Processing GPS data with Storm and Kafka on Windows Azure Data Science Core

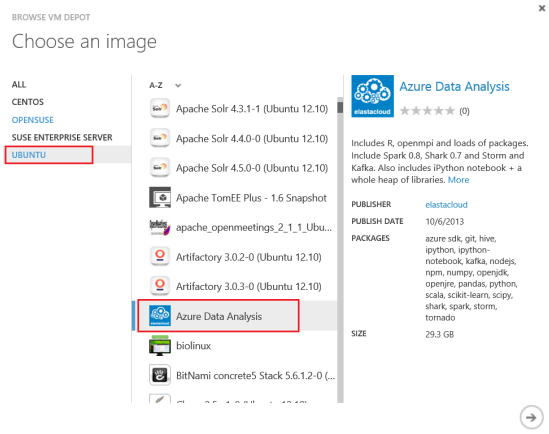
In this example, we'll show you how to deploy a Storm topology in Windows Azure that reads its data from the Kafka messaging system. We'll use a Kafka client application written in Java to send GPS coordinates from anywhere to the Kafka cluster. Our Storm topology will translate those coordinates into JSON objects, use GeoJSON to identify the country those coordinates belong to, and then keep a running count of how many times that a coordinate lands in a country. For persistence, the running count is stored in a Windows Azure Table Storage service, and the topology periodically dumps a compressed block of coordinates to a Windows Azure Blob Storage service. The topology also writes data to Redis for use by other services, such as the web application we use to display the data in real time. The web app is written in Node.js and uses Socket.IO and the express web application framework to read the data from Redis and display it via D3.js.

Use Azure Management Portal to Create a Windows Azure Data Analysis VM

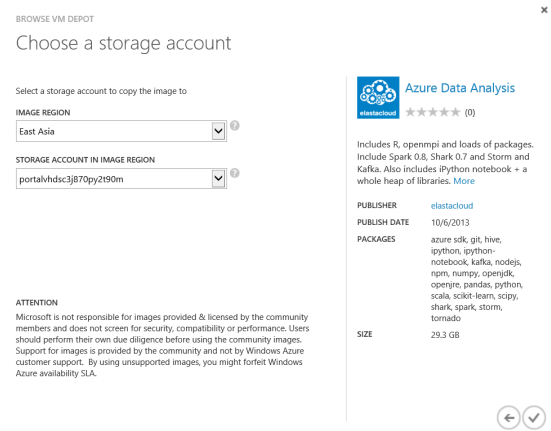
1. Log in to the Windows Azure Management Portal.
2. Click on the **Virtual Machines** tab and click on **Images** near the top of the screen.

3. Click on **Browse VM Depot** in the bar on the bottom

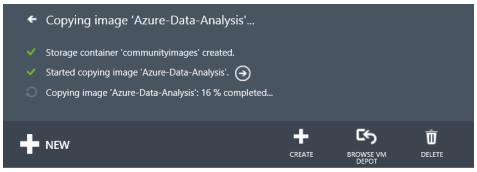
4. Select **Ubuntu** on the left and then select the **Azure Data Analysis** image.



5. Choose the **Image Region** that your storage account is in (i.e. the region you created your affinity group in) from the drop down box, then select your storage account from the drop down box.

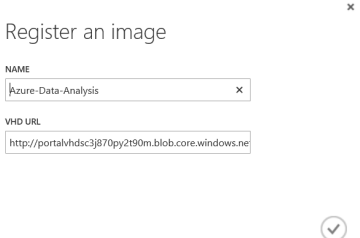


6. Click the check mark button to continue and wait for the disk image to downloaded from the VM Depot to your storage account. You can click on **Details** in the status bar to see the transfer progress.



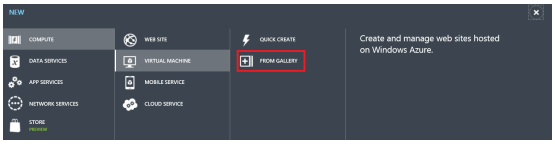
7. Once the image has copied you'll need to register it. Select the image and click **Register** in the bar on the bottom.

8. Enter a name for the image, click the checkmark button, and wait for registration to complete.

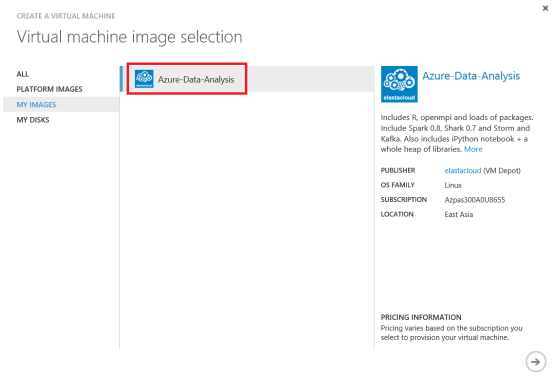


9. Stay on the Virtual Machines tab and click on **Virtual Machine Instances** near the top of the screen.

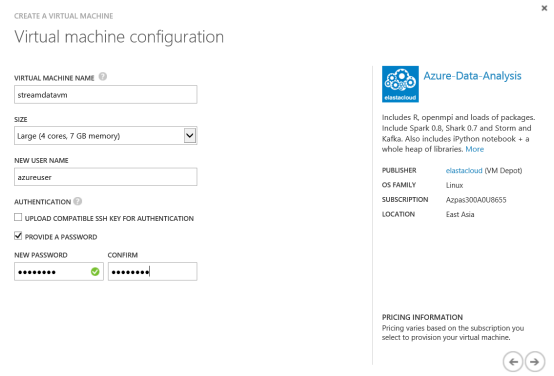
10. Click on **New** in the bottom bar and select **From Gallery**.



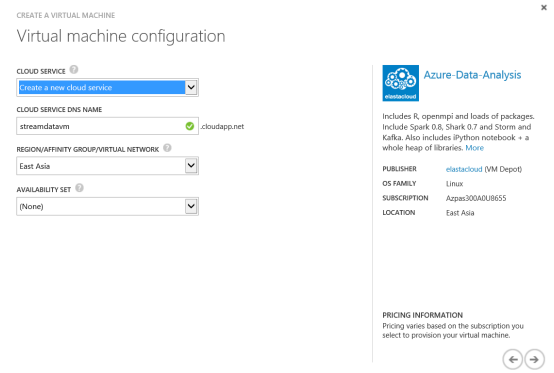
11. Select **My Images** on the left and then select the Azure-Data-Analysis you just registered. Go to the next page.



12. Enter the virtual machine name, select the **Large** machine size from the drop down list, enter a new user name, check the **Provide a Password** box and ender the new user password. Go to the next page.

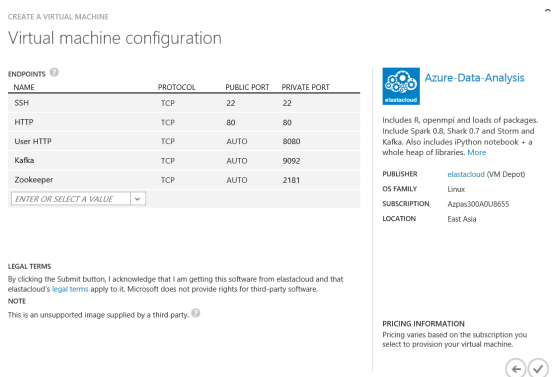


13. Enter a name for the new cloud service configuration and select your affinity group from the drop down box. Go to the next page.



14. We'll need to add several endpoints for the VM. To add an endpoint, enter a name for the endpoint like "HTTP" or "Kafka" in the field under **Name** in the Endpoints table. Add the following TCP endpoints:

    1. HTTP: Port 80
    2. User HTTP: Port 8080
    3. Kafka: Port 9092
    4. Zookeeper: 2181 Your endpoints should look like this:



15. Click the checkmark button and wait for the new VM to be created, provisioned, and started.

16. If your local workstation runs Windows then you'll need to install an SSH client like PuTTY to connect to the Azure Data Science Core VM. If you're using a Mac or Linux client then you already have everything you need.

17. Use your ssh client to connect to the VM.

Preinstalled software on the image

The image Azure Data Analysis has installed some software that we can directly use. If you are curious about what we have done on that image, the following instrcutions will help you.

Please note that not all steps in the section are required. It is only for your reference.

1. Initial Installs including git, libzmq, java, g++ etc.

```
Linux sudo apt-get update sudo apt-get install git sudo apt-get install libzmq-dev sudo apt-get install pkg-config sudo apt-get install openjdk-7-jdk sudo apt-get install build-essential sudo apt-get install automake sudo apt-get install java-gcj-compat-dev sudo apt-get install libtool sudo apt-get install g++ sudo apt-get install make
```

2. Install Zeromq. Storm uses the 0MQ socket library to connect its pieces, so we need to install the latest 0MQ development headers and Java bindings.

```
Linux git clone https://github.com/zeromq/jzmq.git cd jzmq ./autogen.sh ./configure make sudo make install
```

3. Update node, install npm and redis server.

```
Linux sudo add-apt-repository ppa:chris-lea/node.js sudo apt-get update sudo apt-get install nodejs sudo apt-get install redis-server
```

4. Install Maven. Many projects use the Maven project management tool for build management, dependency management, and packaging. Maven projects are described in a **pom.xml** file in the top-level of the project.

```
Linux cd $HOME wget http://www.interior-dsgn.com/apache/maven/maven-3/3.1.0/binaries/apache-maven-3.1.0-bin.tar.gz tar xzf apache-maven-3.1.0-bin.tar.gz echo 'export PATH=$HOME/apache-maven-3.1.0/bin:$PATH' >> ~/.bashrc source ~/.bashrc mvn --version
```

5. Install Leiningen. Some community provided extensions to Storm and Kafka are written in Clojure, a dynamic programming language that targets the Java Virtual Machine. Clojure projects are managed via Leiningen, which is a software management tool very similar to Maven. Installing Leiningen is very easy because it's distributed as a single, simple script file.

```
Linux cd /bin sudo wget https://raw.github.com/technomancy/leiningen/stable/bin/lein sudo chmod +x lein
```

6. Install Kafka. Our example uses the Kafka messaging system to accept messages from clients and queue them until they can be processed. Kafka can achieve very high message throughput and is designed to scale up as needed, so it's a great fit for the cloud.

```
Linux cd $HOME wget http://www.motorlogy.com/apache/incubator/kafka/kafka-0.7.2-incubating/kafka-0.7.2-incubating-src.tgz tar xzf kafka-0.7.2-incubating-src.tgz cd kafka-0.7.2-incubating-src ./sbt update ./sbt package cd $HOME echo 'export PATH=$HOME/kafka-0.7.2-incubating-src/bin:$PATH' >> ~/.bashrc source ~/.bashrc
```

Download and Build the Example Code

1. Clone the example repository:

```
cd $HOME
git clone https://github.com/wenming/gpskafkademo.git
```

2. Use Leiningen to build the Storm uberjar. This produces a single, stand-alone file that can be submitted to a Storm cluster or launched as a locally-hosted server.

```
cd gpskafkademo
lein uberjar
```

3. Use Leiningen to build the Kafka client:

```
cd kafka-gps-client
lein uberjar
```

4. Use Node.js to build the web application:

```
cd ../node
npm install
```

The example is built and all necessary dependencies have been installed. Now we just need to run the example code.

Launch Server Processes

There are several server processes that need to be started before we can launch the example. You can either follow the instructions below to launch all the servers from one console, or open several, separate console windows, connect to the VM in each window, and launch one server process per console. It's much easier to debug connectivity problems if you run each server in its own window. It is important to start the servers in the order shown below.

1. **Zookeeper**: Both Kafka and Storm use Zookeeper to track and manage server instances in their respective clusters. Zookeeper is also the endpoint for clients. Programs wishing to publish Kafka messages connect to the Zookeeper server to be forwarded to the least heavily loaded Kafka server.

```
zookeeper-server-start.sh ~/kafka-0.7.2-incubating-src/config/zookeeper.properties > ~/zookeeper-server.log 2>&1 &
```

   This command starts the zookeeper server on **port 2181** as a background process and records all its output in the **zookeeper-server.log** file in your home directory. If you want to see what the server is doing, you can use the **tail** command:

```
tail -f ~/zookeeper-server.log
```

   Press **Ctrl+C** to close tail.

2. **Kafka**: Once Zookeeper has stated, start the Kafka server:

```
kafka-server-start.sh ~/kafka-0.7.2-incubating-src/config/server.properties > ~/kafka-server.log 2>&1 &
```

   This command starts a single Kafka broker server on **port 9092** as a background process and records all its output in the **kafka-server.log** file in your home directory. If you want to see what the server is doing, you can use the **tail** command:

```
tail -f ~/kafka-server.log
```

   Press **Ctrl+C** to close tail.

3. **Redis**: The Redis server provides a simple key-value store that works especially well with web applications written in Node.js. Start the redis server:

```
/usr/bin/redis-server > ~/redis-server.log 2>&1 &
```

4. To make this easier, we've included a convenience script, **start*server*processes.sh** in *gpskafkademo* that will launch the server processes for you.

Launch the Example

Our example consists of three parts: a web application that presents GPS coordinate data, a Storm topology that processes the data, and a Kafka client application that produces the coordinates. We will start each part of the example in turn.

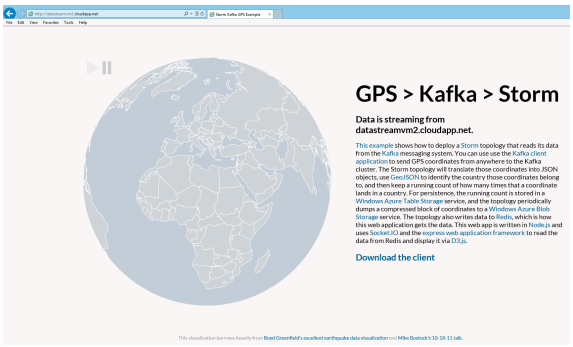
1. Start the web application. The application is served on **port 80** by default so we need to launch it as root.

```
cd $HOME/gpskafkademo/node
sudo node app.js
```

You should see output like this:

```
info  - socket.io started
Listening on port 80
```

2. Open your web browser and go to the cloud service DNS name you specified when you created the VM. You should see the web app:



Nothing interesting is happening because we have not yet started the data stream. Leave this browser window open so you can see the effects of the following commands.

1. Open a second SSH connection to the VM (open PuTTY on Windows or a new terminal on Linux or OS X) and launch the Storm topology:

```
cd $HOME/gpskafkademo
java -cp $(lein classpath) storm.example.KafkaGpsTopology
```

You should see a lot of output as the topology starts. Once it's up and running the output will look like:

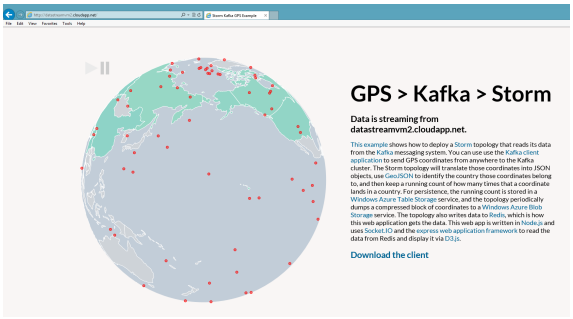
4105 [Thread-25] INFO storm.kafka.PartitionManager - Starting Kafka 127.0.0.1:0 from offset 2185373 4106 [Thread-25] INFO backtype.storm.daemon.executor - Opened spout spout:(6) 4109 [Thread-25] INFO backtype.storm.daemon.executor - Activating spout spout:(6) 4224 [Thread-25] INFO storm.kafka.PartitionManager - Committing offset for 127.0.0.1:9092:0 4224 [Thread-25] INFO storm.kafka.PartitionManager - Comitted offset for 127.0.0.1:9092:0 6241 [Thread-25] INFO storm.kafka.PartitionManager - Committing offset for 127.0.0.1:9092:0 6242 [Thread-25] INFO storm.kafka.PartitionManager - Comitted offset for 127.0.0.1:9092:0

You won't see any change your browser because although the topology has been started there is no data being sent to Kafka for the Storm topology to process.

1. Open a third SSH connection to the VM and start the Kafka client:

```
cd $HOME/gpskafkademo/kafka-gps-client
java -cp $(lein classpath) kafka.example.KafkaGpsDataProducer localhost
```

The client generates random GPS coordinates and sends them to Kafka. Go back to your web browser and you'll see GPS coordinates being plotted on the globe. Countries will change color according to the frequency of "hits".



The client publishes data on the "gps" topic. **localhost** on the command line means we are connecting to Zookeeper on localhost to get connected to the Kafka server. You can specify the connection string as any of:

- zookeeper_host
- zookeeper_host:port
- broker*id*:*kafka*host:kafka_port

- You can run this Kafka client from any machine with Java. To run from your local workstation, download the client JAR file from the web application page and run it as follows:

```
java -cp kafka-gps-client-0.0.1-SNAPSHOT-standalo.jar kafka.example.KafkaGpsDataProducer 0:ds-jlinford.cloudapp.net:9092
```

In this case we've bypassed Zookeeper and connected directly to the Kafka server on port 9092. The **0:** at the start of the connection address indicates that we wish to connect to the Kafka broker with ID 0.