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# Introduction to Azure IoT

Pierre Cauchois, Senior Software Engineer, Microsoft

<http://sched.co/9n2a>





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# Agenda

*How is Microsoft making it easy for embedded systems engineers to connect their “things” to “the cloud”?*

*What do you do once the devices are connected?*



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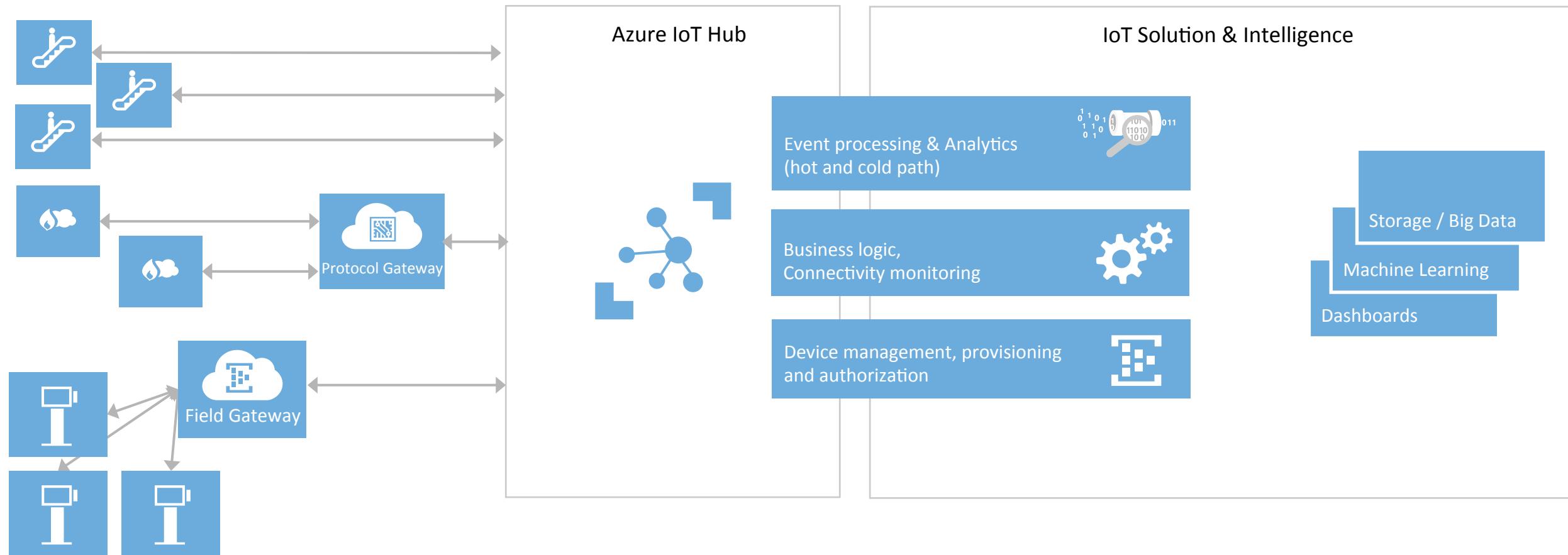
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# *Part 1: Connecting Devices to the Cloud*



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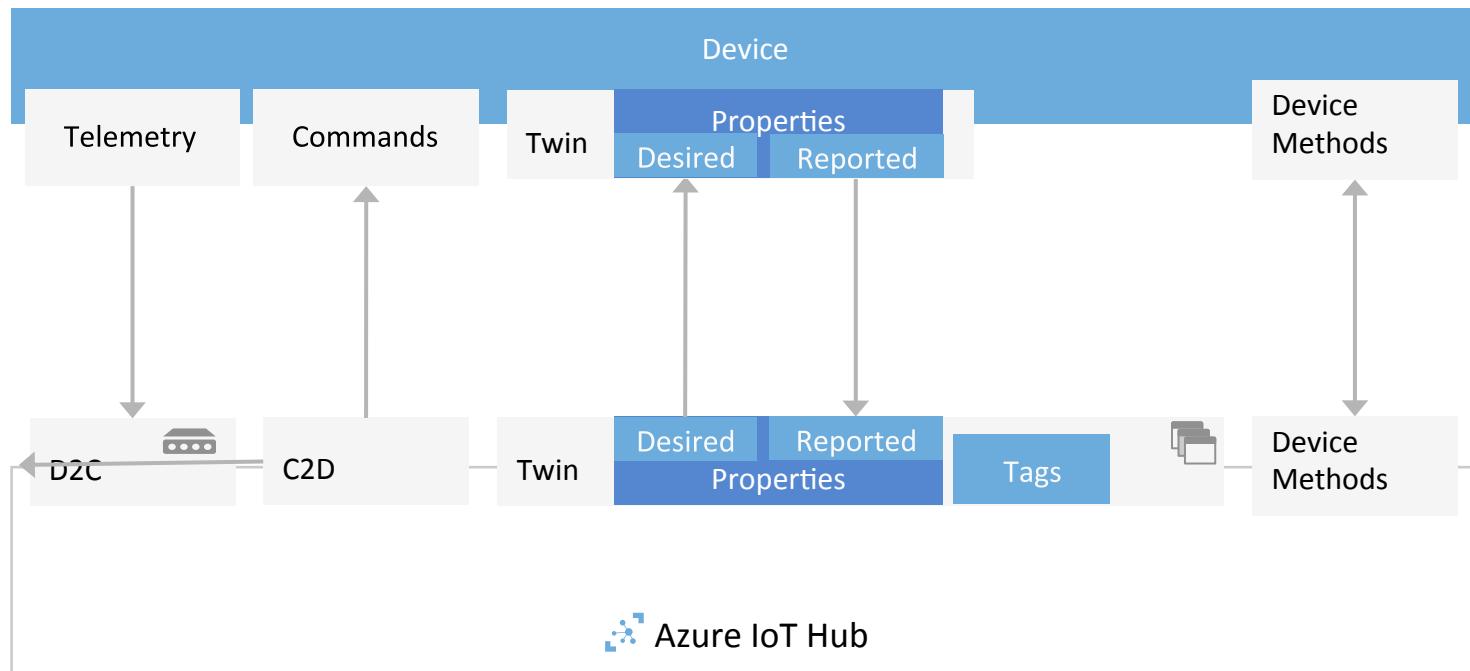
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# Device-facing Endpoints





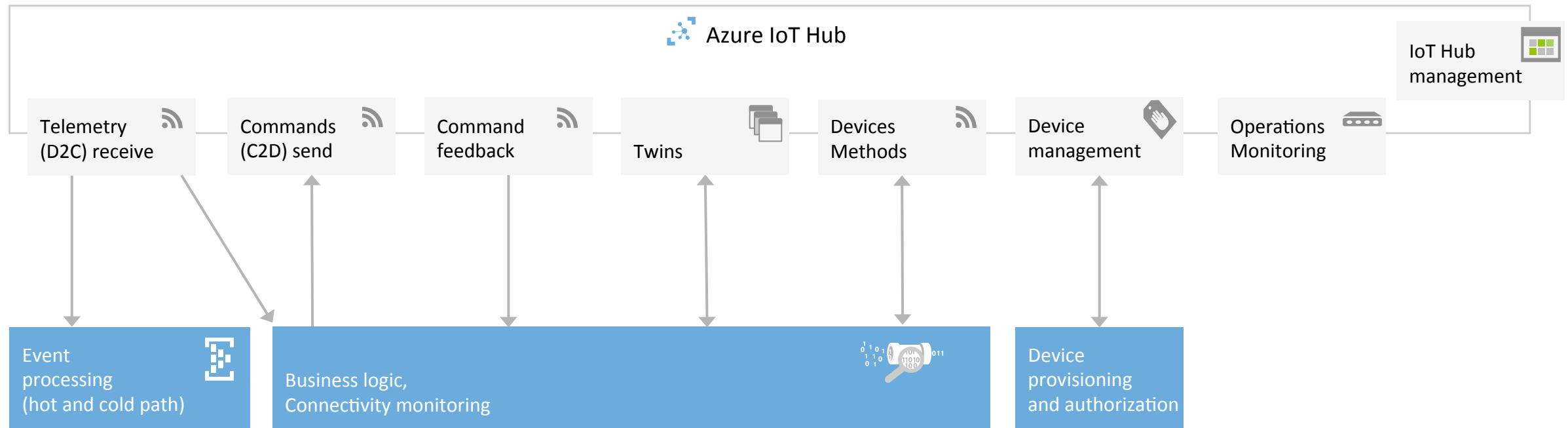
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# Backend-Facing Endpoints





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# SDK Supported Platforms

- Android (Java or Xamarin)
- Arduino
- Debian Linux (v 7.5)
- ESP8266
- Fedora Linux (v 20)
- FreeRTOS
- iOS (Xamarin)
- mbed OS (v 2.0)
- OpenWRT
- Raspbian Linux (v 3.18)
- STM32
- TI RTOS
- Ubilinux (v3.0)
- Ubuntu Linux (v 14.04)
- Windows Desktop (7, 8, 10)
- Windows IoT Core (v 10)
- Windows Server (v 2012 R2)
- Yocto Linux (v 2.1)
- ... and more



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# SDK Languages



## C library:

- Microcontrollers
- RTOS
- Linux
- Windows



## Node.js library:

- Node.js (v 0.10+)
- Node-RED



## Java library:

- Java (v 1.7+)
- Android



## C# libraries supported:

- Windows Desktop (7,8,10)
- Universal Windows Platform
- Windows 10 IoT Core
- Xamarin (iOS, Android)



## Python library:

- v 2.7.x
- v 3.5.x



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# Getting an SDK

- Clone on Github
- Look for it on your favoring package manager (npm, maven, nuget, apt...)
- Examples in this presentation will be node.js
  - <https://github.com/azure/azure-iot-sdk-node>



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# Giving the device an identity

- Device Identity == Identifier + Secret
- Secret:
  - Symmetric keys stored in the Device Registry + Token generated from this key and used by the device (*obviously, the key never travels on the wire*)
  - x509 Certs/Keys on the Device + Certificate Thumbprints in the Device Registry
- TPM Support to store secrets

<https://github.com/Azure/azure-iot-hub-vs-cs/wiki/Device-Provisioning-with-TPM>



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# Managing Device Identities

- Each identity supports 2 keys or 2 cert thumbprints for easy roll-over
- Single-device and Bulk APIs to create, update or delete device identities



# Giving the Device an Identity

## Device

```
var Protocol = require('azure-iot-device-amqp').Amqp;  
  
var Client = require('azure-iot-device').Client;  
  
var connectionString = 'HostName=<hub-name>.azure-  
devices.net;DeviceId=<some-device-id>;SharedAccessKey=<base64-  
key>';  
  
var client = Client.fromConnectionString(connectionString, Protocol);;
```

## Service

```
var iothub = require('azure-iothub');  
  
var connectionString = '[IoT Connection String]';  
  
var registry = iothub.Registry.fromConnectionString(connectionString);  
  
var device = { /* device description */ };  
registry.create(device, function(err, res) {  
    /* do something with the result */  
});  
/* update and delete work the same way */  
/* Bulk APIs also available */
```



# Sending a Message (“Telemetry” scenario)

## Device

```
var message = new Message("foo");
client.sendEvent(message, function (err, res) {/* deal with result */});
```

## Service

```
var EventHubClient = require('azure-event-hubs').Client;
var client = EventHubClient.fromConnectionString(connectionString);
client.open()
    .then(client.getPartitionIds.bind(client))
    .then(function (partitionIds) {
        return Promise.map(partitionIds, function (partitionId) {
            return client.createReceiver('$Default', partitionId).then(function(receiver) {
                receiver.on('message', printEvent);
            });
        });
    });
});
```

<https://docs.microsoft.com/en-us/azure/iot-hub/iot-hub-devguide-d2c-guidance>



# Receiving a Message (“Command” scenario)

## Device

```
client.on('message', function (msg) {  
  /* do something with the command */  
  client.complete(msg, function (err, res) {  
    /* We could also “reject” or “abandon” the message */  
    /* do something with the result */  
  });  
});
```

## Service

```
var Client = require('azure-iothub').Client;  
  
var connectionString = '[IoT Hub Connection String]';  
  
var client = Client.fromConnectionString(connectionString);  
client.send(<deviceId>, <message>, function (err, res) {  
  /* do something with the result */  
});
```



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# Sending and Receiving Messages

- MQTT\_S (and over Websockets)
- AMQP\_S (and over Websockets)
- HTTPS
- Protocol Gateway:
  - <https://docs.microsoft.com/en-us/azure/iot-hub/iot-hub-protocol-gateway>
  - <https://github.com/Azure/azure-iot-protocol-gateway>



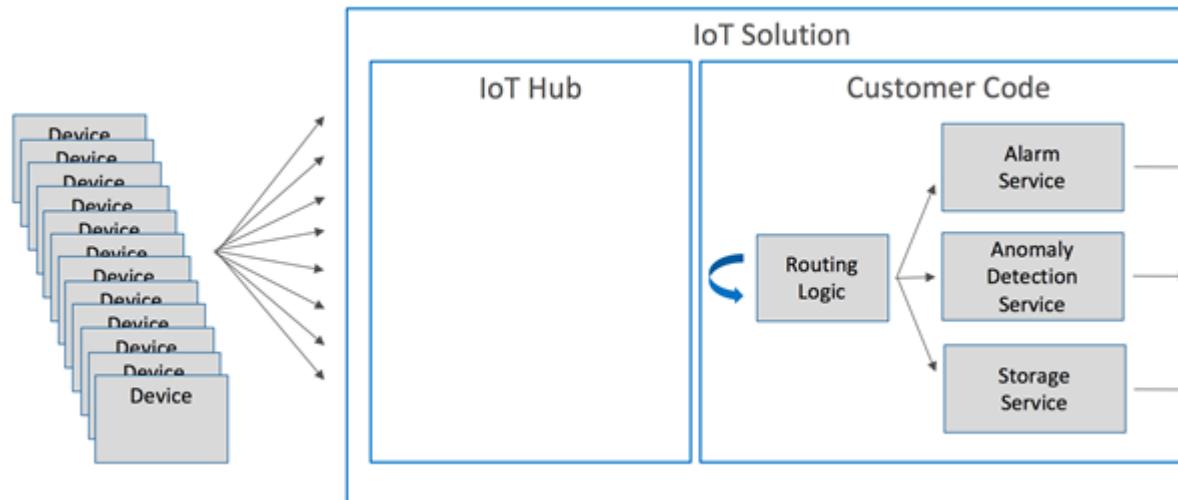
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# Routing messages (new!)



<https://azure.microsoft.com/en-us/blog/azure-iot-hub-message-routing-enhances-device-telemetry-and-optimizes-iot-infrastructure-resources/>



# Upload large amounts of data at once

## Device

```
client.uploadToBlob(<blob_name>, <file_stream>, <file_size>, function
  (err, result) {
    /* do something with the result */
  });

```

## Service

```
client.getFileNotificationReceiver(function(err, receiver) {
  receiver.on('message', function(msg) {
    /* msg contains the file location and a token to access it */
    receiver.complete(msg, function(err, res) { /* do something */ });
  });
});

```

- <https://azure.microsoft.com/en-us/blog/upload-files-from-devices-with-azure-iot-hub/>
- <https://docs.microsoft.com/en-us/azure/iot-hub/iot-hub-devguide-file-upload>



# Execute code on the device and return the result (“Device Methods”)

## Device

```
client.onDeviceMethod(<method_name>, function (request, response) {  
  /* Do something with the content of the request */  
  
  response.send(<status_code>, <payload>, function(err, res) {  
    /* do something with the result */  
  
  });  
});
```

## Service

```
var methodParams = {  
  methodName: '<Method Name>',  
  payload: '[Method Payload]',  
  responseTimeoutInSeconds: 30 //default  
};  
  
client.invokeDeviceMethod(<device_id>, methodParams, function (err,  
res) {  
  /* deal with result */  
});
```

<https://docs.microsoft.com/en-us/azure/iot-hub/iot-hub-node-node-direct-methods>



# Maintain a device state and metadata (“Device Twin”)

## Device

```
client.getTwin(function(err, twin) {  
  
  twin.on('properties.desired', function(delta) {  
  
    /* Do something with the delta (new property values) */  
  
  });  
  
  twin.properties.reported.update(patch, function(err) {  
  
    /* Do something if that failed */  
  
  });  
});
```

## Service

```
registry.getTwin(deviceld, function(err, twin) {  
  
  var twinPatch = {  
  
    tags: { city: "Redmond" },  
  
    properties: { desired: { telemetryInterval: 1000 } }  
  };  
  
  twin.update(twinPatch, function(err, twin) {  
  
    /* Do something */  
  
  });  
});
```

<https://docs.microsoft.com/en-us/azure/iot-hub/iot-hub-node-node-twin-getstarted>



# Schedule tasks on devices

## Device

```
/* Same as desired properties update or device method call */
```

## Service

```
var Protocol = require('azure-iot-device-amqp').Amqp;  
var Client = require('azure-iot-device').Client;  
var Message = require('azure-iot-device').Message;
```

```
var client = Client.fromConnectionString(connectionString, Protocol);  
var message = new Message("foo");  
client.sendEvent(message, function (err, res) {/* deal with result */});
```



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# Query device twins

```
var query = registry.createQuery('SELECT * FROM devices', 100);
var onResults = function(err, results) {
    /* Do something with the results */
    if (query.hasMoreResults) {
        query.nextAsTwin(onResults);
    }
};
query.nextAsTwin(onResults);
```

<https://docs.microsoft.com/en-us/azure/iot-hub/iot-hub-devguide-query-language>





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# Monitor Operations and Errors (Service)

```
var EventHubClient = require('azure-event-hubs').Client;
var client = EventHubClient.fromConnectionString(connectionString, '/messages/operationsMonitoringEvents/*');
client.open()
  .then(client.getPartitionIds.bind(client))
  .then(function (partitionIds) {
    return Promise.map(partitionIds, function (partitionId) {
      return client.createReceiver('$Default', partitionId).then(function(receiver) {
        receiver.on('message', printEvent);
      });
    });
  });
});
```

<https://docs.microsoft.com/en-us/azure/iot-hub/iot-hub-operations-monitoring>





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# Summary: Azure IoT Hub enables you to:

- Use open source, cross-platform SDKs that lets you:
- Manage device identities
- Send and receive millions of messages using industry protocols
- Route these messages to various endpoints
- Upload large amounts of data that wouldn't fit in messages
- Store and query device state and metadata
- Execute code or schedule tasks on devices
- Monitor operations in real time
- Connect devices to the rest of the Azure stack (stream analytics, storage, databases, machine learning...)
- ...



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# How to try and get started?

- Start for free
- Scale as you need
- Priced according to message processing capacity
- <https://azure.microsoft.com/en-us/pricing/calculator/>



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# No Internet Connectivity, No Problem: The Gateway SDK

- <https://github.com/azure/azure-iot-gateway-sdk>
- Open-Source & Cross Platform (duh!)
- Modular, with connectors to mainstream programming languages
- Easily add support for local communication protocols
- Supports OPC-UA

Earlier Breakout Session: Building Modular IoT Gateways with OSS: <http://sched.co/9mAh>





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# The Device Catalog

Azure Certified for IoT device catalog - Preview

Find your IoT device

Certified for IoT devices tailored to your needs

Tell us what device you are looking for

Register Devices    Learn More

Partner Dashboard

Microsoft Azure Certified

Industry    Device Type    Tested Compatible Sensors    Tested Built-in Sensors    Operating System    Connectivity    I/O Hardware Interfaces    Chip Manufacturers    Programming Languages    Industry Protocols    Industry Certification    Kit Available    Cloud Protocol    Geo Availability

NISE50  <b>NEXCOM</b> The Intelligent Systems	AAEON BOXER-6614  <b>AAEON</b> on ASUSTeK CO.	PDSB 325  <b>NEXCOM</b> The Intelligent Systems	AAEON ACP-1104  <b>AAEON</b> on ASUSTeK CO.	AAEON GENE-BT05  <b>AAEON</b> on ASUSTeK CO.
AAEON-UP  <b>AAEON</b> on ASUSTeK CO.	AAEON PICO-BT01  <b>AAEON</b> on ASUSTeK CO.	NISE 50C  <b>NEXCOM</b> The Intelligent Systems	Adafruit Feather M0 Wifi  Adafruit Feather Huzzah 	

- <https://catalog.azureiotsuite.com/>
- Browse/Search using various criteria and applications
- Hundreds of certified devices
- Fully-fledged certification program



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## ***Part 2: What to do with these connected devices?***



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# Build your own IoT Solution

- Process Data in Realtime with Stream Analytics
- Build Dashboards with Power BI
- Get Smart with Azure Machine Learning
- Store into Azure Storage or Azure Data Lake
- Run Big Data Analytics with Azure Data Lake Analytics or HDInsight
- Go serverless with Azure Functions
- ...



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# Use a Preconfigured Solution: Azure IoT Suite



## Predictive maintenance

Anticipate maintenance needs and avoid unscheduled downtime by connecting and monitoring your devices for predictive maintenance.



## Remote monitoring

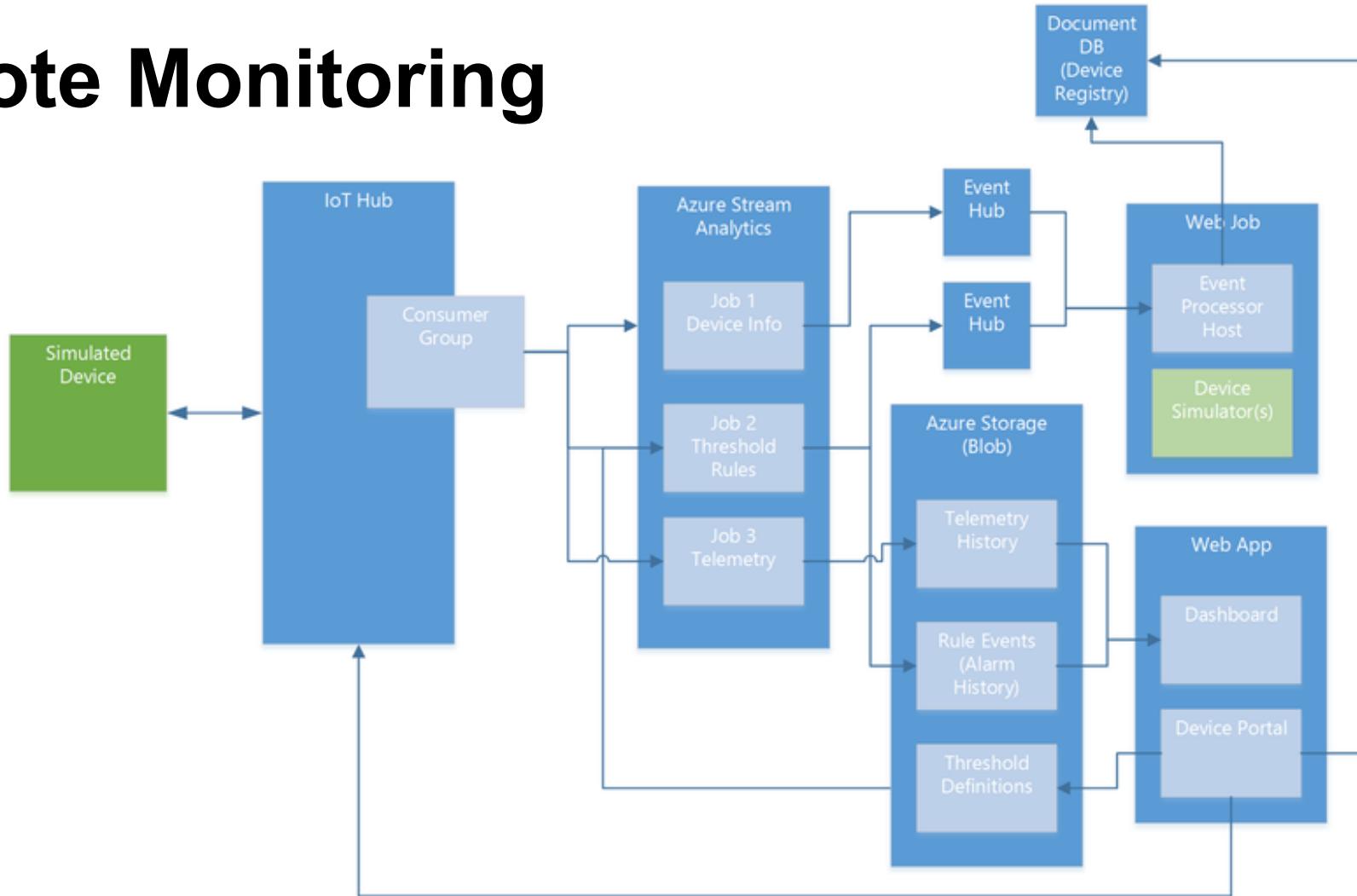
Connect and monitor your devices to analyze untapped data and improve business outcomes by automating processes.

<https://www.azureiotsuite.com>



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# Remote Monitoring





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Microsoft Azure IoT Suite ⓘ RMSolution ADMINISTRATOR Sign Out

Devices List (4)

STATUS	DEVICE ID	MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	FIRMWARE	PLATFORM	PROC
Running	SampleDevice001_363	Contoso Inc.	MD-183	SER5094	1.43	Plat-9	i3-938
Running	SampleDevice002_363	Contoso Inc.	MD-762	SER7925	1.0	Plat-30	i3-2457
Running	SampleDevice003_363	Contoso Inc.	MD-161	SER4940	1.1	Plat-59	i3-3716
Running	SampleDevice004_363	Contoso Inc.	MD-192	SER4277	1.54	Plat-48	i3-7923

> DEVICE DETAILS

Actions

- Disable Device
- Add Rule...
- Commands

Device Properties Edit

DEVICEID  
SampleDevice001\_363 edit

HOSTNAME  
RMsolution.azure-devices.net edit

HUBENABLEDSTATE  
True

CREATETIME  
09/29/2015, 9:14:38 AM

DEVICESTATE  
normal

UPDATEDTIME  
09/29/2015, 9:16:19 AM

MANUFACTURER  
Contoso Inc.

MODELNUMBER  
MD-183

SERIALNUMBER  
SER5094

+ ADD A DEVICE

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Microsoft Azure IoT Suite i RMsolution ADMINISTRATOR Sign Out

DASHBOARD DEVICES RULES ACTIONS ADD A DEVICE

Bird's eye | Seattle, Washington, USA

Device to View: SampleDevice001\_363

Telemetry History

Humidity Temperature

Alarm History

TIME	DEVICE ID	RULE OUTPUT	VALUE
09/29/2015 9:22:25 AM	SampleDevice001_363	AlarmTemp	43.817
09/29/2015 9:22:25 AM	SampleDevice001_363	AlarmHumidity	22.588
09/29/2015 9:22:23 AM	SampleDevice001_363	AlarmTemp	42.933
09/29/2015 9:22:23 AM	SampleDevice001_363	AlarmHumidity	25.135

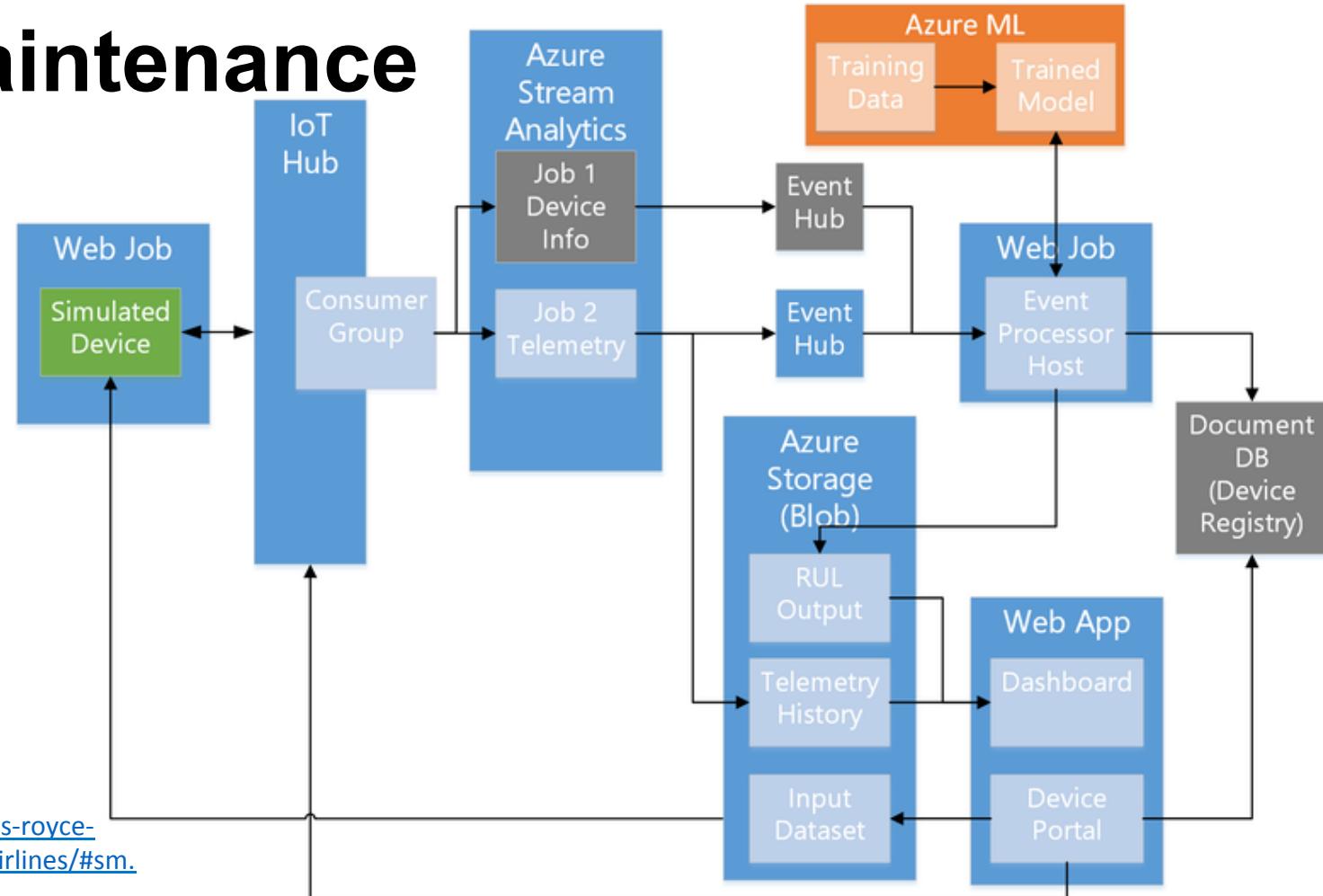
Max of device humidity Min of device humidity Average of device humidity

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# Predictive Maintenance



<https://news.microsoft.com/2016/04/24/microsoft-and-rolls-royce-collaborate-to-offer-advanced-operational-intelligence-to-airlines/#sm.007tm3tf1554eba11kf2rd2sidaxf>



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Microsoft Azure IoT - Predictive maintenance

dmgmori.azurewebsites.net

jerfost@microsoft.com

Aircraft map

Simulation in progress

Engine #1 Engine #2

Sensor history

Sensor 9 Sensor 11

Engine 1 Engine 2

48 47 46

9:36:30 PM 9:36:45 PM 9:37:00 PM 9:37:15 PM

8,160 8,140 8,120

9:36:30 PM 9:36:45 PM 9:37:00 PM 9:37:15 PM

Sensor 14 Sensor 15

Engine 1 Engine 2

9.00 8.50 8.00

9:36:30 PM 9:36:45 PM 9:37:00 PM 9:37:15 PM

9,080 9,060 9,040

9:36:30 PM 9:36:45 PM 9:37:00 PM 9:37:15 PM

Remaining Useful Life (RUL) IN CYCLES

206 149 !

ENGINE #1 ENGINE #2

Cycles #

25 25

ENGINE #1 ENGINE #2

Remaining Useful Life (RUL) history IN CYCLES

Engine 1 Engine 2

200

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← → ⌂ | 🔒 dmgmori.azurewebsites.net

Microsoft Azure IoT - Predictive maintenance

jerfost@microsoft.com

Aircraft map

Simulation in progress

Engine #1 Engine #2

Sensor history

Sensor 9

■ Engine 1 ■ Engine 2

48 47 46

9:40:00 PM 9:40:30 PM

Sensor 11

■ Engine 1 ■ Engine 2

8,160 8,140 8,120

9:40:00 PM 9:40:30 PM

Sensor 14

■ Engine 1 ■ Engine 2

9.00 8.50 8.00

9:40:00 PM 9:40:30 PM

Sensor 15

■ Engine 1 ■ Engine 2

9,080 9,060 9,040

9:40:00 PM 9:40:30 PM

Remaining Useful Life (RUL) IN CYCLES

157 ! 150 !

ENGINE #1 ENGINE #2

Cycles #

42 42

ENGINE #1 ENGINE #2

Remaining Useful Life (RUL) history IN CYCLES

■ Engine 1 ■ Engine 2

200 150

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The screenshot displays a Microsoft Azure IoT predictive maintenance dashboard. At the top, there's a header bar with navigation icons, a URL (dmgmori.azurewebsites.net), and a user profile (jerfost@microsoft.com). The main content area is divided into several sections: 1) An 'Aircraft map' showing a side-view diagram of an aircraft with two engines labeled 'Engine #1' and 'Engine #2'. A green banner above the map says 'Simulation in progress'. 2) A 'Sensor history' section containing four line charts for Sensors 9, 11, 14, and 15, comparing data from Engine 1 (purple) and Engine 2 (teal) over time. 3) A 'Remaining Useful Life (RUL) IN CYCLES' section showing values of 157 and 150 for Engine #1 and Engine #2 respectively, each accompanied by a yellow warning icon. 4) A 'Cycles #' section showing values of 42 for both engines. 5) A 'Remaining Useful Life (RUL) history IN CYCLES' section at the bottom showing historical data for both engines. The overall interface is clean and modern, using a dark theme with light-colored cards for each data point.



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Microsoft Azure Machine Learning Studio

Remaining Useful Life [Predictive Exp.]

In draft Draft saved at 12:50:09 PM

Properties Project

Experiment Properties

- START TIME -
- END TIME -
- STATUS CODE InDraft
- STATUS DETAILS None

Go to web service

Prior Run

Summary

Enter a few sentences describing your experiment (up to 140 characters).

Description

Enter the detailed description for your experiment.

Quick Help

Search experiment items

Remaining Useful Life [train...]

Score Model

Select Columns in Dataset

Edit Metadata

Enter Data Manually

Web service input

Web service output

MINI MAP

NEW

RUN HISTORY

SAVE

SAVE AS

DISCARD CHANGES

RUN

DEPLOY WEB SERVICE

PUBLISH TO GALLERY



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# There's more: Connected Vehicle Platform

Microsoft Connected Vehicle Platform  
helps automakers transform cars



Posted January 5, 2017 By **Peggy Johnson** - Executive Vice President, Business Development



f in 6566 t

*Renault-Nissan is first auto manufacturer to commit to platform to build connected cars*



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# Security Program for Azure IoT

<https://blogs.microsoft.com/iot/2016/10/26/introducing-the-security-program-for-azure-iot/>

<https://blogs.microsoft.com/iot/2016/12/07/azure-iot-hub-awarded-9-industry-certifications-for-public-cloud-computing/>



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# ***Questions?***



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# *Thank You!*

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- @pierreca
- <https://azure.com/iot>
- <https://azure.com/iotdev>
- <https://blogs.microsoft.com/iot>