Self-guided Lab: Big Data: Advanced Analytics with U-SQL

Introduction

The purpose of this lab is to give you a taste of the new Big Data query language, U-SQL and its cognitive extensions by taking you through the journey of analysis some documents and images. And this lab will explore how to use R & Python extensions at scale using U-SQL to describe a massively parallel program.

Prerequisites

In order to log into the HOL Virtual Machine, use the following credentials:

Username: WTT
Password: P@ssword1

You will need access to an Azure Data Lake Analytics account. If you have access to an Azure Data Lake Analytics account you can use your own account, or you can log into the HOL account with the following credentials.

Username: user1@bigdatademos.onmicrosoft.com
Password: azure123!

Please choose the *adlhol* ADLA account.

What is U-SQL?

U-SQL is the Big Data query language of the Azure Data Lake Analytics (ADLA) service.

U-SQL evolved from an internal Microsoft Big Data query language called SCOPE. It combines a familiar SQL-like declarative language with the extensibility and programmability provided by C# types and the C# expression language, together with

support for Big Data processing concepts such as "schema on reads", custom processors and reducers.

U-SQL is however not ANSI SQL nor is it Transact-SQL. For starters, its keywords such as SELECT have to be in UPPERCASE. U-SQL uses the C# type system. Within SELECT clauses, WHERE predicates, and so on, U-SQL uses C# expressions. This means the data types are C# types and use C# NULL semantics, and the comparison operators within a predicate follow C# syntax (e.g., `a == "foo"`).

The Azure Data Lake Analytics service includes some useful cognitive libraries that you can install that provides you with image and text processing capabilities, such as image tagging, OCR processing and keyphrase extraction and also libraries to invoke Python and R code at scale on data stored in the Azure Data Lake.

How do I write U-SQL?

In the current ADLA batch service, U-SQL is written and executed as a batch script. It follows the following general pattern:

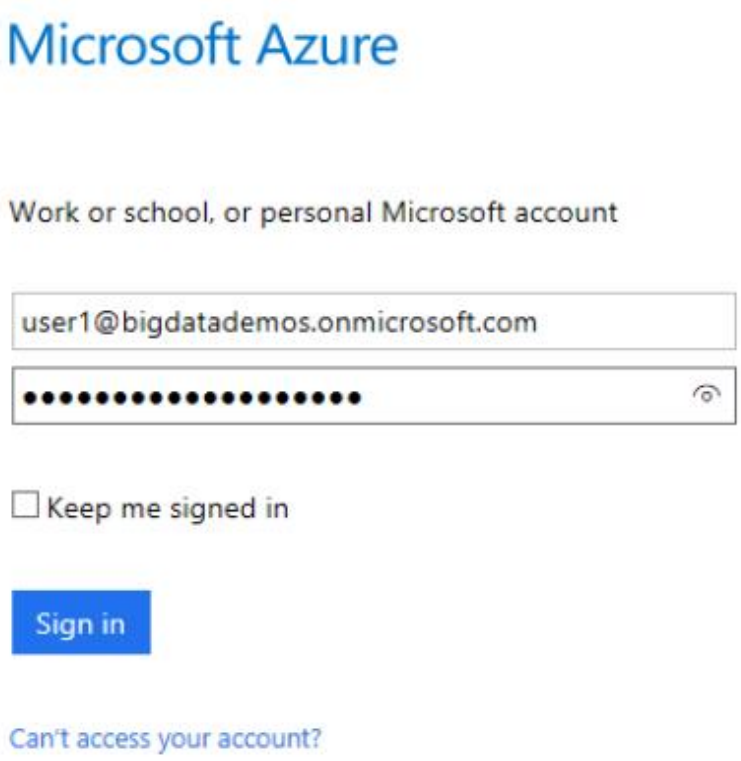
1. Retrieve data from stored locations in rowset format. These stored locations can be:
    - Files that will be schematized on read with EXTRACT expressions.
    - U-SQL tables that are stored in a schematized format.
2. Transform the rowset(s).
    - You can compose script multiple transformations over the rowsets in an expression flow format.
3. Store the transformed rowset data. You can:
    - Store it in a file with an OUTPUT statement.
    - Store it in a U-SQL table.

U-SQL also enables you to use data definition statements such as CREATE TABLE to create metadata artifacts.

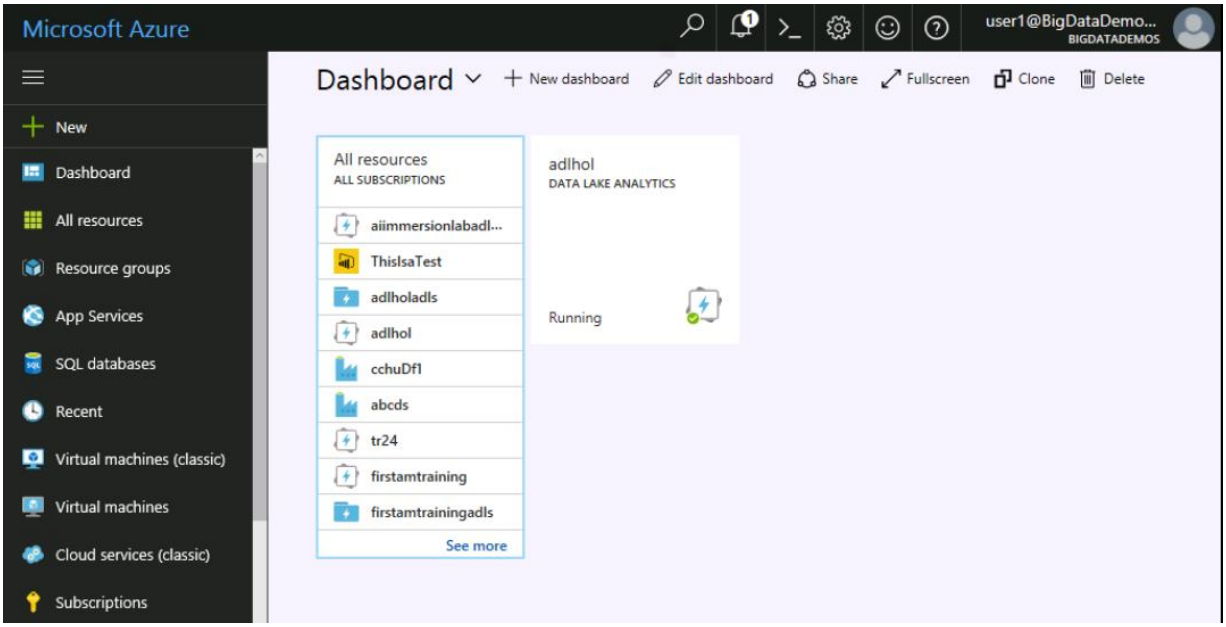
Getting started

To get started with the lab, following these steps:

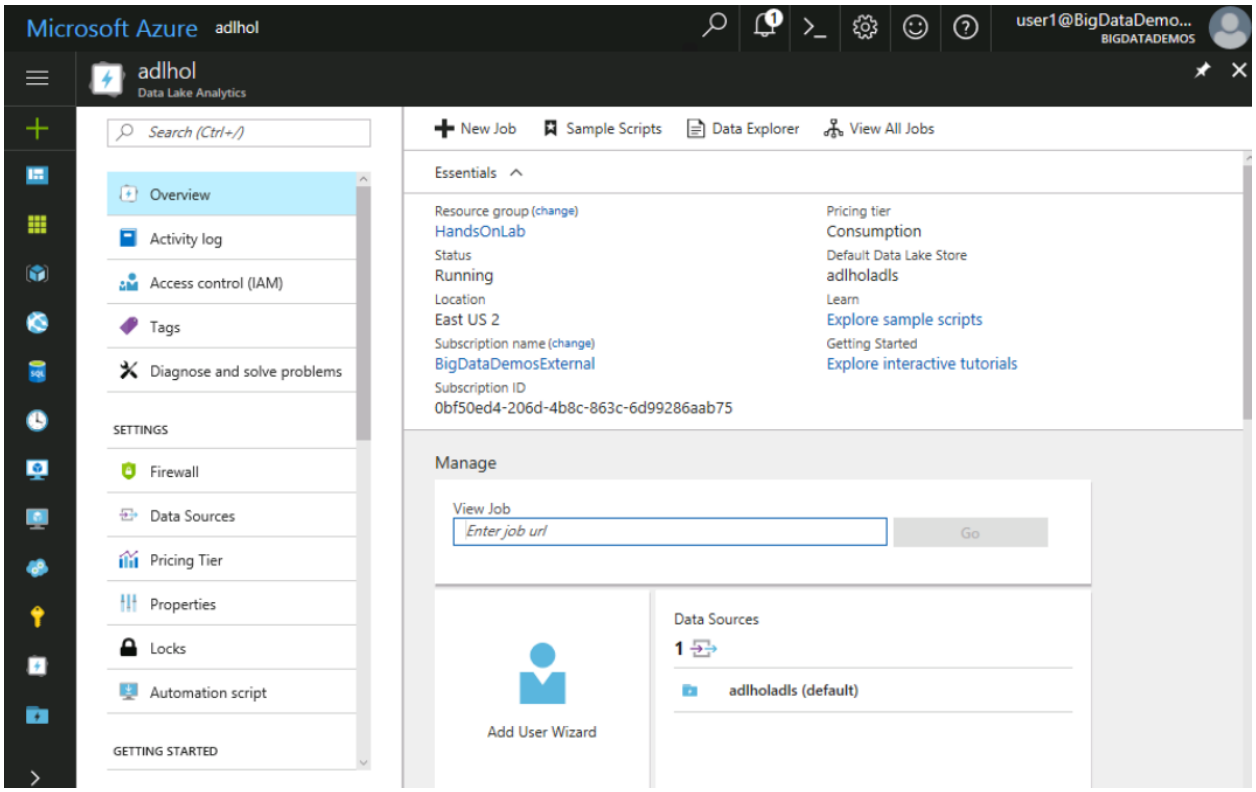
1. Open the address http://portal.azure.com in your webbrowser of choice.
2. Log into the account provided above if prompted



3. Now you should be logged into the Azure Portal which should look like:



4. Open the **adlhol** DATA LAKE ANALYTICS account by clicking on it. You should now see the ADLA portal page:



At the top of the page you will see - among others - the menus **New Job** and **Data Explorer** and details about the jobs that have been running on the account.

Installing the Cognitive Libraries

In this lab, we will use the cognitive libraries that have been **pre-installed** on the **adlhol** main account. If you want to install them later in your own account, follow the following steps:

1. Click on the **Sample Scripts** menu
2. Select **... More** and then **Install U-SQL Extensions**. That will copy the files and install them in your account (it will take several minutes to install).

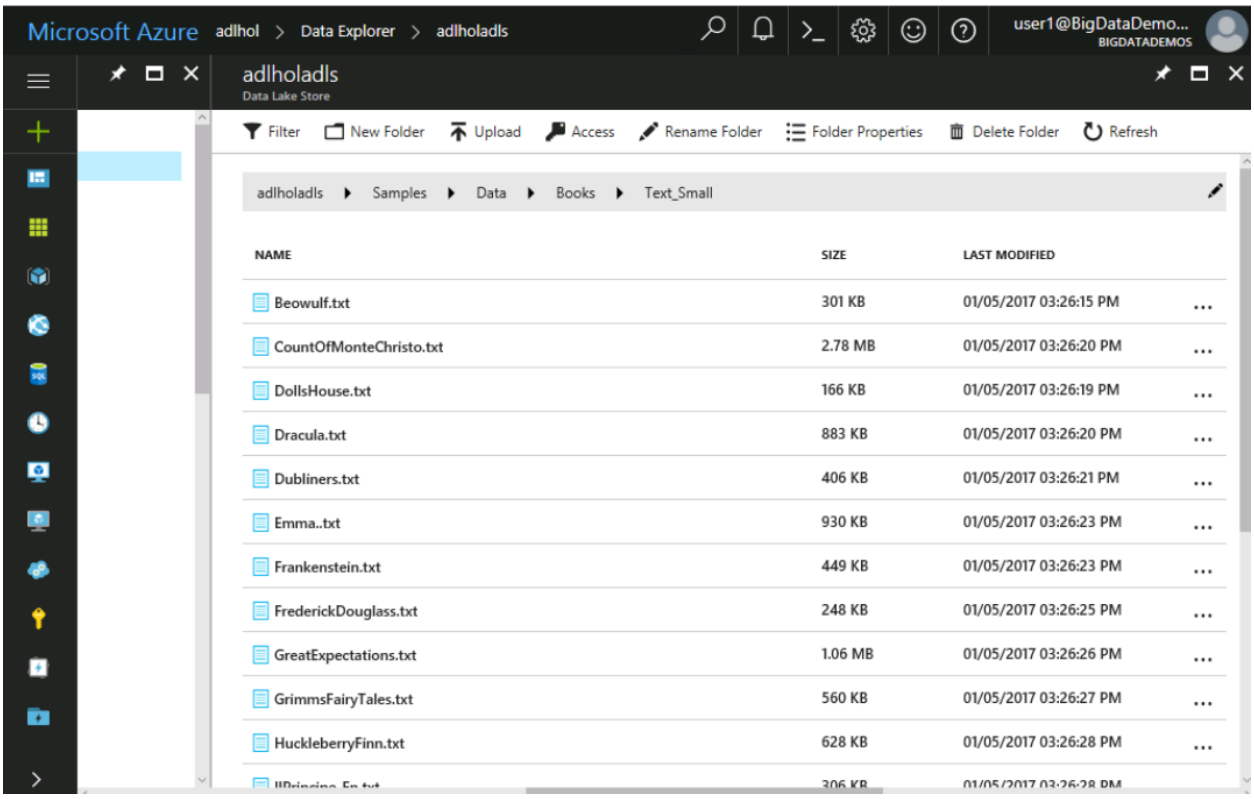
Exploring the Sample Data

The sample data for the cognitive services code consists of a subset of the Project Gutenberg public domain books in text format as well as some jpeg from the same source and some screen shots of some of the book pages.

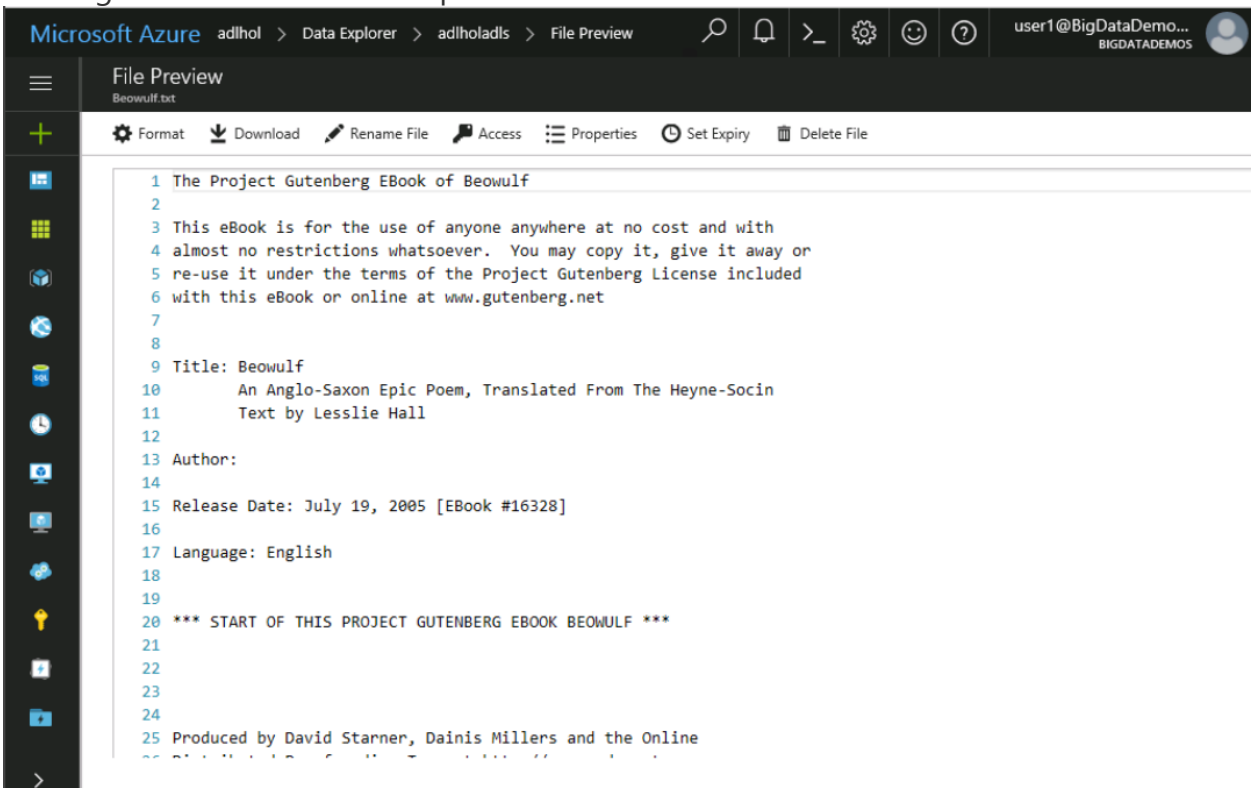
The files are already preloaded in the **adlholadls** account. Your scripts will reference the data directly from that account.

You can see the files by following these steps:

1. On the main Data Lake Analytics blade (see step 4 earlier), click on the **Data Explorer** menu.
2. Navigate to `\Samples\Data\Books\Text_Small` to see the first set of books that we will look at:

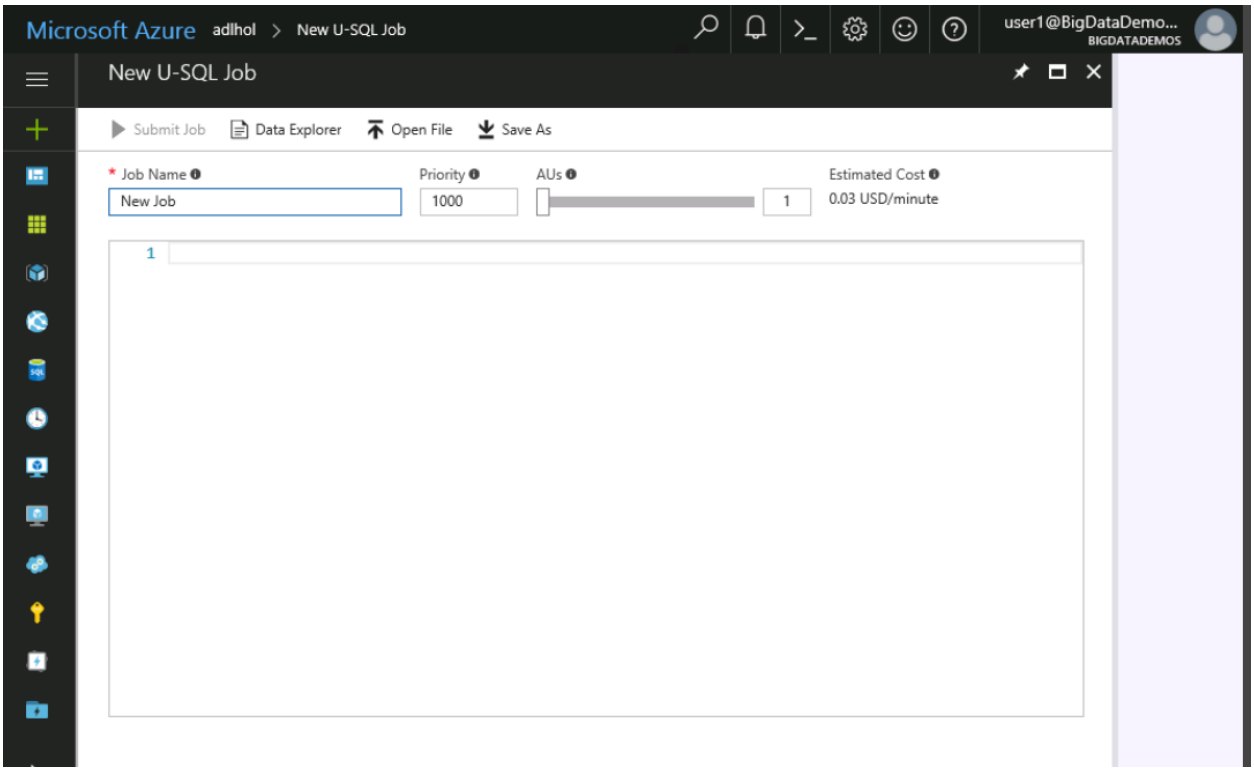


3. Clicking on the first book will open it in a file viewer:



Using the Azure Portal to submit U-SQL Jobs

Now open another browser window or tab and repeat the steps to open your assigned ADLA account or go back to the main ADLA account page. You then click on **New Job** to get the following job submission window:



Now you are ready to start with the first exercise.

Exercise 1: Extracting key phrases from the books

In this exercise you will submit a U-SQL script that schematizes the small book set using a custom extractor provided for the lab. The extractor parses each book into several rows containing author and title of the book and book parts that are small enough to fit into a U-SQL `string` typed column. The script then applies the cognitive libraries key

phrase extraction processor, aggregates the key phrases into a combined list, and writes the results into an output file.

Running the script

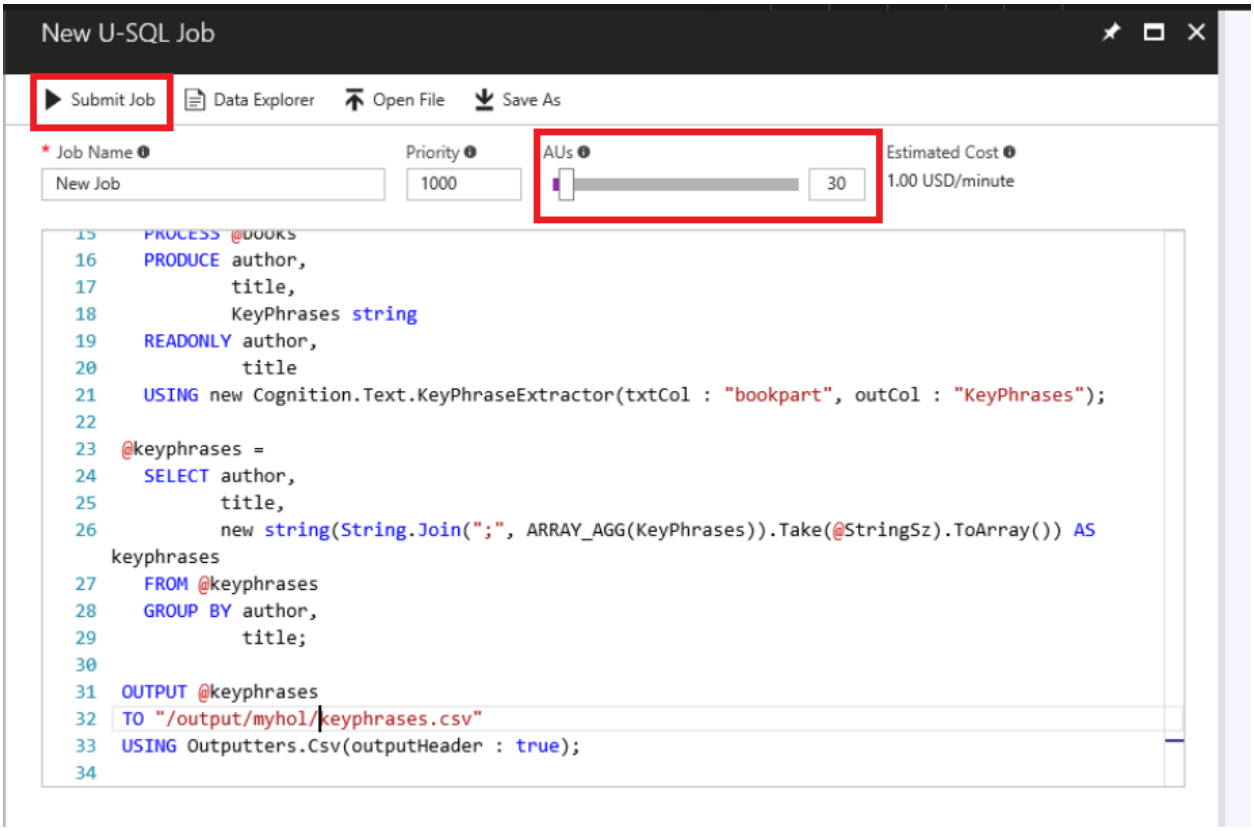
1. Copy the following U-SQL script into the "New U-SQL Job" window in the portal:

```
REFERENCE ASSEMBLY adlhol.master.AIImmersion;
REFERENCE ASSEMBLY adlhol.master.TextKeyPhrase;

 // Set a String size limit for the string aggregation value.
 // Since we flow UTF-8, 128kB of Unicode is too big in the general case, so I set it a
bit smaller
 // since I assume we operate on mainly ASCII range characters.
 DECLARE @StringSz = 127 * 1024;

 @books =
   EXTRACT author string, title string, bookpart string
   FROM "adl://adlholadls.azuredatalakestore.net/Samples/Data/Books/Text_Small/{*}.txt"
   USING new AIImmersion.BookExtractor();

 @keyphrases =
   PROCESS @books
   PRODUCE author,
           title,
           KeyPhrases string
   READONLY author,
            title
   USING new Cognition.Text.KeyPhraseExtractor(txtCol : "bookpart", outCol :
"KeyPhrases");

 @keyphrases =
   SELECT author,
          title,
          new string(String.Join(";", ARRAY_AGG(KeyPhrases)).Take(@StringSz).ToArray()) AS
keyphrases
   FROM @keyphrases
   GROUP BY author,
            title;

 OUTPUT @keyphrases
 TO "/output/<replace_this_with_your_output_name>/keyphrases.csv"
 USING Outputters.Csv(outputHeader : true);
```

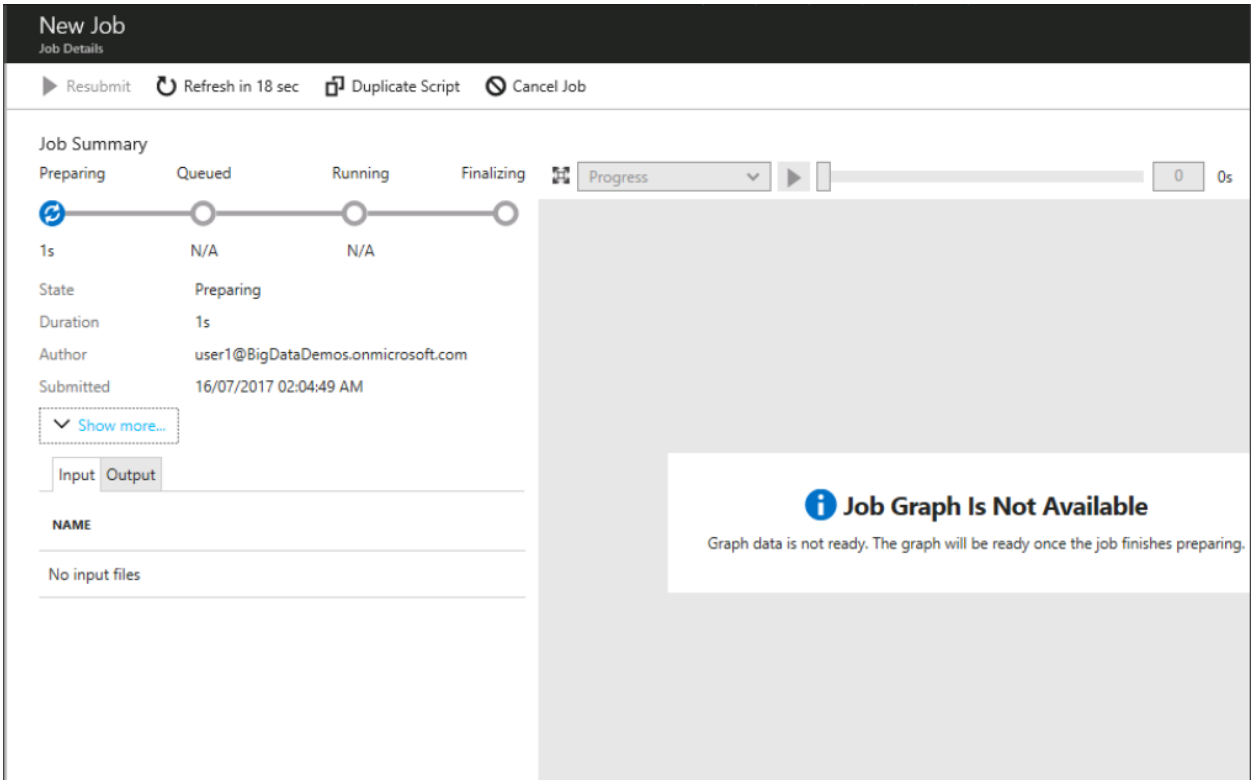
2. Change the name of the output file from <*replace_this_with_your_output_name*> to something unique.

3. Select the number of AUs for the job with the slider. Since the job operates on about 30 files, any of the following numbers make sense: 10, 15, 30.

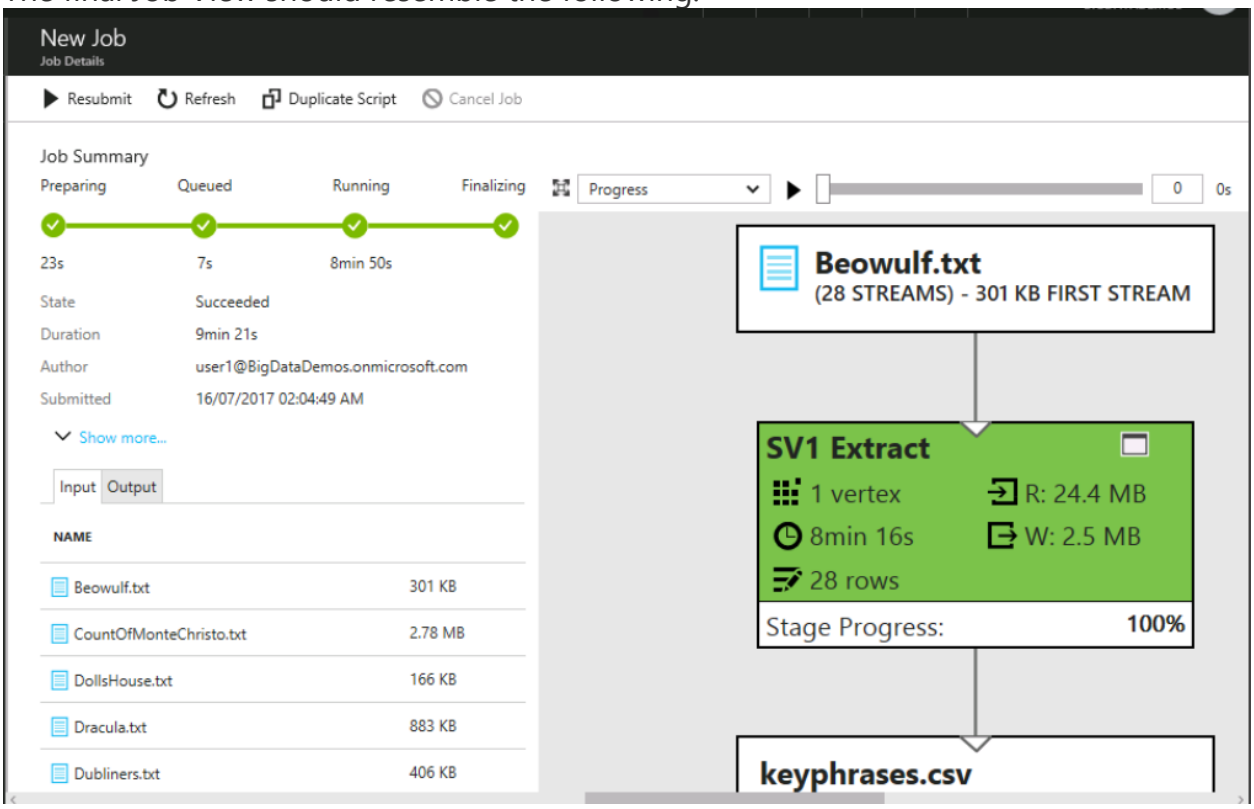
4. To submit your script, click the **Submit Job** button at the top-left of the window.



After a short while, the Job View of the submitted job should appear.

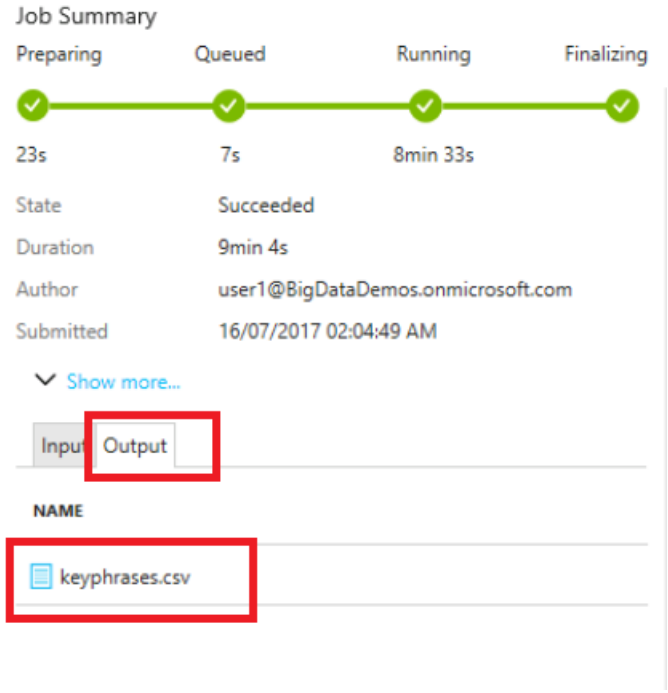


5. Wait until the job has completed (with 30 AUs it will take about 9 to 10 minutes). The final Job View should resemble the following:

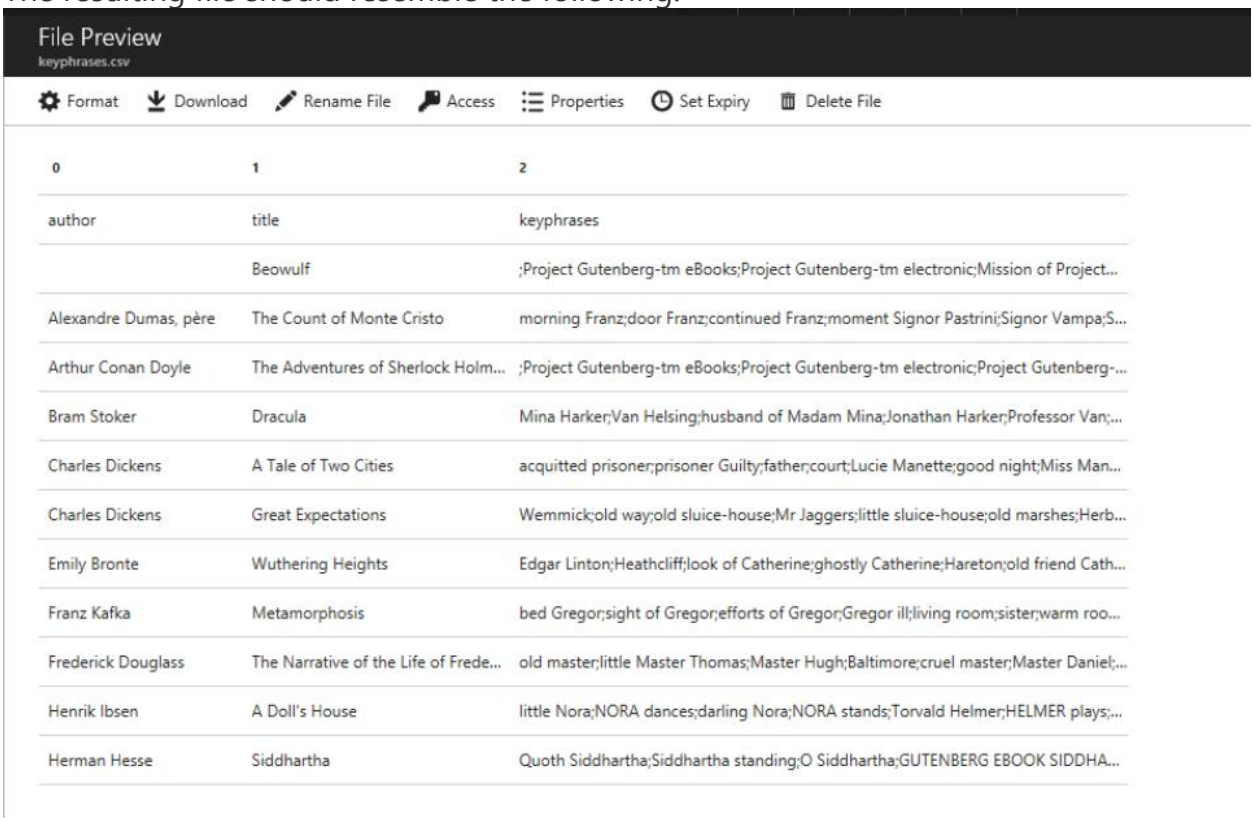


If the job fails, please look at the **Error** tab and correct the mistake.

6. Finally check the result by opening the resulting file by clicking on the "Output" tab and the `keyphrases.csv` filename:



The resulting file should resemble the following:



0	1	2
author	title	keyphrases
	Beowulf	;Project Gutenberg-tm eBooks;Project Gutenberg-tm electronic;Mission of Project...
Alexandre Dumas, père	The Count of Monte Cristo	morning Franz;door Franz;continued Franz;moment Signor Pastrini;Signor Vampa;S...
Arthur Conan Doyle	The Adventures of Sherlock Holm...	;Project Gutenberg-tm eBooks;Project Gutenberg-tm electronic;Project Gutenberg-...
Bram Stoker	Dracula	Mina Harker;Van Helsing;husband of Madam Mina;Jonathan Harker;Professor Van;...
Charles Dickens	A Tale of Two Cities	acquitted prisoner;prisoner Guilty;father;court;Lucie Manette;good night;Miss Man...
Charles Dickens	Great Expectations	Wemmick;old way;old sluice-house;Mr Jaggers;little sluice-house;old marshes;Herb...
Emily Bronte	Wuthering Heights	Edgar Linton;Heathcliff;look of Catherine;ghostly Catherine;Hareton;old friend Cath...
Franz Kafka	Metamorphosis	bed Gregor;sight of Gregor;efforts of Gregor;Gregor ill;living room;sister;warm roo...
Frederick Douglass	The Narrative of the Life of Frede...	old master;little Master Thomas;Master Hugh;Baltimore;cruel master;Master Daniel;...
Henrik Ibsen	A Doll's House	little Nora;NORA dances;darling Nora;NORA stands;Torvald Helmer;HELMER plays;...
Herman Hesse	Siddhartha	Quoth Siddhartha;Siddhartha standing;O Siddhartha;GUTENBERG EBOOK SIDDHA...

This script illustrates the following concepts:

- *Rowset variables*. Each query expression that produces a rowset can be assigned to a variable. Variables in U-SQL follow the T-SQL variable naming pattern of an ampersand (@) followed by a name (such as **@books** in this case). Note that the assignment statement does not execute the query. It merely names the expression and gives you the ability to build-up more complex expressions.

- *The EXTRACT expression*. This gives you the ability to define a schema as part of a read operation. For each column, the schema specifies a paired value consisting of a column name and a C# type name. It uses a so-called extractor, which can be built-in or created by the user. In this case we are using a user-defined extractor called **AIImmersion.BookExtractor()** that is provided by the U-SQL Assembly **adlhol.master.AIImmersion**.

- *U-SQL file set*. The extractor reads from a file and generates a rowset. If you specify a wild-card pattern in the file name of the EXTRACT expression, then the set of files that match the pattern will be passed to the extractor. In this case the pattern is specified as `adl://adlholadls.azuredatalakestore.net/Samples/Data/Books/Text_Small/{*}.txt` and selects all the files in the specified directory ending with `.txt`.

- *Cross account access*. Both the U-SQL assemblies and the files may be stored in different ADLA and ADLS accounts respectively. You can use the ADLA account name and the ADLA database name in that account to reference the U-SQL assembly, assuming you have read permissions. And you can fully qualify the URI for the files, assuming you have access to the store and RX permissions on the folders and files in the path.

- *Cognition library processor*. The `PROCESS` expression applies the cognition library keyphrase extraction processor on each of the book parts. It takes the name of the input column and the name of the output column as arguments. Since the other columns in the rowset are not being processed by the keyphrase extraction processor, they have to be marked as `READ ONLY` so they are passed-through to the result.

- *The OUTPUT statement*. This takes a rowset and serializes it as a comma-separated file into the specified location. Like extractors, outputters can be built-

in or created by the user. However, in this case we are using the built-in **Csv** (comma-separated value) outputter provided by the Outputters class. With the provided argument we specify that we want to also output the column names as headers.

Exercise 2: Using Image Processing OCR

In this exercise, you will use the cognition library's image OCR capability to extract the text from a set of images and apply the keyphrase extraction on it.

Running the script

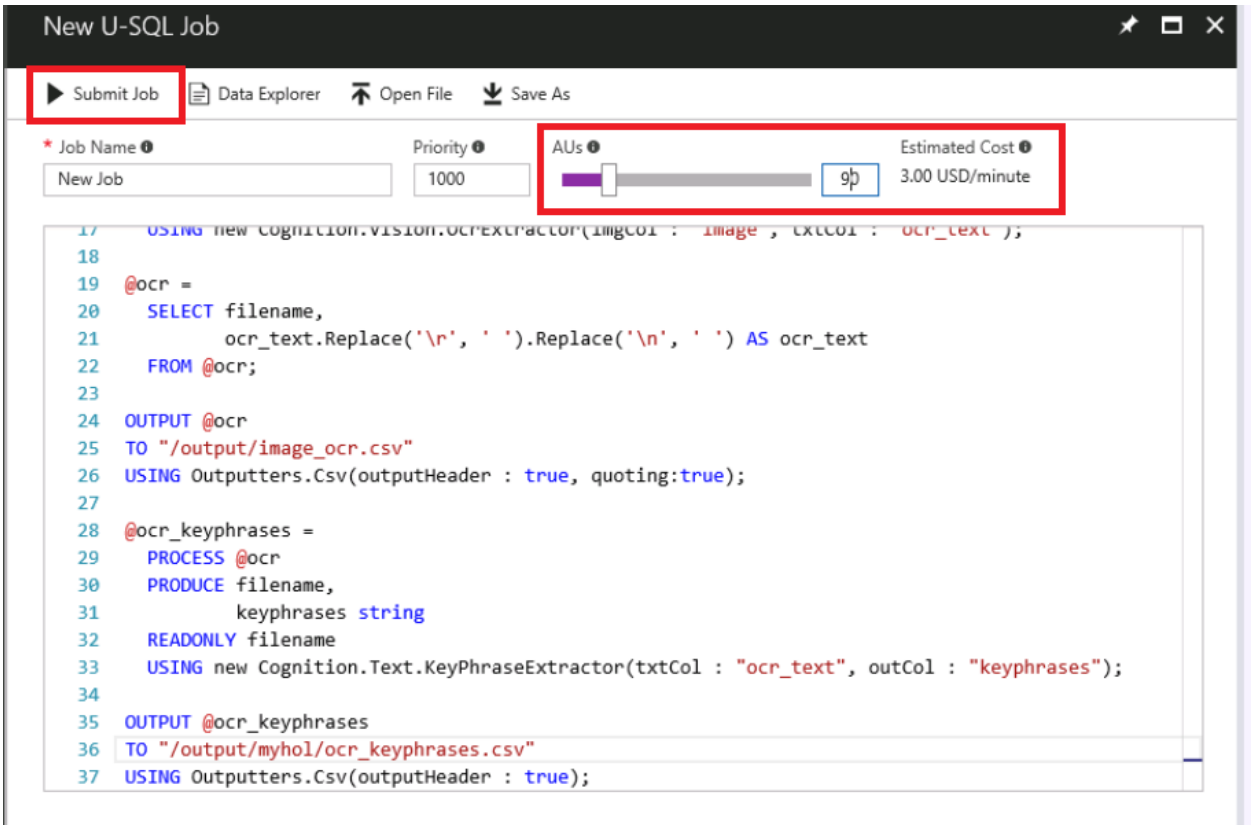
1. Navigate back to the "New U-SQL Job window in the portal and copy the following U-SQL Script into the window:

```
REFERENCE ASSEMBLY adlhol.master.ImageCommon;
REFERENCE ASSEMBLY adlhol.master.ImageOcr;
REFERENCE ASSEMBLY adlhol.master.TextKeyPhrase;

SET @@FeaturePreviews = "FileSetV2Dot5:on";

@images =
  EXTRACT filename string, image byte[]
  FROM "adl://adlholadls.azuredatalakestore.net/Samples/Data/Books/Images/{filename}.jpg"
  USING new Cognition.Vision.ImageExtractor();

@ocr =
  PROCESS @images
  PRODUCE filename,
          ocr_text string
  READONLY filename
  USING new Cognition.Vision.OcrExtractor(imgCol : "image", txtCol : "ocr_text");

@ocr =
  SELECT filename,
         ocr_text.Replace('\r', ' ').Replace('\n', ' ') AS ocr_text
  FROM @ocr;

OUTPUT @ocr
TO "/output/<replace_this_with_your_output_name>/image_ocr.csv"
USING Outputters.Csv(outputHeader : true, quoting:true);

@ocr_keyphrases =
  PROCESS @ocr
  PRODUCE filename,
          keyphrases string
  READONLY filename
  USING new Cognition.Text.KeyPhraseExtractor(txtCol : "ocr_text", outCol :
"keyphrases");
```

```
OUTPUT @ocr_keyphrases
TO "/output/<replace_this_with_your_output_name>/ocr_keyphrases.csv"
USING Outputters.Csv(outputHeader : true);
```

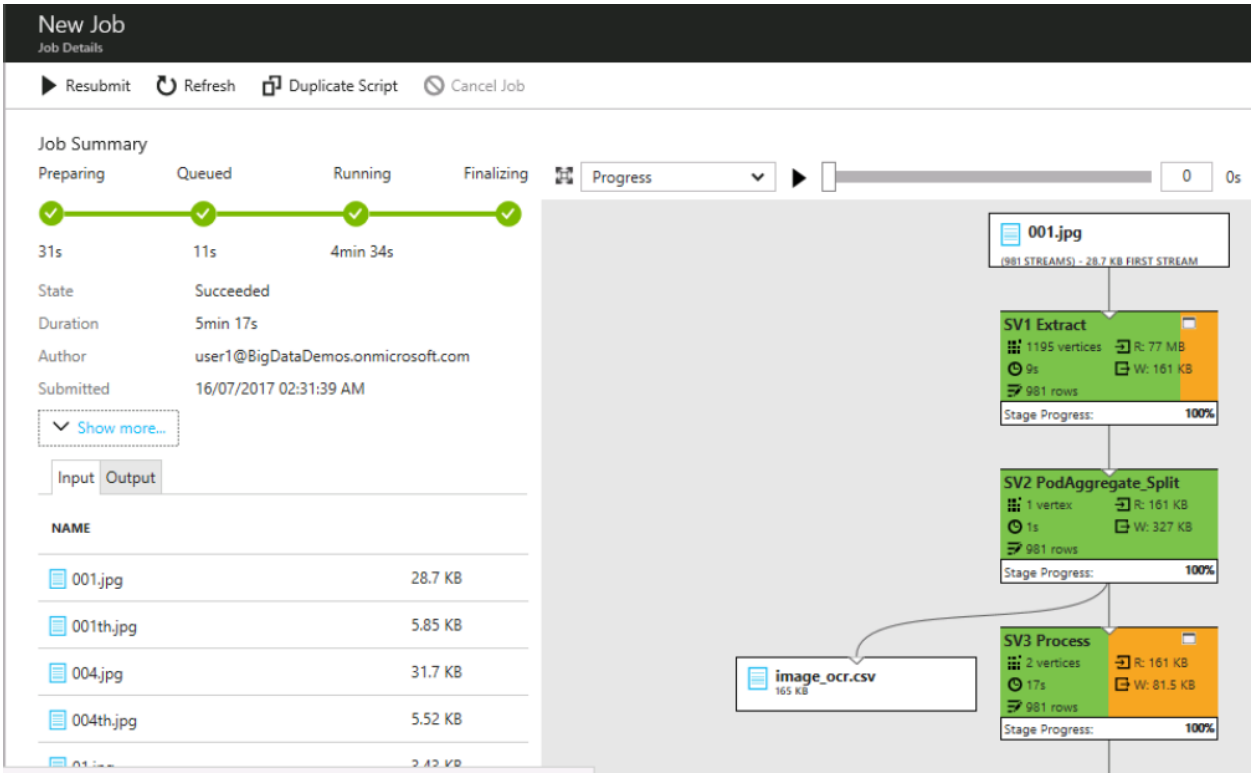
2. As before, change the name of the **two** output file locations from <*replace_this_with_your_output_name*> to something unique to you.

3. As before, set the number of Analytics Units (AUs) and submit it. Since we are approximately processing over 900 files, you should use 90 or 100 to get a reasonable scale out.

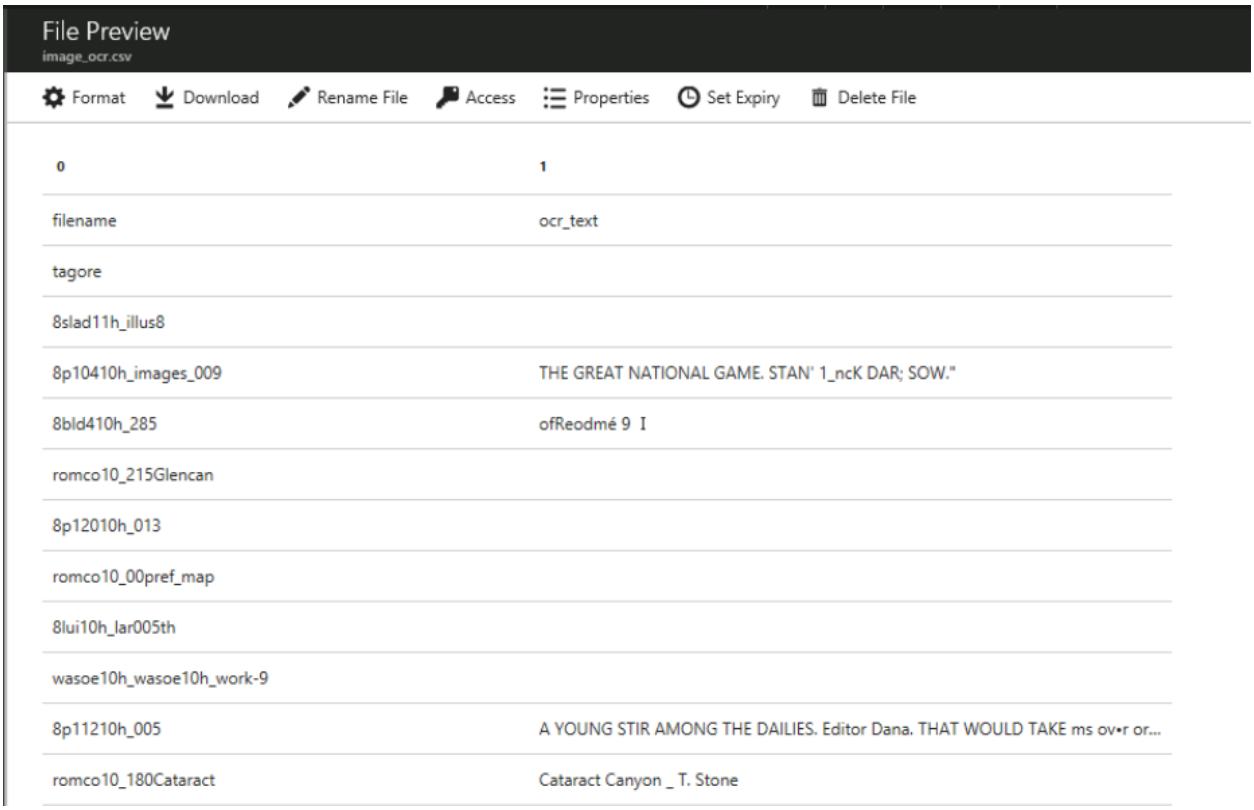


4. Submit your script as in Exercise 1 and wait for the job to complete and verify the results. Note that this job will run for about 5 minutes with 90 AUs specified.

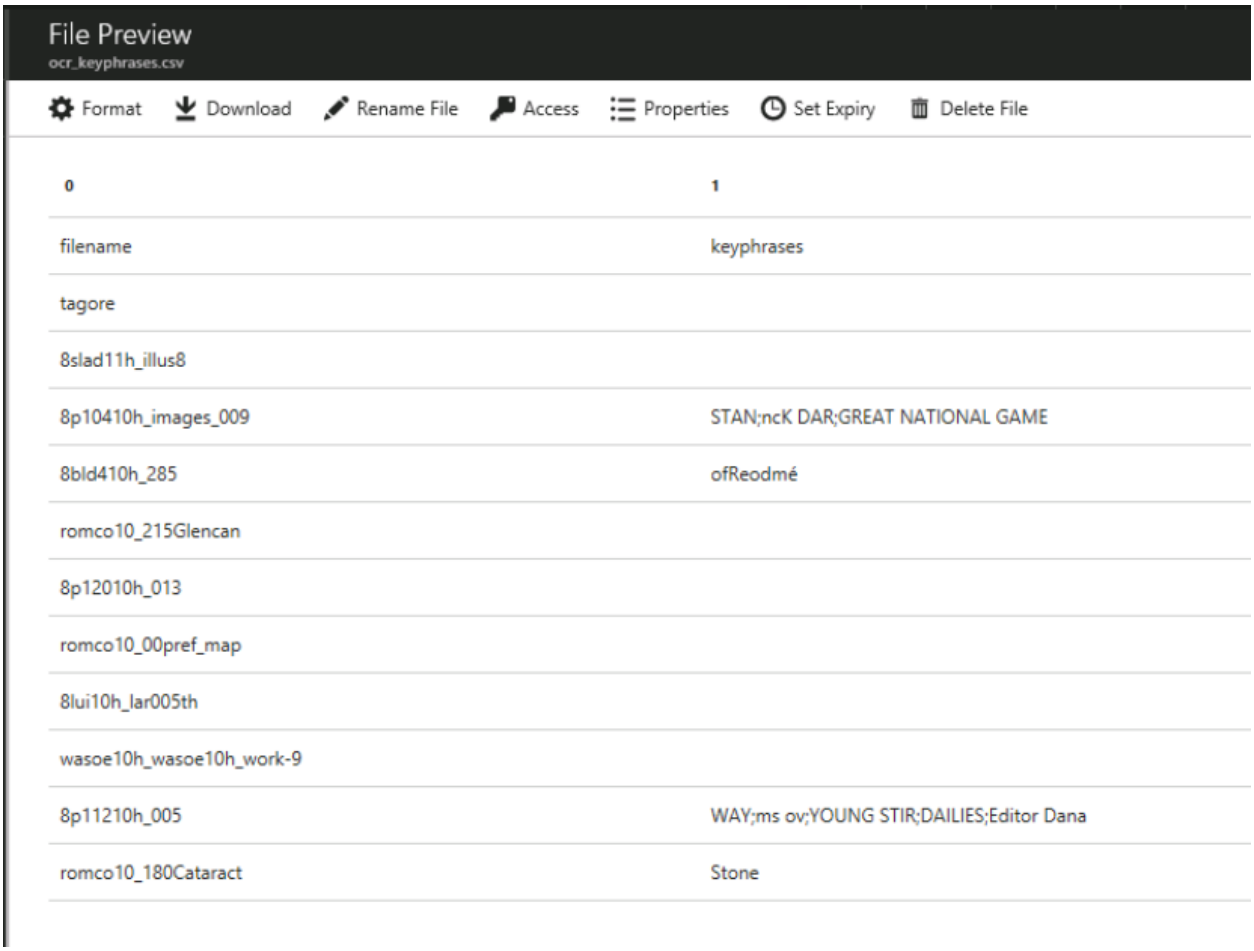
   The successful submission will look like:



The script produces two result files, one containing the OCR extracted text in `image_ocr.csv` and the other containing the keyphrase extraction on it in `ocr_keyphrases.csv`:



0	1
filename	ocr_text
tagore	
8slad11h_illus8	
8p10410h_images_009	THE GREAT NATIONAL GAME. STAN' 1_ncK DAR; SOW."
8bld410h_285	ofReodmé 9 I
romco10_215Glencan	
8p12010h_013	
romco10_00pref_map	
8lui10h_lar005th	
wasoe10h_wasoe10h_work-9	
8p11210h_005	A YOUNG STIR AMONG THE DAILIES. Editor Dana. THAT WOULD TAKE ms ov•r or...
romco10_180Cataract	Cataract Canyon _ T. Stone



Exercise 3: Finding potentially related images and books

In this exercise, you will combine the two previous exercises and find potentially related images and books. Instead of reading the books' keyphrases from the files, you will use a predefined table that contains the book authors, titles and their related keyphrases in rows, one row per keyphrase per book and author.

Running the script

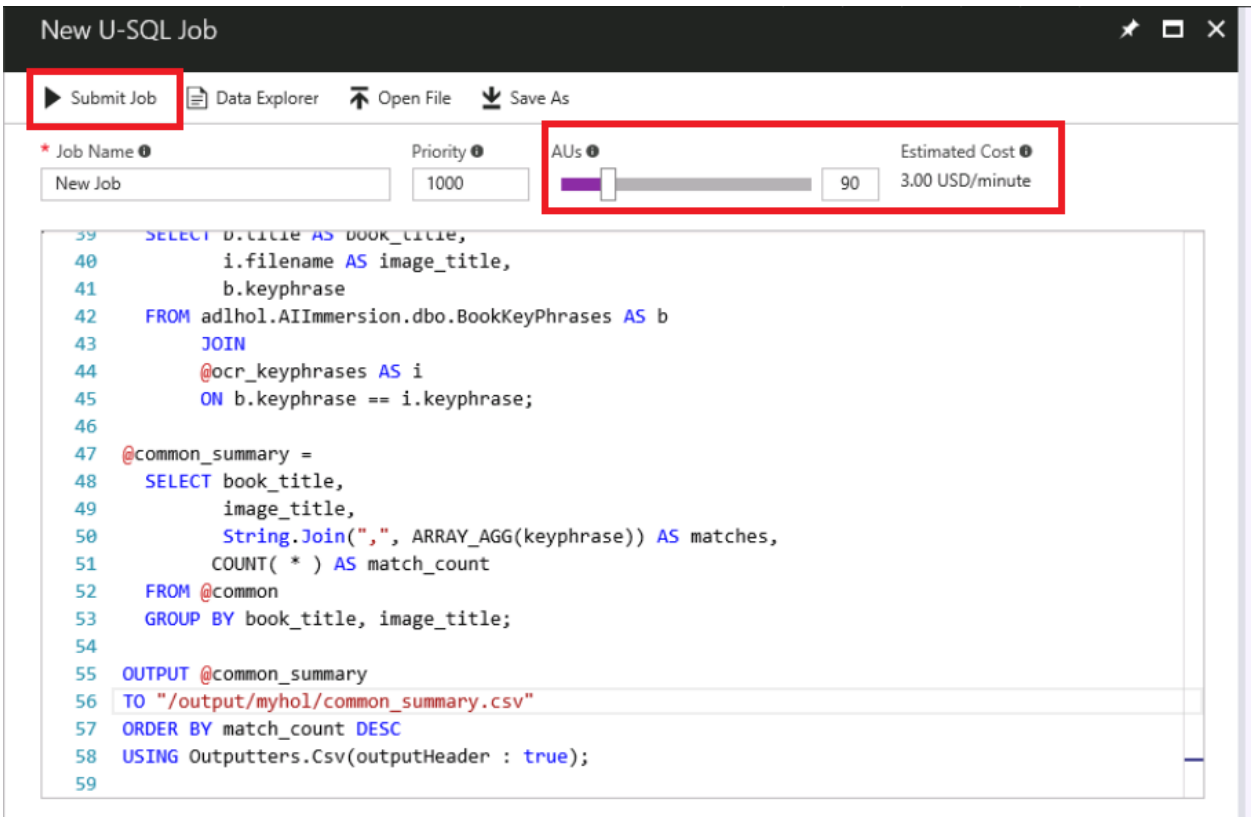
1. Navigate back to the “New U-SQL Job” window and replace its content by copying the following U-SQL script into the window:

```
REFERENCE ASSEMBLY adlhol.master.ImageCommon;
```

```
REFERENCE ASSEMBLY adlhol.master.ImageOcr;
REFERENCE ASSEMBLY adlhol.master.TextKeyPhrase;

SET @@FeaturePreviews = "FileSetV2Dot5:on";

@images =
  EXTRACT filename string, image byte[]
  FROM "adl://adlholadls.azuredatalakestore.net/Samples/Data/Books/Images/{filename}.jpg"
  USING new Cognition.Vision.ImageExtractor();

@ocr =
  PROCESS @images
  PRODUCE filename,
          ocr_text string
  READONLY filename
  USING new Cognition.Vision.OcrExtractor(imgCol : "image", txtCol : "ocr_text");

@ocr =
  SELECT filename,
         ocr_text.Replace('\r', ' ').Replace('\n', ' ') AS ocr_text
  FROM @ocr;

@ocr_keyphrases =
  PROCESS @ocr
  PRODUCE filename,
          keyphrases string
  READONLY filename
  USING new Cognition.Text.KeyPhraseExtractor(txtCol : "ocr_text", outCol :
"keyphrases");

@ocr_keyphrases =
  SELECT filename,
         keyphrase
  FROM @ocr_keyphrases
       CROSS APPLY
         EXPLODE(keyphrases.Split(';')) AS K(keyphrase);

@common =
  SELECT b.title AS book_title,
         i.filename AS image_title,
         b.keyphrase
  FROM adlhol.AIImmersion.dbo.BookKeyPhrases AS b
       JOIN
       @ocr_keyphrases AS i
       ON b.keyphrase == i.keyphrase;

@common_summary =
  SELECT book_title,
         image_title,
         String.Join(",", ARRAY_AGG(keyphrase)) AS matches,
        COUNT( * ) AS match_count
  FROM @common
  GROUP BY book_title, image_title;

OUTPUT @common_summary
TO "/output/<replace_this_with_your_output_name>/common_summary.csv"
ORDER BY match_count DESC
USING Outputters.Csv(outputHeader : true);
```

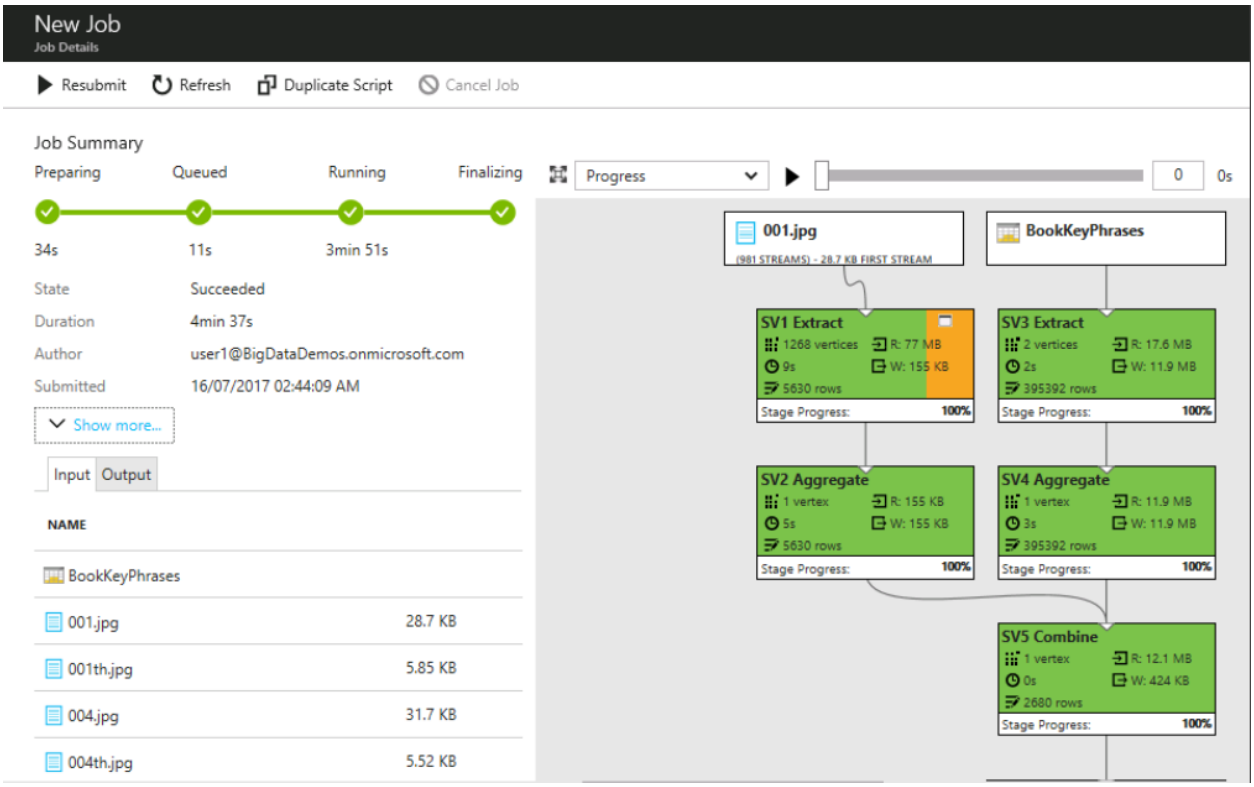
2. Change the name of the output file
   from <*replace_this_with_your_output_name*> to something unique.

3. As before, set the number of Analytics Units (AUs) and submit it. Since we are approximately processing over 900 files, you should use 90 or 100 to get a reasonable scale out.

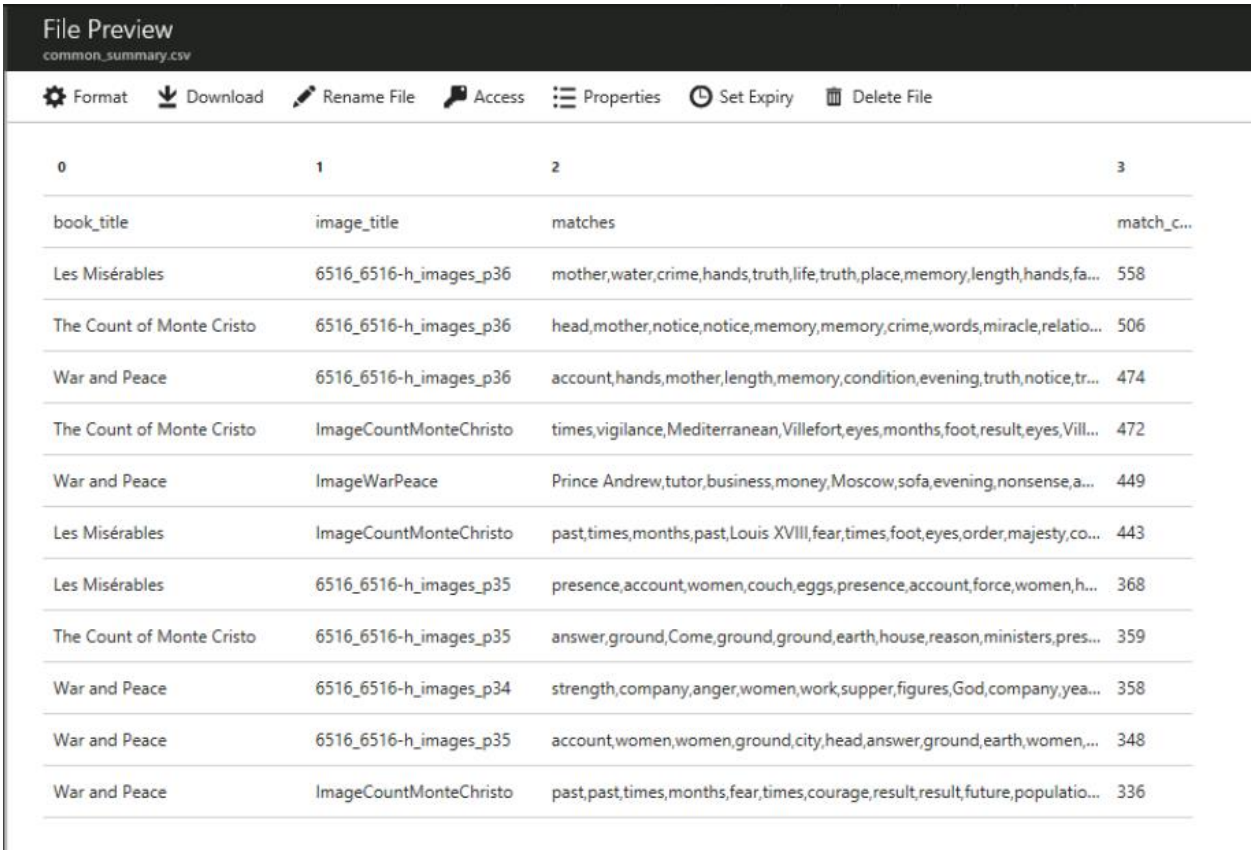


4. Wait for the job to complete and verify the results. Note that this job will run for about 4 to 5 minutes with 90 AUs.

   The successful submission will look like:



The script produces a result file that contains for each matching book and image combination the concatenated list of matching keyphrases as well as the count of matches:



0	1	2	3
book_title	image_title	matches	match_c...
Les Misérables	6516_6516-h_images_p36	mother,water,crime,hands,truth,life,truth,place,memory,length,hands,fa...	558
The Count of Monte Cristo	6516_6516-h_images_p36	head,mother,notice,notice,memory,memory,crime,words,miracle,relatio...	506
War and Peace	6516_6516-h_images_p36	account,hands,mother,length,memory,condition,evening,truth,notice,tr...	474
The Count of Monte Cristo	ImageCountMonteChristo	times,vigilance,Mediterranean,Villefort,eyes,months,foot,result,eyes,Vill...	472
War and Peace	ImageWarPeace	Prince Andrew,tutor,business,money,Moscow,sofa,evening,nonsense,a...	449
Les Misérables	ImageCountMonteChristo	past,times,months,past,Louis XVIII,fear,times,foot,eyes,order,majesty,co...	443
Les Misérables	6516_6516-h_images_p35	presence,account,women,couch,eggs,presence,account,force,women,h...	368
The Count of Monte Cristo	6516_6516-h_images_p35	answer,ground,Come,ground,ground,earth,house,reason,ministers,pres...	359
War and Peace	6516_6516-h_images_p34	strength,company,anger,women,work,supper,figures,God,company,yea...	358
War and Peace	6516_6516-h_images_p35	account,women,women,ground,city,head,answer,ground,earth,women,...	348
War and Peace	ImageCountMonteChristo	past,past,times,months,fear,times,courage,result,result,future,populatio...	336

You will notice that images that contain a screen shot of the book have a high match to the book themselves. Also books that have similar locations and topics such as War and Peace, Les Miserables and the Count of Monte Christo have a close match. There is also a surprising high match for images which names start with 6516. If you look at these images, you will notice that these are copies of bible pages that seem to have a lot of key phrase matches with the given books.

The above query used a JOIN expression. When you work with joins in U-SQL, note that:

- U-SQL only supports the ANSI-compliant JOIN syntax (*Rowset1* JOIN *Rowset2* ON *predicate*). The older syntax (FROM*Rowset1*, *Rowset2* WHERE *predicate*) is not supported.
- The predicate in a JOIN has to be an equality join and no expression. If you want to use an expression, add it to the SELECT clause of a previous rowset. If you want to do a different comparison, you can move it into the WHERE clause. If no predicate is left for the ON clause, turn the join into a CROSS JOIN.

U-SQL requires this manual rewrite to make it explicit where the cost is when joining two data sets. Currently only equijoins have more efficient processing than a cross join with filters.

Conclusion and more Information

This lab has hopefully given you a small taste of U-SQL and its cognitive capabilities. As you would expect, there are many more advanced features that this lab cannot cover.

You can find further references and documentation at the following locations:

- Data Lake homepage (with links to documentation)
- Azure Data Lake Analytics Documentation Hub
- U-SQL Reference documentation
- ADL Tools for VS download page
- Data Lake feedback page

We hope you come back and use Azure Data Lake Analytics and U-SQL for your Big Data processing needs!

You can find a public copy of this self-guided HOL at:

- http://aka.ms/usql-cognitive-hol

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