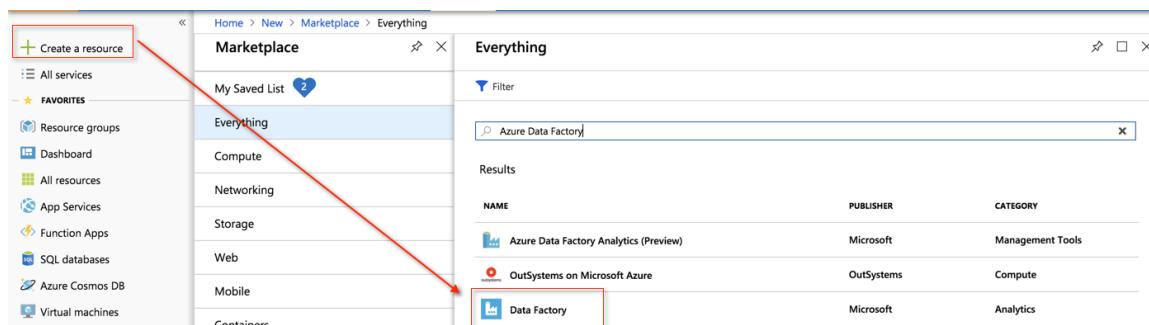
3. Next, we will go ahead, and **Uninstall Microsoft Data Management Gateway** as seen in the following screenshot:



4. Select **Yes** to get rid of all data as seen in the following screenshot:



5. As we move forward in this section, we will require accessing the Azure Portal (<https://portal.azure.com>) inside of a browser within the data science virtual machine to set up **Azure Data Factory V2**.
6. Once again, as we did with the Blob Storage as well as with the Data Science Virtual Machine, we are ready to create a new resource. This time we will build an orchestrator that will create a job to move our CSV file from on-premise on our Virtual Machine to our storage in Blob on Azure. The next step is to create a resource for **Azure Data Factory** as seen in the following screenshot:



7. Once the resource is created, we will want to specify the following options and then click on **Create**:

New data factory

* Name ✓

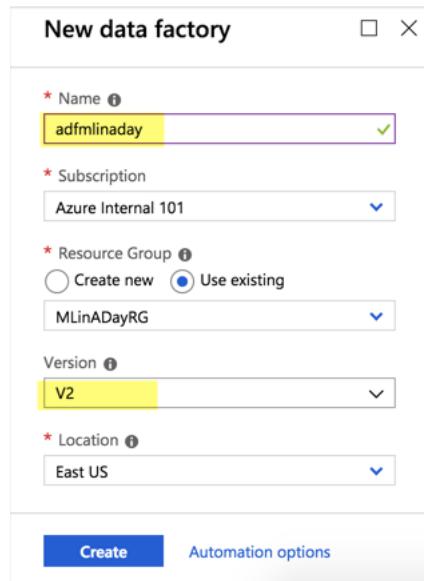
* Subscription

* Resource Group Create new Use existing

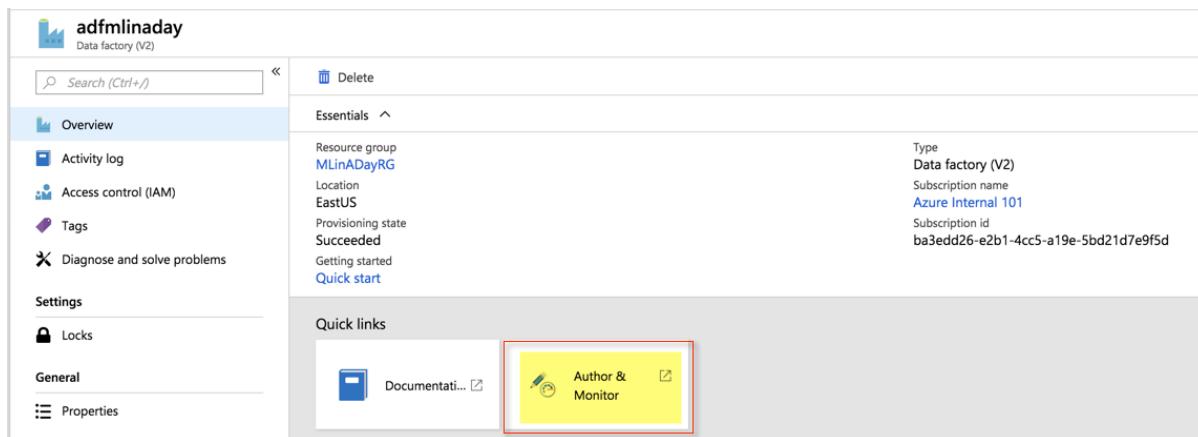
Version

* Location

Create Automation options

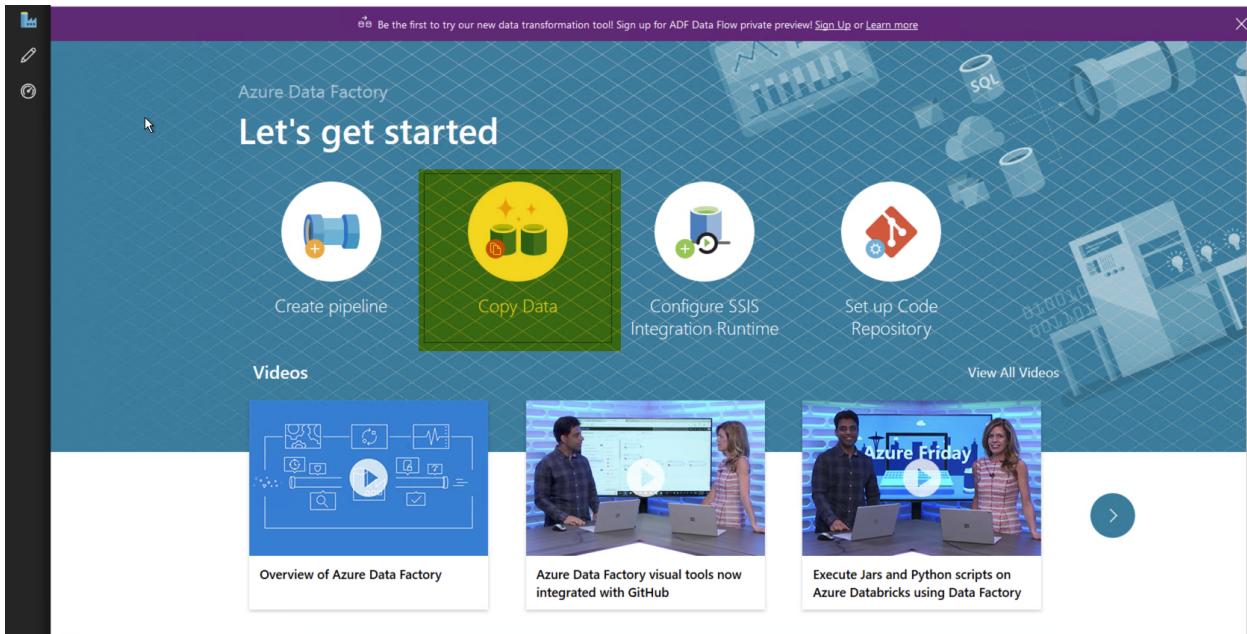


- Once the resource is completed, we can go to the resource and click on the icon **Author & Monitor** as seen in the following screenshot:

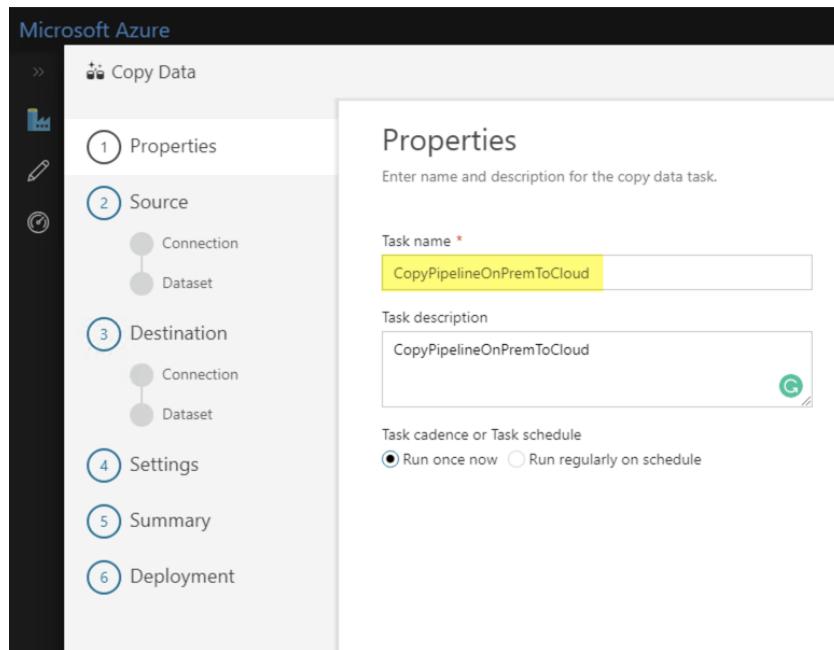


The screenshot shows the Azure Data Factory landing page for a resource named 'adfmmlinaday'. The left sidebar includes 'Overview', 'Activity log', 'Access control (IAM)', 'Tags', 'Diagnose and solve problems', 'Settings' (with 'Locks'), and 'General' (with 'Properties'). The main area displays 'Essentials' information: Resource group 'MLinADayRG', Location 'EastUS', Provisioning state 'Succeeded', and Getting started 'Quick start'. To the right, detailed properties are listed: Type 'Data factory (V2)', Subscription name 'Azure Internal 101', and Subscription id 'ba3edd26-e2b1-4cc5-a19e-5bd21d7e9f5d'. The 'Quick links' section contains icons for 'Documentation' and 'Author & Monitor', with the latter being the one highlighted.

- We are now in the landing page for Azure Data Factory. The next step is to click on the second icon, **Copy Data**:



10. Our first task is to enter name and description for the copy data task as seen in the following screenshot:



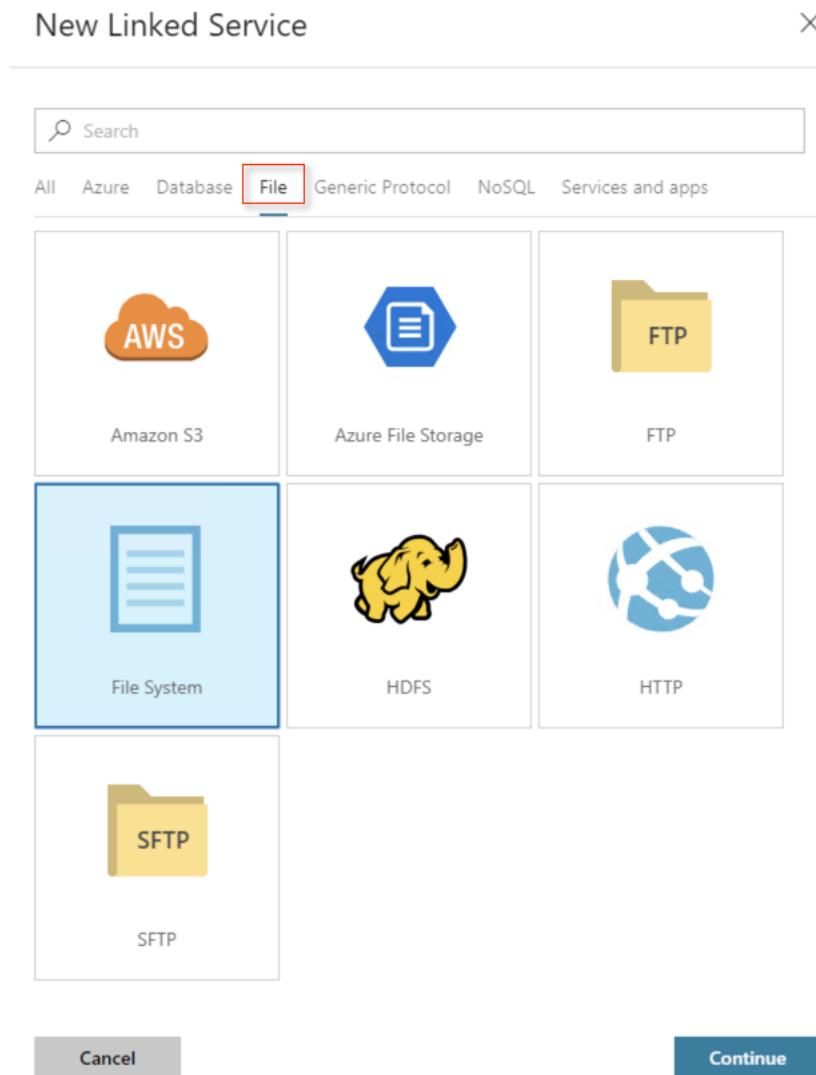
11. We named the task **CopyPipelineOnPremToCloud**. The next step is to specify a data source. Since this source will be on-premise on our virtual machine, we will need to set up + **Create a new connection** as seen in the following screenshot:

Source data store

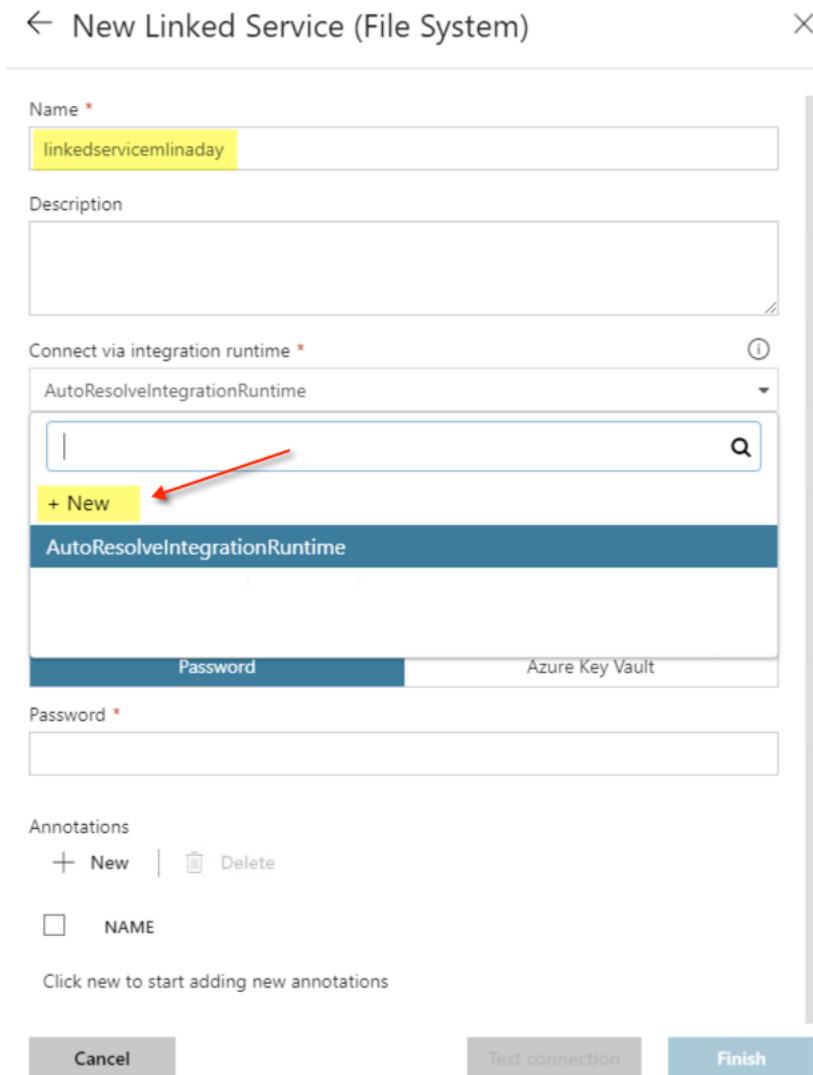
Specify the source data store for the copy task. You can use an existing data store connection or specify a new data store.

The screenshot shows a navigation bar with tabs: All, Azure, Database, File, Generic Protocol, NoSQL, and Services and apps. The 'All' tab is selected. Below the tabs is a search bar with the placeholder 'All' and a dropdown arrow. To its right is a 'Filter by name' input field and a yellow button labeled '+ Create new connection'.

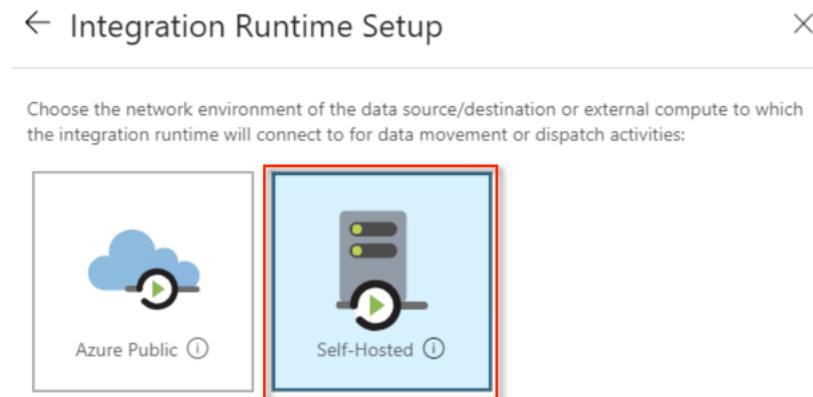
12. Select **File** and then **File System** for a **new Linked Service** between on-premise and in Azure. Then select **Continue** as seen in the following screenshot:



13. Specify a name for the Linked Service such as **linkedservicemlinaday** as well as clicking on a **+New integration runtime** as seen in the following screenshot:

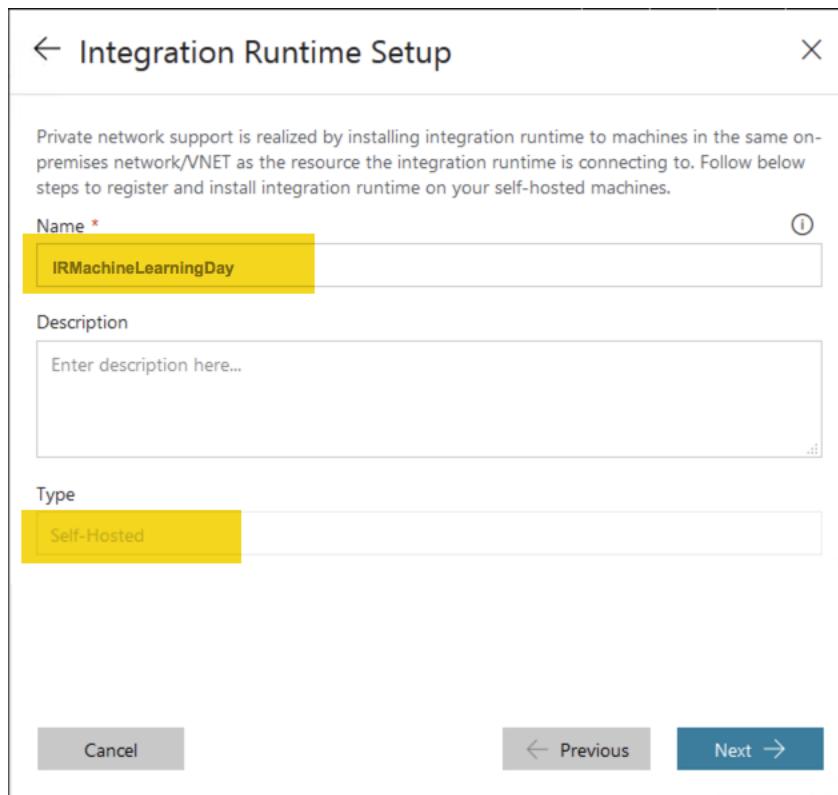


14. Select a **Self-Hosted** setup for the integration runtime as seen in the following screenshot:

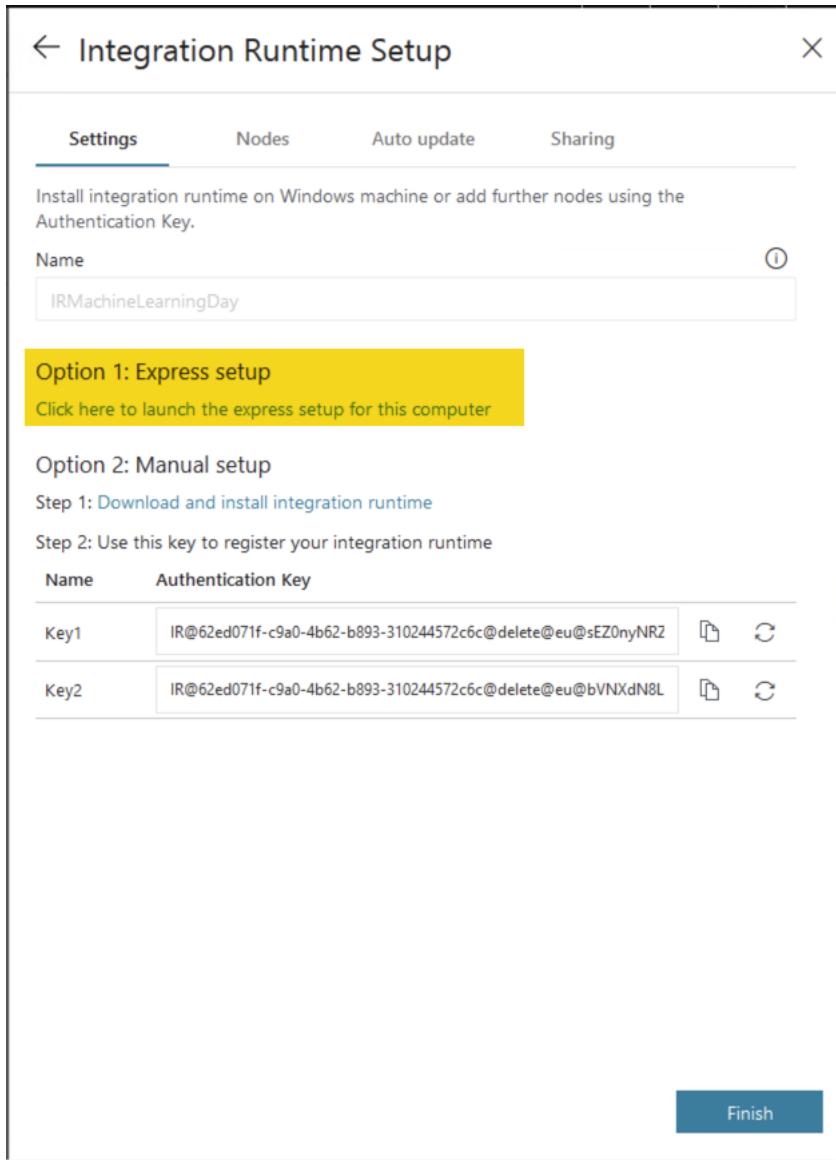


Choose an **Azure Public** environment if you are accessing services with publicly accessible endpoints. Choose **Self-Hosted** if you are accessing services in a private network like your on-premises environment, or in Virtual Network Environments like Azure Virtual Network. For our purposes, we will go with Self-Hosted.

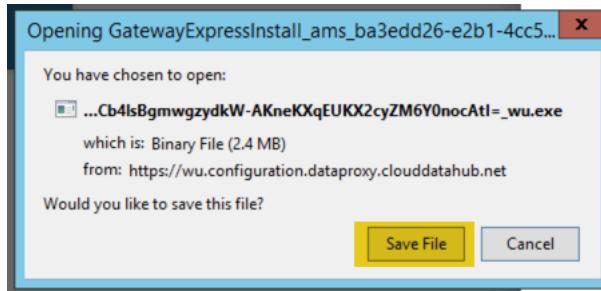
15. Private network support is realized by installing integration runtime to machines in the same on-premises network/VNET as the resource the integration runtime is connecting to. Follow below steps to register and install integration runtime on your self-hosted machines with a name called **IRMachineLearningDay** and then select **Next** as seen in the following screenshot:



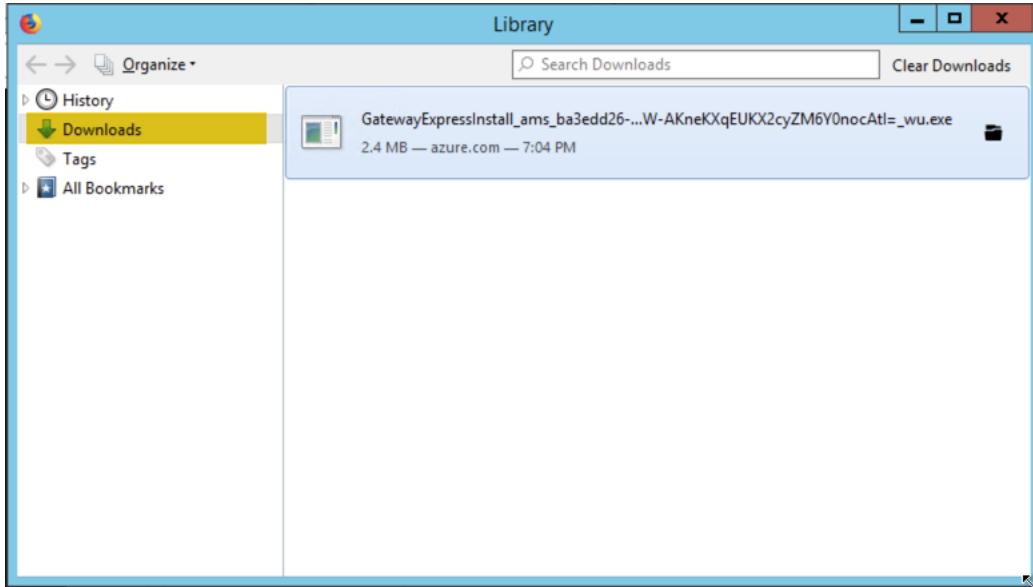
16. Select **Option 1: Express Setup** for the Integration Runtime as seen in the following screenshot:



17. Save the Express Setup File (usually it will default to the Downloads folder) as seen in the following screenshot:



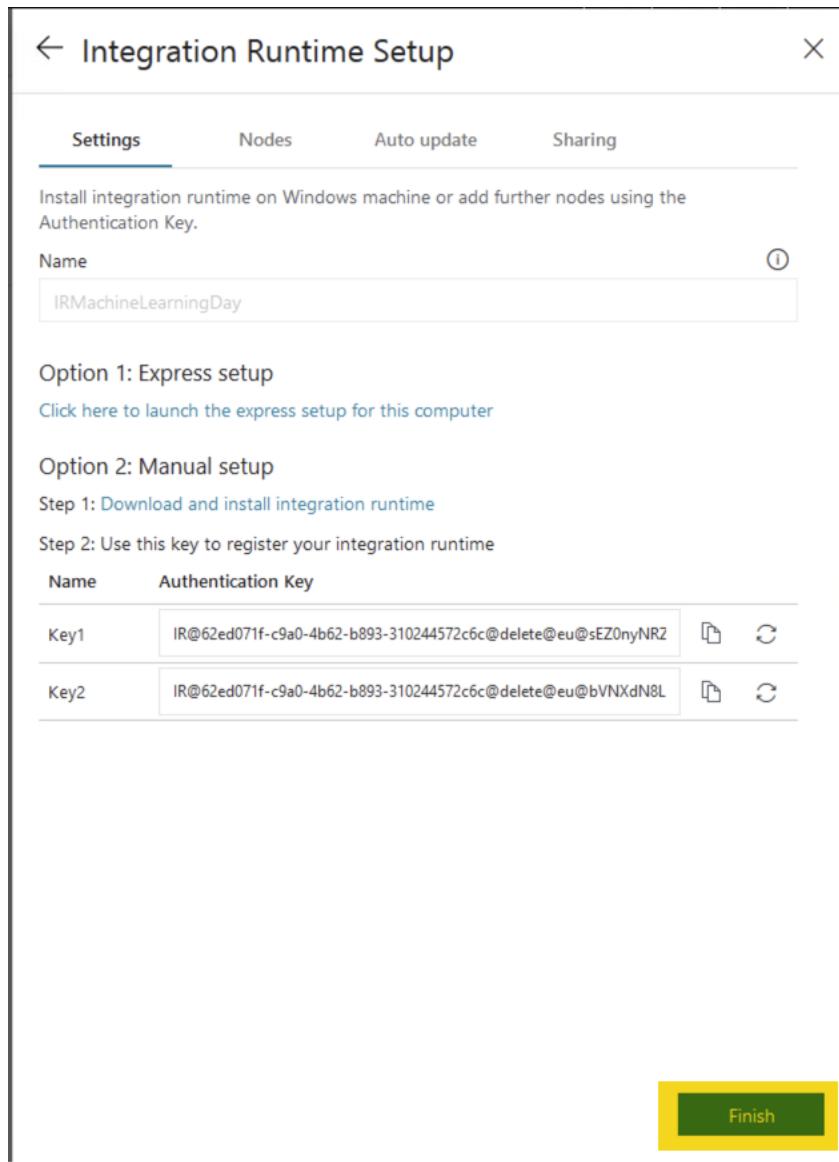
18. Execute the File from the **Downloads** folder as seen in the following screenshot:



19. The Integration Runtime should begin installation. Once complete, select **Close** as seen in the following screenshot:



20. Select **Finish** on the **Integration Runtime Setup** as seen in the following screenshot:



21. We can return now to the **Linked Service (File System)** and enter our user credentials that we initially created for our Data Science Virtual Machine (DSVM) (**User name = demouser & Password = #MLinaDay20!8**) and enter them into our Service as well as the location of the csv file (**C:**) and select **Test Connection** as seen in the following screenshot:

← New Linked Service (File System)

Name *
linkedservicemelinaday

Description

Connect via integration runtime *
IRMachineLearningDay (Unavailable)

Edit Integration Runtime

Host *
C:\

User name *
demouser

Password
••••••••••

Azure Key Vault

Annotations

+ New |

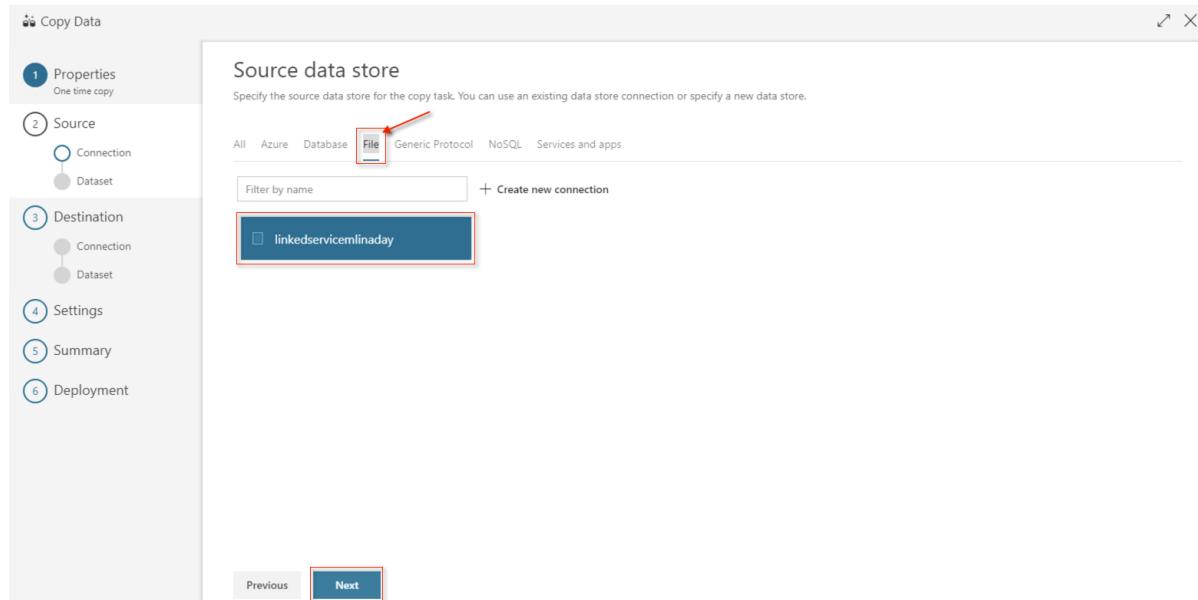
NAME

✓ Connection successful

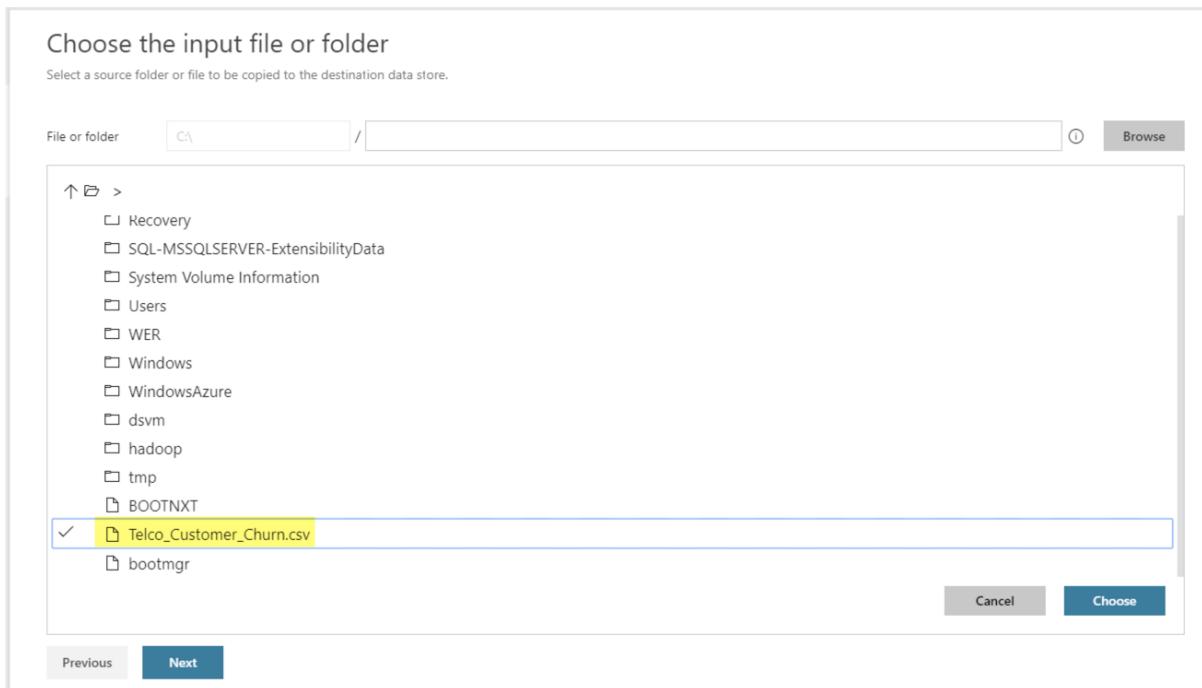
Cancel Test connection Finish

The screenshot shows the 'New Linked Service (File System)' configuration dialog. The 'Name' field is populated with 'linkedservicemelinaday'. The 'Connect via integration runtime' dropdown lists 'IRMachineLearningDay (Unavailable)'. The 'Host' field is set to 'C:\'. The 'User name' field contains 'demouser'. The 'Password' field is obscured by a series of dots. A green checkmark next to the text 'Connection successful' indicates a successful test connection. At the bottom, there are 'Cancel', 'Test connection', and 'Finish' buttons, with 'Test connection' being highlighted.

22. Hopefully we will get a **Connection Successful** message next to a green checkmark. If so, go ahead and select **Finish**.
23. Now that our Connection is set up to our virtual machine with an integration runtime, we can specify the data store type as **File** and select **Next** as seen in the following screenshot:



24. Choose the input file or folder as seen in the following screenshot for the **Telco_Customer_Churn.csv**:



25. Specify the **File Format**, **Column Delimiter**, and select **Column Names in the first row** and select **Next** as seen in the following screenshot (we should see a preview of our dataset):

File format settings

File format Detect Text Format

Column delimiter Use custom delimiter

Row delimiter Use custom delimiter

Skip line count Column names in the first row

Preview Schema

customerID	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	MultipleLines	InternetService	OnlineSecurity	OnlineBackup	DeviceProtection	TechSupport	StreamingTV
7590-VHVEG	Female	0	Yes	No	1	No	No phone service	DSL	No	Yes	No	No	No
5575-GNVDE	Male	0	No	No	34	Yes	No	DSL	Yes	No	Yes	No	No

Previous Next

26. We are now ready to specify our **Destination data store**. We can do so by **+ Create new connection** to our Blob store container as seen in the following screenshot:

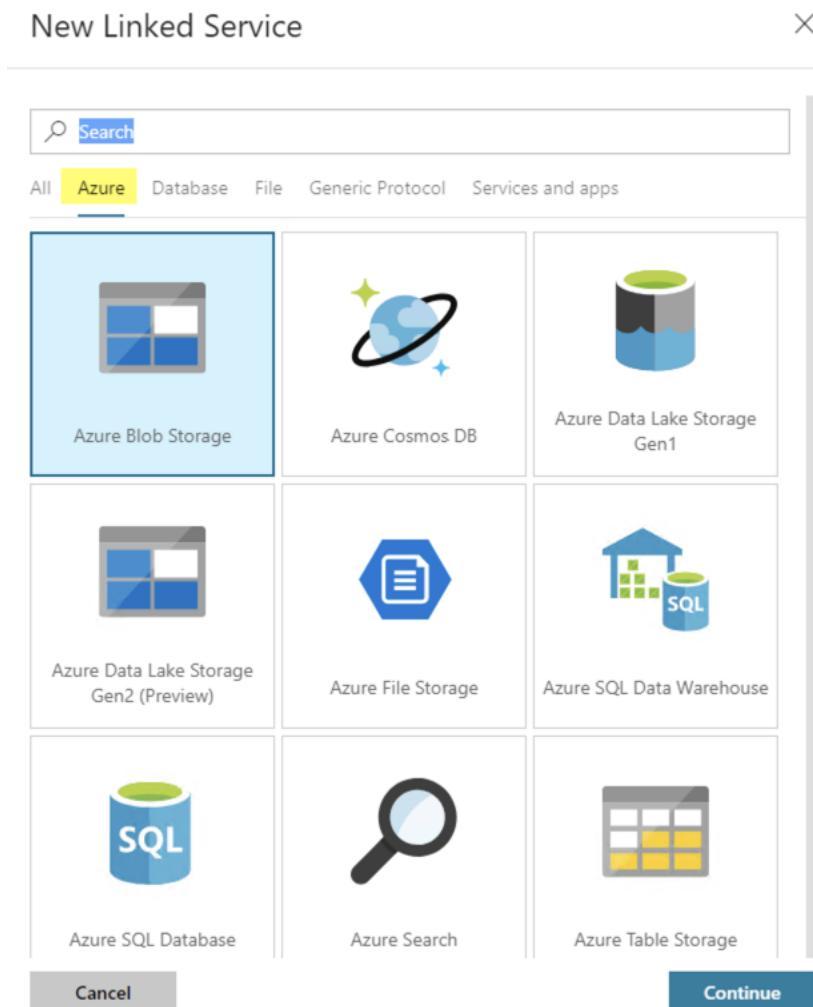
Destination data store

Specify the destination data store for the copy task. You can use an existing data store connection or specify a new data store.

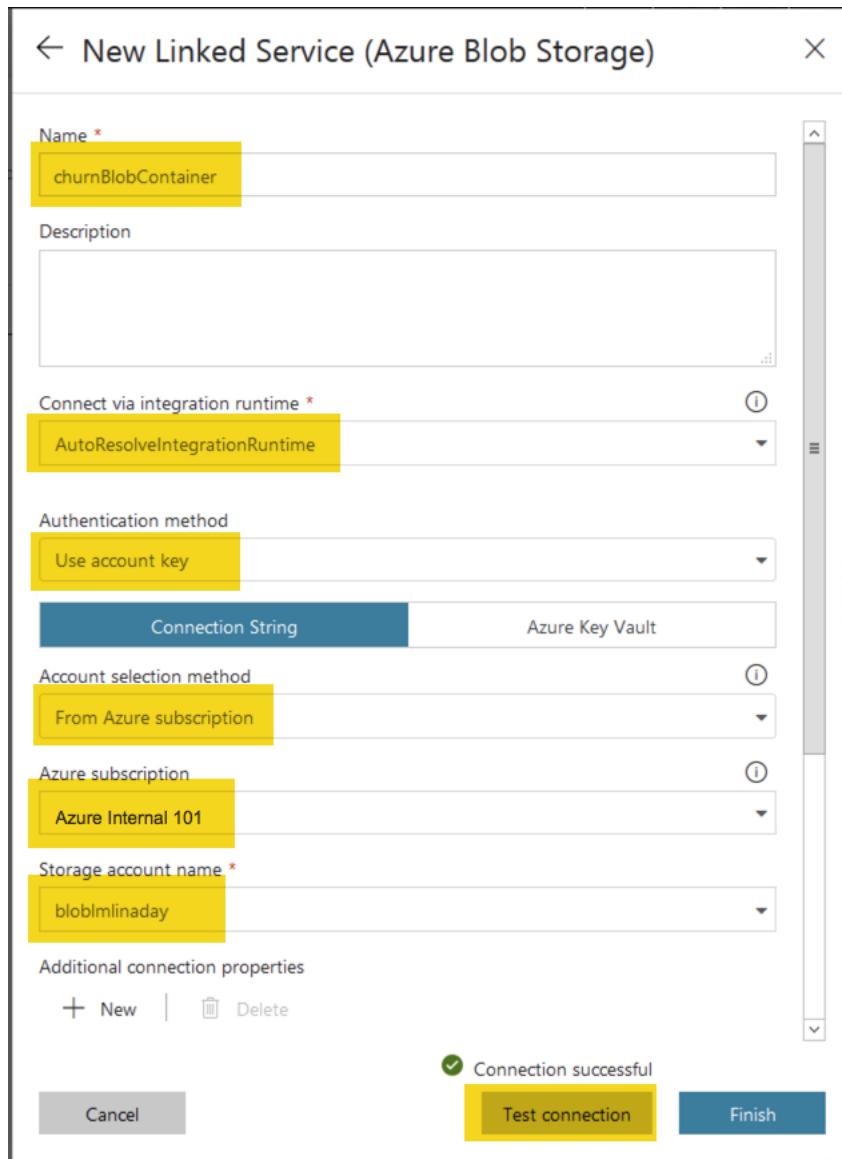
All Azure Database File Generic Protocol NoSQL Services and apps

All Filter by name

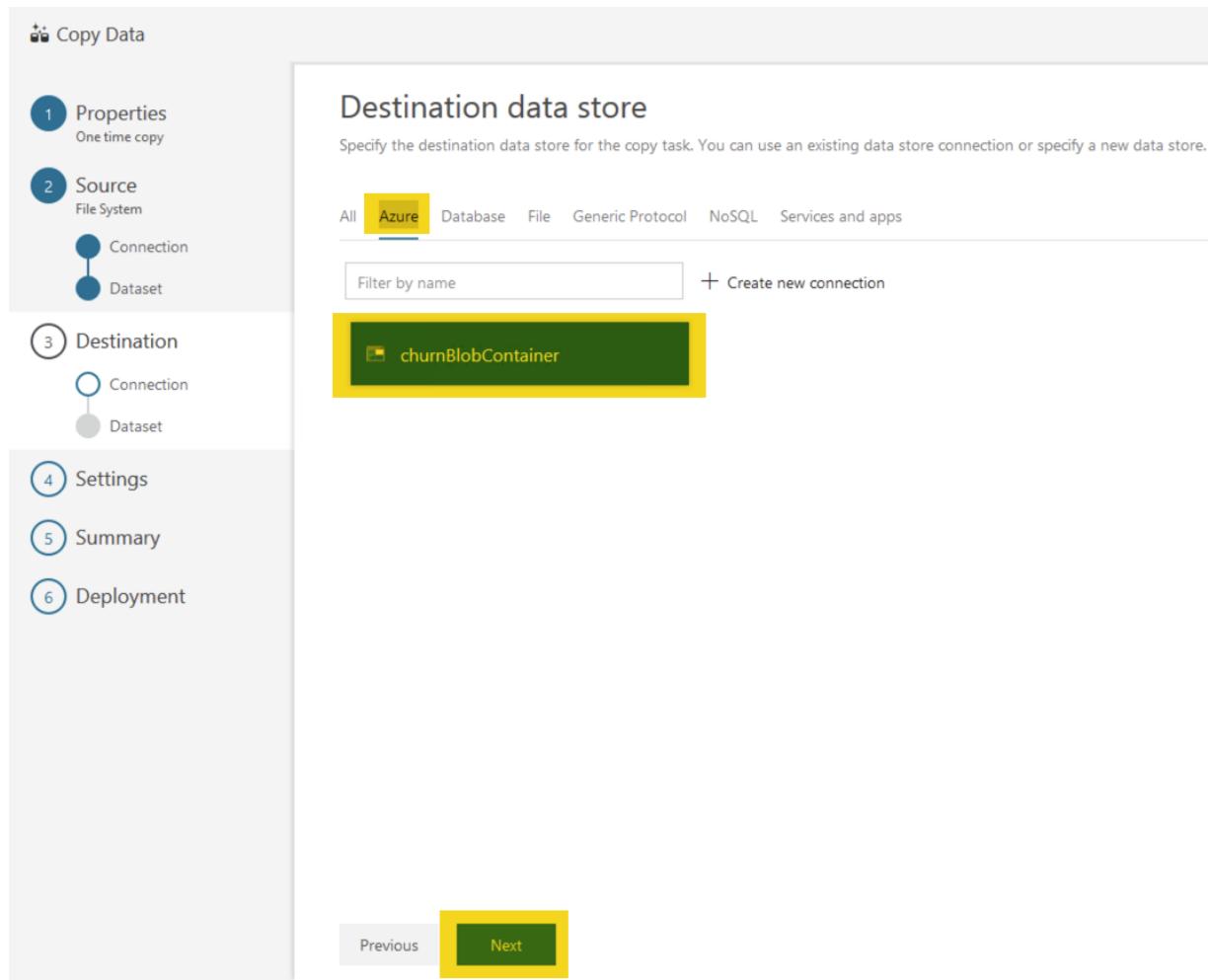
27. Search under **Azure** for **Azure Blob Store** as seen in the following screenshot:



28. Specify a name for the Linked Service to Azure Blob Storage such as **churnBlobContainer**. Additionally, select your **Azure Subscription** as well as your Blob Storage Account name and **Test the Connection** as seen in the following screenshot:



29. Once connection is successful, click on **Finish**.
30. Select the **Azure** tab as the **Destination Data Store** while also selecting the **churnBlobContainer** as the connection and then click on **Next** as seen in the following screenshot:



31. Specify the **folder path** which is the container (**churn**) and give a name to your file such as **Telco_Customer_Churn.csv** as seen in the following screenshot (you can leave Compression Type and Copy Behavior as None):

The screenshot shows the 'Choose the output file or folder' step of the 'Copy Data' wizard. It asks to 'Specify a folder that will contain output files or a specific output file in the destination data store.' The 'Folder path' field contains 'churn' and has a 'Browse' button. The 'File name' field contains 'Telco_Customer_Churn.csv'. Under 'Compression Type', 'None' is selected. Under 'Copy behavior', 'None' is selected. At the bottom, there are 'Previous' and 'Next' buttons, with the 'Next' button highlighted by a yellow box.

32. Specify the following **File format settings** and select **Next** as seen in the following screenshot:

File format settings

File format ⓘ
 Text format

Column delimiter ⓘ
 Comma (,)

Use custom delimiter

Row delimiter ⓘ
 Carriage Return + Line feed (\r\n)

Use custom delimiter

Skip line count ⓘ

Add header to file

► Advanced

Previous Next

33. Set **Fault tolerance setting** to **Skip incompatible Rows** as seen in the following screenshot:

Settings
More options for data movement

► Fault tolerance settings
Fault tolerance Skip incompatible rows ⓘ

► Performance settings
 Enable Staging ⓘ

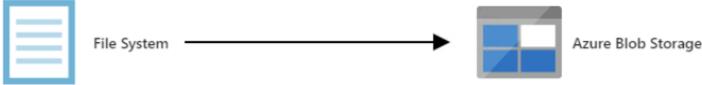
► Advanced settings

Previous Next

34. Review your summary pipeline to confirm all selections are accurate and select **Next** as seen in the following screenshot:

Summary

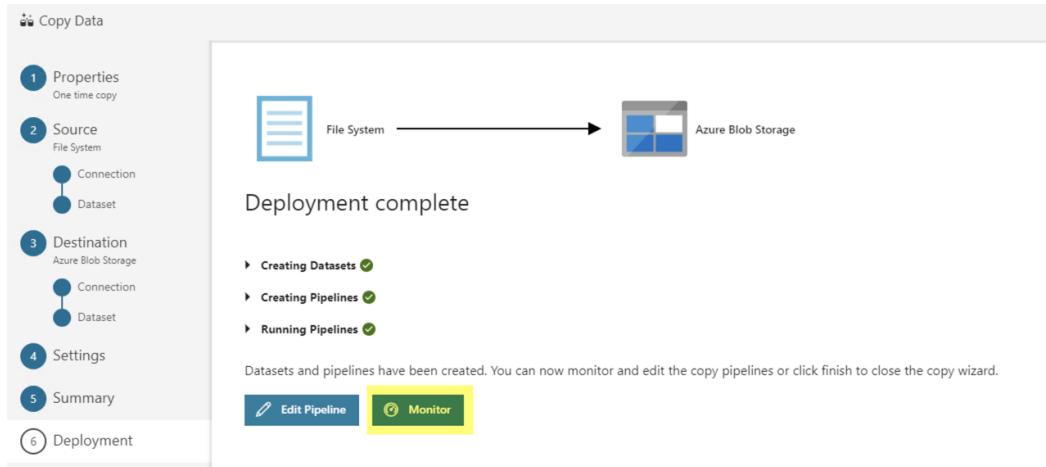
You are running pipeline to copy data from File System to Azure Blob Storage.



Properties		Edit
Task name	CopyPipelineOnPremToCloud	
Task description	CopyPipelineOnPremToCloud	
Source		Edit
Connection name	linkedservicemlinaday	
Dataset name	SourceDataset_tc1	
File name	Telco_Customer_Churn.csv	
Directory path		
Destination		Edit
Connection name	churnBlobContainer	
Dataset name	DestinationDataset_tc1	
File name	churn.csv	

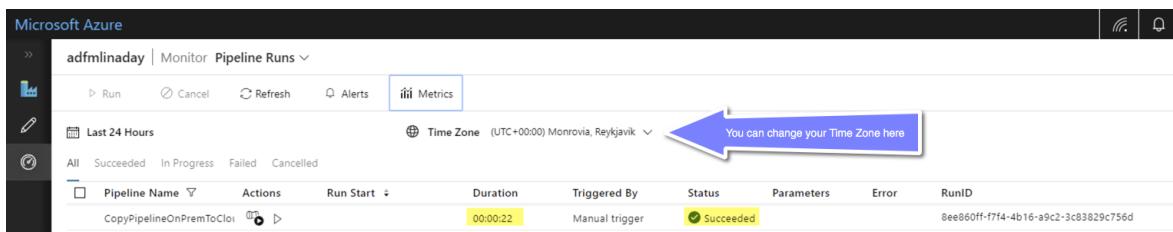
Next

35. Deployment is now complete, and progress can be seen by clicking on **Monitor** as seen in the following screenshot:



The screenshot shows the 'Copy Data' wizard at step 6: Deployment. On the left, a sidebar lists steps 1 through 6. Step 6 is highlighted. The main area displays a summary of the deployment: 'Deployment complete'. It shows a flow diagram from 'File System' to 'Azure Blob Storage'. Below the diagram, a list of tasks is shown with green checkmarks: 'Creating Datasets', 'Creating Pipelines', and 'Running Pipelines'. A message states: 'Datasets and pipelines have been created. You can now monitor and edit the copy pipelines or click finish to close the copy wizard.' At the bottom, there are 'Edit Pipeline' and 'Monitor' buttons, with 'Monitor' being highlighted with a yellow background.

36. The **Monitor** tab will give us some summary statistics as to whether or not our deployment succeeded and how long it took as seen in the following screenshot:



The screenshot shows the Microsoft Azure portal's 'Monitor Pipeline Runs' interface. The top navigation bar includes 'Metrics' and a time zone dropdown set to 'Monrovia, Reykjavik'. A blue arrow points to this dropdown with the text 'You can change your Time Zone here'. The main table displays a single pipeline run for 'CopyPipelineOnPremToCloud'. The run started 00:00:22 ago and was triggered by a manual trigger. The status is 'Succeeded' (indicated by a green circle). The table has columns for Pipeline Name, Actions, Run Start, Duration, Triggered By, Status, Parameters, Error, and RunID.

37. We can return to our blob container and confirm that our file made it there successfully. Anytime we wish to see anything we have deployed:

- we first go to <https://portal.azure.com>
- Then we select **Resource Groups** on the left-hand side as seen in the following screenshot:

NAME	SUBSCRIPTION	LOCATION
MLinADayRG	Azure Internal 101	East US

- Finally, we can view any of the resources we have created as seen in the following screenshot:

NAME	TYPE	LOCATION
adfmlinaday	Data factory (V2)	East US
blobmlinaday	Storage account	East US

- We can do a final test and see that our container now holds the **churn.csv** file in our blob container as seen in the following screenshot:

NAME	MODIFIED	ACCESS TIER	BLOB TYPE	SIZE	LEASE STATE
churn.csv	Hot (Inferred)	Block blob	954.59 KB	Available	...

39. A simple click on the **churn.csv** file in the container and selecting **Edit blob** will reveal the contents of the file and confirm that our deployment to the cloud from on-premise was successful as seen in the following screenshot:

The screenshot shows the Azure Storage Blob service interface. On the left, there's a sidebar with 'Upload', 'Refresh', and 'More' buttons. Below that is a search bar for blobs by prefix and a checkbox for deleted blobs. The main area shows a list of blobs under 'churn' with one item: 'churn.csv'. This file is highlighted with a red box. At the top right, there are 'Save', 'Discard', 'Refresh', 'Download', 'Delete', 'Overview', 'Snapshots', 'Edit blob' (which is highlighted with a red arrow), and 'Generate SAS' buttons. The 'Edit blob' button is currently active, displaying the CSV file's contents. The CSV data starts with:

```

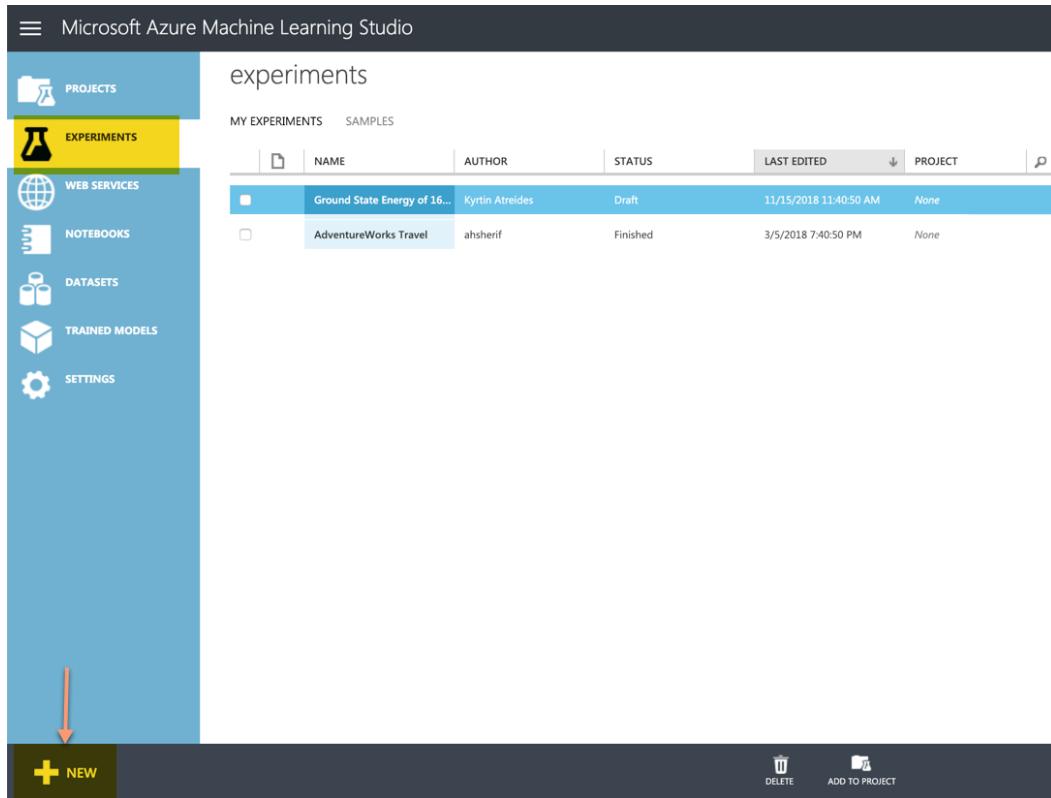
1 customerID,gender,SeniorCitizen,Partner,Dependents,tenure,PhoneService,MultipleLines,InternetService,Online
2 7590-VHVEG,Female,0,Yes,No,1,No,No phone service,DSL,No,Yes,No,No,No,Month-to-month,Yes,Electronic check,
3 5575-GNVED,Male,0,No,No,34,Yes,No,DSL,Yes,No,Yes,No,No,One year,Mailed check,56.95,1889.5,No
4 3668-QPYBK,Male,0,No,No,2,Yes,No,DSL,Yes,Yes,No,No,No,Month-to-month,Yes,Mailed check,53.85,108.15,Yes
5 7795-CFOCW,Male,0,No,No,45,No,No phone service,DSL,Yes,No,Yes,Yes,No,No,One year,No,Bank transfer (automatic)
6 9237-HQITU,Female,0,No,No,2,Yes,No,Fiber optic,No,No,No,No,No,Month-to-month,Yes,Electronic check,70.7,1:
7 9305-CDSKC,Female,0,No,No,8,Yes,Yes,Fiber optic,No,No,No,Yes,No,Yes,Month-to-month,Yes,Electronic check,99.
8 1452-KTOKW,Male,0,No,Yes,22,Yes,Yes,Fiber optic,No,Yes,No,No,Yes,No,Month-to-month,Yes,Credit card (automat
9 6713-OKOMC,Female,0,No,No,10,No,No phone service,DSL,Yes,No,No,No,No,Month-to-month,No,Mailed check,29.7
10 7892-POOKP,Female,0,Yes,No,28,Yes,Yes,Fiber optic,No,No,Yes,Yes,Yes,Yes,Month-to-month,Yes,Electronic check,
11 6388-TABGU,Male,0,No,Yes,62,Yes,No,DSL,Yes,Yes,No,No,No,One year,No,Bank transfer (automatic),56.15,3487
12 9763-GRSKD,Male,0,Yes,Yes,13,Yes,No,DSL,Yes,No,No,No,No,Month-to-month,Yes,Mailed check,49.95,587.45,No
13 7469-LKBCI,Male,0,No,No,16,Yes,No,No,internet service,No,internet service,No,internet service,No,internet
14 8091-TTVAX,Male,0,Yes,No,58,Yes,Yes,Fiber optic,No,No,Yes,No,Yes,One year,No,Credit card (automatic),10
15 0280-XJGEX,Male,0,No,No,49,Yes,Yes,Fiber optic,No,Yes,Yes,No,Yes,Yes,Month-to-month,Yes,Bank transfer (auto
16 5129-JLPIS,Male,0,No,No,25,Yes,No,Fiber optic,Yes,No,Yes,Yes,Yes,Yes,Month-to-month,Yes,Electronic check,10
17 3655-SNOYZ,Female,0,Yes,69,Yes,Yes,Fiber optic,Yes,Yes,Yes,Yes,Yes,Two year,No,Credit card (automat
18 8191-XWSZG,Female,0,No,No,52,Yes,No,No,internet service,No,internet service,No,internet service,No,internet
19 9959-WOFKT,Male,0,No,Yes,71,Yes,Yes,Fiber optic,Yes,No,Yes,Yes,Two year,No,Bank transfer (automatic),
20 4190-MFLUW,Female,0,Yes,Yes,10,Yes,No,DSL,No,No,Yes,Yes,No,Month-to-month,No,Credit card (automatic),55.
21 4183-MYFRB,Female,0,No,No,21,Yes,No,Fiber optic,No,Yes,Yes,Yes,No,No,Month-to-month,Yes,Electronic check,90
22 8779-ORMVY,Male,1,No,No,1,No,No phone service,DSL,No,No,Yes,No,No,Yes,Month-to-month,Yes,Electronic check,3
23 1680-VDCWW,Male,0,Yes,No,12,Yes,No,No,internet service,No,internet service,No,internet service,No,internet
24 1066-JKSGK,Male,0,No,No,1,Yes,No,No,internet service,No,internet service,No,internet service,No,internet
25 3638-WEABW,Female,0,Yes,No,58,Yes,Yes,DSL,Yes,No,Yes,No,Two year,Yes,Credit card (automatic),59.9,350
26 6322-HRPFA,Male,0,Yes,Yes,49,Yes,No,DSL,Yes,Yes,No,Yes,No,Month-to-month,No,Credit card (automatic),59.6
27 6865-JZNKO,Female,0,No,No,30,Yes,No,DSL,Yes,Yes,No,No,No,Month-to-month,Yes,Bank transfer (automatic),55.
28 6467-CHFZW,Male,0,Yes,Yes,47,Yes,Yes,Fiber optic,No,Yes,No,Yes,Yes,Month-to-month,Yes,Electronic check,9
29 8665-UTDHZ,Male,0,Yes,Yes,1,No,No phone service,DSL,No,Yes,No,No,No,Month-to-month,No,Electronic check,3
30 5248-YGIJM,Male,0,Yes,No,72,Yes,Yes,DSL,Yes,Yes,Yes,Yes,Two year,Yes,Credit card (automatic),90.25,6

```

At the bottom right, there are 'Preview', 'Csv', and a dropdown menu.

Section 4: Build a clustering unsupervised model in Azure Machine Learning Studio

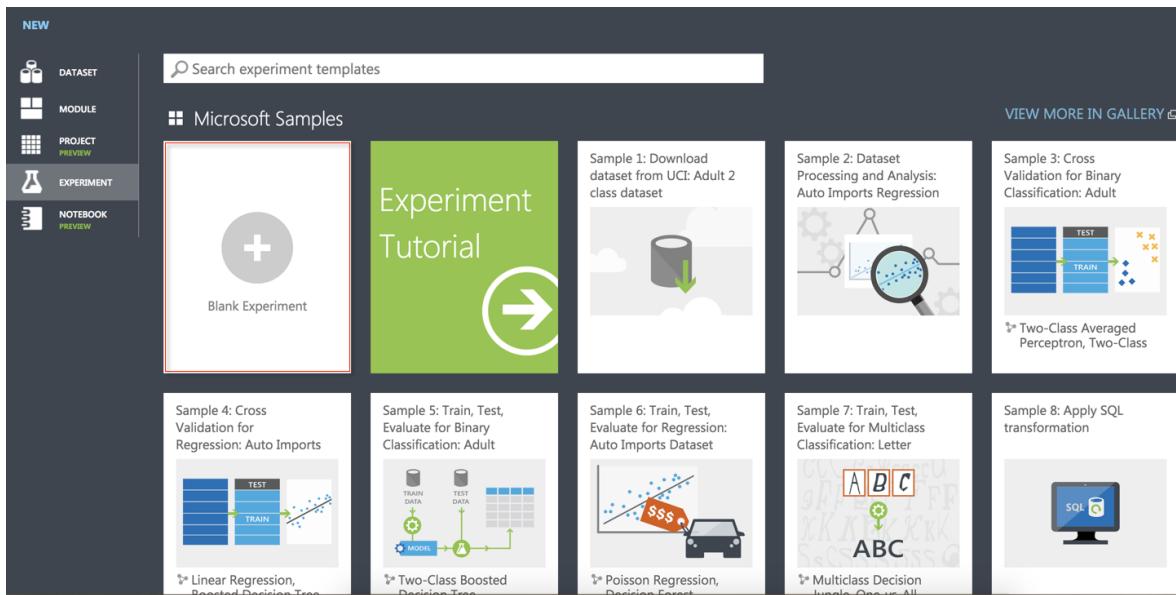
1. Clustering is the process of grouping similar entities together. The goal of this unsupervised machine learning technique is to find similarities in the fields that we have about our customers and group them into 10 distinct clusters.
2. Sign into Azure Machine Learning Studio using your Azure login Credentials in the following website:
<https://studio.azureml.net/>
3. If you are not already directed to create a new experiment, go ahead and select the Experiments tab on the menu on the left-hand side as seen in the following screenshot. All current and future experiments will reside in this section.



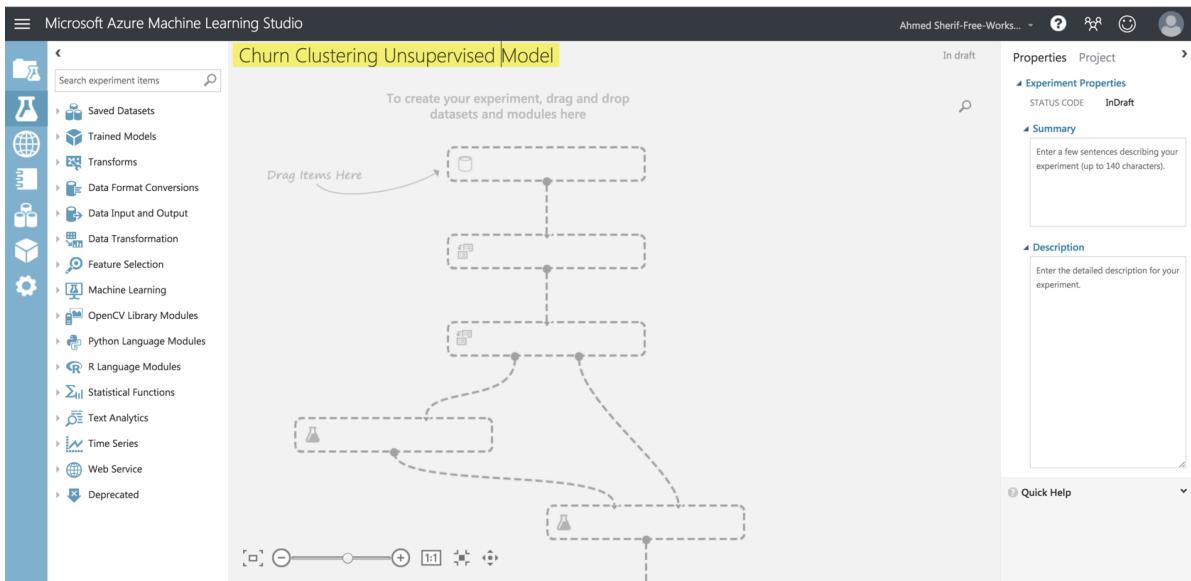
The screenshot shows the Microsoft Azure Machine Learning Studio interface. On the left, there is a vertical sidebar with icons for Projects, Experiments (which is highlighted in yellow), Web Services, Notebooks, Datasets, Trained Models, and Settings. The main area is titled "experiments" and contains a table with two rows of data. The columns are labeled NAME, AUTHOR, STATUS, LAST EDITED, and PROJECT. The first row has a checkbox, the name "Ground State Energy of 16...", author "Kyrtin Atreides", status "Draft", last edited "11/15/2018 11:40:50 AM", and project "None". The second row also has a checkbox, the name "AdventureWorks Travel", author "ahsherif", status "Finished", last edited "3/5/2018 7:40:50 PM", and project "None". At the bottom of the sidebar, there is a red arrow pointing down to a button labeled "+ NEW". At the bottom right of the main area, there are "DELETE" and "ADD TO PROJECT" buttons.

	NAME	AUTHOR	STATUS	LAST EDITED	PROJECT
<input type="checkbox"/>	Ground State Energy of 16...	Kyrtin Atreides	Draft	11/15/2018 11:40:50 AM	None
<input type="checkbox"/>	AdventureWorks Travel	ahsherif	Finished	3/5/2018 7:40:50 PM	None

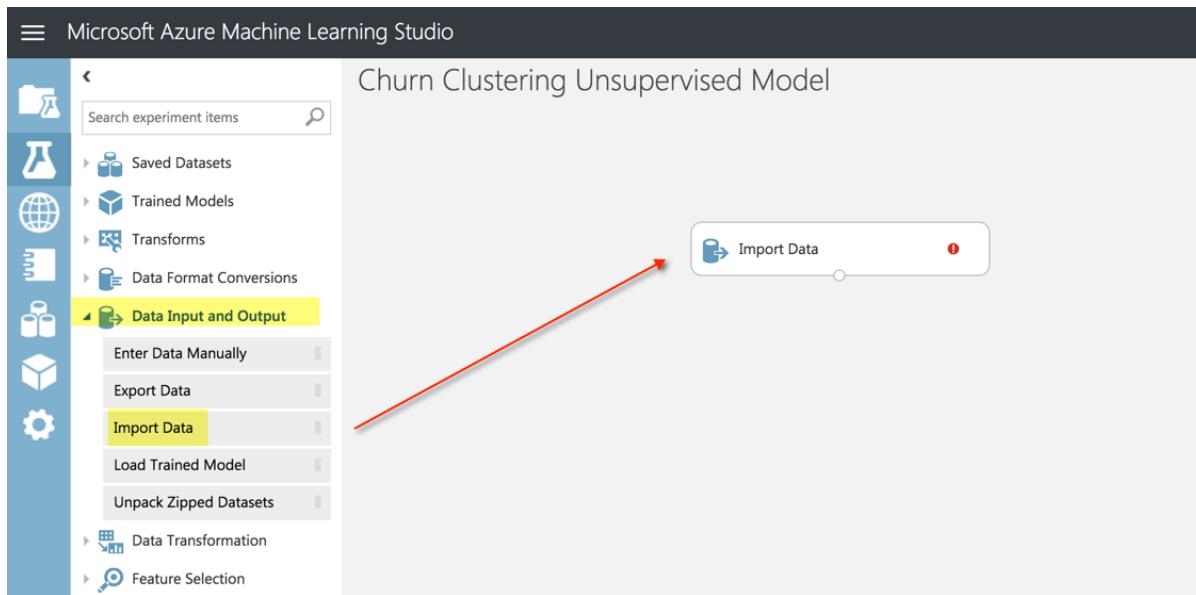
4. Next click on +NEW on the button of the screen and select **Blank Experiment** as seen in the following screenshot:



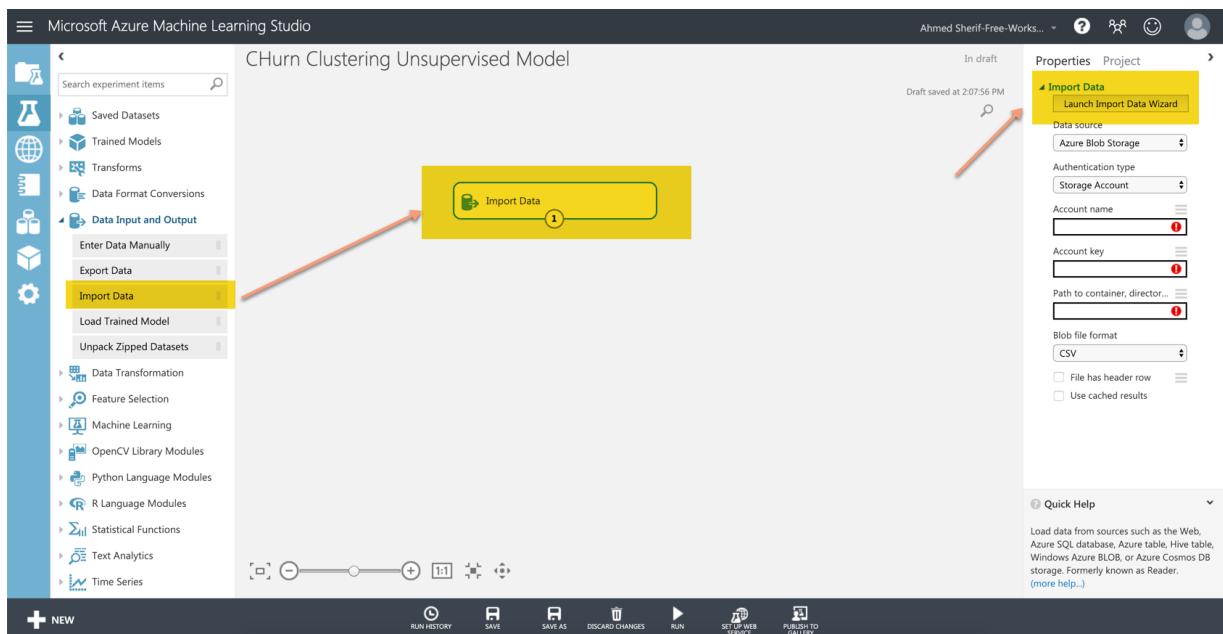
5. Click on the title of the experiment and change the name to **Churn Clustering Unsupervised Model** as seen in the following screenshot:



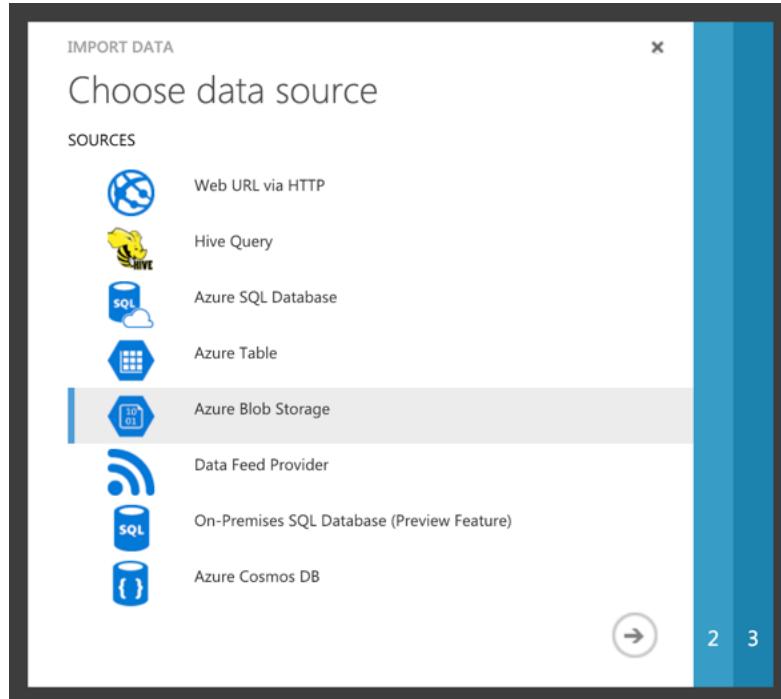
6. Expand the **Data Input and Output** category and drag the **Import Data** into the Workflow as seen in the following screenshot:



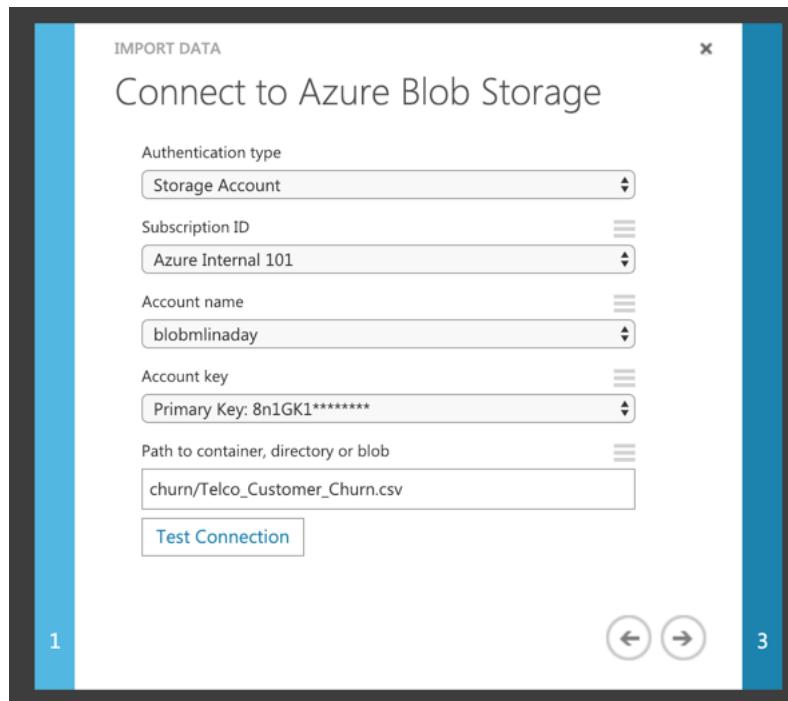
- As you click on the **Import Data** icon in the workflow, you will have the option to configure your data to pull from the Azure Blob Container you created a few sections ago using the Launch Import Wizard as seen in the following screenshot:



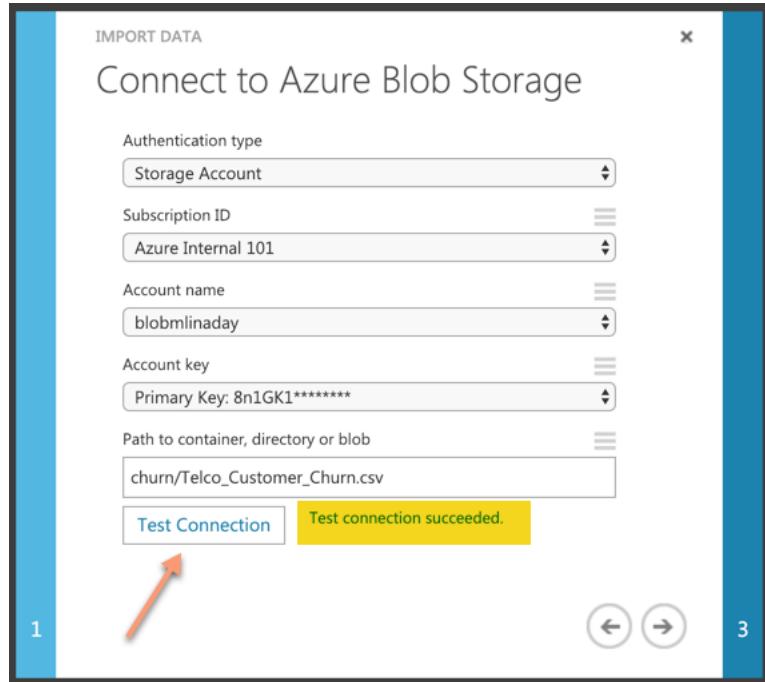
- Select Azure Blob Storage



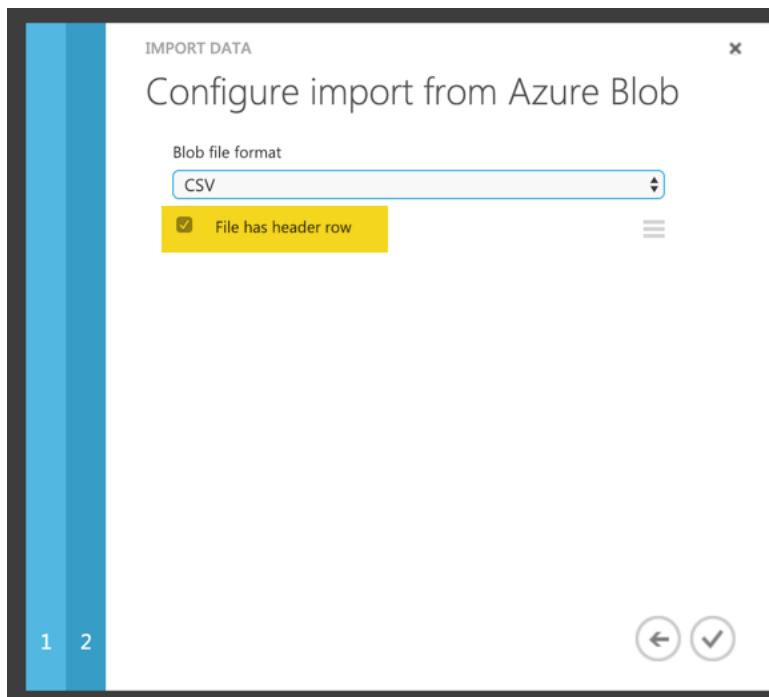
9. Specify the following credentials from the drop-down boxes for your accounts:



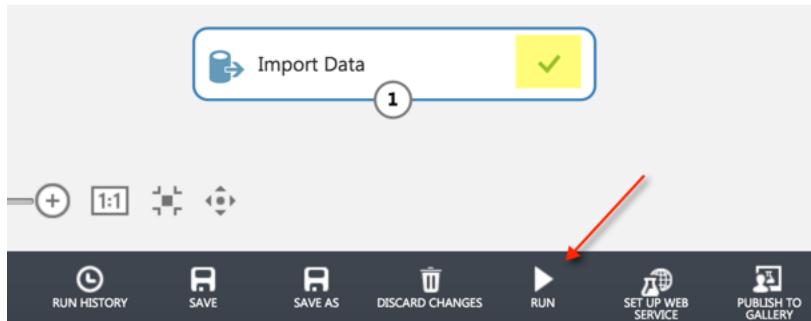
10. Test the connection to make sure the credentials work. Once it is validated you should see a green checkmark as seen in the following screenshot:



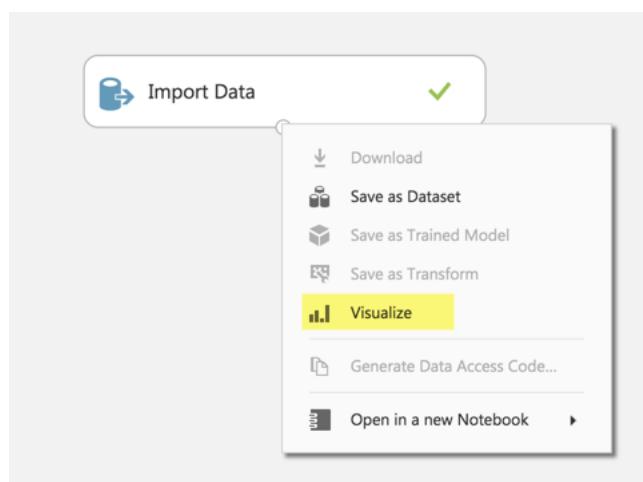
11. Check to include a **file header row** for the data and maintain a **CSV** file structure as seen in the following screenshot:



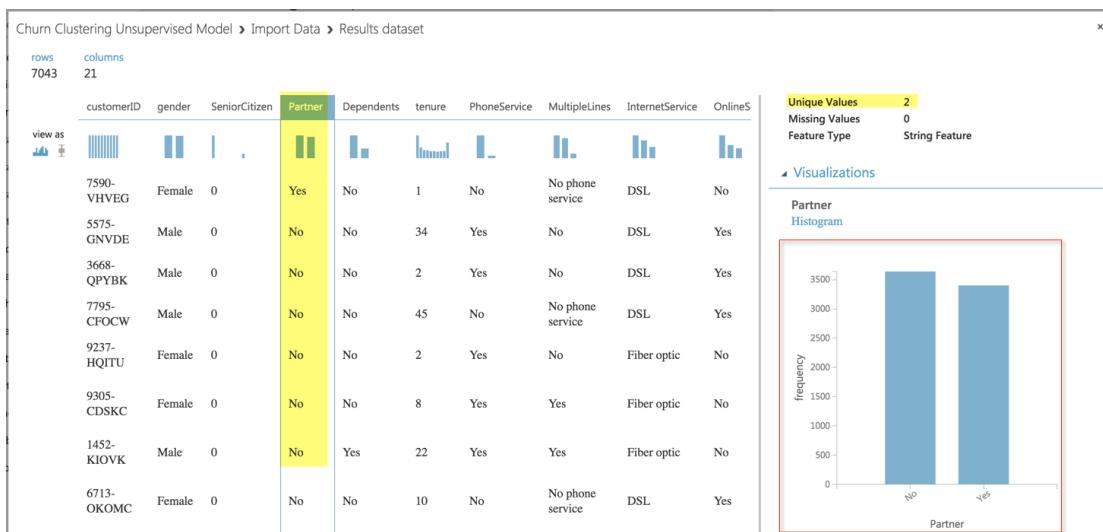
12. Back in the Azure ML Studio workflow, the credentials can be confirmed by clicking on the **RUN** icon at the bottom of the screen and seeing the green check mark next to **Import Data**.



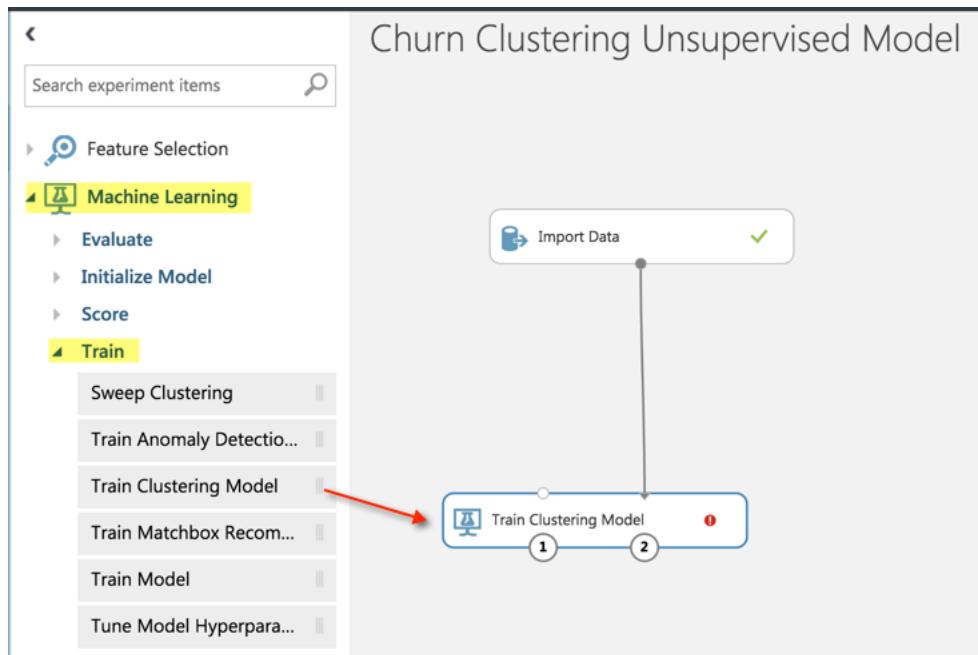
13. ***Every time a new node is added and attached to an existing node, you will need to select the RUN icon to see the new results***
14. Once we have confirmed the connection is working, we can right-click on the number 1 on the first workflow and **Visualize** the dataset as seen in the following screenshot:



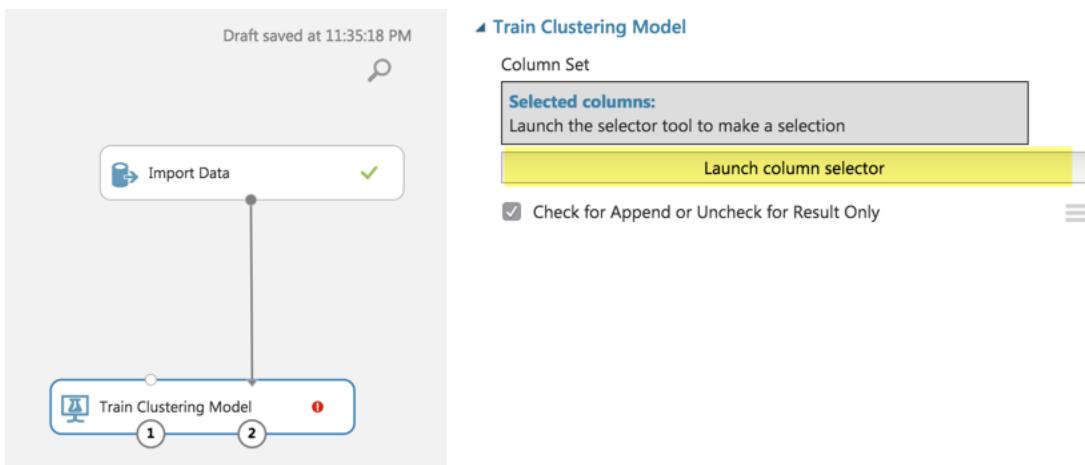
15. Take some time to click on the columns to identify the summary statistics for both the numeric fields and the categorical fields as seen in the following screenshot:



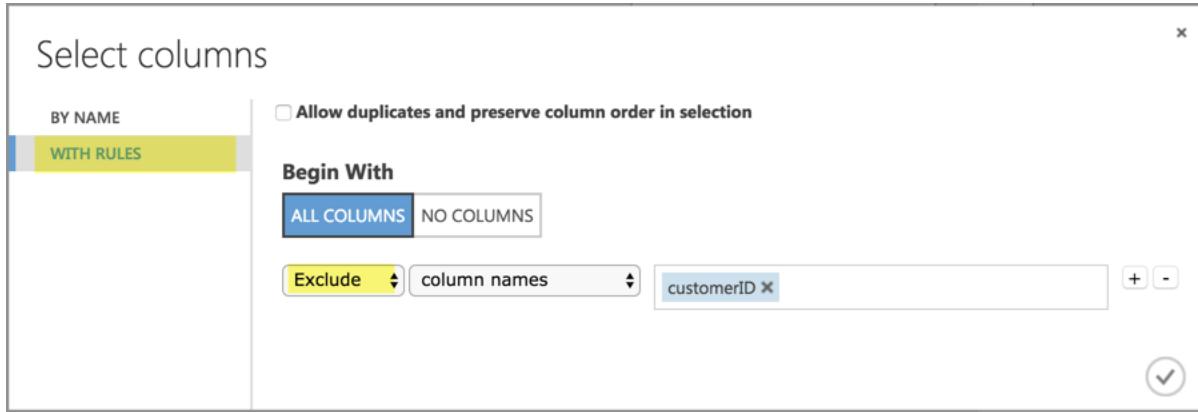
16. Import **Train Clustering Model** from the **Machine Learning** Node and connect it to the **Import Data** module as seen in the following screenshot:



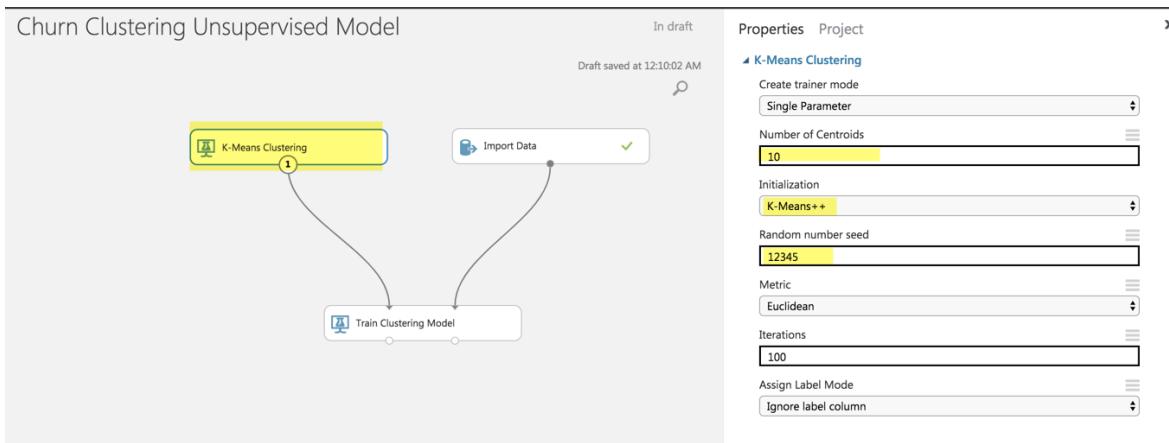
17. Next, click on the **Train Clustering Model** module, **Launch Column Selector**, connect the node back to the **Import Data** node, and configure the columns to be selected as seen in the following screenshot:



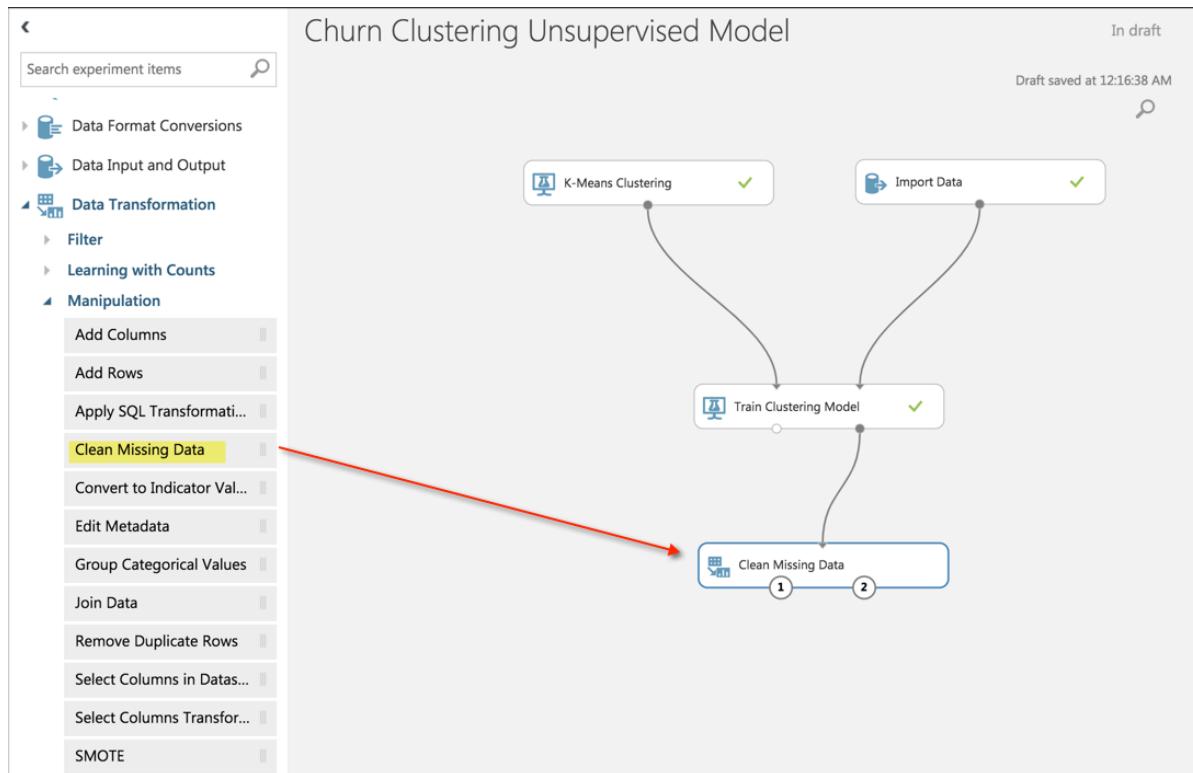
18. **CustomerID** is not a column that will help us out in clustering customers into 1 of 10 categories; therefore, we will remove it from the cluster algorithm.
19. So, you will need to configure the **clustering model** and **Select All columns** from the dataset except for the column called **customerID** as seen in the following screenshot:



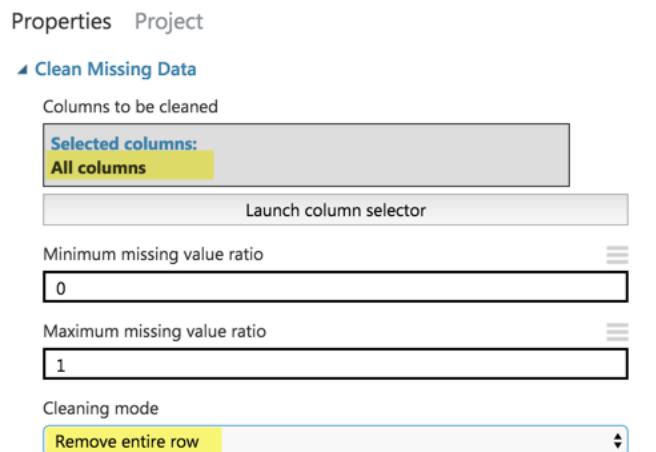
20. Next, we will attach the **K-Means Clustering** model to the **Train Clustering Model** and assign the following parameters to the clustering model, as seen in the following screenshot:



21. Select **RUN**
22. Next, we will do some data cleanup and remove any rows that have missing values by pulling in the **Clean Missing Data** module and connecting it to the **Train Clustering Model** as seen in the following screenshot:



23. We can configure the **Clean Missing Data** module by clicking on it and selecting the following configuration to remove any rows if they meet the following criteria:

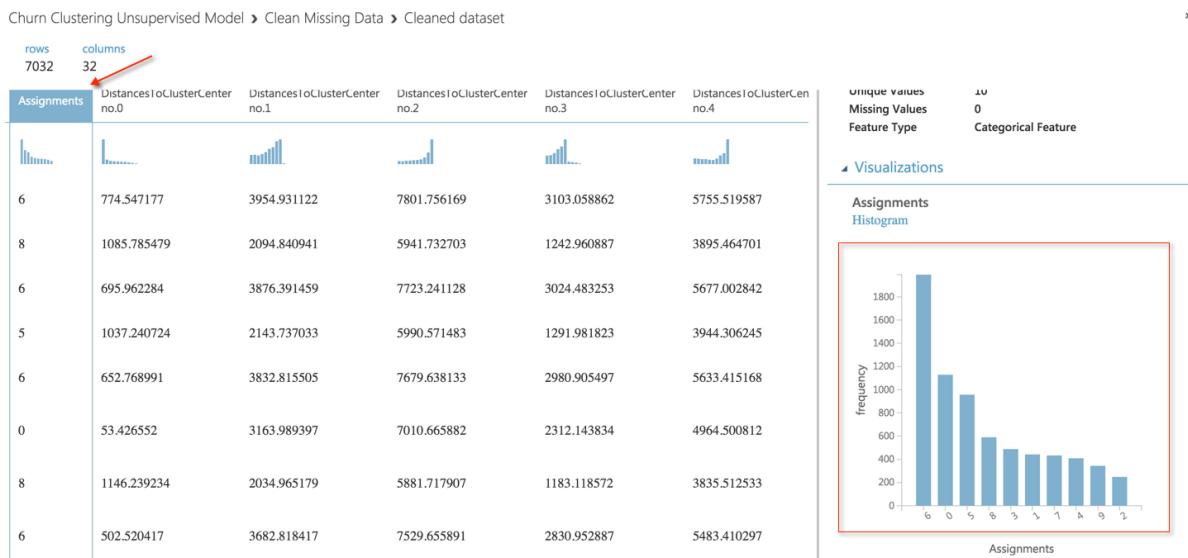


24. Select **RUN**

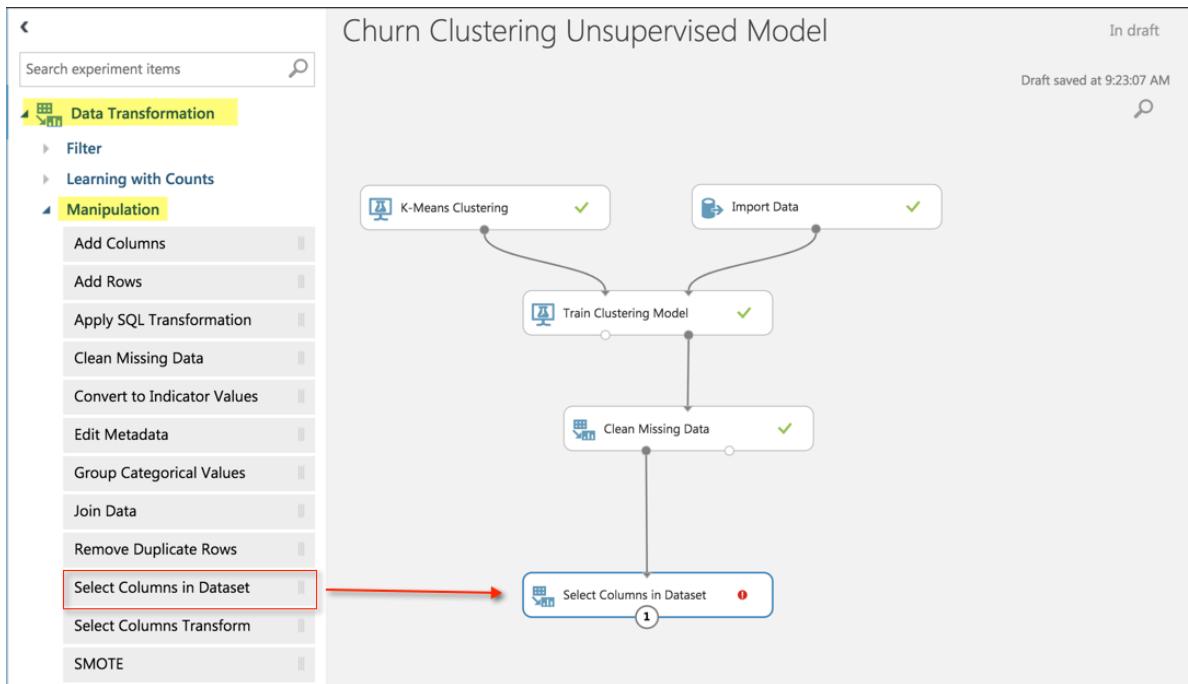
25. The clustering outcome produces several columns that are not necessary for our purposes for this workshop as can be seen by visualizing the **Clean Missing Data** module as seen in the following screenshot:

Churn Clustering Unsupervised Model > Clean Missing Data > Cleaned dataset							
rows	columns						
Churn	Assignments	DistancesToClusterCenter no.0	DistancesToClusterCenter no.1	DistancesToClusterCenter no.2	DistancesToClusterCenter no.3	DistancesToClusterCenter no.4	DistancesToC no.4
No	6	774.547177	3954.931122	7801.756169	3103.058862	5755.519587	
No	8	1085.785479	2094.840941	5941.732703	1242.960887	3895.464701	
Yes	6	695.962284	3876.391459	7723.241128	3024.483253	5677.002842	
No	5	1037.240724	2143.737033	5990.571483	1291.981823	3944.306245	
Yes	6	652.768991	3832.815505	7679.638133	2980.905497	5633.415168	
Yes	0	53.426552	3163.989397	7010.665882	2312.143834	4964.500812	
No	8	1146.239234	2034.965179	5881.717907	1183.118572	3835.512533	
No	6	502.520417	3682.818417	7529.655891	2830.952887	5483.410297	

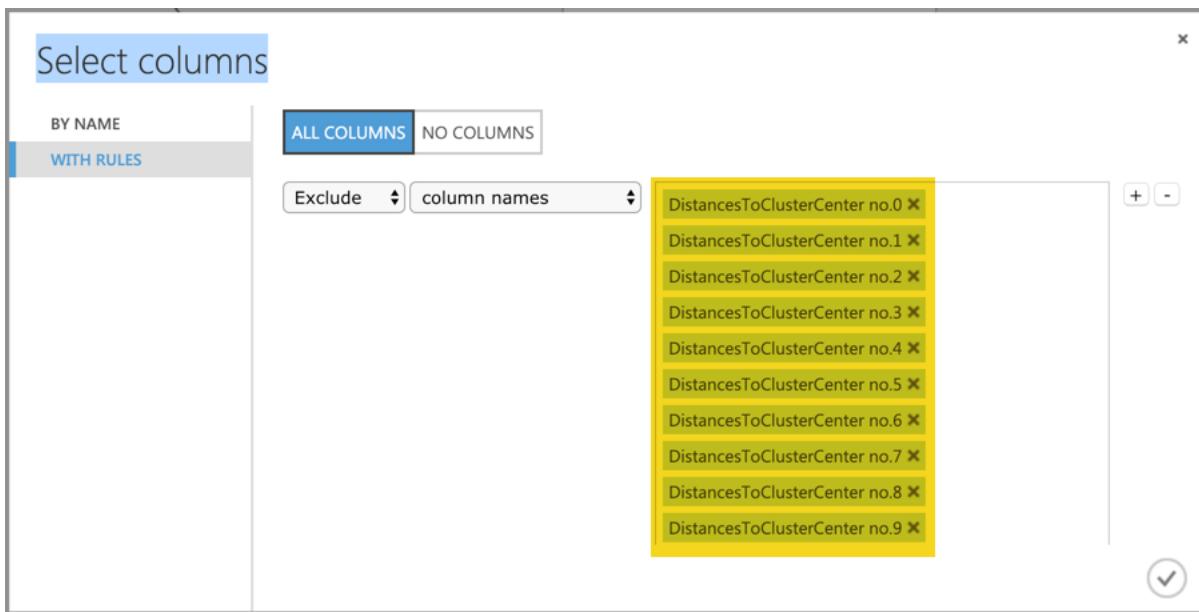
26. We are truly only interested in the assignments, which is grouping each customer into a category of **0** through **9** as seen when we visualize a histogram of the unique values as seen in the following screenshot:



27. All other columns that start with **DistancesToClusterCenter** are not relevant for our purposes and can be removed. The easiest way to do this is to drag into our workflow **Select Columns in Dataset** as seen in the following screenshot:

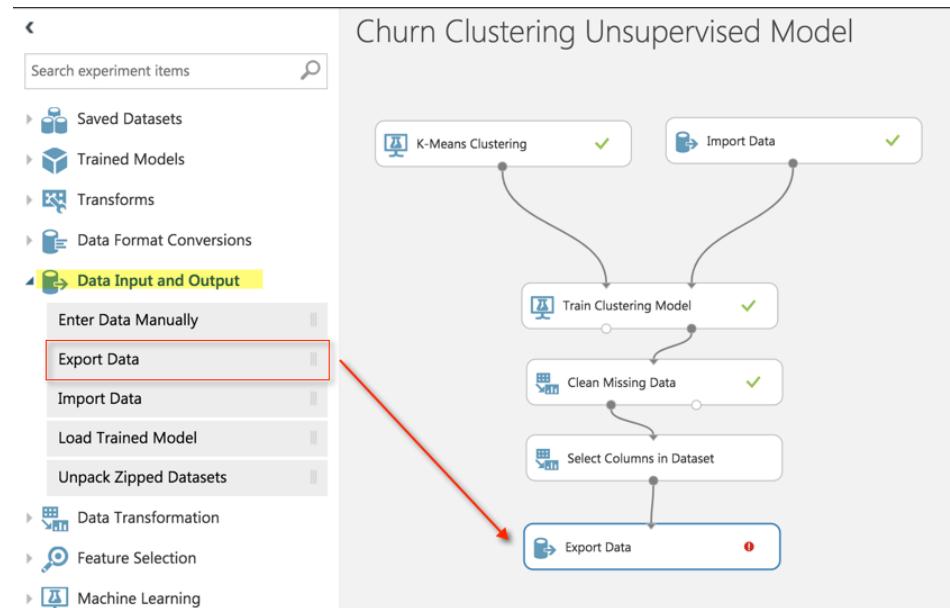


28. We can then configure the module for **Select Columns in Dataset** by **Launching Column Selector**, select **WITH RULES**, and exclude column names DistancetoClusterCenter no.0 through DistancetoClusterCenter no.9, as seen in the following screenshot:

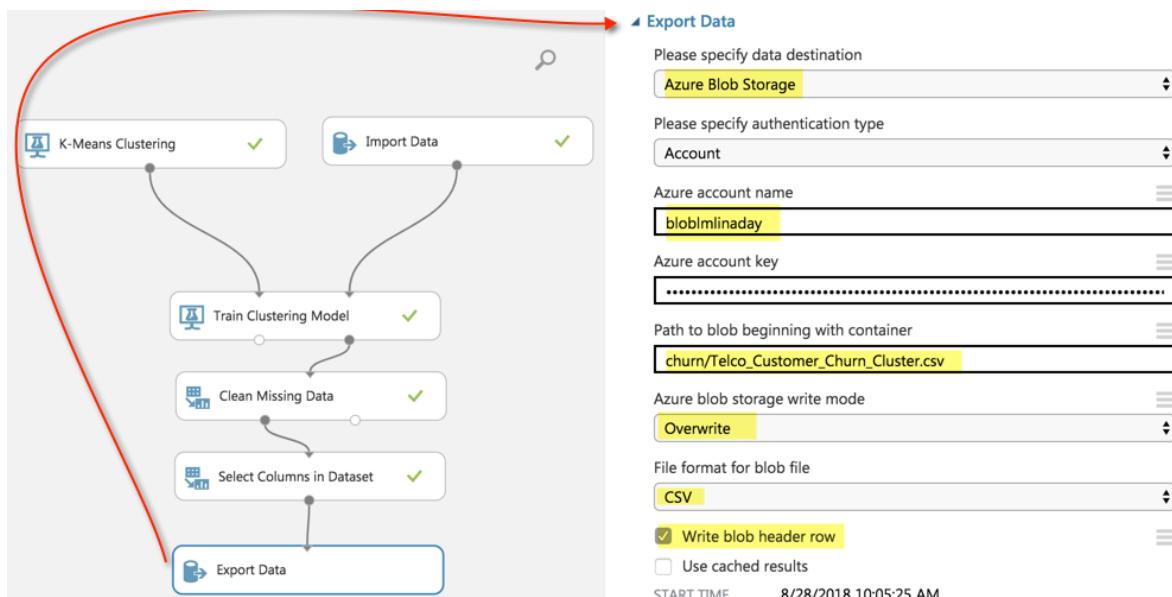


29. Select **RUN**

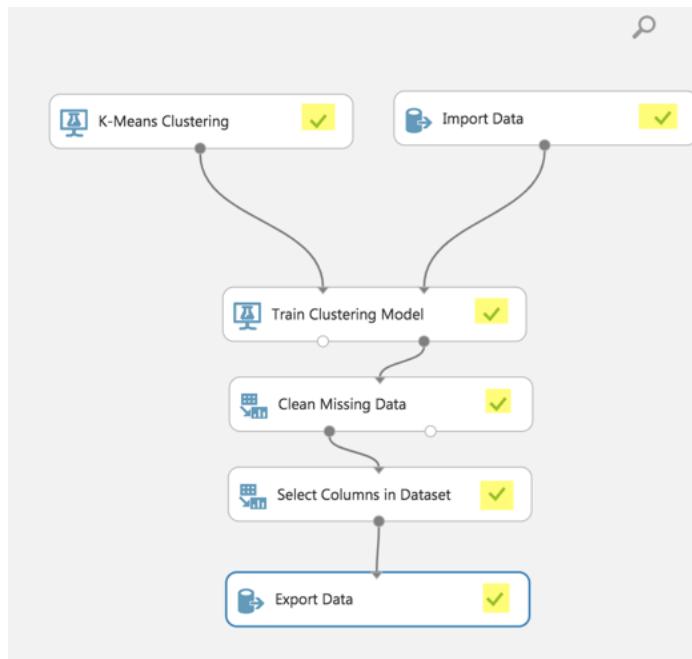
30. We are finally ready to send out revised dataset with only the columns that we need back to blob storage using the **Export Data** module as seen in the following screenshot:



31. Unlike the Import Data module, we do not have a wizard to help us out. So, we will have to input our credentials manually.
32. We will need to configure the connection to export the new dataset, **Telco_Customer_Churn_Cluster.csv**, back to the same blob container, **churn**, using the following configuration as seen in the following screenshot (*please note that you should continue to use the same Key1 from Blob storage that was saved to a notepad from an earlier section*):



33. Once we are done, we can execute our workflow one last time by clicking on the **RUN** button.
34. Once completed, we should hopefully see all green checkmarks next to each step of our workflow as seen in the following screenshot:



35. We can revisit our Blob container in the Azure Portal and view our newly added dataset alongside our existing dataset as seen in the following screenshot:

NAME	MODIFIED	BLOB TYPE
Telco_Customer_Churn_Cluster.csv	2018-02-22, 10:05:29 AM	Block blob
Telco_Customer_Churn.csv	2018-02-22, 11:32:04 AM	Block blob

36. Finally, we will right-click on the csv file and obtain our **Generate SAS** as seen in the following screenshot:

37. A **shared access signature (SAS)** is a URL that grants restricted access rights to Azure Storage resources (a specific blob in this case). You can provide a shared access signature to clients who should not be trusted with your storage account key but whom you wish to delegate access to certain storage account resources. By distributing a shared access signature URI to these clients, you grant them access to a resource for a specified period of time. Select Generate blob SAS token and URL as seen in the following screenshot:

The screenshot shows the Azure Storage Blob SAS generation interface for the file 'Telco_Customer_Churn_Cluster.csv'. The 'Generate SAS' button is highlighted in yellow. An arrow points to the 'Expiry' field, which is set to 2028-09-10 at 8:59:46 PM UTC-04:00. Another arrow points to the generated SAS URL at the bottom, which is a long string starting with 'sp=r&t=' followed by various parameters.

38. Keep a copy of the SAS URL as it will come in handy in the next section when we are reading the file from Blob to Azure Databricks. Additionally, make sure to set expiry date sometime in the future so that it does not expire while you are working on the workshop. Set a time expiration for at least 1 month from the day you are performing the workshop.
39. We are now ready to bring our new dataset with the additional features from clustering into Azure Databricks to do some supervised learning with **SparkML**.

Section 5: Set up a Spark Cluster on Databricks and connect to Azure Blob Storage Account

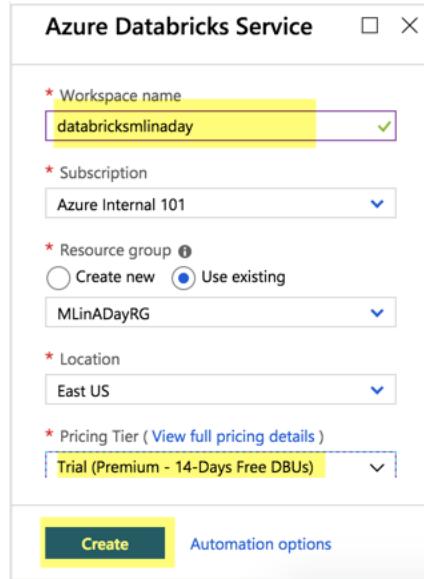
1. Return to the Azure portal (<https://portal.azure.com>) and provision an **Azure Databricks** workspace by selecting Azure Databricks from the **marketplace** as seen in the following screenshot:

The screenshot shows the Microsoft Azure portal interface. At the top, there's a navigation bar with 'Preview' (orange), 'Microsoft Azure' (blue), 'Report a bug' (orange), and a search bar ('Search resources, services, and documents'). Below the navigation bar, the main content area has a breadcrumb trail: 'Home > New > Azure Databricks'. The central panel is titled 'Azure Databricks' (Microsoft) and contains the following information:

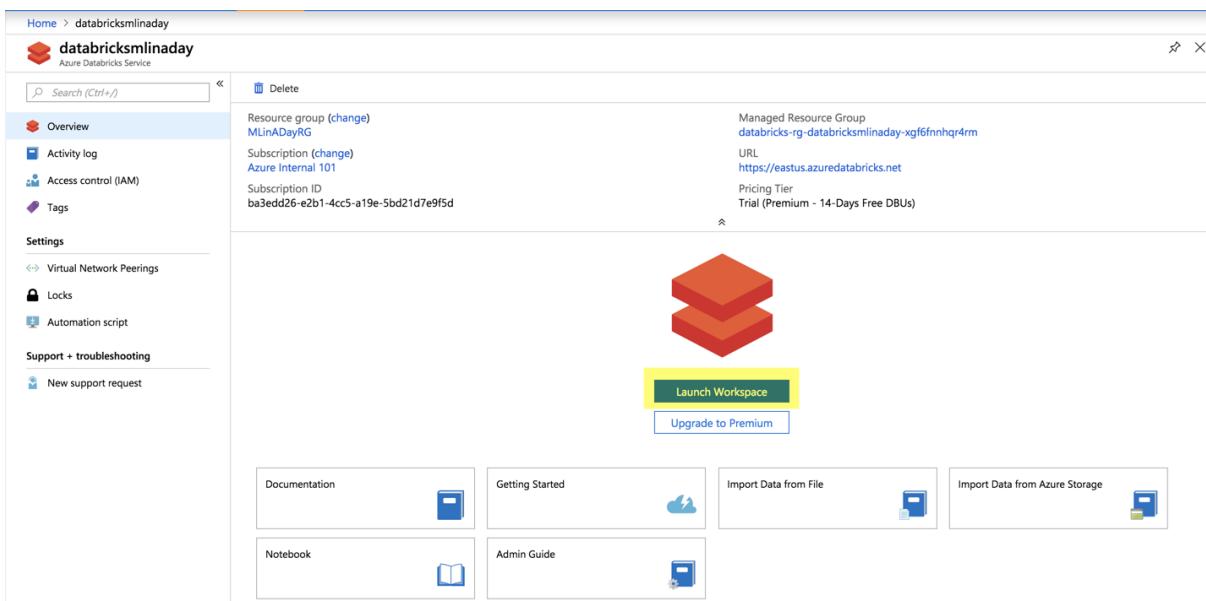
- Fast, easy, and collaborative Apache Spark-based analytics platform**
- Accelerate innovation by enabling data science with a high-performance analytics platform that's optimized for Azure.**
- Drive innovation and increase productivity**
- Bring teams together in an interactive workspace. From data gathering to model creation, use Databricks Notebooks to unify the process and instantly deploy to production. Launch your new Spark environment with a single click. Integrate effortlessly with a wide variety of data stores and services such as [Azure SQL Data Warehouse](#), [Azure Cosmos DB](#), [Azure Data Lake Store](#), [Azure Blob storage](#), and [Azure Event Hub](#). Add advanced artificial intelligence (AI) capabilities instantly and share your insights through rich integration with PowerBI.**
- Build on secure, trusted cloud**
- Protect your data and business with Azure Active Directory integration, role-based controls, and enterprise-grade SLAs. Get peace of mind with fine-grained user permissions, enabling secure access to Databricks Notebooks, clusters, jobs, and data.**
- Scale without limits**
- Globally scale your analytics and data science projects. Build and innovate faster using advanced machine learning capabilities. Add capacity instantly. Reduce cost and complexity with a fully managed, cloud-native platform. Target any size data or project using a complete set of analytics technologies including SQL, Streaming, MLlib, and GraphX.**

A 'Save for later' button is located at the bottom left of the central panel. At the bottom of the page, there's a preview of the Azure portal with a 'Create' button highlighted in yellow.

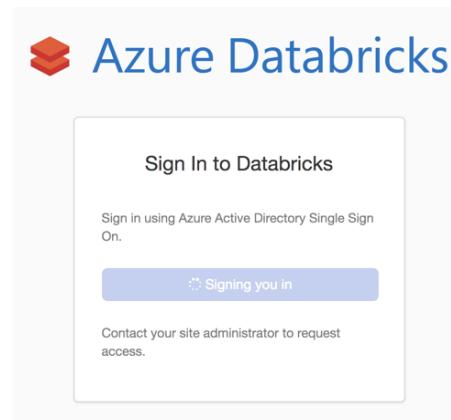
2. Enter the **Workspace** specifications as seen in the following screenshot:



3. Make sure you select the **Trial (Premium 14-Days Free DBUs)** for this specific workshop. Your IT team will thank you later on!
4. Once it has been provisioned, you can go to the resource and **launch the workspace** as seen in the following screenshot:



5. You will then be taken to the Databricks workspace and signed in automatically through your **Azure Active Directory** credentials as seen in the following screenshot:



6. You will then land in the **Azure Databricks** home page. The first thing we will need to do is provision a **new cluster**, as seen in the following screenshot:

A screenshot of the Azure Databricks home page. At the top, there's a Microsoft Azure header with a "PORTAL" tab, a "Free trial ends in 14 days. Upgrade to Premium in Azure Portal" message, and a user profile icon. The main title "Azure Databricks" is at the top center. To the left is a sidebar with icons for Home, Workspace, Recent, Data, Clusters, Jobs, and Search. The main area has three sections: "Explore the Quickstart Tutorial" (with a "New Cluster" button highlighted in yellow), "Import & Explore Data" (with a "Drop files or click to browse" button), and "Create a Blank Notebook" (with a "Create" button). Below these are three tabs: "Common Tasks" (with "New Notebook", "Upload Data", "Create Table", and "New Cluster" buttons), "Recents" (empty), and "Documentation" (with "Databricks Guide", "Python, R, Scala, SQL", and "Importing Data" buttons). The "New Cluster" button under "Common Tasks" is highlighted with a yellow box.

7. For our purposes for this workshop, we will provision a **Standard** mode cluster with **Python Version 3** support called **Machine learning in a Day Cluster** as seen in the following screenshot:

Create Cluster

New Cluster | Cancel | Create Cluster | 2-8 Workers: 28.0-112.0 GB Memory, 8-32 Cores, 1.5-6 DBU
1 Driver: 14.0 GB Memory, 4 Cores, 0.75 DBU Cost \$0.55 per DBU

Cluster Name: Machine Learning in a Day Cluster

Cluster Mode: Standard (selected)

Databricks Runtime Version: 4.2 (includes Apache Spark 2.3.1, Scala 2.11)

Python Version: 3

Driver Type: Same as worker

Worker Type: Standard_DS3_v2 | Min Workers: 2 | Max Workers: 8 | Enable autoscaling (checked)

Auto Termination: Terminate after 120 minutes of inactivity

- Once we select **Create Cluster**, it will begin provisioning and we can move onto creating our first notebook as seen in the following screenshot:

Free trial ends in 14 days. Upgrade to Premium in Azure Portal ?

Azure Databricks

Explore the Quickstart Tutorial
Spin up a cluster, run queries on preloaded data, and display results in 5 minutes.

Import & Explore Data
Quickly import data, preview its schema, create a table, and query it in a notebook.

Create a Blank Notebook
Create a notebook to start querying, visualizing, and modeling your data.

Common Tasks

- New Notebook (highlighted)
- Upload Data
- Create Table
- New Cluster
- New Job
- Import Library
- Read Documentation

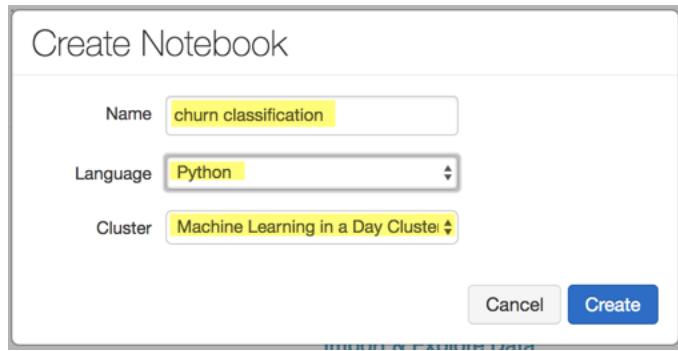
Recents

Recent files appear here as you work.

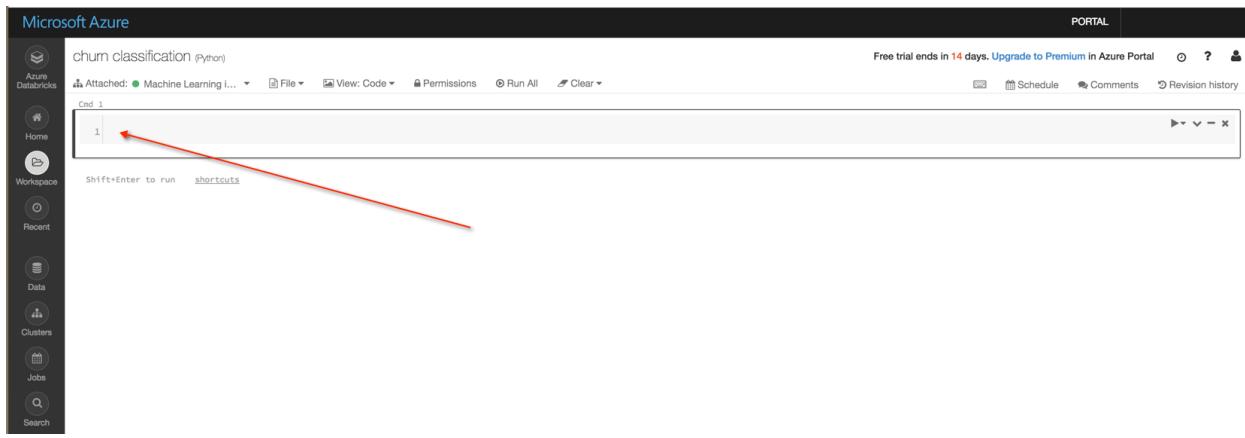
Documentation

- Databricks Guide
- Python, R, Scala, SQL
- Importing Data

- We name our notebook, **churn classification**, and assign it a default language of **Python** with the cluster we just created as seen in the following screenshot:



10. We are now in our notebook where we will be building our machine learning classification model in cells as seen in the following screenshot:



11. We are going to construct our URL to our blob file. This will require using the SAS URL link that we copied from step 26 from the previous section. We will set the URL to a variable and read it into a Spark DataFrame using the following script in the cell:

```
SAS_url =
'https://blobmlinaday.blob.core.windows.net/churn/Telco_Customer_Churn_Cluster.csv
?sp=r&st=2018-09-03T16:59:46Z&se=2018-09-04T00:59:46Z&spr=https&sv=2017-11-
09&sig=GyDm%2FSFyXWAjq3%2BbfwZUhiGBjoNb2X%2F81%2BI2OHKA0Nw%3D&sr=b'
```

Please note that your SAS_url will be different than the one in this documentation

12. Next, we will read our dataset into a Python DataFrame known as pandas as seen in the following screenshot:

```
import pandas as pd
pandas_df = pd.read_csv(SAS_url)

df = spark.createDataFrame(pandas_df)
```

13. The concept of a Dataframe comes from the world of statistical software used in empirical research; it generally refers to "tabular" data: a data structure representing cases (rows), each of which consists of a number of observations or measurements (columns). Think of a spreadsheet in a CSV or Excel format or a table in a SQL database.
14. The script appears as the following in the notebook:

The screenshot shows the Microsoft Azure Databricks workspace interface. On the left is a sidebar with icons for Home, Workspace, Clusters, Jobs, and Search. The main area has tabs for 'churn classification (Python)' and 'Attached: Machine Learning i...'. At the top right, it says 'PORTAL' and 'Free trial ends in 11 days. Upgrade to Premium in Azure Portal'. Below that are buttons for 'Schedule', 'Comments', and 'Revision history'. The workspace contains four command cells (Cmd 1, Cmd 2, Cmd 3, Cmd 4) showing Python code and its execution logs.

```

Cmd 1
1 # Please note your SAS_url link will be different
2 SAS_url = 'https://bloblinaday.blob.core.windows.net/churn/Telco_Customer_Churn_Cluster.csv?sp=r&st=2018-09-03T16:59:46Z&se=2018-09-04T00:59:46Z&spr=https&sv=2017-11-09&sig=GyDm#2FSFyXWAjq3%2BbfwZUyGBjohB2x2F81%2B120HKA0Nw#3D&sr=b'
Command took 0.01 seconds -- by ahsherif@microsoft.com at 9/3/2018, 1:07:50 PM on Machine Learning in a Day Cluster

Cmd 2
1 import pandas as pd
2 pandas_df = pd.read_csv(SAS_url)
Command took 0.26 seconds -- by ahsherif@microsoft.com at 9/3/2018, 1:09:03 PM on Machine Learning in a Day Cluster

Cmd 3
1 df = spark.createDataFrame(pandas_df)
> df: pyspark.sql.dataframe.DataFrame = [customerID: string, gender: string ... 20 more fields]
Command took 1.33 seconds -- by ahsherif@microsoft.com at 9/3/2018, 1:10:23 PM on Machine Learning in a Day Cluster

Cmd 4
1

```

1. The easiest way to create a visualization in Databricks is to call the following script:

```
display(df)
```

2. Our Spark DataFrame, **df**, is created and can be viewed by executing `display(df)` as seen in the following screenshot:

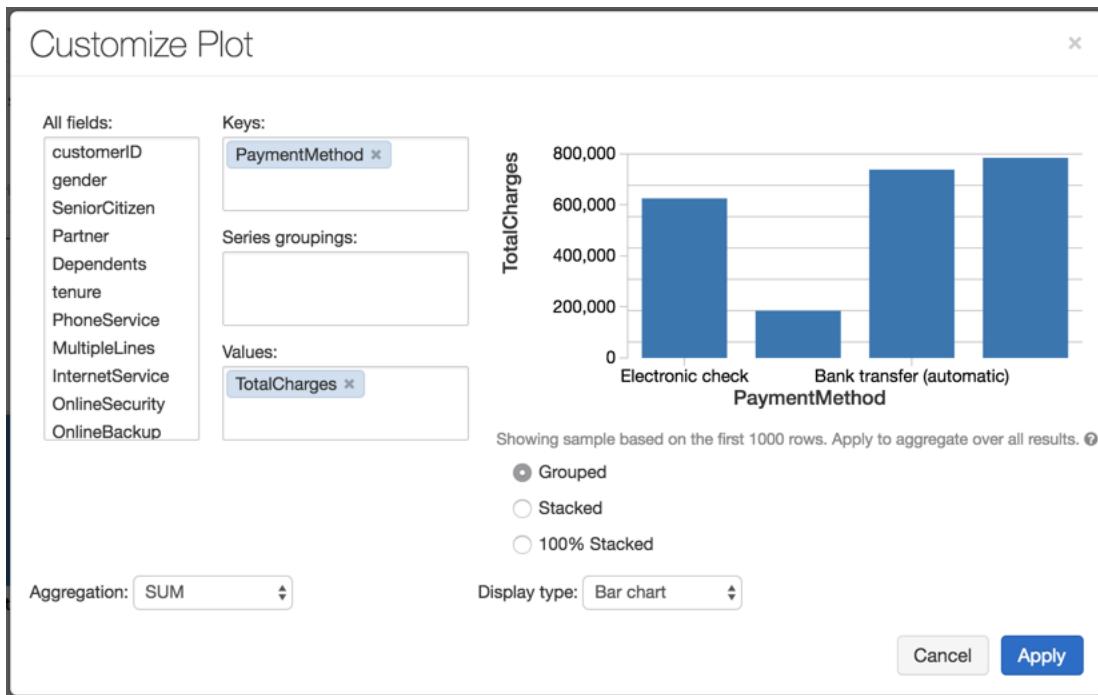
The screenshot shows the Microsoft Azure Databricks workspace interface. It displays the output of the `display(df)` command, which shows a table of 1000 rows from the dataset. An orange arrow points from the bottom of the table to the bar chart icon in the toolbar below it.

customerID	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	MultipleLines	InternetService	OnlineSecurity	OnlineBackup	DeviceProtection	TechSupport	StreamingTV	Stream
7580-VHVEG	Female	0	Yes	No	1	No	No phone service	DSL	No	Yes	No	No	No	No
5575-GNVDE	Male	0	No	No	34	Yes	No	DSL	Yes	No	Yes	No	No	No
3668-QPYBK	Male	0	No	No	2	Yes	No	DSL	Yes	Yes	No	No	No	No
7795-CFOCW	Male	0	No	No	45	No	No phone service	DSL	Yes	No	Yes	Yes	No	No
9237-HQITU	Female	0	No	No	2	Yes	No	Fiber optic	No	No	No	No	No	No
0955-JNSKC	Female	0	No	No	8	Yes	Yes	Fiber optic	No	No	No	No	Yes	Yes

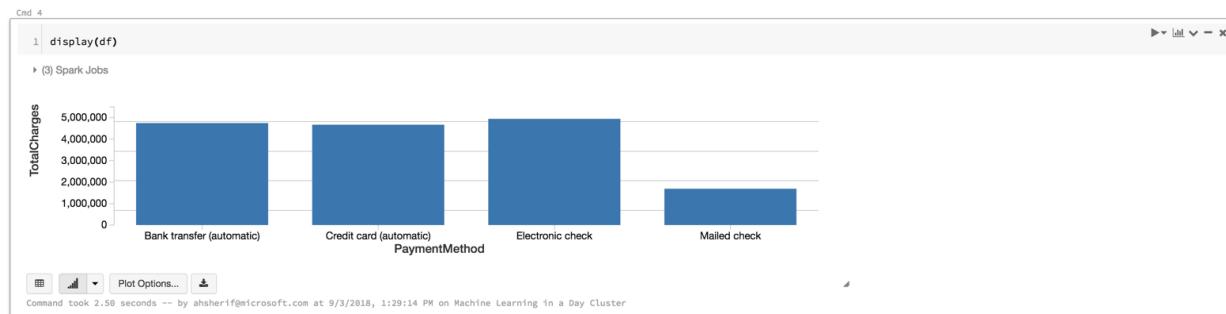
Showing the first 1000 rows.

Command took 2.12 seconds -- by ahsherif@microsoft.com at 9/3/2018, 1:21:44 PM on Machine Learning in a Day Cluster

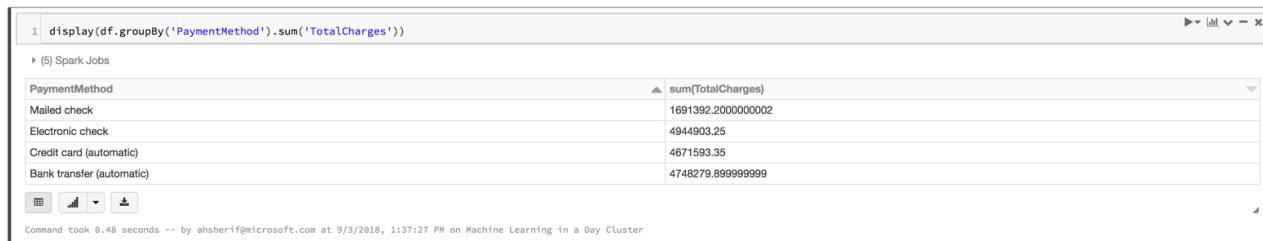
3. Databricks gives us the option to convert DataFrames into visualizations on the fly without having to code them using the bar chart icon underneath the DataFrame. For example, we can create a bar chart with **PaymentMethod** on the x-axis and **TotalCharges** on the y-axis by sum by clicking on the bar chart icon on the bottom of the DataFrame as seen in the following screenshot:



- Once we apply the **keys**, **groupings**, and **values** we can see the output directly within the cell of the notebook as seen in the following screenshot:



- Querying and manipulating DataFrames in Spark is not that hard to learn, especially if you have some existing skills in Python, SQL, or R. We can use Python syntax to do some data analysis and view **TotalCharges** by **PaymentMethod** using the following Python syntax script `display(df.groupBy('PaymentMethod').sum('TotalCharges'))` as seen in the following screenshot:



- However, we can also do the same data analysis using SQL syntax. First, we create a view using the following script: `df.createTempView('sqlView')`.
- Then we create a cell with SQL syntax and execute the following script:

```
%sql
```

```
select PaymentMethod, sum(TotalCharges) from sqlView group by 1 order by 1 asc;
```

8. The output of the script can be seen in the following screenshot:

The screenshot shows a Databricks notebook interface. At the top, it says "churn classification (Python)". Below that, there are tabs for "Attached" (Machine Learning), "File", "View: Code", "Permissions", "Run All", and "Clear". A message at the top right says "Free trial ends in 11 days. Upgrade to Premium in Azure Portal". On the far right are icons for Help, Profile, and Logout.

Two code cells are shown:

Cmd 6

```
1 df.createTempView('sqlView')
```

Command took 0.06 seconds -- by ahsherif@microsoft.com at 9/3/2018, 1:52:46 PM on Machine Learning in a Day Cluster

Cmd 7

1 **sql**
2 **select PaymentMethod, sum(TotalCharges) from sqlView group by 1 order by 1 asc;**

▶ (1) Spark Jobs

PaymentMethod	sum(TotalCharges)
Bank transfer (automatic)	4748279.899999999
Credit card (automatic)	4671593.35
Electronic check	4944903.25
Mailed check	1691392.200000004

Command took 0.71 seconds -- by ahsherif@microsoft.com at 9/3/2018, 1:53:24 PM on Machine Learning in a Day Cluster

9. The results should match exactly what we had in the Python Script output. At this point we are ready to move on from just doing some data analysis with Spark on Databricks.

Section 6: Implementing Engineering Techniques to Enhance data for Machine Learning

1. Feature engineering is the process of using domain knowledge of the data to create features that make machine learning algorithms work. Feature engineering is fundamental to the application of machine learning and is both difficult and expensive. It is often stated that feature engineering takes roughly 80% of the time from a data scientist's day job.
2. The classification goal is to predict whether the customer will leave or churn (**Yes/No**).
3. We can take a look at our distribution of **Churn** by frequency to see what our distribution of churned customers we have in our sample set by executing the following script as seen in the following screenshot:

```
display(df.groupBy('Churn').count())
```

	count
No	5163
Yes	1869

4. So, about 27% or **1,869** of the customers that we have were churned versus 73% or **5,163** that remained with the company within the last year. Finally, we can take a look at the clusters that we created over in AML studio and see once again how they were distributed amongst the 10 clusters (0-9) that we created for them using the following script, , as seen in the following screenshot:

```
%sql
```

```
select Assignments, count(*) as Total_Count from sqlView group by 1 order by 2 desc;
```

Assignments	Total_Count
6	1992
0	1129
5	957
8	590
3	488
1	442
7	433
4	409
9	344
2	248

5. We have the ability to see the schema of the DataFrame by executing `df.printSchema()` as seen in the following screenshot:

```
Cmd 9
1 df.printSchema()

root
|-- customerID: string (nullable = true)
|-- gender: string (nullable = true)
|-- SeniorCitizen: long (nullable = true)
|-- Partner: string (nullable = true)
|-- Dependents: string (nullable = true)
|-- tenure: long (nullable = true)
|-- PhoneService: string (nullable = true)
|-- MultipleLines: string (nullable = true)
|-- InternetService: string (nullable = true)
|-- OnlineSecurity: string (nullable = true)
|-- OnlineBackup: string (nullable = true)
|-- DeviceProtection: string (nullable = true)
|-- TechSupport: string (nullable = true)
|-- StreamingTV: string (nullable = true)
|-- StreamingMovies: string (nullable = true)
|-- Contract: string (nullable = true)
|-- PaperlessBilling: string (nullable = true)
|-- PaymentMethod: string (nullable = true)
|-- MonthlyCharges: double (nullable = true)
|-- TotalCharges: double (nullable = true)
|-- Churn: string (nullable = true)
|-- Assignments: long (nullable = true)

Command took 0.02 seconds -- by ahsherif@microsoft.com at 9/3/2018, 7:37:56 PM on Machine Learning in a Day Cluster
```

6. While most fields are string, we do have some that are **long** integer and some that are **double**. Other than **customerID**, all of the variables will be our independent variables (**what we will use to predict**) and **Churn** will be our dependent variable (**what we are predicting**).
7. For the purposes of machine learning, these string or categorical variables will need to be encoded to numeric variables. First, we will start with the **Churn** column and assign a value of 0 for **No** and 1 for **Yes** using the following script as seen in the following screenshot:

```
from pyspark.sql import functions as F
df = df.withColumn('Churn', F.when(df['Churn']=='Yes', 1).otherwise(0))
```

```
1 from pyspark.sql import functions as F
2 df = df.withColumn('Churn', F.when(df['Churn']=='Yes', 1).otherwise(0))

▼ df: pyspark.sql.dataframe.DataFrame
  customerID: string
  gender: string
  SeniorCitizen: long
  Partner: string
  Dependents: string
  tenure: long
  PhoneService: string
  MultipleLines: string
  InternetService: string
  OnlineSecurity: string
  OnlineBackup: string
  DeviceProtection: string
  TechSupport: string
  StreamingTV: string
  StreamingMovies: string
  Contract: string
  PaperlessBilling: string
  PaymentMethod: string
  MonthlyCharges: double
  TotalCharges: double
  Churn: integer
  Assignments: long

Command took 0.13 seconds -- by ahsherif@microsoft.com at 9/3/2018, 8:34:14 PM on Machine Learning in a Day Cluster
```

8. `pyspark.sql.functions` help apply SQL-type functionality to DataFrames for manipulation.
9. The **Churn** column is now converted to an **integer** data type from a **string** data type. We can identify all of our string or categorical columns by executing the following script and seeing the output in the following screenshot:

```
categorical_variables = [i[0] for i in df.dtypes if i[1] == 'string']
```

Cmd 13

```
1 categorical_variables = [i[0] for i in df.dtypes if i[1] == 'string']
```

Command took 0.01 seconds -- by ahsherif@microsoft.com at 9/3/2018, 8:51:36 PM on Machine Learning in a Day Cluster

Cmd 14

```
1 categorical_variables
```

Out[35]:

```
['customerID',
'gender',
'Partner',
'Dependents',
'PhoneService',
'MultipleLines',
'InternetService',
'OnlineSecurity',
'OnlineBackup',
'DeviceProtection',
'TechSupport',
'StreamingTV',
'StreamingMovies',
'Contract',
'PaperlessBilling',
'PaymentMethod']
```

Command took 0.01 seconds -- by ahsherif@microsoft.com at 9/3/2018, 8:51:44 PM on Machine Learning in a Day Cluster

10. We have 16 categorical variables, but only 15 of them are useful from a machine learning perspective as **customerID** does not provide any intrinsic value. Therefore, we can remove it from our list of columns by executing the following script as seen in the following screenshot:

```
categorical_variables = categorical_variables[1:]
```

```
1 categorical_variables = categorical_variables[1:]
2 categorical_variables
```

Out[37]:

```
['gender',
'Partner',
'Dependents',
'PhoneService',
'MultipleLines',
'InternetService',
'OnlineSecurity',
'OnlineBackup',
'DeviceProtection',
'TechSupport',
'StreamingTV',
'StreamingMovies',
'Contract',
'PaperlessBilling',
'PaymentMethod']
```

Command took 0.01 seconds -- by ahsherif@microsoft.com at 9/3/2018, 8:55:35 PM on Machine Learning in a Day Cluster

11. **StringIndexer** encodes a string column of labels to a column of label indices. The indices are in [0, numLabels), ordered by label frequencies, so the most frequent label gets index 0. The unseen labels will be put at index numLabels if user chooses to keep them. If the input column is numeric, we cast it to string and index the string values.

12. We import **StringIndexer** to transform each categorical column into a numeric column with a **_numeric** suffix using the following script (Python Script is whitespace sensitive, so keep the formatting on the tabs and indents, otherwise you will receive an error):

```
from pyspark.ml.feature import StringIndexer
indexers = []
for categoricalCol in categorical_variables:
    stringIndexer = StringIndexer(inputCol=categoricalCol,
outputCol=categoricalCol+"_numeric")
    indexers += [stringIndexer]
```

```
1 from pyspark.ml.feature import StringIndexer
2 indexers = []
3 for categoricalCol in categorical_variables:
4     stringIndexer = StringIndexer(inputCol=categoricalCol, outputCol=categoricalCol+"_numeric")
5     indexers += [stringIndexer]
```

Command took 0.11 seconds -- by ahsherif@microsoft.com at 9/3/2018, 9:12:53 PM on Machine Learning in a Day Cluster

13. Next, we will apply the transformation on the DataFrame using the following script:

```
models = []
for model in indexers:
    indexer_model = model.fit(df)
    models+=[indexer_model]

for i in models:
    df = i.transform(df)
```

14. The output of the DataFrame should now reveal the newly added columns when executing the `df.printSchema` script as seen in the following screenshot:

```
1 models = []
2 for model in indexers:
3     indexer_model = model.fit(df)
4     models+=[indexer_model]
5
6 for i in models:
7     df = i.transform(df)

> (16) Spark Jobs
> df: pyspark.sql.dataframe.DataFrame = [customerID: string, gender: string ... 35 more fields]

Command took 2.72 seconds -- by ahsherif@microsoft.com at 9/3/2018, 9:12:54 PM on Machine Learning in a Day Cluster
```

Cmd 18

```
1 df.printSchema

Out[22]: <bound method DataFrame.printSchema of DataFrame[customerID: string, gender: string, SeniorCitizen: bigint, Partner: string, Dependents: string, tenure: bigint, PhoneService: string, MultipleLines: string, InternetService: string, OnlineSecurity: string, OnlineBackup: string, DeviceProtection: string, TechSupport: string, StreamingTV: string, StreamingMovies: string, Contract: string, PaperlessBilling: string, PaymentMethod: string, MonthlyCharges: double, TotalCharges: double, Churn: int, Assignments: bigint, gender_numeric: double, Partner_numeric: double, Dependents_numeric: double, PhoneService_numeric: double, MultipleLines_numeric: double, InternetService_numeric: double, OnlineSecurity_numeric: double, OnlineBackup_numeric: double, DeviceProtection_numeric: double, TechSupport_numeric: double, StreamingTV_numeric: double, StreamingMovies_numeric: double, Contract_numeric: double, PaperlessBilling_numeric: double, PaymentMethod_numeric: double]>
```

Command took 0.01 seconds -- by ahsherif@microsoft.com at 9/3/2018, 10:04:56 PM on Machine Learning in a Day Cluster

15. Every column ending with **_numeric** has a **double** precision data type. We can do a side-by-side comparison of one of the columns, `PaymentMethod`, to see how the **_numeric** column compares to the string column by executing the following script and seeing the output in the following screenshot:

```
display(df.select('PaymentMethod', 'PaymentMethod_numeric'))
```

```
1 display(df.select('PaymentMethod', 'PaymentMethod_numeric'))
```

▶ (2) Spark Jobs

PaymentMethod	PaymentMethod_numeric
Electronic check	0
Mailed check	1
Mailed check	1
Bank transfer (automatic)	2
Electronic check	0
Electronic check	0
Credit card (automatic)	3
Mailed check	1
Electronic check	0

Showing the first 1000 rows.

Command took 0.30 seconds -- by ahsherif@microsoft.com at 9/3/2018, 10:46:17 PM on Machine Learning in a Day Cluster

16. We have two columns, **MonthlyCharges** and **TotalCharges**, that need to be normalized from their original values. They are considered continuous variables and not categorical variables.
17. Normalization is a technique often applied as part of data preparation for machine learning. The goal of normalization is to change the values of numeric columns in the dataset to use a common scale, without distorting differences in the ranges of values or losing information. Normalization is also required for some algorithms to model the data correctly. For example, assume your input dataset contains one column with values ranging from 0 to 1, and another column with values ranging from 10,000 to 100,000. The great difference in the scale of the numbers could cause problems when you attempt to combine the values as features during modeling.
18. Normalization avoids these problems by creating new values that maintain the general distribution and ratios in the source data, while keeping values within a scale applied across all numeric columns used in the model.
19. We can make these transformations using the following script as seen in the output in the following screenshot:

```
from pyspark.sql.functions import min, max

minMonthly = df.agg(min(df.MonthlyCharges)).head()[0]
maxMonthly = df.agg(max(df.MonthlyCharges)).head()[0]

minTotal = df.agg(min(df.TotalCharges)).head()[0]
maxTotal = df.agg(max(df.TotalCharges)).head()[0]

df = df.withColumn('MonthlyCharges_Normalized',
                    (df.MonthlyCharges - minMonthly)/(maxMonthly-minMonthly))
df = df.withColumn('TotalCharges_Normalized',
                    (df.TotalCharges - minTotal)/(maxTotal-minTotal))
```

```

1 from pyspark.sql.functions import min, max
2
3 minMonthly = df.agg(min(df.MonthlyCharges)).head()[0]
4 maxMonthly = df.agg(max(df.MonthlyCharges)).head()[0]
5
6 minTotal = df.agg(min(df.TotalCharges)).head()[0]
7 maxTotal = df.agg(max(df.TotalCharges)).head()[0]
8
9
10 df = df.withColumn('MonthlyCharges_Normalized', (df.MonthlyCharges - minMonthly)/(maxMonthly-minMonthly))
11 df = df.withColumn('TotalCharges_Normalized', (df.TotalCharges - minTotal)/(maxTotal-minTotal))
12 |

```

▶ (4) Spark Jobs
▶ df: pyspark.sql.dataframe.DataFrame = [customerID: string, gender: string ... 22 more fields]

Command took 0.83 seconds -- by ahsherif@microsoft.com at 9/4/2018, 10:07:01 AM on Machine Learning in a Day Cluster

20. We can do a side-by-side comparison of the original **MonthlyCharges** column with the newly added **MonthlyCharges_Normalized** column by executing the following script and seeing the output in the following screenshot:

MonthlyCharges	MonthlyCharges_Normalized
29.85	0.11542288557213931
56.95	0.3850746268656717
53.85	0.35422885572139307
42.3	0.23930348258706466
70.7	0.5218905472636817
99.65	0.809950248756219
89.1	0.7049751243781094
29.75	0.11442786069651742

Showing the first 1000 rows.

Command took 0.21 seconds -- by ahsherif@microsoft.com at 9/4/2018, 10:07:04 AM on Machine Learning in a Day Cluster

21. We have now completed our feature engineering process and we are ready to assign the columns that we will use as the final features for making our machine learning model work as efficiently as possible. The final **features** will be selected using the following script:

```

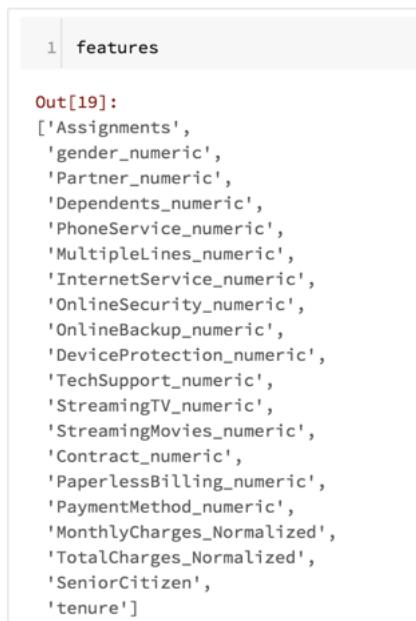
features = [
    'Assignments',

    'gender_numeric',
    'Partner_numeric',
    'Dependents_numeric',
    'PhoneService_numeric',
    'MultipleLines_numeric',
    'InternetService_numeric',
    'OnlineSecurity_numeric',
    'OnlineBackup_numeric',
    'DeviceProtection_numeric',
    'TechSupport_numeric',
    'StreamingTV_numeric',
    'StreamingMovies_numeric',
    'Contract_numeric',
    'PaperlessBilling_numeric',
]

```

```
'PaymentMethod_numeric',
'MonthlyCharges_Normalized',
'TotalCharges_Normalized',
'SeniorCitizen',
'tenure'
]
```

22. The output of the new list of columns can be seen in the following screenshot:



The screenshot shows a Jupyter Notebook cell with the title "1 features". The code cell contains the following output:

```
Out[19]:
['Assignments',
 'gender_numeric',
 'Partner_numeric',
 'Dependents_numeric',
 'PhoneService_numeric',
 'MultipleLines_numeric',
 'InternetService_numeric',
 'OnlineSecurity_numeric',
 'OnlineBackup_numeric',
 'DeviceProtection_numeric',
 'TechSupport_numeric',
 'StreamingTV_numeric',
 'StreamingMovies_numeric',
 'Contract_numeric',
 'PaperlessBilling_numeric',
 'PaymentMethod_numeric',
 'MonthlyCharges_Normalized',
 'TotalCharges_Normalized',
 'SeniorCitizen',
 'tenure']
```

23. We will apply **VectorAssembler** to all of our features. VectorAssembler is a transformer that combines a given list of columns into a single vector column. It is useful for combining raw features and features generated by different feature transformers into a single feature vector, in order to train ML models like logistic regression. We can specify which columns will be vectorized by applying the following script:

```
from pyspark.ml.feature import VectorAssembler

feature_vectors = VectorAssembler(
    inputCols = features,
    outputCol = "features")
```

24. We can transform the DataFrame to include the newly created column, **features**, by executing the following script:
- ```
df = feature_vectors.transform(df)
```

25. We can see the output of the field, **features**, by executing `display(df.select('features'))`, as seen in the following screenshot:

```
1 display(df.select('features'))
```

▶ (2) Spark Jobs

**features**

```
▶ [0,20,[0,1,2,4,5,6,8,16,17,19],[6,1,1,1,2,1,1,0.11542288557213931,0.001275098084468036,1]]
▶ [0,20,[0,6,7,9,13,14,15,16,17,19],[8,1,1,1,2,1,1,0.3850746268656717,0.21586660512347103,34]]
▶ [0,20,[0,6,7,8,15,16,17,19],[6,1,1,1,1,0.35422885572139307,0.010310408492960998,2]]
▶ [1,20,],[5,0,0,0,1,2,1,1,0,1,1,0,0,2,1,2,0.23930348258706466,0.21024117239787676,0,45]
▶ [0,20,[0,1,16,17,19],[6,1,0.5218905472636817,0.015330025386568196,2]]
▶ [0,20,[1,5,9,11,12,16,17,19],[1,1,1,1,1,0.809950248756219,0.09251096238172167,8]]
▶ [0,20,[0,3,5,8,11,15,16,17,19],[8,1,1,1,1,3,0.7049751243781094,0.22277867528271408,22]]
▶ [0,20,[0,1,4,5,6,7,14,15,16,17,19],[6,1,1,2,1,1,1,1,0.11442786069651742,0.03266789753057927,10]]
```

Showing the first 1000 rows.

grid chart download copy

26. There are only two columns now that are of interest to us: **Churn** and **features**. **Churn** is our label column that we are trying to predict, and **features** is our predictor column that is combined with all of our predictor variables in one vector as seen in the following screenshot:

```
1 display(df.select('Churn', 'features'))
```

▶ (2) Spark Jobs

| Churn | features                                                                                         |
|-------|--------------------------------------------------------------------------------------------------|
| 0     | [0,20,[0,1,2,4,5,6,8,16,17,19],[6,1,1,1,2,1,1,0.11542288557213931,0.001275098084468036,1]]       |
| 0     | [0,20,[0,6,7,9,13,14,15,16,17,19],[8,1,1,1,2,1,1,0.3850746268656717,0.21586660512347103,34]]     |
| 1     | [0,20,[0,6,7,8,15,16,17,19],[6,1,1,1,1,0.35422885572139307,0.010310408492960998,2]]              |
| 0     | [1,20,],[5,0,0,0,1,2,1,1,0,1,1,0,0,2,1,2,0.23930348258706466,0.21024117239787676,0,45]           |
| 1     | [0,20,[0,1,16,17,19],[6,1,0.5218905472636817,0.015330025386568196,2]]                            |
| 1     | [0,20,[1,5,9,11,12,16,17,19],[1,1,1,1,1,0.809950248756219,0.09251096238172167,8]]                |
| 0     | [0,20,[0,3,5,8,11,15,16,17,19],[8,1,1,1,1,3,0.7049751243781094,0.22277867528271408,22]]          |
| 0     | [0,20,[0,1,4,5,6,7,14,15,16,17,19],[6,1,1,2,1,1,1,1,0.11442786069651742,0.03266789753057927,10]] |

Showing the first 1000 rows.

grid chart download copy

27. One final modification we will make is convert the name **Churn** into **label** as it will better generalize the purpose of that field. We execute the following script, `df = df.withColumnRenamed('Churn', 'label')`, to rename the existing field to **label**. The output of the script can be seen by scrolling down to the location where **Churn** was and now seeing it replaced with **label** as seen in the following screenshot:

```
1 df = df.withColumnRenamed('Churn', 'label')

▼ df: pyspark.sql.dataframe.DataFrame
 MonthlyCharges: double
 TotalCharges: double
 label: integer
 Assignments: long
 MonthlyCharges_Normalized: double
 TotalCharges_Normalized: double
 gender_numeric: double
 Partner_numeric: double
 Dependents_numeric: double
 PhoneService_numeric: double
 MultipleLines_numeric: double
 InternetService_numeric: double
 OnlineSecurity_numeric: double
 OnlineBackup_numeric: double
 DeviceProtection_numeric: double
 TechSupport_numeric: double
 StreamingTV_numeric: double
 StreamingMovies_numeric: double
 Contract_numeric: double
 PaperlessBilling_numeric: double
 PaymentMethod_numeric: double
 ▼ features: udt
```

## Section 7: Apply Classification Supervised Model with Logistic Regression on Azure Databricks

1. Logistic regression is a method for classifying data into discrete outcomes. For example, we might use logistic regression to classify a customer as **Y** or **N** for Churn.
2. In machine learning we usually split our data into two subsets: training data and testing data (sometimes we even split them into three: train, validate and test), and fit our model on the train data, in order to make predictions on the test data. This is used to help solve the problem of overfitting. Overfitting is the problem of fitting your model so well to the data that you have but not taking into consideration future data points. It lacks generality.
3. We split our data into a testing and training dataset using the following script with the output in the following screenshot:  
`trainDF, testDF = df.randomSplit([0.8, 0.2], seed = 1234)`

```
1 trainDF, testDF = df.randomSplit([0.8, 0.2], seed = 1234)

▶ [trainDF: pyspark.sql.dataframe.DataFrame = [customerID: string, gender: string ... 38 more fields]
▶ [testDF: pyspark.sql.dataframe.DataFrame = [customerID: string, gender: string ... 38 more fields]

Command took 0.05 seconds -- by ahsherif@microsoft.com at 9/4/2018, 10:53:01 AM on Machine Learning in a Day Cluster
```

4. The randomness is set to **1234** for reproducibility.
5. We can see the number of rows from our original DataFrame assigned to test versus train by executing the following script with the output seen in the following screenshot:

```
print('training data: '+str(trainDF.count()), ', testing data:
'+str(testDF.count()))
```

```
1 print('training data: '+str(trainDF.count()), ', testing data: '+str(testDF.count()))

▶ (2) Spark Jobs
training data: 5640 , testing data: 1392
```

6. Next, we want to build out our **logistic regression classification** model pipeline and **fit** it on our training DataFrame using the following script:

```
from pyspark.ml.classification import LogisticRegression
logreg = LogisticRegression(labelCol="label", featuresCol="features", maxIter=10)
LogisticRegressionModel = logreg.fit(trainDF)
```

7. Next, we test the model against our test DataFrame, **testDF**, using the following script to create a new DataFrame called **predictedDF**:

```
predictedDF = LogisticRegressionModel.transform(testDF)
```

8. The output of our predicted values along with the original label can be seen by executing the following script with the output in the following screenshot:

```
display(predictedDF.select('label', 'probability', 'prediction'))
```

|                              |                                                                   |
|------------------------------|-------------------------------------------------------------------|
| 1                            | display(predictedDF.select('label', 'probability', 'prediction')) |
| ▶ (3) Spark Jobs             |                                                                   |
| label                        | probability                                                       |
| 0                            | ▶ [1,2,][0.2453414700108091,0.7546585299891908]                   |
| 0                            | ▶ [1,2,][0.8531850801244731,0.14681491987552686]                  |
| 0                            | ▶ [1,2,][0.9156653394194328,0.0843346605805672]                   |
| 0                            | ▶ [1,2,][0.5615028194673514,0.4384971805326486]                   |
| 1                            | ▶ [1,2,][0.5183021325512303,0.4816978674487698]                   |
| 1                            | ▶ [1,2,][0.6351426553451417,0.36485734465485836]                  |
| 1                            | ▶ [1,2,][0.5640926911816028,0.4359073088183972]                   |
| 0                            | ▶ [1,2,][0.873286076625449,0.12671392337455098]                   |
| Showing the first 1000 rows. |                                                                   |
|                              |                                                                   |

9. In the field of machine learning, a *confusion matrix*, is a specific table layout that allows visualization of the performance of an algorithm, typically a supervised learning one (in unsupervised learning it is usually called a matching matrix). Each row of the matrix represents the instances in a predicted class while each column represents the instances in an actual class.
10. We can create a confusion matrix to identify *False Positives*, *False Negatives*, *True Positives*, and *True Negatives* using the following script with the output seen in the following screenshot:

```
display(predictedDF.crosstab('label', 'prediction'))
```

|                  |                                                      |
|------------------|------------------------------------------------------|
| 1                | display(predictedDF.crosstab('label', 'prediction')) |
| ▶ (5) Spark Jobs |                                                      |
| label_prediction | 0.0 1.0                                              |
| 1                | 171 206                                              |
| 0                | 910 105                                              |
|                  |                                                      |

11. We made **910 + 206 = 1,116** correct predictions and **171+105 = 276** false predictions for an overall accuracy of ~ **80%**
12. We can calculate the accuracy of the model by executing the following script and view the output as seen in the following screenshot:

```
from sklearn import metrics

actual = predictedDF.select('label').toPandas()
predicted = predictedDF.select('prediction').toPandas()
print('accuracy score = {}'.format(metrics.accuracy_score(actual, predicted)*100))
```

```
1 from sklearn import metrics
2
3 actual = predictedDF.select('label').toPandas()
4 predicted = predictedDF.select('prediction').toPandas()
5 print('accuracy score = {}'.format(metrics.accuracy_score(actual, predicted)*100))
```

▶ (2) Spark Jobs  
accuracy score = 80.17241379310344

13. In addition, the *ROC* (Receiver Operating Characteristic) Curve or Area Under the Curve is another way to measure the performance of the model. The ROC curve is created by plotting the true positive rate (TPR) against the false positive rate (FPR) at various threshold settings. The true-positive rate is also known as sensitivity, recall or probability of detection in machine learning. The false-positive rate is also known as the fall-out or probability of false alarm[1] and can be calculated as  $(1 - \text{specificity})$ .
14. We can calculate the ROC or Area Under the Curve by executing the following script and see the output as seen in the following screenshot:

```
from pyspark.ml.evaluation import BinaryClassificationEvaluator
evaluator = BinaryClassificationEvaluator()
print('ROC score = {}'.format(round(evaluator.evaluate(predictedDF)*100,2)))
```

```
1 from pyspark.ml.evaluation import BinaryClassificationEvaluator
2
3 evaluator = BinaryClassificationEvaluator()
4 print('ROC score = {}'.format(round(evaluator.evaluate(predictedDF)*100,2)))
```

▶ (4) Spark Jobs  
ROC score = 85.32

15. We have a high ROC score of **85.32%**. The higher the score or closer it is to 100% the better.

## Section 8: Export predicted DataFrame from Spark on Azure Databricks to Power BI for visualizations

1. We are able to stream our DataFrames from Spark on Azure Databricks to other Business Intelligence tools such as Power BI, Tableau, and Alteryx.

2. First, we will create another view that called **PredictionScoresDF** using the following script:

```
predictedDF.createOrReplaceTempView('PredictionScoresDF')
```

3. Next, we will create a table, **PredictionScore**, accessible outside of Spark using the following script:

```
%sql
create table PredictionScore as
select * from PredictionScoresDF;
```

4. We can then see this table, **PredictionScore**, outside of the notebook and within the Data section within Databricks as seen in the following screenshot:

The screenshot shows the Azure Databricks interface. On the left, there's a sidebar with icons for Home, Workspace, Recent, Data (which is selected), Clusters, Jobs, and Search. The main area is titled "churn classification (Python)". It shows a notebook with two cells. The first cell contains the Python code `predictedDF.createOrReplaceTempView('PredictionScoresDF')` and runs successfully. The second cell contains the SQL command `%sql create table PredictionScore as select \* from PredictionScoresDF;` and also runs successfully, creating the table in the default database. Arrows point from the "Data" icon in the sidebar to both the "Tables" list and the newly created "predictionscore" table.

5. When clicking on the table, **predictionscore**, within Databricks, we can view both the **sample data** as well as the **schema** inside of the table as seen in the following screenshot:

This screenshot shows the "predictionscore" table details in the Databricks Data section. The top part displays the table schema with columns like col\_name, customerID, gender, SeniorCitizen, Partner, Dependents, tenure, PhoneService, MultipleLines, InternetService, OnlineSecurity, OnlineBackup, DeviceProtection, TechSupport, StreamingTV, StreamingMovies, and Contract. The bottom part shows a "Sample Data" table with two rows of sample data. The first row is for customerID 0064-SUDOG, and the second row is for customerID 0164-XAIPR.

| customerID | gender | SeniorCitizen | Partner | Dependents | tenure | PhoneService | MultipleLines | InternetService | OnlineSecurity      | OnlineBackup        | DeviceF             |
|------------|--------|---------------|---------|------------|--------|--------------|---------------|-----------------|---------------------|---------------------|---------------------|
| 0064-SUDOG | Female | 0             | Yes     | Yes        | 12     | Yes          | No            | No              | No internet service | No internet service | No internet service |
| 0164-XAIPR | Female | 0             | No      | No         | 24     | Yes          | No            | No              | No internet service | No internet service | No internet service |

6. Next, we will click on the **Clusters** icon on the left-hand side of the menu and select our current cluster, **Machine Learning in a Day Cluster**, as seen in the following screenshot:

The screenshot shows the Azure Databricks Clusters page. On the left, there's a sidebar with icons for Home, Workspace, Recent, Data, and Clusters. The 'Clusters' icon is highlighted with a red arrow. The main area shows a table of clusters. One cluster, 'Machine Learning in a Day Cluster', is highlighted with a yellow box and has a green dot next to its name. The table columns include Name, State, Nodes, Driver, Worker, Runtime, Creator, and Actions. At the top right, it says 'Free trial ends in 10 days. Upgrade to Premium in Azure Portal'.

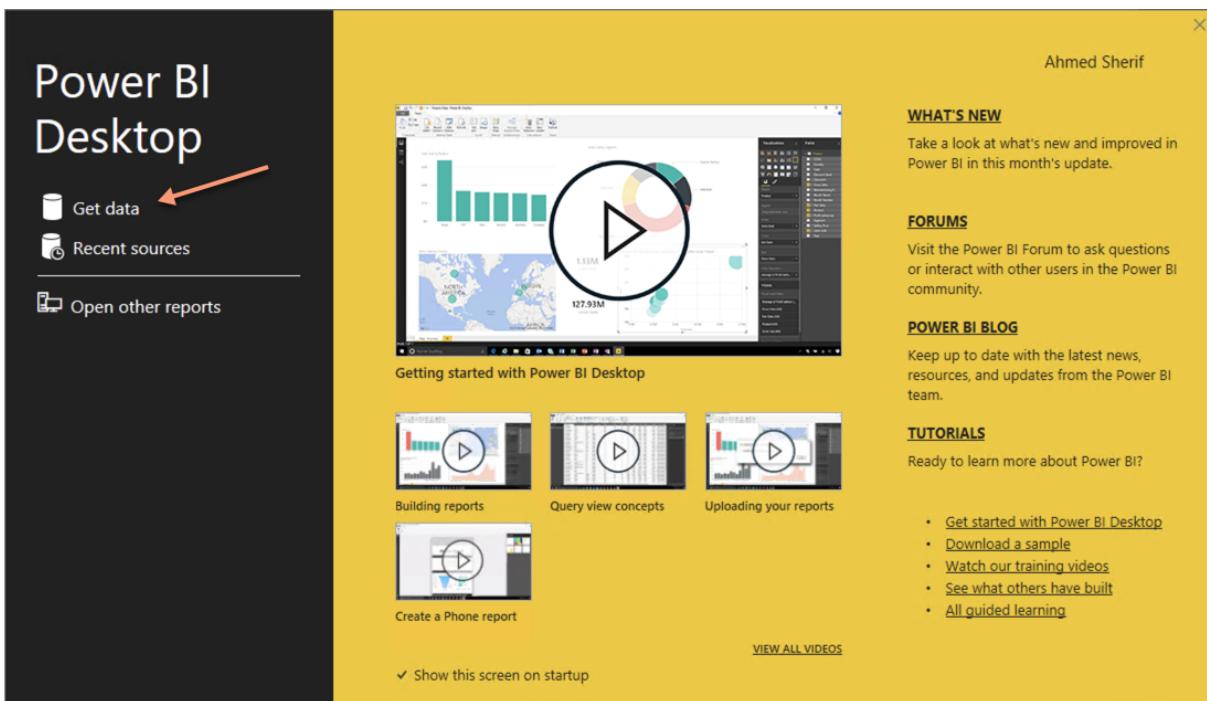
7. Once inside the cluster, click on the **JDBC/ODBC** tab and click on the link in the bottom **To Learn More About Connecting your Favorite BI Tools to Databricks**.

The screenshot shows the configuration page for the 'Machine Learning in a Day Cluster'. The sidebar has icons for Home, Workspace, Recent, Data, Clusters (which is selected), Jobs, and Search. The main page title is 'Clusters / Machine Learning in a Day Cluster'. It shows basic cluster settings like Worker Type (Standard\_DS3\_v2), Min Workers (2), Max Workers (8), and Auto Termination (set to terminate after 120 minutes of inactivity). Below these, the 'JDBC/ODBC' tab is selected. It displays connection details: Server Hostname (eastus.azuredatabricks.net), Port (443), Protocol (HTTPS), and HTTP Path (sql/protocolv1/o/2535530955171549/0831-164140-ayes780). Under JDBC URL, two examples are shown: jdbc:hive2://eastus.azuredatabricks.net:443/default;transportMode=http;ssl=true;httpPath=sql/protocolv1/o/2535530955171549/0831-164140-ayes780 and jdbc:hive2://eastus.azuredatabricks.net:443/default;transportMode=http;ssl=true;httpPath=sql/protocolv1/o/2535530955171549/machine-learning-in-a-day-cluster. At the bottom, a green box contains the text 'Learn more about connecting your favorite BI tool to Databricks.' with a link.

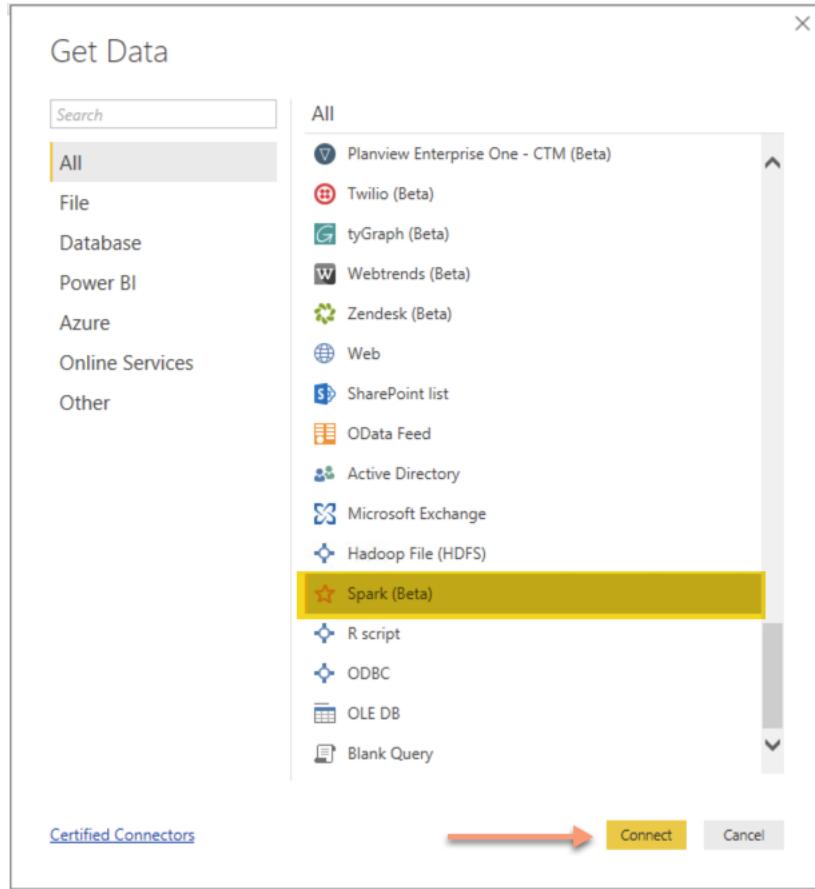
8. Select **Power BI** as the **Business Intelligence tool** of choice for connecting to Databricks as seen in the following screenshot:

The screenshot shows the Azure Databricks documentation for Business Intelligence Tools. The left sidebar has a 'Business Intelligence Tools' section under 'Getting Started Guide'. The 'Power BI' item is highlighted with a yellow box. The main content area has a yellow header 'Business Intelligence Tools' and a sub-section 'General instructions' with a bullet point 'Connecting BI Tools'. Below that is a 'Tools' section with 'Power BI' listed. At the bottom, there are 'PREVIOUS' and 'NEXT' buttons.

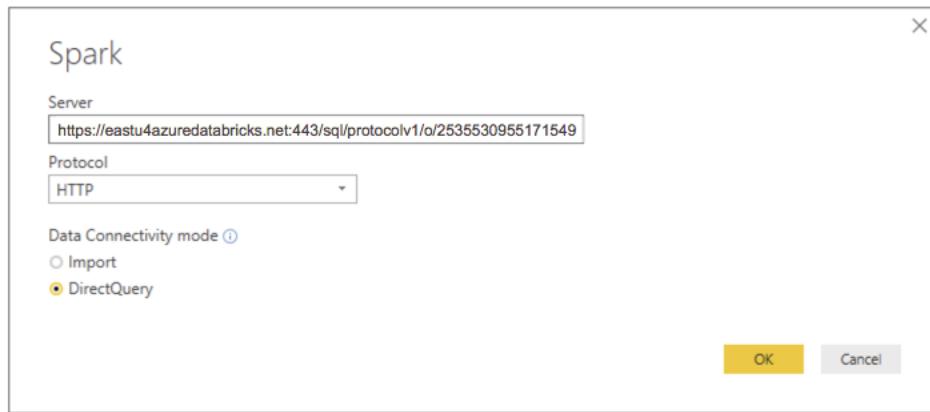
9. Databricks should have step-by-step directions for connecting Tables from Spark to Power BI as found in the following link: <https://docs.azuredatabricks.net/user-guide/bi/power-bi.html>
10. There should be a Power BI desktop installation already available in our Data Science Virtual machine that we can use. When we sign into Power BI, we will first select **Get Data** as seen in the following screenshot:



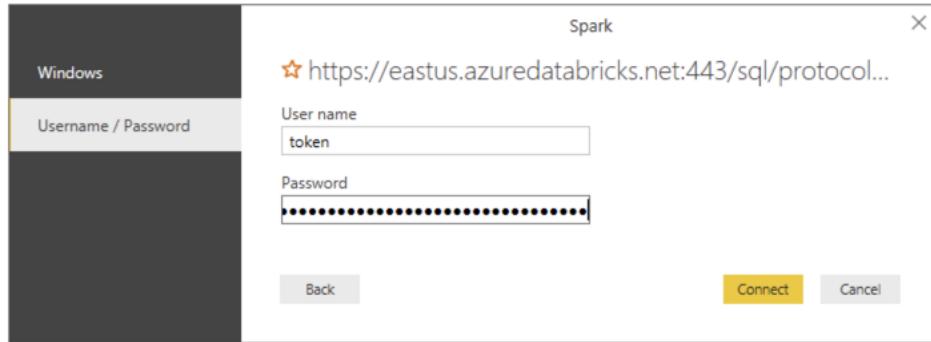
11. Select **Spark (Beta)** and **Connect** as seen in the following screenshot:



12. Enter the **Server** and **Protocol** Type as well as **DirectQuery** as the **data connectivity mode** as seen in the following screenshot:



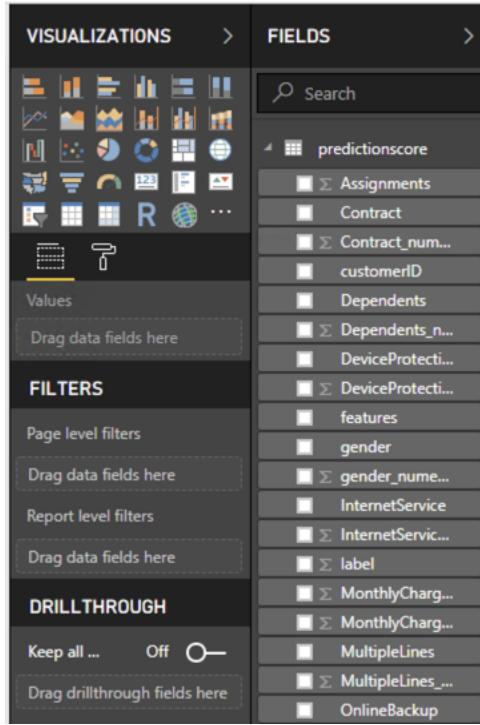
13. Next, Enter the User Name and Password credentials as seen in the following screenshot:



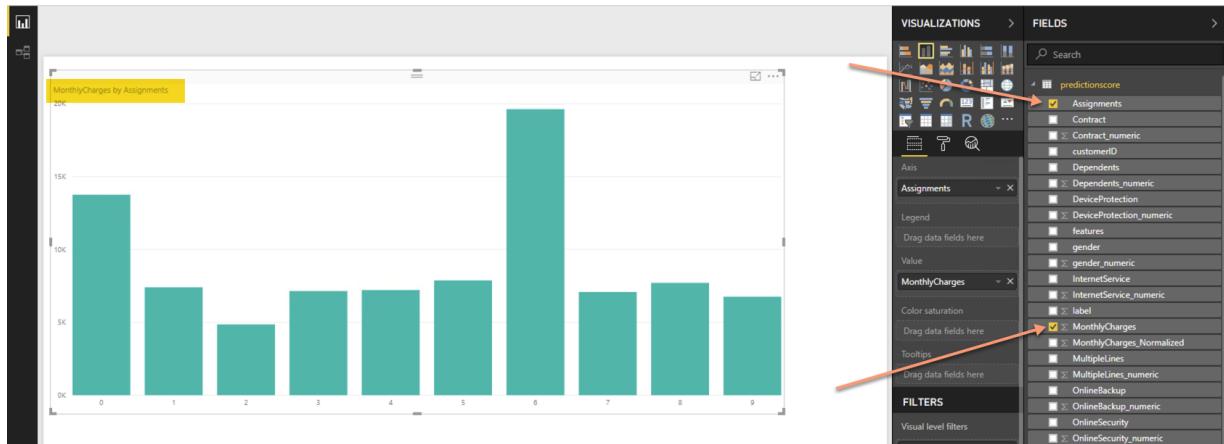
14. We can now view our data from the **predictionscore** table in Spark now viewed directly within Power BI as seen in the following screenshot:

| customerID | gender | SeniorCitizen | Partner | Dependents | tenure | PhoneService     | MultipleLines | InternetService | OnlineSecurity      | OnlineBackup        |
|------------|--------|---------------|---------|------------|--------|------------------|---------------|-----------------|---------------------|---------------------|
| 0064-SUDOG | Female | 0 Yes         | Yes     | 12         | Yes    | No               | No            | No              | No internet service | No internet service |
| 0164-XAIRP | Female | 0 No          | No      | 24         | Yes    | No               | No            | No              | No internet service | No internet service |
| 0230-UBYPQ | Male   | 1 Yes         | No      | 63         | No     | No phone service | DSL           | Yes             | No                  |                     |
| 0298-XACET | Male   | 0 Yes         | Yes     | 52         | No     | No phone service | DSL           | No              | Yes                 |                     |
| 0422-UXFAP | Female | 0 Yes         | No      | 51         | Yes    | Yes              | Fiber optic   | No              | No                  |                     |
| 0644-QQMDK | Male   | 1 No          | No      | 4          | Yes    | No               | Fiber optic   | No              | No                  |                     |
| 0657-DOGUM | Female | 0 Yes         | No      | 48         | Yes    | Yes              | DSL           | Yes             | No                  |                     |
| 0674-EYYZV | Female | 0 No          | No      | 1          | Yes    | No               | DSL           | No              | No                  |                     |
| 0872-CASZU | Male   | 0 Yes         | No      | 59         | Yes    | Yes              | DSL           | Yes             | No                  |                     |
| 0886-QGENL | Female | 1 Yes         | No      | 27         | Yes    | No               | Fiber optic   | Yes             | No                  |                     |
| 0902-RFHOF | Male   | 0 No          | No      | 38         | Yes    | No               | No            | No              | No internet service | No internet service |

15. Once we select **Load**, the dataset with all of the columns will be available for us to visualize inside of Power BI as seen in the following screenshot:



16. We can then create a simple visualization of a bar chart using **MonthlyCharges by Assignment** as seen in the following screenshot:



17. We have successfully completed this workshop!!