ConnectTheDots – Quick Start

# Intro

The MS Open Tech ConnectTheDots.IO project illustrates how to connect sensors and devices to the Azure Cloud, und use Azure to analyze and visualize the resulting data streams.

In a typical topology, sensors (here several Arduino Uno R3 boards with Arduino Weather Shields) connect to one or more local IoT Gateways (here Raspberry PI devices), which relay the data to Azure Event Hubs. Once in the cloud, the data streams are fed into a web dashboard and to near real-time analytics engines (here Azure Stream Analytics, in this case to generate averages and alerts across all devices). The real-time data streams, average, and alerts are then visualized in an Azure Website, which can be viewed with any HTML5-capable browser. The high level architecture for the ConnectTheDots.IO project is shown in Figure 1.

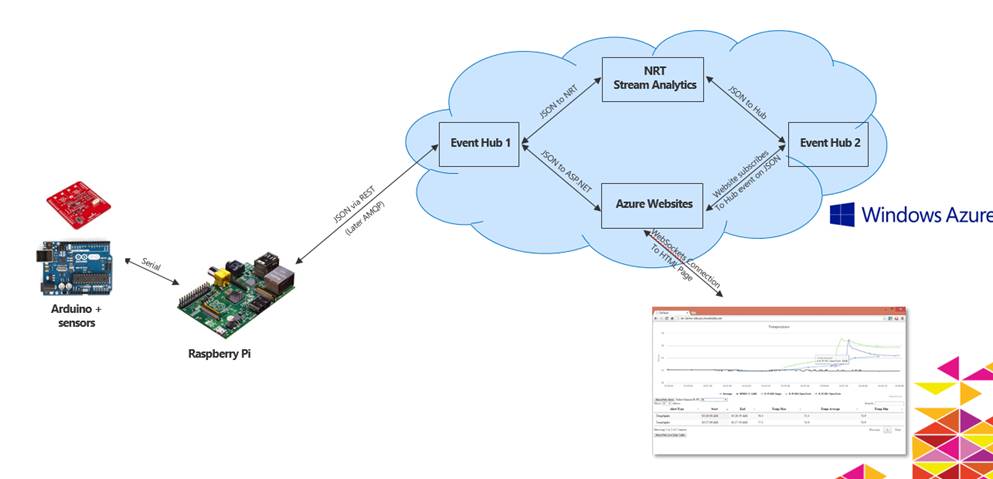


Figure 1: ConnectTheDots.IO architecture

The ConnectTheDots.IO project provides you with all the code and step-by-step instructions to build and deploy such an end-to-end solution.

# Prerequisites:

1. Microsoft Azure subscription ([free trial subscription](http://azure.microsoft.com/en-us/pricing/free-trial/) is sufficient)
2. Access to the [Azure Streaming Analytics Preview](https://account.windowsazure.com/PreviewFeatures)
3. Visual Studio 2013 [– Community Edition](http://www.visualstudio.com/downloads/download-visual-studio-vs)

## Hardware:

1. [Raspberry PI B/B+](http://www.raspberrypi.org/products/model-b-plus/) with Internet access
2. [Arduino Uno R3](http://arduino.cc/en/Main/ArduinoBoardUno)
3. [SparkFun Weather Shield](https://www.sparkfun.com/products/12081) for Arduino (make sure you also have the required headers etc. as specified on the SparkFun site)

Note: Only the models above have been tested. The Weather Shield sample code from Sparkfun, for example, may need to be modified before it will work reliably on Arduino Due or Arduino Uno R2.

# Step-by-step

1. Download and Build “ConnectTheDots”:
   1. Download or clone the “ConnectTheDots” depot from <https://github.com/MSOpenTech/connectthedots-pr>
   2. Open ConnectTheDots.sln in Visual Studio and build the solution
   3. If the AMQP.Net Lite NuGet package cannot be found (it has not been published as of this writing), you will need to build it yourself:
      1. Download or clone from <http://amqpnetlite.codeplex.com>
      2. To avoid errors for platforms for which you don’t have tooling, comment out or remove all <file> elements except for “bin\Release\Amqp.Net\\*.\*” in Amqp.Net.nuspec:

<files>

<file src="bin\Release\Amqp.Net\\*.\*" target="lib\net" />

<!--<file src="bin\Release\Amqp.NetCF39\\*.\*" target="lib\netcf39" />

<file src="bin\Release\Amqp.NetMF42\\*.\*" target="lib\netmf42" />

<file src="bin\Release\Amqp.NetMF42\le\\*.p\*" target="lib\netmf42\le" />

<file src="bin\Release\Amqp.NetMF42\be\\*.p\*" target="lib\netmf42\be" />

<file src="bin\Release\Amqp.NetMF43\\*.\*" target="lib\netmf43" />

<file src="bin\Release\Amqp.NetMF43\le\\*.p\*" target="lib\netmf43\le" />

<file src="bin\Release\Amqp.NetMF43\be\\*.p\*" target="lib\netmf43\be" />

<file src="bin\Release\Amqp.Store\\*.\*" target="lib\windows8" />

<file src="bin\Release\Amqp.WP\\*.\*" target="lib\windowsphone8" />-->

</files>

* + 1. Open a Developer Command Prompt for VS2013, and run build.cmd. You should now see AMQPNetLite.0.1.0-alpha.nupkg in the build/packages folder.
    2. Add this folder as a private NuGet location:
       1. Open Tools, Options, NuGet Package Manager, Package Sources and add “<youramqpnetlitepath>\Build\Packages” as a new package source.
    3. Build the ConnectTheDots.sln solution again.

1. Create Azure resources for Event Hub:
   1. Download publishsetting file
      1. Go to <https://manage.windowsazure.com/publishsettings/index?client=powershell>) and save to local disk <publishsettingsfile> (contains keys to manage all resources in your subscriptions, so handle with care).
      2. If you have access to multiple subscriptions, make sure the file only contains the subscription that you want to use, otherwise, remove the other XML elements for the other subscriptions.
   2. Run ConnectTheDotsCloudDeploy from a command prompt, passing a name to be used for all cloud resources, and the publishsettings file
      1. Chose a <name> that has only letters and number

cd ConnectTheDotsCloudDeploy\bin\debug\

ConnectTheDotsCloudDeploy.exe –n <name> -ps <publishsettingsfile>

* 1. Note the device connection strings displayed by the tool, as you will need them to provision the devices later, i.e.

D:\Source\Repos\connectthedots\Azure\ConnectTheDotsCloudDeploy\bin\Debug>

ConnectTheDotsCloudDeploy.exe -n ctdtest1 -ps d:\temporary\MarkusHMSDN.publishsettings

Creating Service Bus namespace ctdtest1-ns in location Central US

Namespace cdttest1-ns in state Activating. Waiting...

Namespace cdttest1-ns in state Activating. Waiting...

Namespace cdttest1-ns in state Activating. Waiting...

Creating Event Hub EHDevices

Creating Consumer Group WebSite on Event Hub EHDevices

Creating Consumer Group WebSiteLocal on Event Hub EHDevices

Creating Event Hub EHAlerts

Creating Consumer Group WebSite on Event Hub EHAlerts

Creating Consumer Group WebSiteLocal on Event Hub EHAlerts

Creating Storage Account cdttest1storage in location Central US

Service Bus management connection string (i.e. for use in Service Bus Explorer):

Endpoint=sb://ctdtest1-ns.servicebus.windows.net/;SharedAccessKeyName=RootManageSharedAccessKey;SharedAccessKey=zzzzzzz

Device AMQP address strings (for Raspberry PI/devices):

amqps://D1:xxxxxxxx@yyyyyyyy.servicebus.windows.net

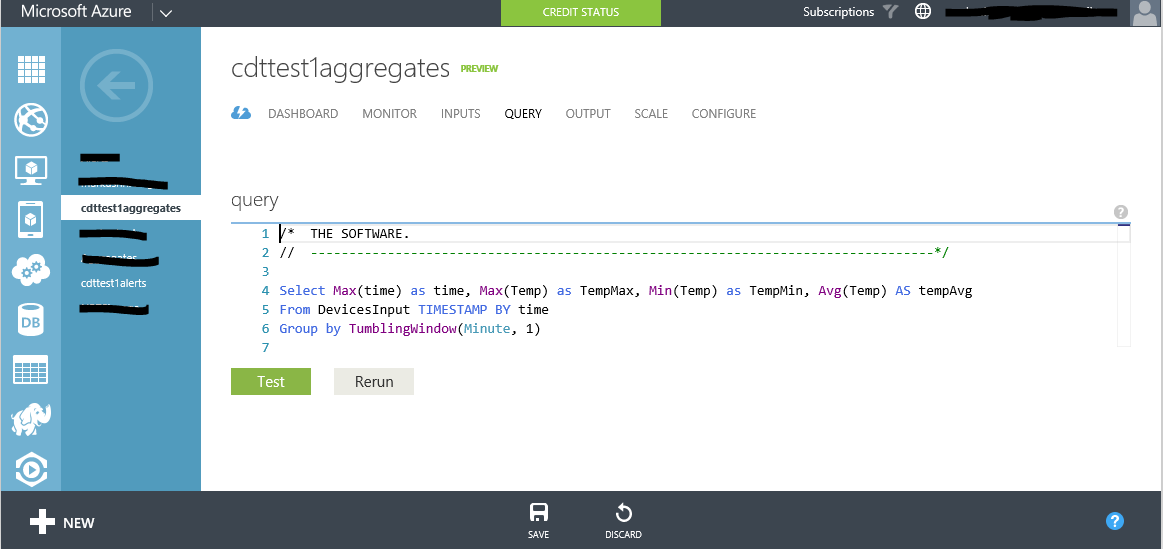
amqps://D2:xxxxxxxx@yyyyyyyy.servicebus.windows.net

amqps://D3:xxxxxxxx@yyyyyyyy.servicebus.windows.net

amqps://D4:xxxxxxxx@yyyyyyyy.servicebus.windows.net

Web.Config saved to D:\Source\Repos\connectthedots\Azure\ConnectTheDotsWebSite\web.config

1. Create Azure Stream Analytics jobs:
   1. Make sure you have access to the preview: if not sign up at <https://account.windowsazure.com/PreviewFeatures>
   2. In the [Azure Management Portal](http://azure.com/), create a new job “**Aggregates**”:
      1. “+” in lower left corner -> Data Services -> Stream Analytics -> Quick Create -> Job name “Aggregates”.
      2. Add Input
         1. Inputs tab -> Add an Input -> Data Stream, Event Hub
         2. Input Alias: “DevicesInput”
         3. Choose the namespace <name>-ns,
         4. Event Hub “ehdevices”
         5. Policy Name: “StreamingAnalytics”
         6. Serialization: JSON, UTF8
      3. Query:
         1. Query tab
         2. Copy/paste contents “Queries\Aggregates.sql”



* + - 1. Save
    1. Create output
       1. Output tab -> Add an Output, Event Hub,
       2. Choose the namespace <name>-ns,
       3. Event Hub “ehalerts”
       4. Policy name “StreamingAnalytics”
       5. Serialization “JSON”, UTF8
    2. Start the Job
       1. Dashboard, Start
  1. Create a new job “**Alerts**”: as above, but use “alerts.sql” contents for the query (in step iii/2.)

1. Publish the Azure Website
   1. In VS: Right-click on Azure\ConnectTheDotsWebSite, Publish.
   2. Select Azure Web Sites, create new one.
   3. Publish
   4. Enable WebSockets for the new Azure Web site
      1. Browse to <https://manage.azure.com> and select your Azure Web Site.
      2. Click on the Configure tag. Then set WebSockets to On
   5. Open the site in a browser to verify it has deployed correctly.
      1. Click on Show/Hide Live Data Table: you should see “Connected.” As the top entry. if you see “ERROR undefined” you likely didn’t enable WebSockets for the Azure Web Site (step d above).
2. Provision the Raspberry PI:
   1. Get a Raspbian NOOBS SD Card or download a NOOBS image as per the instructions on <http://www.raspberrypi.org/downloads/>
   2. Boot the NOOBS SD Card and choose Raspbian (see <http://www.raspberrypi.org/help/noobs-setup/> for more information).
   3. Connect to the Raspberry PI via SSH, either via a [USB-Serial adapter](https://learn.adafruit.com/adafruits-raspberry-pi-lesson-5-using-a-console-cable/connect-the-lead) or via the network (enable once as per [these instructions](http://www.raspberrypi.org/documentation/remote-access/ssh/README.md) while booting via a monitor on HDMI and a USB keyboard).
      1. For Windows, download PuTTY and PSCP from [here](http://www.chiark.greenend.org.uk/~sgtatham/putty/download.html).
   4. Install the Mono runtime and root certs required SSL:
      1. Run the following from a shell (i.e. via SSH).   
         Note: Especially steps 1 and 2 can take a long time to download/un-compress.
         1. sudo apt-get update
         2. sudo apt-get upgrade
         3. sudo apt-get install mono-complete
         4. mozroots --import --ask-remove
   5. Create a directory /home/pi/ RaspberryPiGateway:

mkdir /home/pi/ RaspberryPiGateway

* 1. On your PC, update Devices\RaspberryPiGateway\scripts\**autorun.sh** with one of the amqp address strings returned by ConnectTheDotsCloudDeploy.exe, i.e. amqps://D1:xxxxxxxx@yyyyyyyy.servicebus.windows.net:

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#!/bin/bash

echo "Running CloudDemo..."

#sudo -u pi /usr/bin/mono /home/pi/RaspberryPiGateway/RaspberryPiGateway.exe -forever -deviceid C8CA5B13-A550-4FF0-B823-46D8A2640880 -devicename "R-PI 001" -address amqps://D1:xxxxxxxx@yyyyyyyy.servicebus.windows.net -target ehdevices -tracelevel information >> /home/pi/RaspberryPiGateway/RaspberryPiGateway.log &

…

Note: Make sure you use an editor that preserves Unix line end (Visual Studio does by default, Notepad does NOT). Otherwise the autorun.sh file will not execute on the Raspberry PI.

[ Feel free to pick a -deviceid or -devicename of your liking, or just leave as is. ]

* 1. Copy the required files from Devices\RaspberryPiGateway\bin\Debug to Raspberry’s /usr/pi/RaspberryPiGateway/:
     1. RaspberryPiGateway.exe, Amqp.Net.dll, Newtonsoft.Json.dll, scripts/autorun.sh
        1. You can use Devices\RaspberryPiGateway\scripts\scprpi.cmd to copy via SSH (update the IP address and SCPR download location in the .CMD file as necessary), or copy directly to the SD card.
  2. On the Raspberry PI Make /home/pi/RaspberryPiGateway/autorun.sh executable:

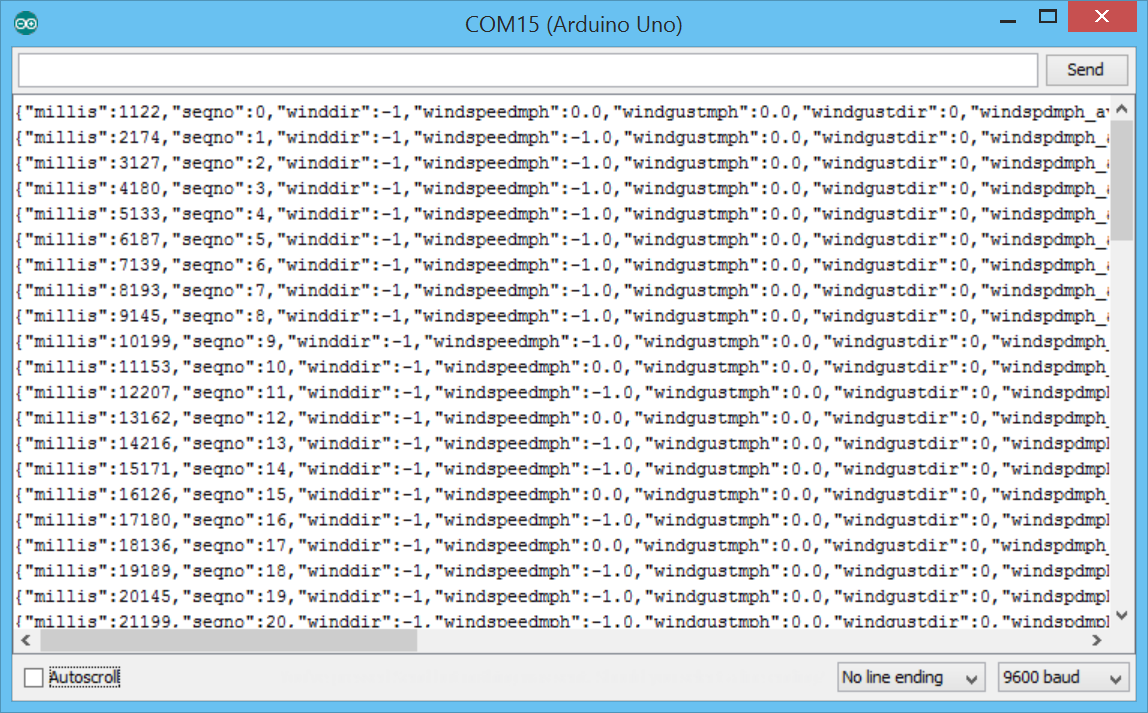
sudo chmod 755 /home/pi/RaspberryPiGateway/autorun.sh

* 1. On the Raspberry PI, modify /etc/**rc.local** by adding one line to start the gateway program on every boot (OK to skip this if you prefer to run manually after every reboot via /autorun.sh from a shell/SSH session):

/home/pi/RaspberryPiGateway/autorun.sh &

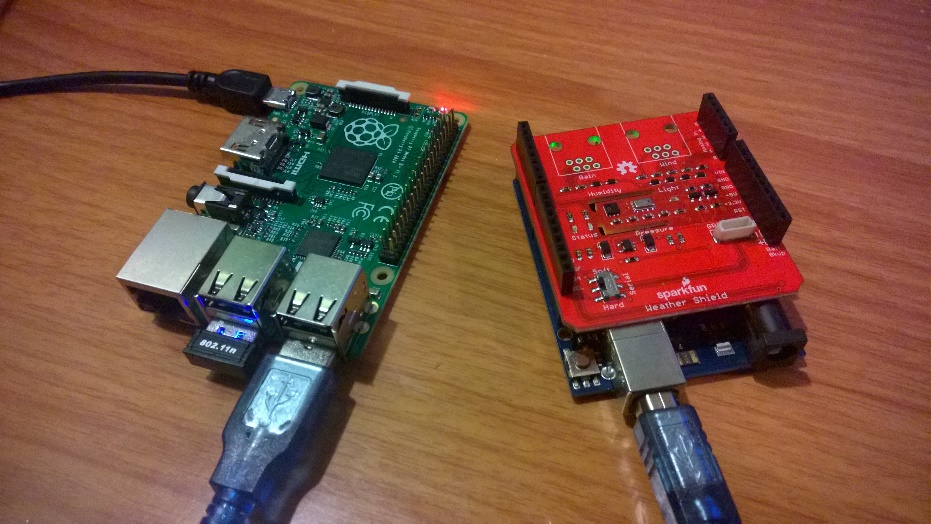
Tips: To edit this file, you can use **sudo nano /etc/rc.local**, to exit the editor: ctrl-x.

1. Prepare the Arduino Uno R3:
   1. Connect the Arduino Uno R3 directly to your computer with the USB cable
   2. Install and run the [Arduino IDE](http://arduino.cc/en/Main/Software) (we recommend the 1.5.8 version, with the Windows Installer).
   3. If necessary, install the Windows device drivers for the Arduino on your computer, following the instructions [here](http://arduino.cc/en/Guide/windows#toc4).
   4. Download the Weather Shield libraries from [here](https://dlnmh9ip6v2uc.cloudfront.net/assets/b/5/9/7/f/52cd8187ce395fa7158b456c.zip) (as per the instruction in the [Weather Shield Hookup guide](https://learn.sparkfun.com/tutorials/weather-shield-hookup-guide)).
      1. Extract all files from the ZIP file to a temporary location, then import the two folders (HTU21D\_Humidity and MPL3115A2\_Pressure) in the Arduino IDE by clicking Sketch, Import Library, Add Library and selecting the folder (once for each folder).
   5. In the Arduino IDE open Devices\Arduino\WeathershieldJson.ino (it is modified from the original Spark fun sample to send data in JSON format)
   6. Compile and upload the Weather Shield sketch to the Arduino: File/Upload or Crtl-U or press the Right Arrow.
   7. Open the serial monitor (shift-ctrl-m). You should now see temperature and other data on the serial monitor:



* 1. Disconnect the Arduino from your computer

1. Run Raspberry PI + Arduino
   1. Plug Arduino’s USB cable into one of the Raspberry PI USB ports:



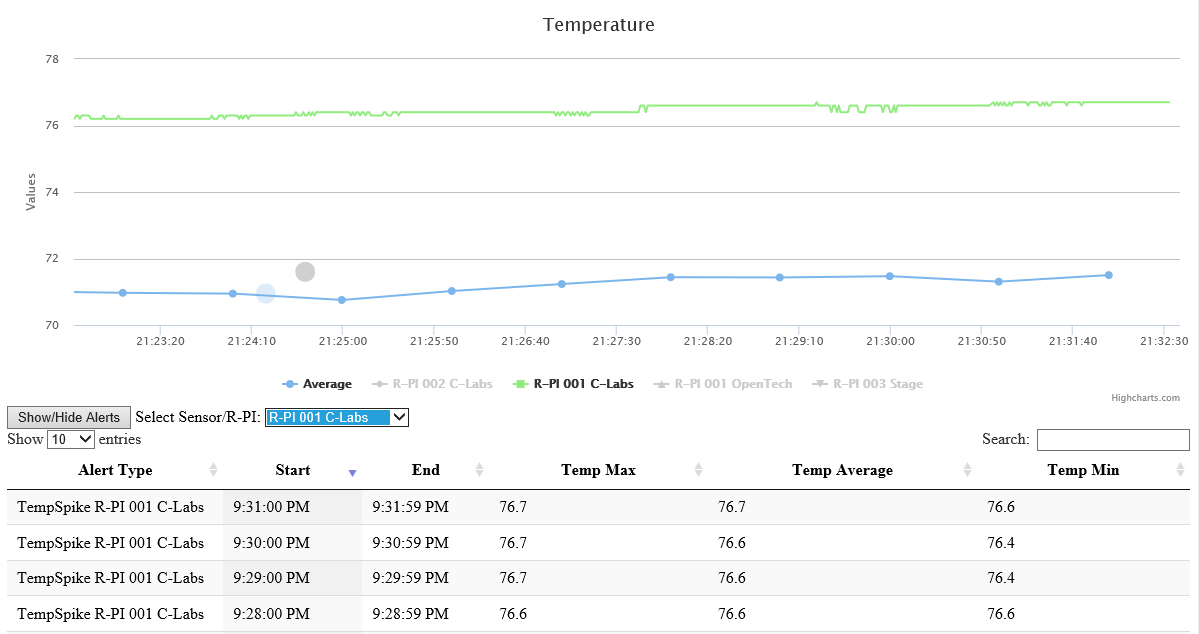
Note/Tip: The R-PI in the picture uses a WIFI dongle instead of Ethernet. Look [here](http://www.howtogeek.com/167425/how-to-setup-wi-fi-on-your-raspberry-pi-via-the-command-line/) for tips to configure your SSID/keys.

* 1. (Re-)start Raspberry PI

You should now see average temperature measurements showing up in the web browser every minute.

If you select “All”, you should see raw readings from the device coming in every second.

If the temperature exceeds 75 degrees (F), you should see an alert showing in the alerts table, once per minute while the temperature on any of the devices exceeds 75 degrees (F).



# Additional things to try:

To add **more devices**, you can modify the parameters to RaspberryPiGateway.exe in autorun.sh before copying the file to additional Raspberry PI: generate a new GUID as the device id, chose a new device display name and chose one of the other AMQP connection strings (so can turn off rogue devices in the cloud later). [ Currently only the device display name really needs to be different between devices.].

**Multi-environment deployment** (i.e. test, demo, production): Use ASP.Net Web.config transforms to keep separate settings for each of your deployments. You can associate a transform with each publisher profile, and the deployment tool will generate a transform file if you specify the -transform command line parameter, and use the profile name as the -n parameter, i.e.

cd ConnectTheDotsCloudDeploy\bin\debug\

ConnectTheDotsCloudDeploy.exe –n <name> -ps <publishsettingsfile> -transform

**Running without hardware:** The RaspberryPiGateway is a C# console application that can also run on Windows. Specify a COM port on the command line (i.e. -serial COM10) and you can receive serial data from an Arduino Uno.

If you do not have an Arduino or no Weather Shield, you can compile the RaspberryPiGateway to generate random temperature data by uncommenting the following line in Devices\RaspberryPIGateway\Program.cs:

~~//~~#define SIMULATEDATA

**Change the alert threshold:** Thethresholdof 75 is in the Azure Streaming Analytics query (Alerts.sql).

**Troubleshooting tips:**

Raspberry Pi:

* Diagnostics logs: tail /home/RaspberryPiGateway/RaspberryPiGateway.log
* You can run the gateway exe manually, i.e.

cd /home/pi/RaspberryPiGateway

mono RaspberryPiGateway.exe -forever -deviceid C8CA5B13-A550-4FF0-B823-46D8A2640880 -devicename "R-PI 001" -address amqps://D1:xxxxxxxx@yyyyyyyy.servicebus.windows.net -target ehdevices -tracelevel information

Additional options:

* **-tracelevel verbose**: logs/shows more details
* **-tracelevel error**: logs/shows only errors (use this if you plan to run your Gateway for a long time, otherwise your SD Card will fill up)
* **-serial <port>**: use a different port than the default /dev/ttyACM0, i.e. -serial /dev/ttyACM1 (or -serial COM10 for use on Windows).
* **-frequency <milliseconds>**: send data to the cloud at a different time interval. Default: 1000 (1 second).

If you want to “stress test” your Raspberry PI/network connection, uncomment “#define LOG\_MESSAGE\_RATE” Devices\RaspberryPIGateway\Program.cs and use –frequency 0 (you may also want to un-define the TRACE symbol in VS build options, or use -tracelevel error, or you may be measuring the speed of your SD Card). [ ad hoc observations: expect ~200-400 msg/s on a R-PI B+. EventHub will throttle at 1000 msg/s per partition. ].

* Make sure autorun.sh does not have Windows line endings (CR/LF). It will only run with Unix line endings (LF). See [here](http://www.microhowto.info/howto/convert_the_line_endings_in_a_text_file_from_unix_to_dos_format.html) for some tips.
* To stop the gateway program: killall mono
  + To see if it’s running: ps -C mono

Azure:

* Failure while running ConnectTheDotsCloudDeploy.exe or forgot to save device or management connection strings: Just rerun the tool. It will only create missing resources, and obtain connection strings.
* No data coming into browser: make sure WebSockets are enabled in Azure Web Services (see above).
* Verify if data comes into Event Hub either from the devices or Azure Streaming Analytics: Use [Service Bus Explorer](https://code.msdn.microsoft.com/windowsazure/Service-Bus-Explorer-f2abca5a), connect with the management connection string returned by ConnectTheDotsCloudDeploy.exe:

D:\Source\Repos\connectthedots\Azure\ConnectTheDotsCloudDeploy\bin\Debug>

ConnectTheDotsCloudDeploy.exe –n ctdtest1 –ps d:\temporary\MarkusHMSDN.publishsettings

Creating Service Bus namespace ctdtest1-ns in location Central US

…

**Service Bus management connection string (i.e. for use in Service Bus Explorer):**

**Endpoint=sb://ctdtest1-ns.servicebus.windows.net/;SharedAccessKeyName=RootManageSharedAccessKey;SharedAccessKey=zzzzzzz**

…

* View web site trace logs: Server Explorer, Azure, Web Site, right-click on the site and click “View streaming logs”). You should see error and informational traces that can help you pinpoint issues.
* Run the web site locally (just hit “F5” in VS) and observe the debug output window for any error or informational traces [ You can safely run locally even while you are running a site in the cloud. The local site uses different Event Hub consumer groups. ]