

Azure and IoT Hub



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[http://codevalue.net](#)

[https://www.meetup.com/Code-Digest/](#)

Code.Digest();

About Me

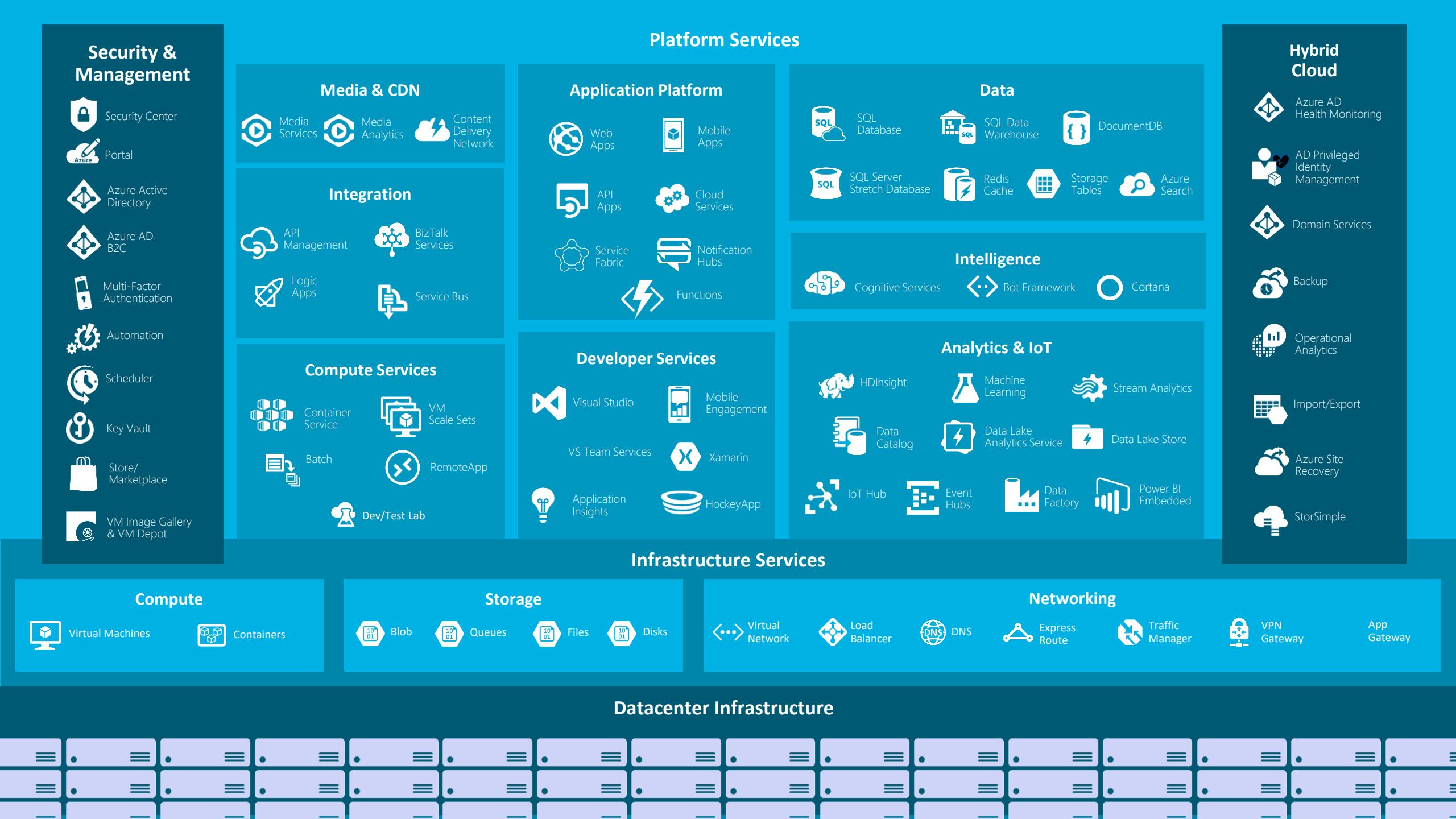


Code.Digest();

Alex Pshul

- Architect, Consultant and lecturer
- More than 9 years of hands on experience
- Co-organizer of the Code.Digest Meetup
 - <https://www.meetup.com/Code-Digest/>
- Talk to me about:
 - Software Development
 - Hardware and Gadgets
 - Gaming
 - Animals

Microsoft Azure



Microsoft Azure

Search resources, services and docs



Smart Home

+ New dashboard

Upload dashboard

Download dashboard

Edit dashboard

Share

Fullscreen

Clone

Delete

Create a resource

All services

FAVORITES

Dashboard

Resource groups

All resources

Recent

App Services

SQL databases

Virtual machines (classic)

Virtual machines

Cloud services (classic)

Subscriptions

Azure Active Directory

Monitor

Security Center

Cost Management + Billing

Help + support

Advisor

Jerusalem

Edit

Pacific Time (US ... Edit

watertank
AZURE IOT HUB

15:53

06:53

WEDNESDAY, MARCH 21, 2018

WEDNESDAY, MARCH 21, 2018

Active

Resource groups
ALL SUBSCRIPTIONS

Refresh

advabirthday

West Europe

alonfunctionappdemo

North Europe

alonmachinerg

West Europe

alonml

West Europe

AzureIoTHubSupport

North Europe

cloud-shell-storage-westeurope

West Europe

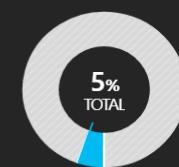
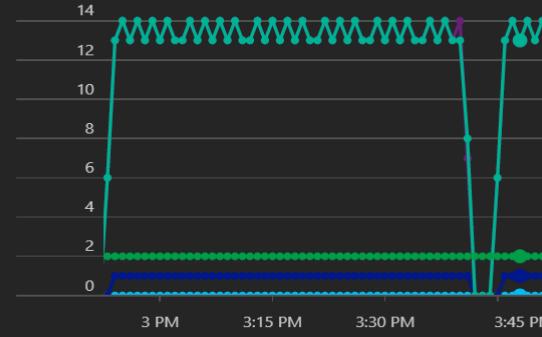
croptimal

North Europe

deletemesoon

West Europe

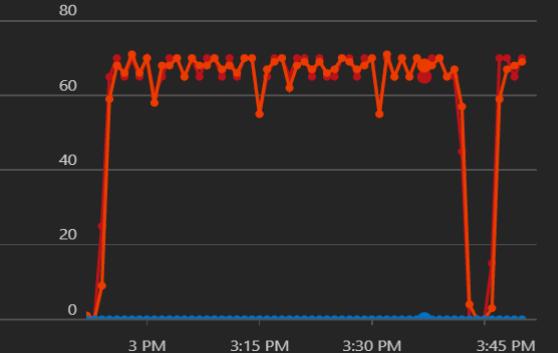
See more...

3/21/2018 UTC
WATERTANKMESSAGES
20661 / 400k
DEVICES
2eventhubfortimeserie...
EVENTHUBCommands completed, Connected devices and 3 ...
WATERTANKCOMMANDS COMPLETED
0CONNECTED DEVICES
0.9watertankvalues
STREAMING JOBwatertank
FUNCTION APP

Running

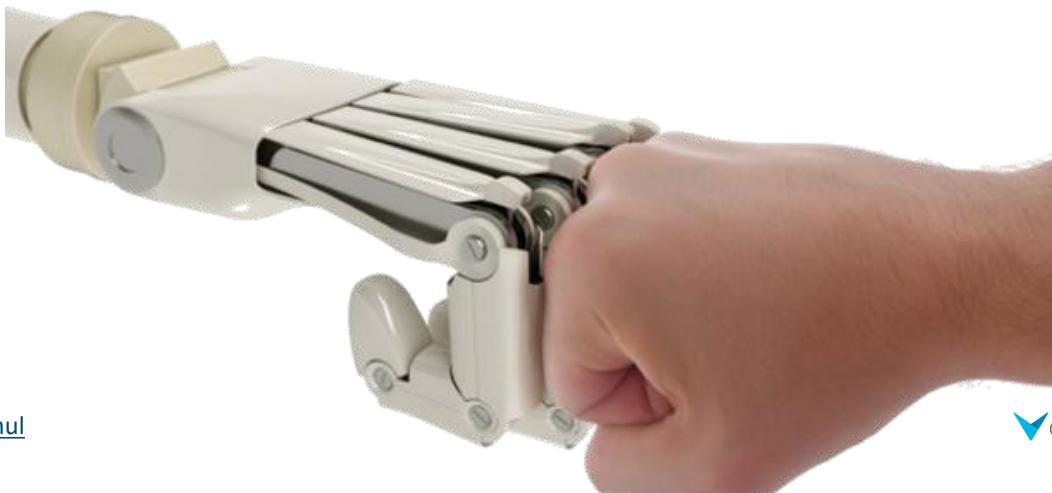


Data Conversion Errors, Input Events and 2 more ...

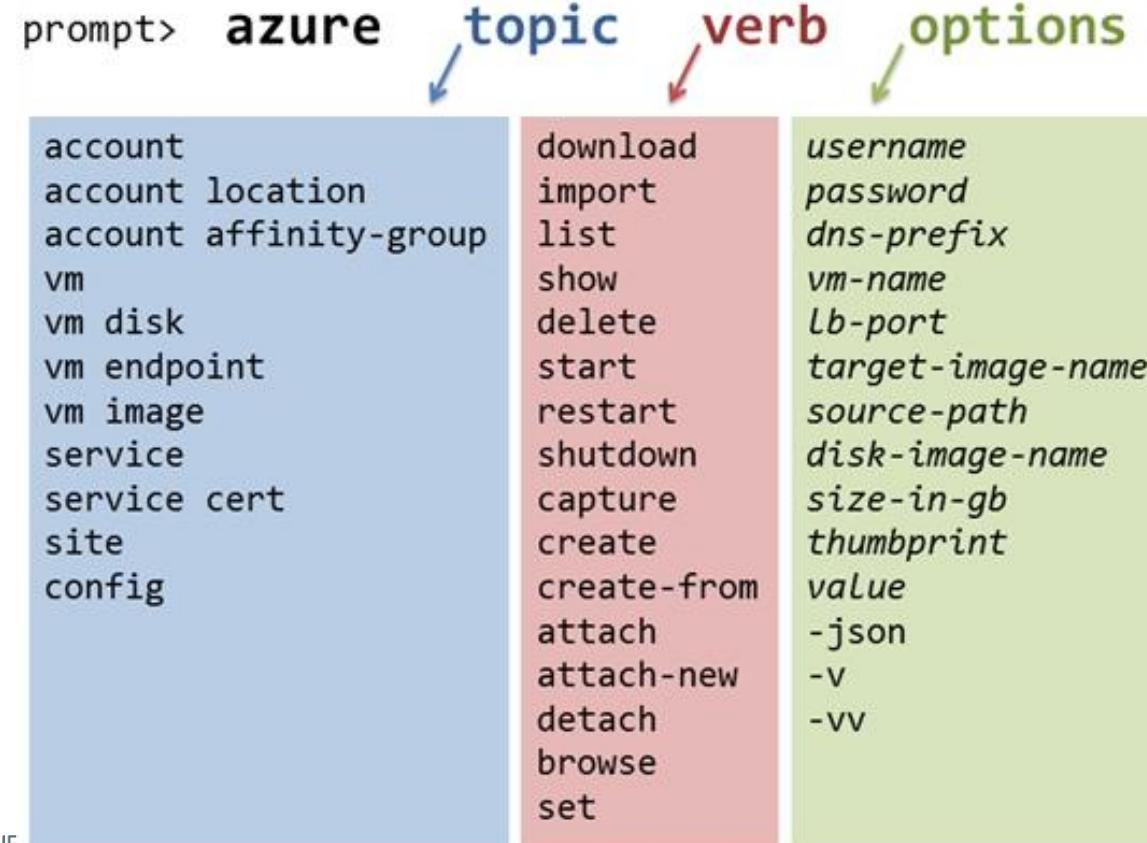
DATA CONVERSION ERR...
0INPUT EVENTS
3.52 kwatertank
TIMESERIESINSIGHTSEVIRO...

Automation is key

- Manual deployment, management and resources-definition can only take you so far
- Automate Azure with:
 - Azure PowerShell
 - Azure CLI (Windows, Mac, Linux)
 - Azure Resource Manager (ARM)



Command-Line Syntax Overview

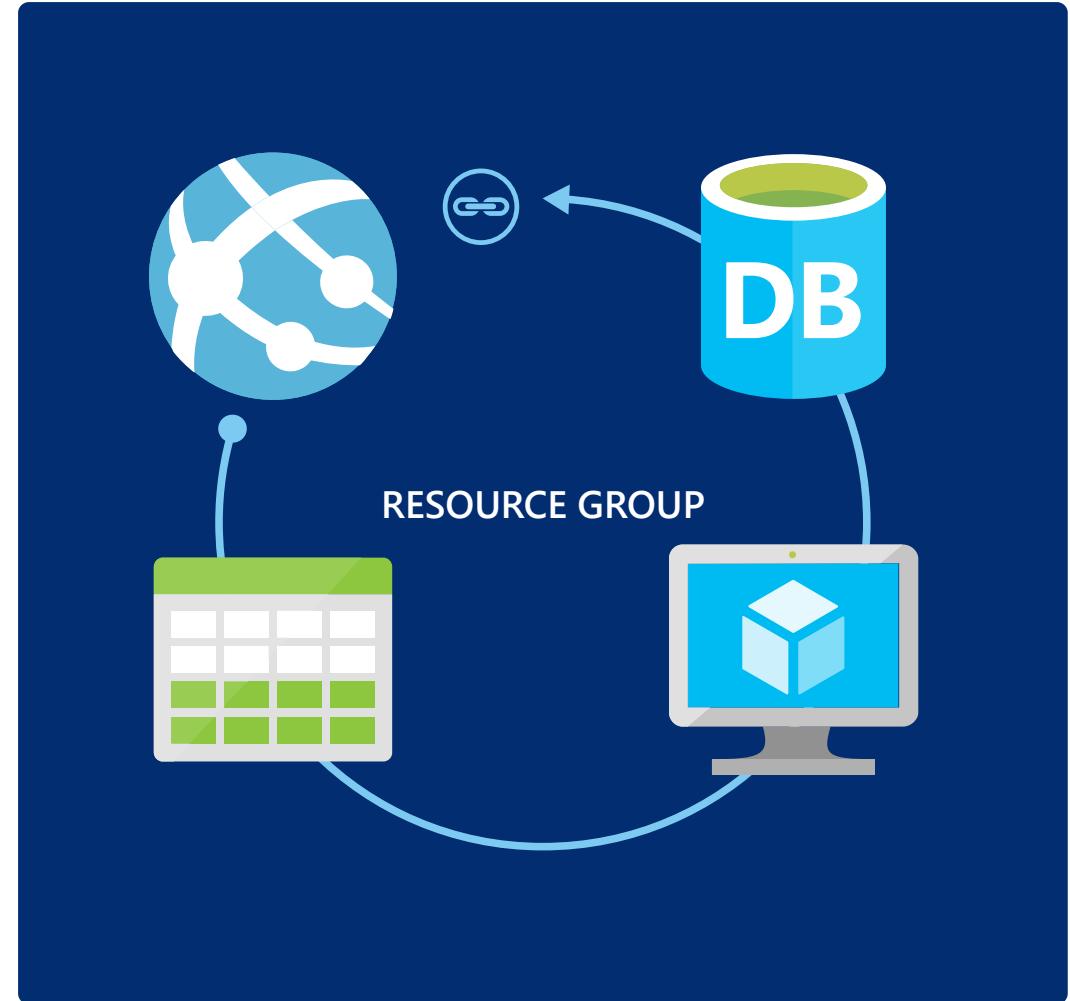


Azure Resource Manager (ARM)

- A holistic view of the entire cloud application resources
- Instead of looking at them as separate entities, they are part of a whole
- Benefits
 - Deploy, manage and monitor the entire solution group
 - Repeatedly deploy your solution
 - Declarative templates
 - Easy resource dependency management (ordered deployment)
 - Native RBAC support to all services in the resource group
 - Simple logical organization with tags
 - Clear billing

Resource Groups

- Tightly coupled containers of multiple resources
- Every resource exist in one (and only one) resource group
- Resource groups can span regions
- You can deploy, update, delete a resource group as a whole
- Easy to understand billing



Azure Resource Explorer

- resources.azure.com
- Resources management site
- “Explorer like” experience for browsing subscriptions, providers, resources and templates

The screenshot shows the Azure Resource Explorer (Preview) interface. At the top, there's a navigation bar with a logo, a search bar, and a user dropdown set to "tamir dresher (tamirdresher@gmail.com)". The main area has a title "Default-MachineLearning-SouthCentralUS". Below the title are buttons for "Data (GET, PUT)", "Actions (POST, DELETE)", "Create", and "Documentation". Under "Actions (POST, DELETE)", there are "PowerShell", "GET", and "Edit" buttons, with "Edit" being the active one. A URL "https://management.azure.com/subscriptions/785eaf75-ac1e-47f8-a80a-808ee4478db9/resourceGroups/Default-MachineLearning-SouthCentralUS" is displayed. A code editor window shows the JSON response for a GET request:

```
1 {  
2   "id": "/subscriptions/785eaf75-ac1e-47f8-a80a-808ee4478db9/resourceGroups/Default-MachineLearning-SouthCentralUS",  
3   "name": "Default-MachineLearning-SouthCentralUS",  
4   "location": "southcentralus",  
5   "properties": {  
6     "provisioningState": "Succeeded"  
7   }  
8 }
```

ARM cmdlets

- Execute and manage deployments
 - New-AzureResourceGroupDeployment
- Create individual resources
 - New-AzureRmResource
- Invoke specific actions on existing resources
 - Invoke-AzureRmResourceAction

```
New-AzureResource -Location "west US" -Properties @{"test"="test"} -ResourceName myTestSiteName -ResourceType  
microsoft.web/sites -ResourceGroupName myResourceGroup -Force
```

ARM Templates

- Declarative JSON files that specifies resource and their dependencies
- Idempotent
- Parametrized
- Source-control friendly

imperative

```
New-AzureVM -VM $myVM  
New-AzureRmStorageAccount -StorageAccountName $acct  
Set-AzureRmVNetConfig -ConfigurationPath -Path
```



declarative

```
{  
  "$schema": "https://..../deploymentTemplate.json#",  
  "contentVersion": "1.0.0.0",  
  "parameters": {},  
  "variables": {},  
  "resources": [],  
  "outputs": {}  
}
```

Deploying Templates

A screenshot of the Microsoft Azure portal. On the left, there's a sidebar with 'New', 'Resource groups', 'All resources', 'Recent', 'Web Apps', 'SQL databases', and 'Virtual machines (classic)'. The main area shows 'Marketplace' and 'Everything' categories. Under 'Template', several options are listed: 'EDI X12 Inbound Logic App Template', 'HTTP Request Response Logic App Template', 'One Way Pipeline Logic App Template', 'Protocol Bridging Logic App Template', and 'Template deployment'. The 'Template deployment' option is highlighted with a red box.

A screenshot of the 'Edit template' page. It shows the 'Custom deployment' header and a large JSON code editor window containing a template definition. The code includes sections for 'Template', 'Parameters', 'Subscription', 'Resource group', 'Resource group location', and 'Legal terms'. At the bottom, there are 'Save' and 'Discard' buttons, with 'Save' highlighted by a red box.

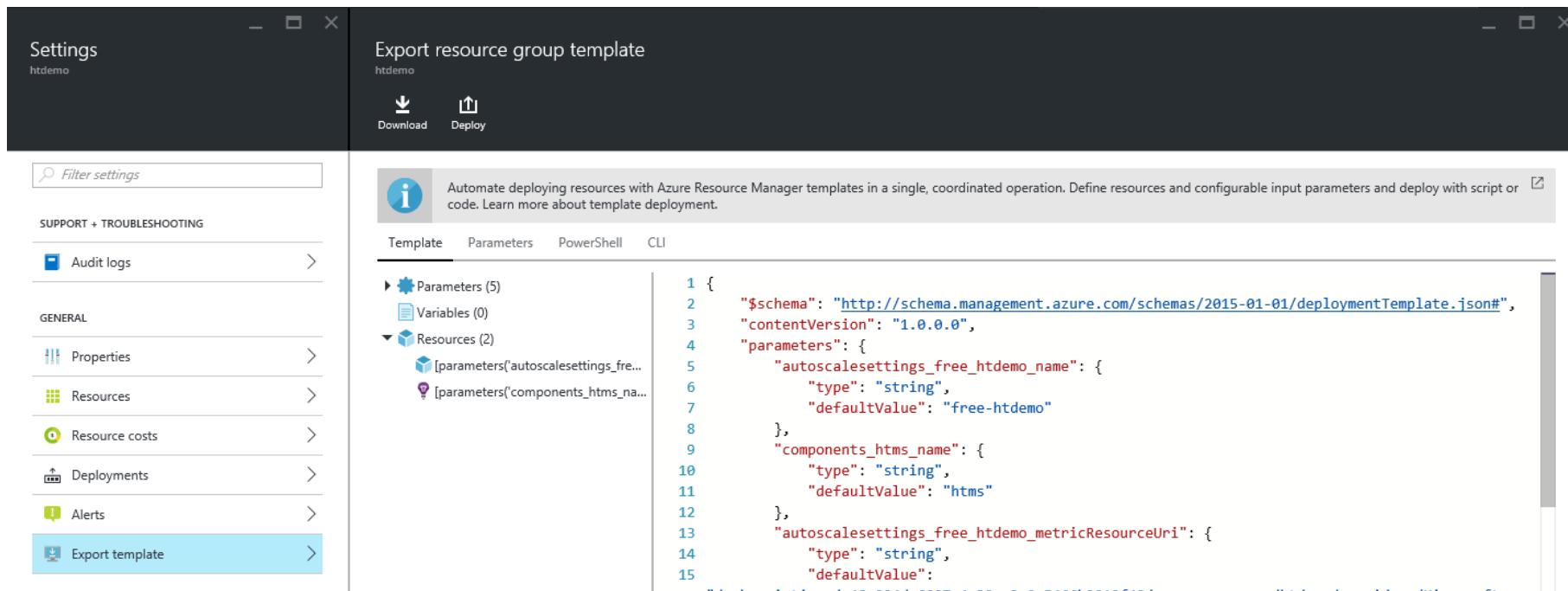
```
187     "createOption": "Empty"
188   }
189 ]
190 },
191 "networkProfile": {
192   "networkInterfaces": [
193     {
194       "id": "[resourceId('Microsoft.Network/networkInterfaces',variables(''
195       )]"
196     }
197   ],
198   "diagnosticsProfile": {
199     "bootDiagnostics": {
200       "enabled": "true",
201       "storageUri": "[concat('http://',parameters('newStorageAccountName'),
202         '.blob.core.windows.net')]"
203     }
204   }
205 }
206 ]
207 }
208 }
```

A screenshot showing two overlapping windows. The left window is 'Custom deployment' with sections for 'Template', 'Parameters', 'Subscription', 'Resource group', 'Resource group location', and 'Legal terms'. The right window is 'Parameters' with sections for 'ADMINUSERNAME', 'ADMINPASSWORD', 'DNSNAMEFORPUBLICIP', 'LOCATION' (set to 'West US'), 'WINDOWSOSVERSION' (set to '2012-R2-Datacenter'), and 'SIZEOFDISKINGB'. Both the 'LOCATION' and 'SIZEOFDISKINGB' fields are highlighted with red boxes.

```
New-AzureRmResourceGroupDeployment -DeploymentName
"Simple-VM" -ResourceGroupName
RG-AZITCAMP -TemplateFile "C:\GitHub\Templates\101-
simple-windows-vm\azureddeploy.json"
```

Creating\Editing Templates

- Visual Studio
- Visual Studio Code
- <http://armviz.io/>
- Export Resource Group Templates



Azure Resource Group Project

The screenshot shows the 'Add New Project' dialog in Visual Studio. The 'Installed' category is selected in the left sidebar. In the main area, the 'Azure Resource Group' template is selected, highlighted with a blue background. The right side displays the details for the 'DocumentDB' template by Microsoft, which allows creating a new Azure DocumentDB Account. The 'Solution Explorer' window on the right shows a project named 'MyAmazingWebApp' containing files like 'Deploy-AzureResourceGroup.ps1' and 'WebSiteSQLDatabase.*.json'.

Add New Project

.NET Framework 4.6. Sort by: Default

Recent

Installed

Type: Visual C#

Visual C# | Type: Visual C#

Search Installed Templates (Ctrl+)

Azure Cloud Service

ASP.NET Web Application

Azure WebJob

Azure Resource Group

DocumentDB MICROSOFT

Windows Virtual Machine Scale Set MICROSOFT

Linux Virtual Machine Scale Set MICROSOFT

Service Fabric Cluster MICROSOFT

Web app MICROSOFT

Web app + SQL MICROSOFT

Windows Virtual Machine MICROSOFT

Windows Server Virtual Machines with Load Balancer

DocumentDB

By Microsoft

Allows you to create a new Azure DocumentDB Account.

VERSION: 2015-04-08

This template allows you to create a new Azure DocumentDB Account. The template allows you to specify a default consistency policy. The default consistency policy will be

Solution Explorer

Search Solution Explorer

Solution 'MyAmazingWebApp' (1 project)

MyAmazingWebApp

- References
- Scripts
 - Deploy-AzureResourceGroup.ps1
- Templates
 - WebSiteSQLDatabase.json
 - WebSiteSQLDatabase.parameters.json

MyAmazingWebApp - Microsoft Visual Studio

File Edit View Project Build Debug Team Tools Architecture Test OzCode ReSharper Analyze Window Help tamir dresher

Debug Any CPU Start

TOTU_Menu.pdf LDDatabase.json WebSiteSQLData...arameters.json

Schema: <http://schema.management.azure.com/schemas/2015-01-01/deploymentTemplate.json#>

```
1 {  
2     "$schema": "http://schema.management.azure.com/schemas/2015-01-01/deploymentTemplate.json#",  
3     "contentVersion": "1.0.0.0",  
4     "parameters": {  
5         "hostingPlanName": {  
6             "type": "string",  
7             "minLength": 1  
8         },  
9         "skuName": {  
10            "type": "string",  
11            "defaultValue": "F1",  
12            "allowedValues": [  
13                "F1",  
14                "D1",  
15                "B1",  
16                "B2",  
17                "B3",  
18                "S1",  
19                "S2",  
20            ]  
21        }  
22    }  
23}
```

JSON Outline

- parameters (10)
- variables (2)
 - webSiteName
 - sqlserverName
- resources (9)
 - SqlServer
 - HostingPlan
 - Website
 - connectionstrings
 - AutoScaleSettings
 - ServerErrorsAlertRule
 - ForbiddenRequestsAlertRule
 - CPUHighAlertRule
 - AutoScaleSettings
 - AppInsightsComponent

How do I deploy project artifacts with an Azure deployment template?

Performance Explorer JSON Outline

Unit Test Sessions Package Manager Console Output Find Results 1 Azure App Service Activity

@Alex Ready Publish

26

More Azure Deployment Links

- <https://github.com/Azure/azure-quickstart-templates/>
- <https://azure.microsoft.com/en-us/documentation/templates/>
- <http://azure.microsoft.com/en-us/documentation/articles/resource-group-overview/>
- <https://azure.microsoft.com/en-us/documentation/articles/best-practices-resource-manager-design-templates/>
- <https://github.com/Azure/azure-content/blob/master/articles/app-service-web/app-service-deploy-complex-application-predictably.md>

Role Based Access Control

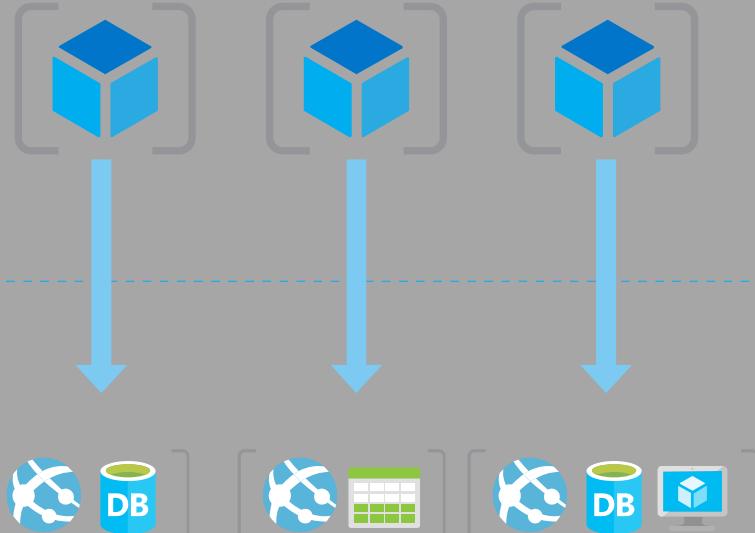
- Allows secure access with granular permissions
- Assignable to users, groups, or service principals
- Built-in roles make it easy to get started
- Key Concepts:
 - Role Definitions – the set of permissions
 - Role Assignments - associate role definitions with an identity
 - Identity == user/group
 - Assignment is per scope (Directory/Subscription/Resource Group/Resource)
 - Inherited – subscription assignments apply to all resources

Role Based Access Control

SUBSCRIPTION



RESOURCE GROUPS



RESOURCES



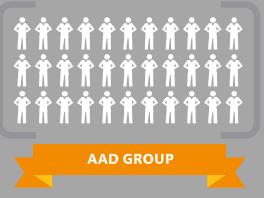
ACCESS INHERITANCE



CONTRIBUTORS



OWNER



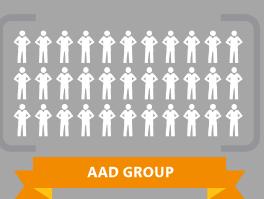
READERS



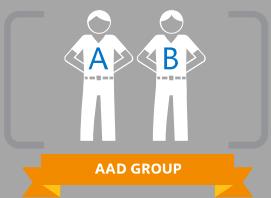
CONTRIBUTORS



OWNER



READERS



CONTRIBUTORS



OWNER



READERS

RBAC Scope

`/subscriptions/{id}/resourceGroups/{name}/providers.../sites/{site}`

subscription level – grants permissions to all resources in the sub

resource group level – grants permissions to all resources in the group

resource level – grants permissions to the specific resource

Built-in Roles

Role name	Permissions
Owner	Full management rights
Contributor	Full management rights except for user management
Reader	View resources and their settings
None	Does not see resources

RBAC in the portal

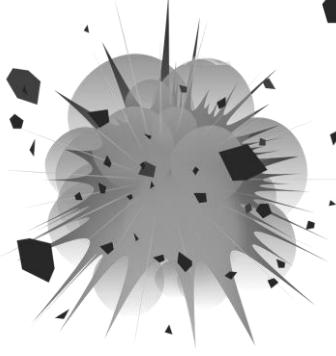
The screenshot shows two side-by-side Azure portal windows. The left window is titled 'internalcourse-resourcemanagement' and displays the 'Essentials' blade for a resource group. It shows the subscription name ('Windows Azure MSDN - Visual Studio Ultim...'), subscription ID ('785eaf75-ac1e-47f8-a80a-808ee4478db9'), last deployment ('7/1/2016 (Succeeded)'), location ('West Europe'), and a storage account named 'myamazingstorage'. The right window is titled 'Users' and lists access roles for the same resource group. It shows three entries: 'exampleapp' with 'Reader' role and 'Inherited' access, 'Subscription admins' with 'Owner' role and 'Inherited' access, and 'tamir.dresher.reader@outlook.com' with 'Reader' role and 'Assigned' access.

USER	ROLE	ACCESS
exampleapp	Reader	Inherited
Subscription admins	Owner	Inherited
tamir.dresher.reader@outlook.com	Reader	Assigned

Azure IoT



Traffic Light History Facts



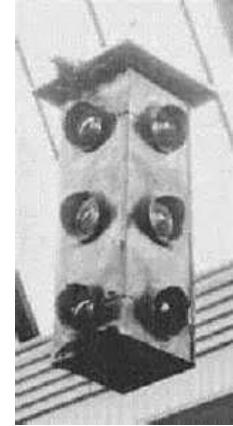
1868
London



1912
SLC



1914
Cleveland



1920
Detroit



1922
Automatic timer
controlled



1950s
Computer
Detection

Agenda

- Introduction
- The Simple System
- IoT Device Lifecycle
- The Modern IoT System
- Azure IoT PaaS & SaaS
- Azure IoT Hub
- Device Registry & Provisioning Service
- Twin, Routing and Jobs
- Smart cloud & intelligence edge
- Summary



IoT - More Than The Core Technology

- It is not (just) the technology that makes IoT what it is
- It is the
 - Concepts, perception, commitment and the challenges
 - Facts that the entire industry is dealing with it nowadays
- The IoT Challenge:
 - *vast amount of devices using different hardware and software technologies, are connected between them and to the cloud which in turn provides many services, which handle a huge stream of data and analyze it and extract vital information about the current state of the system and via extended processing it can even predict future state*

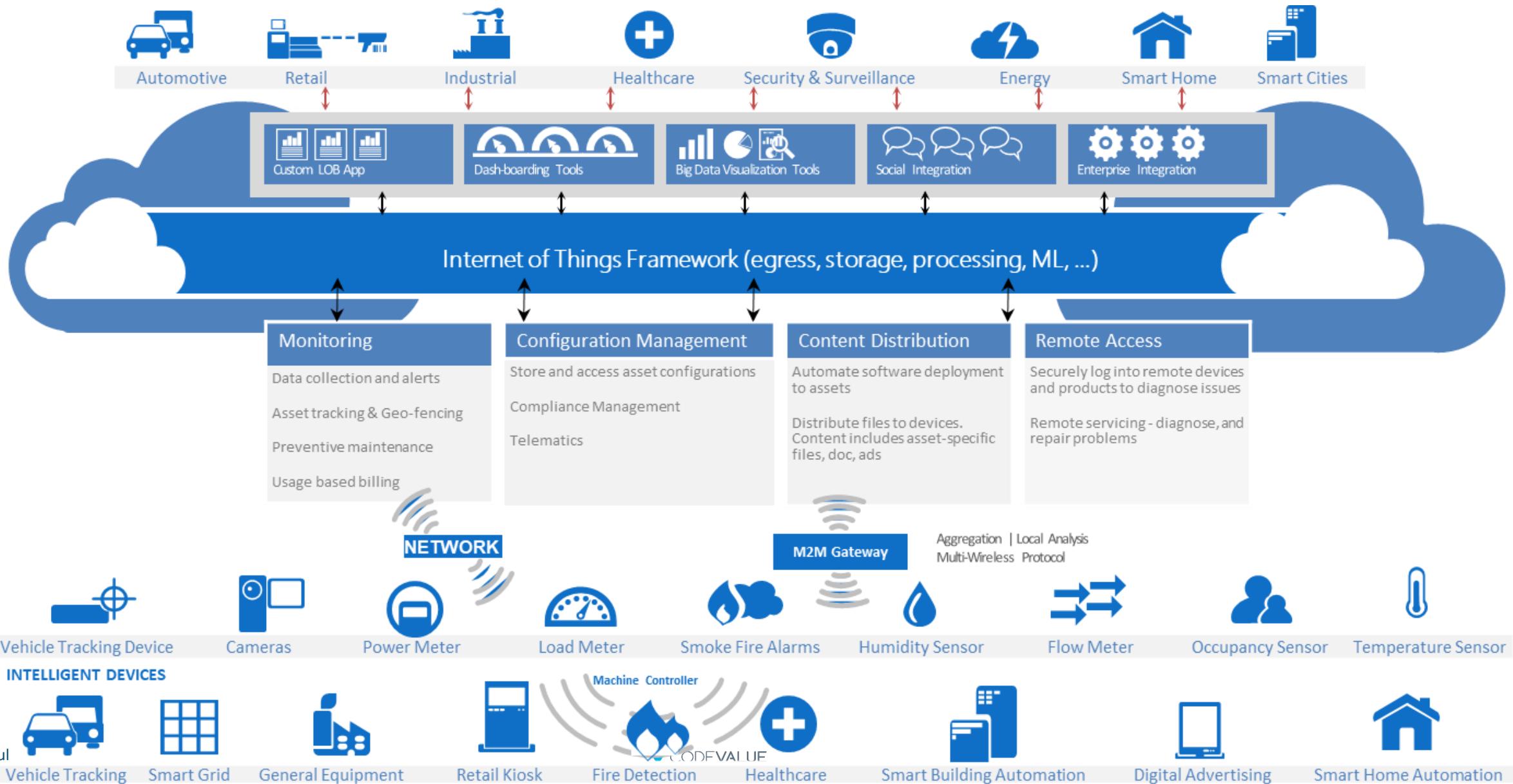
The IoT Challenge - Pets Vs Cattle – Pettle?



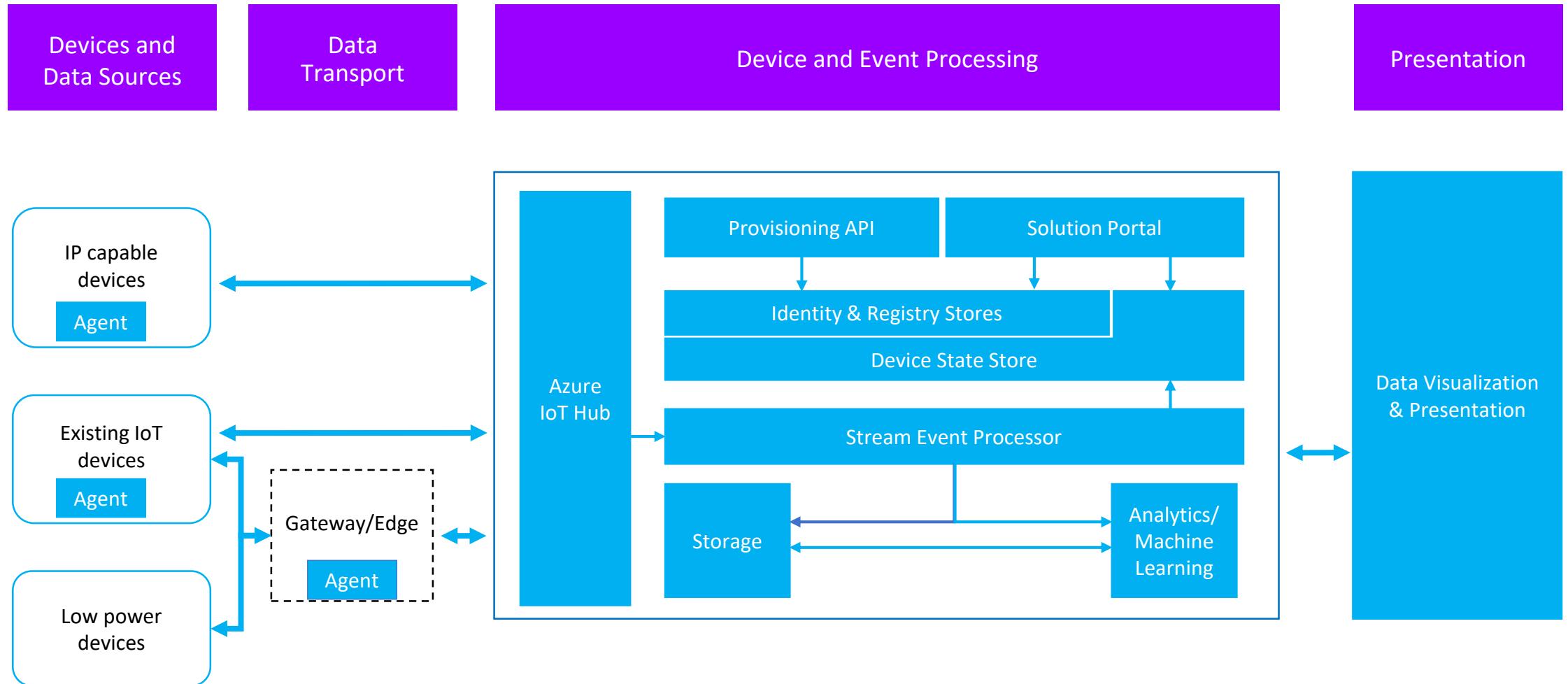
The Modern IoT System

- Most large IoT systems include one or more of the following:
 - Many different end **devices** with **sensors** and **actuators**
 - Local **gateways**
 - A collection of **cloud services** that enables:
 - **Registration** of end devices
 - **Management** of end devices
 - **Controlling** of end devices
 - Different **communication protocols** that provide reliability and security
 - The ability to **collect a vast amount** of data in a very **high rate**
 - The ability to **analyze** the **stream** of information in **close to real-time** manner
 - The ability to **analyze** the **current** and **historical** collected information
 - The ability to **show** the resulted **conclusion** and the **collected data**

High Level Architecture



Azure IoT Services Reference Architecture



Comprehensive set of capabilities for IoT solutions

Solutions

SaaS

Microsoft IoT Central
IoT SaaS

PaaS

Azure IoT Suite

Remote Monitoring

Predictive Maintenance

Connected factory

Services

PaaS Services &
Device Support

Azure IoT Device
SDK

Azure IoT Edge

Azure IoT Hub

Azure Stream
Analytics

Azure HD Insight

Microsoft Flow

Microsoft Power
BI

Certified Devices
Azure Certified
for IoT

Azure IoT Hub
Device Provisioning
Service

Azure Time Series
Insights

Azure Event Hubs

Azure Logic Apps

Azure Active
Directory

Security Program
for Azure IoT

Azure Machine
Learning

Azure Data Lake
Analytics

Notification Hubs

Azure Monitor

Windows 10 IoT
Core

Cosmos DB

Azure Data Lake

Azure Websites

Device Support

Edge Support

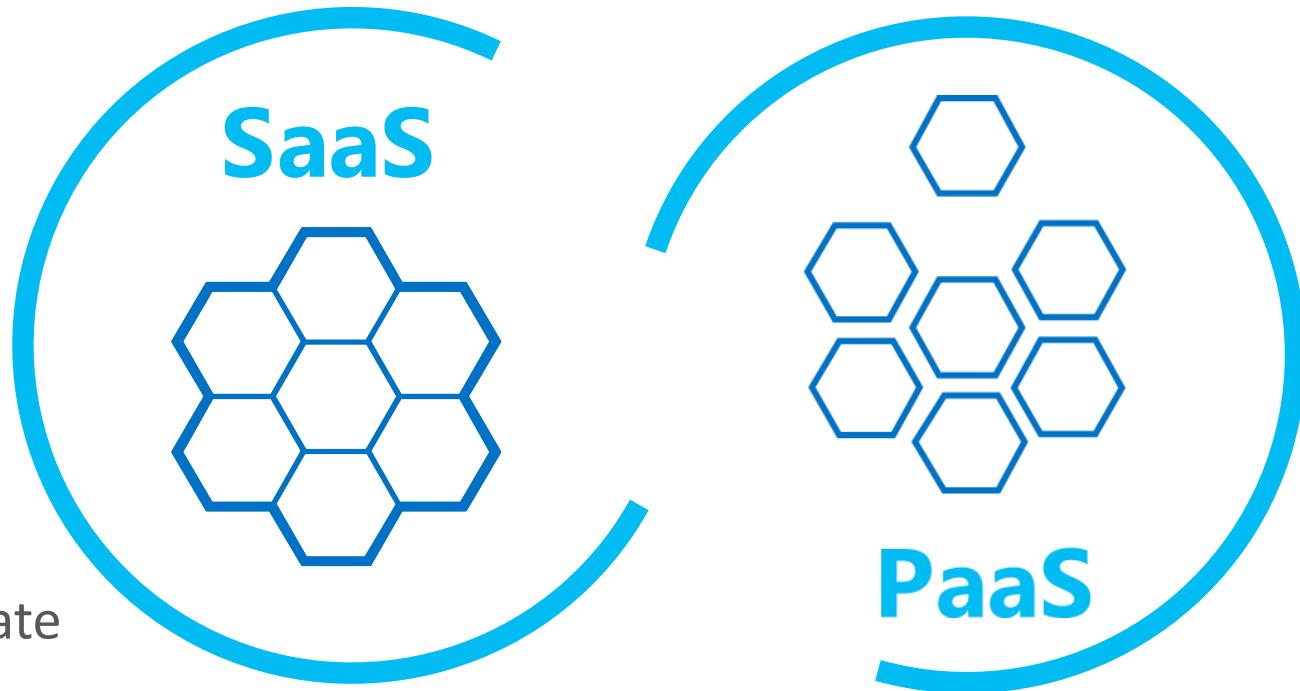
IoT Services

Data & Analytics Services

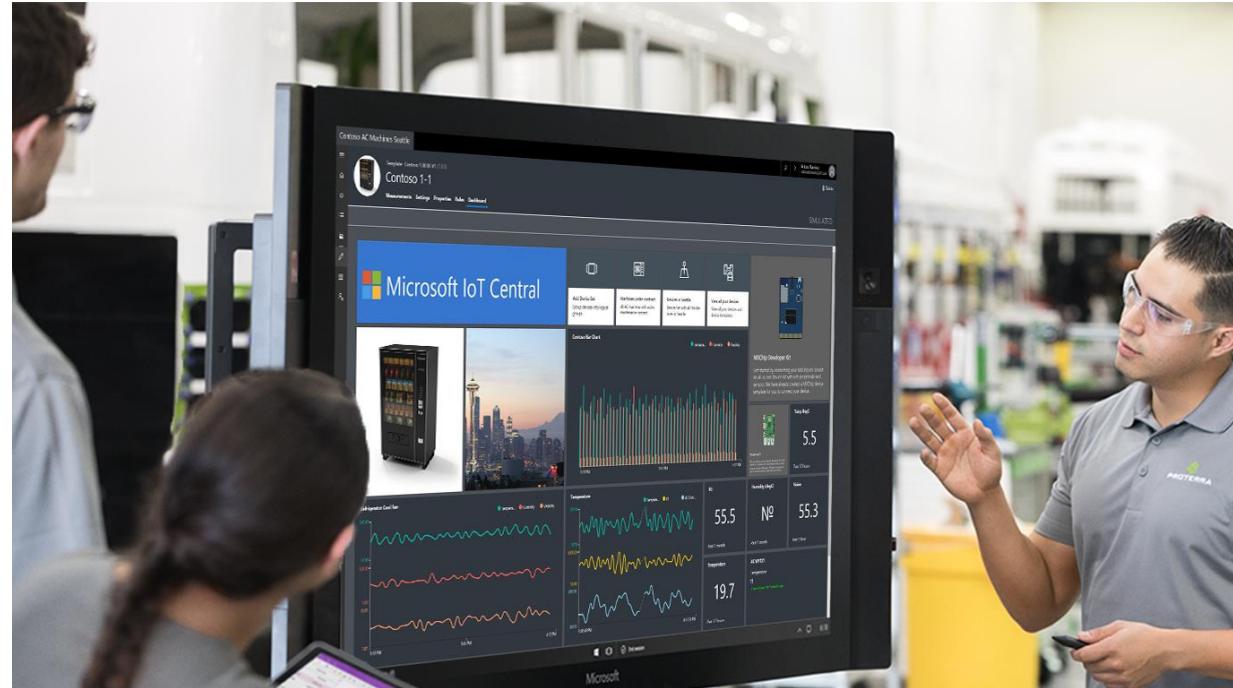
Visualization & Integration Services

Azure IoT solutions approach

- SaaS – Microsoft IoT Central
 - Fully managed IoT SaaS
 - No cloud solution development expertise required
 - Configurable to your needs
 - Ideal for straightforward IoT needs
- PaaS – Azure IoT Suite
 - Preconfigured solutions
 - Deploy in minutes
 - Accelerate time to value
 - Ideal for solutions that require ultimate control



IoT Central Features



Connectivity Hub & Telemetry ingestion

Connects a variety of devices to the cloud through an open platform

Device management

Enables understanding, control, and optimization of investments

Analytics & dashboards

Provide simple and consumable reports and visualizations for any platform

Rules engine

Real time data processing

Time-series insights

Identify trends among millions of IoT events

Digital twin management

Enables actionable insights through modeling and simulation

User and identity management

Delivers customized levels of permissions across users and protect from unauthorized access

Create Application

We just need a few things from you, so we can create your application

Application Name * ⓘ
Contoso Vending

URL * ⓘ
contoso-vending .microsoftiotcentral-ppe.com

Directory * ⓘ
Microsoft (microsoft.onmicrosoft.com)

Azure Subscription * ⓘ
Don't have a subscription? [Create subscription](#)
IOTC_CLIENT_WHITELIST_PRODUCTION

Resource Group * ⓘ
contoso-vending

Region * ⓘ
East US

Application Template

Custom Application
Start with a blank template and define your application from scratch.

Sample Contoso
Get started with a predefined application for a connected device.

Sample Devkits
Want to connect a Raspberry Pi or MXChip IoT DevKit? Start with this predefined app and get them connected in minutes.

Payment plan

Free 30 Day Trial Application

Paid Application
500 USD per application per month (includes 100 devices)
0.50 USD per additional device per month after that
30 USD per additional GB of data

By clicking create, you agree to the Microsoft IoT Central [Terms of use](#) and [Privacy Statement](#).

Create



Refrigerated Vending Machine (1.0.0)

Refrigerated Vending Machine-1

[Measurements](#) [Settings](#) [Properties](#) [Rules](#) [Dashboard](#)

SIMULATED

[+ New Rule](#)[Save](#) [Cancel](#)

Configure Telemetry Rule

Name *

Temperature Monitor

Enable rule for all devices of this template ⓘ

 On

Conditions

Temperature is greater than 15

Actions

Select Action



Email

Coming Soon



Webhook

Invoke a webhook to trigger external custom workflows.

Coming Soon



SMS

Send SMS to one or more recipients to notify about alert.

Coming Soon



SAP

Create service case automatically in your existing SAP instance.



Coming Soon

Logic Apps

Invoke Azure Logic Apps to simplify and implement scalable integrations and workflows in the cloud.



Coming Soon

Azure Functions

Invoke serverless code that enables you to run code on-demand in response to rule events.



Coming Soon

Microsoft Dynamics 365

Integrate with Microsoft Dynamics 365 to automatically create service tickets and schedule proactive maintenance.



Coming Soon

Salesforce

Create service case automatically in your existing Salesforce instance.



Refrigerated Vending Machine (1.0.0)

Refrigerated Vending Machine - SN01255

Connect this device Delete

[Measurements](#) [Settings](#) [Properties](#) [Rules](#) [Dashboard](#)

Machine Info

Installation Address **11/8/2017 7:38:42 AM** Installation Date Model **Double Zone**

Serial Number

SN00001

Maintenance Info

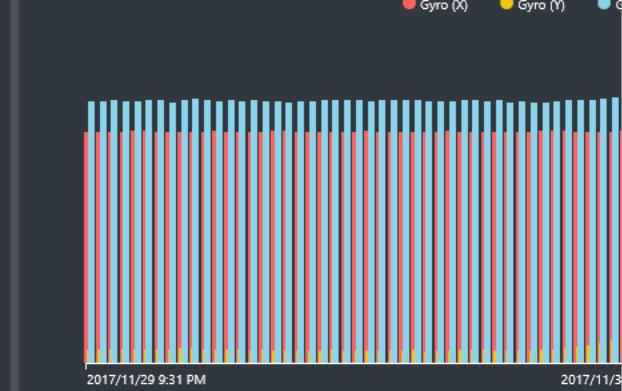
Installation Address **11/8/2017 7:38:42 AM** Installation Date Maintenance Contract **true**

Tampering Threshold **0** Temperature Alert Thresh... **0**

Internal Temperature



Machine Orientation (X,Y,Z Axis)



Customer Info

Customer Address Customer Contact Email Customer Contact Name

Customer Contact Phone **(123) 456-7890** Customer Name

Internal Temperature Trend



Tampering Monitor (X,Y,Z Axis)



Max Temperature (de...

22.7**58****1K**

Past 1 week

Past 1 week

Past 1 week

Environmental Data Trend



Min Temperature (de...

Average Temperature (degC)

18.3

Past 1 week

Mag Field (X Axis) (m...

Mag Field (Y Axis) (m...

Mag Field (Z Axis) (m...

Azure IoT Solution Accelerators

The screenshot shows a web browser window displaying the Microsoft Azure IoT Solution Accelerators website at <https://www.azureiotsolutions.com/Accelerators>. The page has a dark header with the title "Microsoft Azure IoT Solution Accelerators". Below the header, there's a large "Get started" section with a descriptive paragraph and a link to "Which solution is right for you?". The main content area features four cards, each representing a different IoT solution:

- Remote Monitoring**: Shows a worker in a control room monitoring industrial equipment.
- Connected Factory**: Shows an industrial robot working on a car chassis.
- Predictive Maintenance**: Shows a worker inspecting a large aircraft engine.
- Device Simulation**: Shows a shipping port with containers and a plane, illustrating simulated devices.

Each card includes an "Overview", "Demo", and "Deployment guide" link. A "Feedback" button is located on the right side of the page.

Get started

A solution accelerator helps you speed up the development and deployment of your IoT solution. It's open source, so you can customize it to fit your business. Use it as a reference for your own solution, or as a demo to see how a finished solution can work for you.

[Which solution is right for you?](#)

Remote Monitoring

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

[Overview](#)

[Demo](#)

[Deployment guide](#)

Connected Factory

Accelerate your journey to Industrie 4.0 – connect, monitor and control industrial devices for insights using OPC UA to drive operational productivity and profitability.

[Overview](#)

[Demo](#)

[Deployment guide](#)

Predictive Maintenance

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

[Overview](#)

[Demo](#)

[Deployment guide](#)

Device Simulation

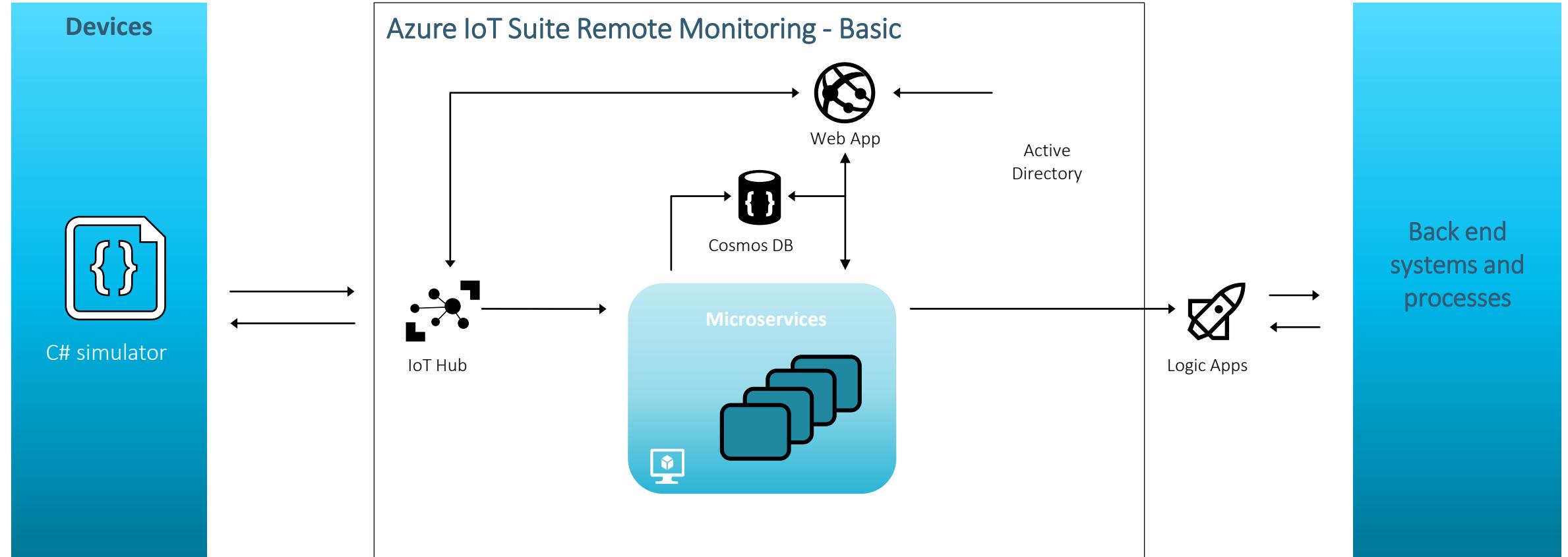
Streamline your IoT solution development by using simulated IoT devices to both build and test your solution throughout the software development lifecycle.

[Overview](#)

[Deployment guide](#)

[Feedback](#)

Azure IoT Suite solution – PaaS (almost) like a SaaS



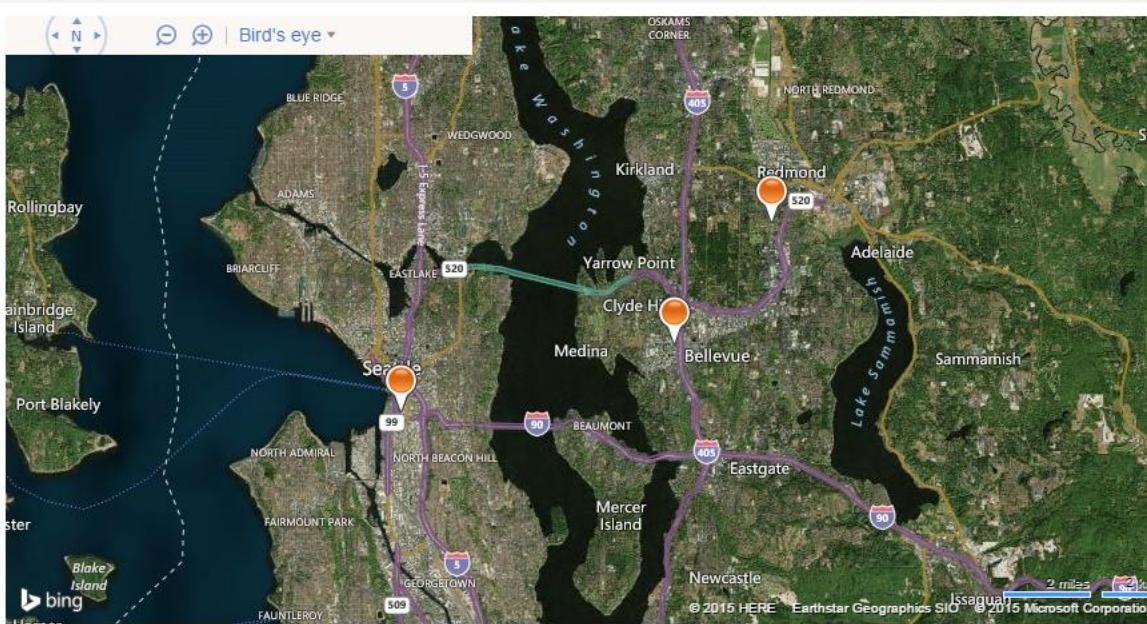
Microsoft Azure IoT Suite

DASHBOARD

DEVICES

RULES

ACTIONS



Alarm History

TIME	DEVICE ID	RULE OUTPUT	VALUE
10/23/2015 4:12:47 PM	SampleDevice001_249	AlarmTemp	43.284
10/23/2015 4:12:47 PM	SampleDevice001_249	AlarmHumidity	28.637
10/23/2015 4:12:20 PM	SampleDevice001_249	AlarmTemp	44.188
10/23/2015 4:12:20 PM	SampleDevice001_249	AlarmHumidity	37.678
10/23/2015 4:11:50 PM	SampleDevice001_249	AlarmTemp	35.810
10/23/2015 4:11:50 PM	SampleDevice001_249	AlarmHumidity	48.104
10/23/2015 4:11:45 PM	SampleDevice001_249	AlarmTemp	35.810

+

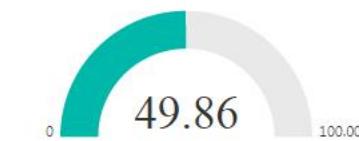
ADD A DEVICE

Device to View: SampleDevice001_249

Telemetry History



Max of device humidity



Min of device humidity



Average of device humidity



Introducing Microsoft Azure IoT Hub

- IoT Hub is available as a stand-alone service or as one of the services used in the new Azure IoT Suite
- Azure IoT Hub is designed to connect your devices to Azure. It supports:
 - Millions of simultaneously connected devices
 - Per-device authentication
 - High throughput data ingestion
 - Scale device management
 - Reliable command and control

IoT Hub Price & Capabilities

FEATURE	BASIC	STANDARD
Device-to-cloud telemetry	✓	✓
Per-device identity	✓	✓
Message Routing, Event Grid Integration	✓	✓
HTTP, AMQP, MQTT Protocols	✓	✓
DPS Support	✓	✓
Monitoring and diagnostics		✓
Cloud-to-device messaging		✓
Device Management, Device Twin		✓
IoT Edge		✓

Price & Capabilities

BASIC TIER	PRICE PER UNIT (PER MONTH)	TOTAL NUMBER OF MESSAGES/DAY PER UNIT	MESSAGE METER SIZE	MAX # OF UNITS
B1	\$10	400,000	4 KB	200
B2	\$50	6,000,000	4 KB	200
B3	\$500	300,000,000	4 KB	10

STANDARD TIER	PRICE PER UNIT (PER MONTH)	TOTAL NUMBER OF MESSAGES/DAY PER UNIT	MESSAGE METER SIZE	MAX # OF UNITS
FREE	FREE	8,000	0.5 KB	1
S1	\$25	400,000	4 KB	200
S2	\$250	6,000,000	4 KB	200
S3	\$2,500	300,000,000	4 KB	10

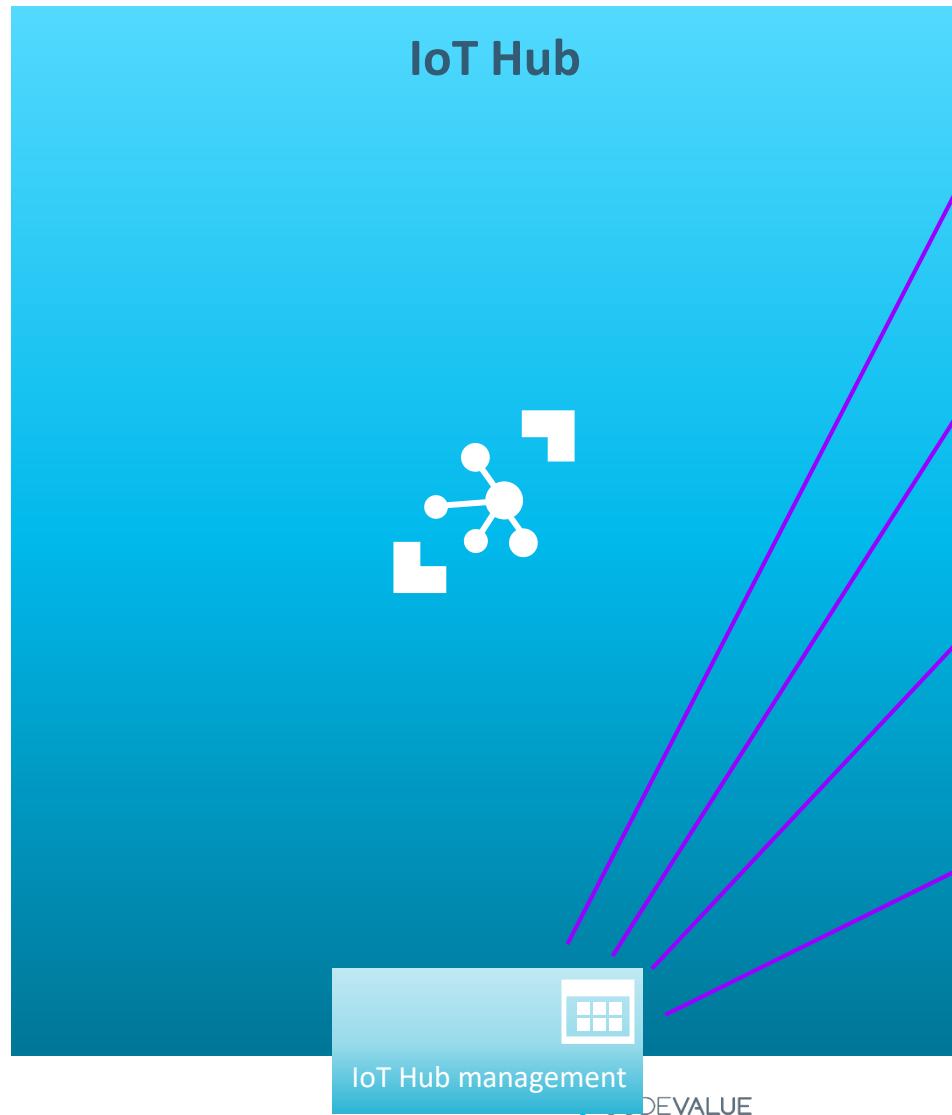
Operation throttles & Other Limits:

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

Limits, Quota & Throttling

TIER	SUSTAINED THROUGHPUT	SUSTAINED SEND RATE
B1, S1	Up to 1111 KB/minute per unit (1.5 GB/day/unit)	Average of 278 messages/minute per unit (400,000 messages/day per unit)
B2, S2	Up to 16 MB/minute per unit (22.8 GB/day/unit)	Average of 4,167 messages/minute per unit (6 million messages/day per unit)
B3, S3	Up to 814 MB/minute per unit (1144.4 GB/day/unit)	Average of 208,333 messages/minute per unit (300 million messages/day per unit)

Pick your favorite to create a hub



Azure Portal

<https://portal.azure.com>

ARM template

<https://azure.microsoft.com/en-us/resources/templates/>

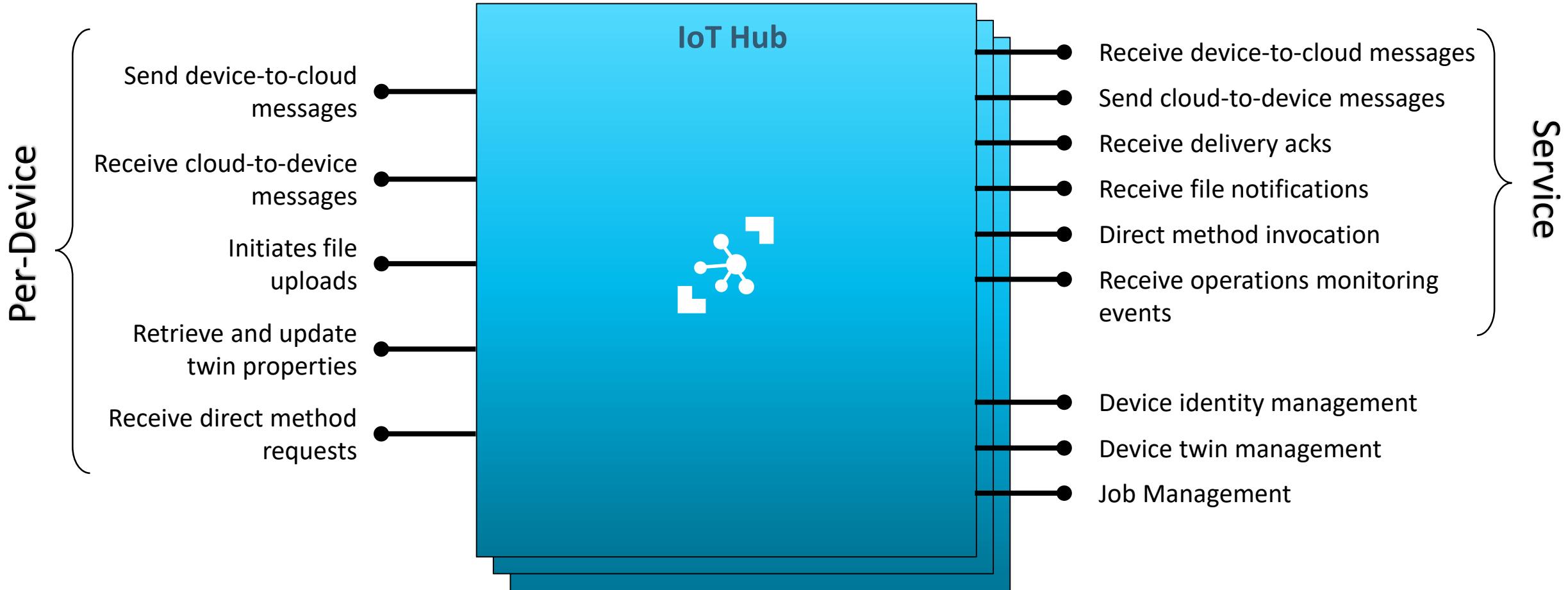
Azure CLI

<https://github.com/Azure/azure-cli> (v2.0 Python)

Powershell

<https://docs.microsoft.com/en-us/powershell/azuresps-cmdlets-docs/>

Azure IoT Hub



Azure IoT Hub SDKs

- **Device-facing**
 - For devices and field gateways
- **Platforms**
 - [Many devices](#)
 - RTOS (FreeRTOS)
 - Linux
(Ubuntu, Debian, Fedora, Raspbian, Angstrom)
 - Windows 7/8/10
 - ARM mbed
 - Android
 - iOS
- **Device SDK by programming language**
 - For device side development
 - [Azure IoT device SDK for C](#)
 - [Azure IoT device SDK for .NET](#)
 - [Azure IoT device SDK for Java](#)
 - [Azure IoT device SDK for Node.js](#)
 - [Azure IoT device SDK for Python](#)
- **Service-facing SDK by programming language**
 - For back-ends and cloud gateways
 - [Azure IoT service SDK for .NET](#)
 - [Azure IoT service SDK for Node.js](#)
 - [Azure IoT service SDK for Java](#)
 - [Azure IoT service SDK for Python](#)
- **Azure IoT Gateway SDK**
 - Infrastructure and modules to create IoT gateway solutions
- **Azure IoT Hub REST API**
 - For all the rest...
- **Advance IoT Hub topics**
 - [IoT Hub endpoints](#)
 - [IoT Hub query language for device twins and jobs](#)
 - [Quotas and throttling](#)
 - [IoT Hub MQTT support](#)

C Language Device SDK

- Many low price, low energy, SoC can be developed only by using the C language
- The IoT team has built a full-blown C SDK to connect and communicate with the IoT Hub
 - It supports all IoT Hub Device capabilities, including:
 - Secure connection and communication using three protocols (HTTP, AMQP, MQTT)
 - Sending telemetry messages using JSON serialization and set of macros to provide message serialization
 - Receiving messages from the cloud
 - Handling device twin synchronization
 - Invoke a function with request-reply message exchange pattern when the IoT Hub calls
 - Upload files
- There are two levels of functions:
 - With *_LL_* - low level API – for device that has no threading capabilities
 - With no *_LL_* - support background message processing using threads
- Follow this intro to understand the various functions



IoT Hub and IoT Device Communication Protocols

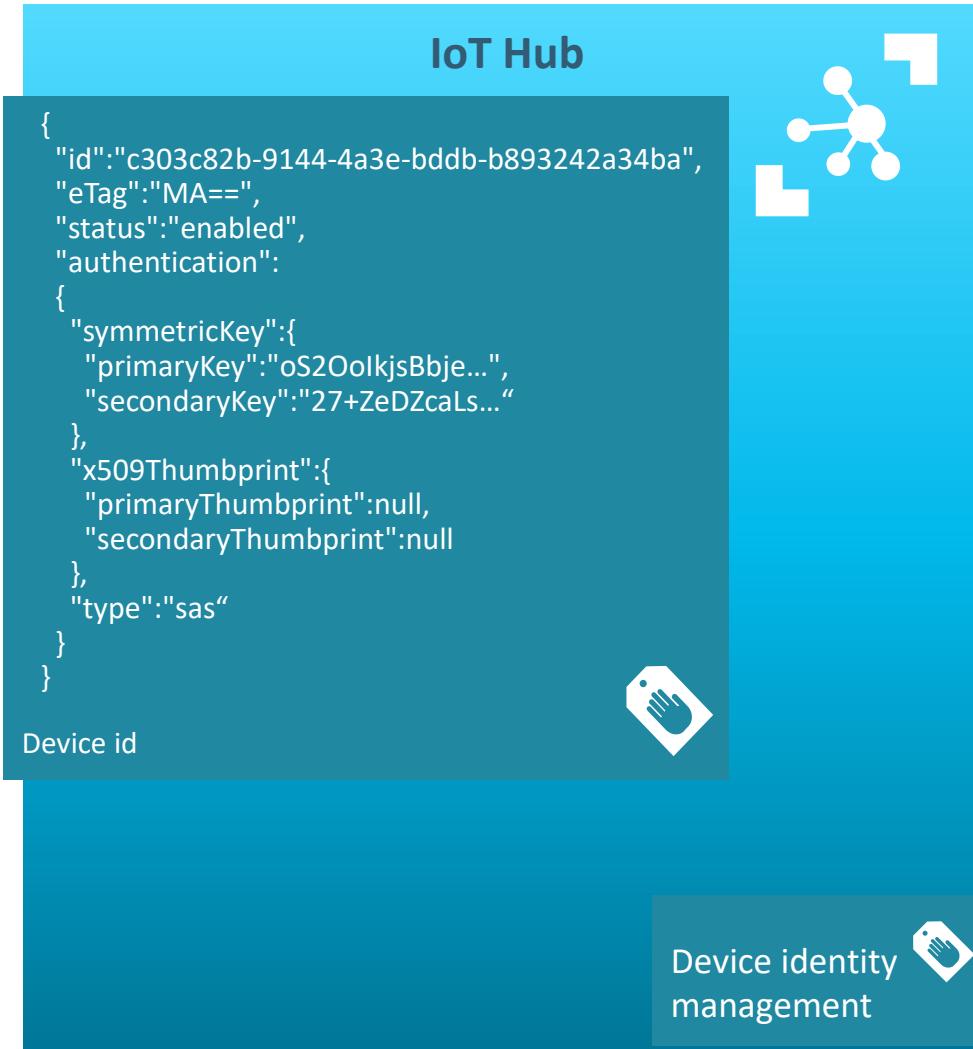
- IoT Hub supports three protocols:
 - HTTP – Use for devices that cannot support other protocols or that are rarely connected
 - AMQP – Use on field and cloud gateways to take advantage of connection multiplexing across devices
 - MQTT – Extremely lightweight, Use on all devices that do not require to connect multiple devices
- You can choose to use any protocol, however you need to take some protocol characteristics into considerations:
 - HTTP does not have an efficient way to implement server push
 - As such, when you are using HTTP, devices poll IoT Hub for cloud-to-device messages
 - AMQP returns errors for many conditions, while MQTT terminates the connection
 - As a result your exception handling logic might require some changes
 - MQTT does not support the *reject* operations when receiving cloud-to-device messages
 - If your back-end app needs to receive a response from the device app, consider using direct methods
 - The MQTT and HTTP libraries have a smaller footprint than the AMQP libraries

Supported Protocols & Port Numbers

Protocol	Port
MQTT	8883
MQTT over WebSockets	443
AMQP	5671
AMQP over WebSockets	443
HTTP	443

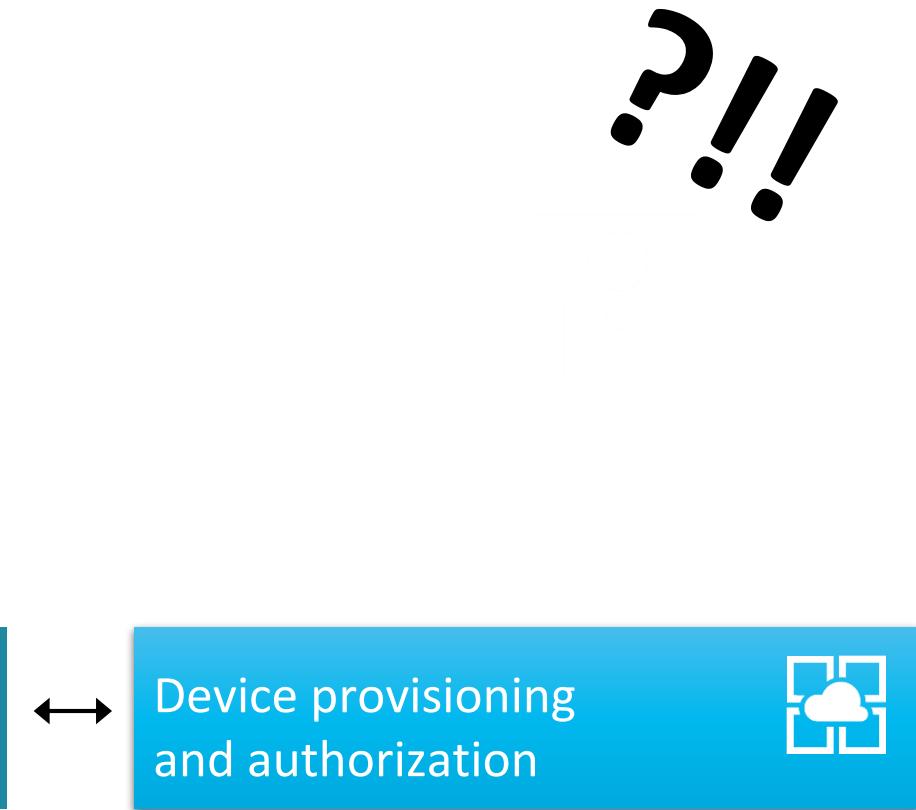
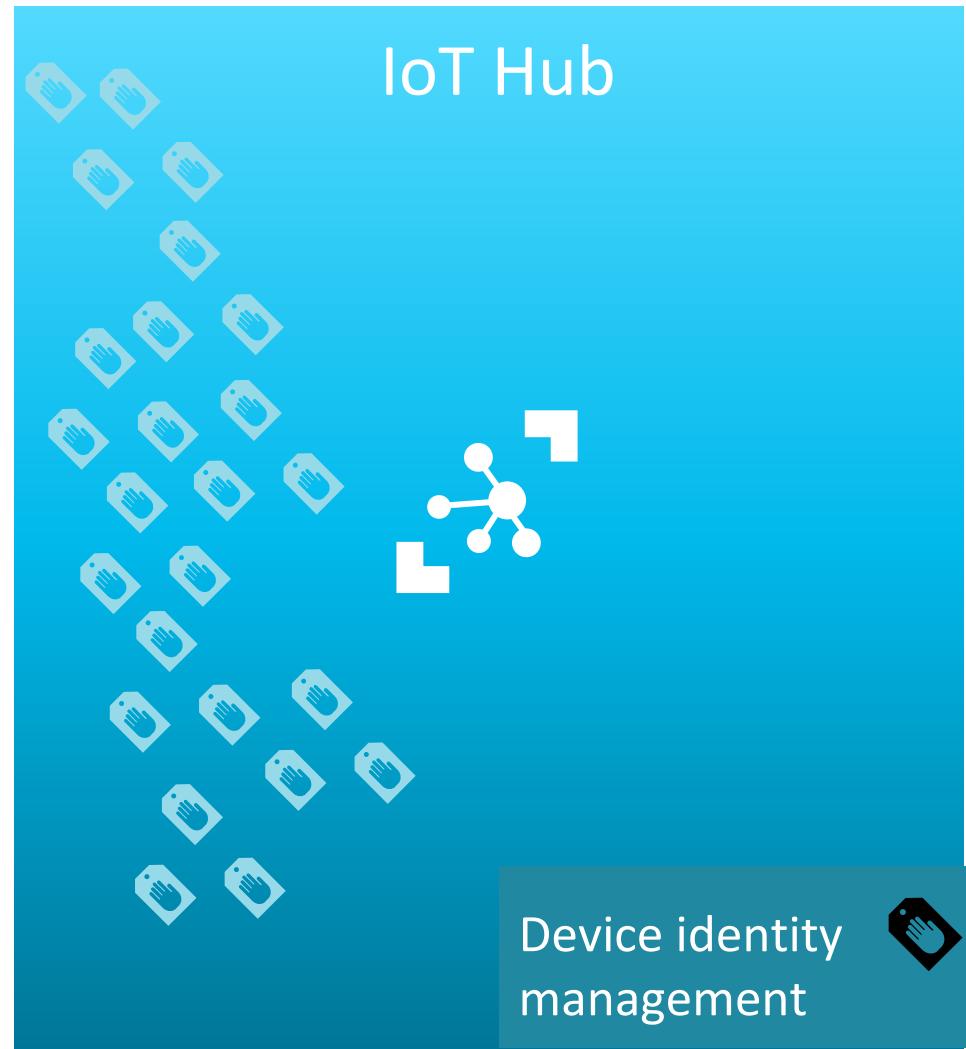
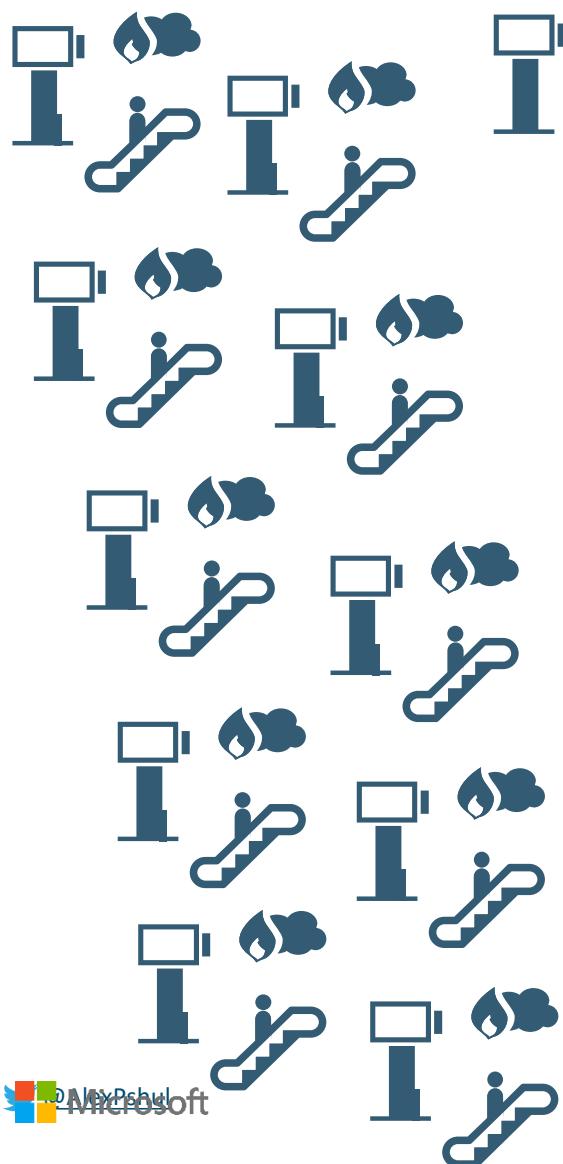
Device registry

- Unique id for each device
- Unique credentials for authentication
 - Private Key/SAS Token
 - X.509 Certificates
- Device Twin

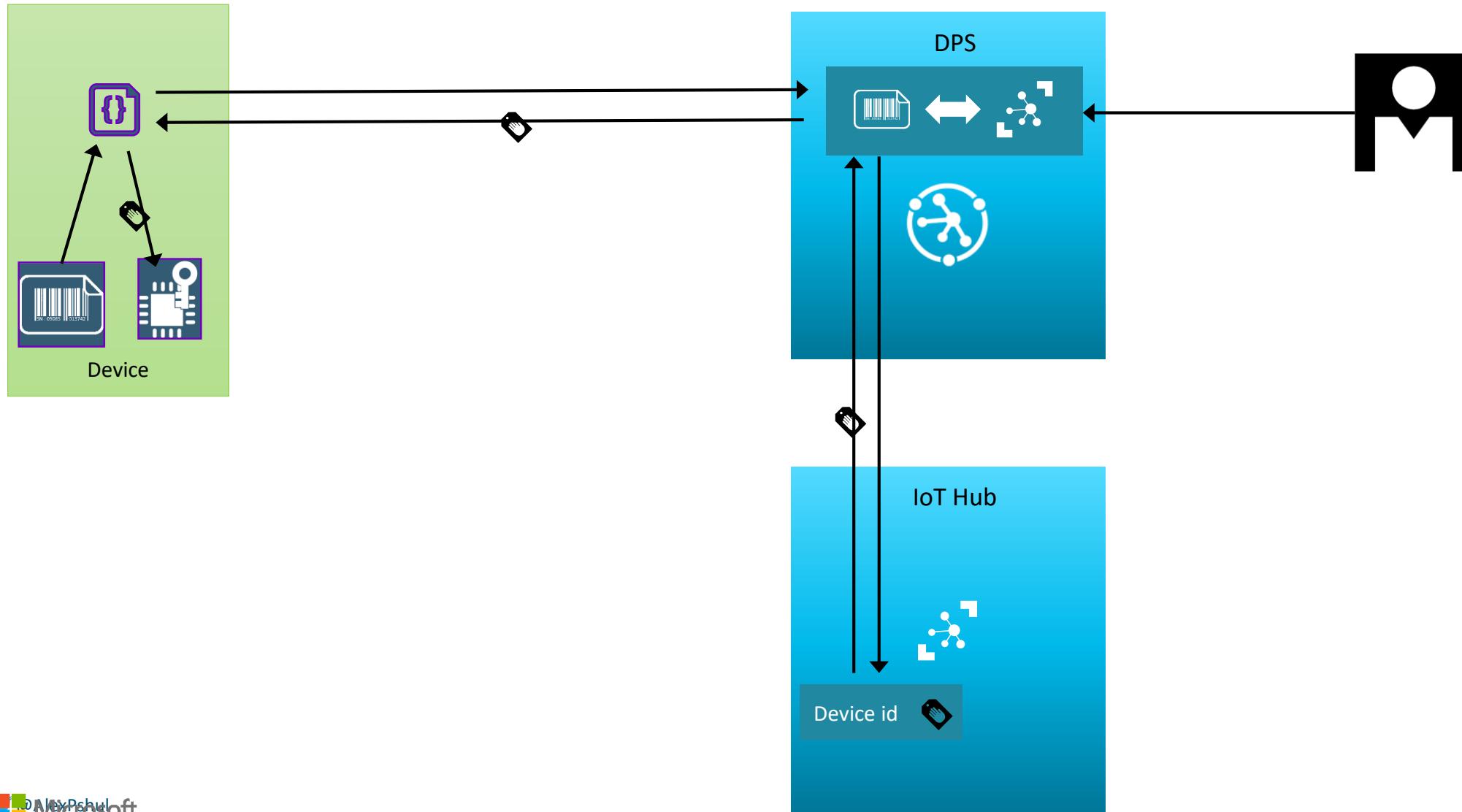


- Azure Portal
 - Development tools
 - Azure CLI
 - VSCode extension
 - Using a client SDK
 - .Net
 - Node
 - Java
 - Python
- Device provisioning and authorization

Provisioning at scale



Device Provisioning Service



Device Twins

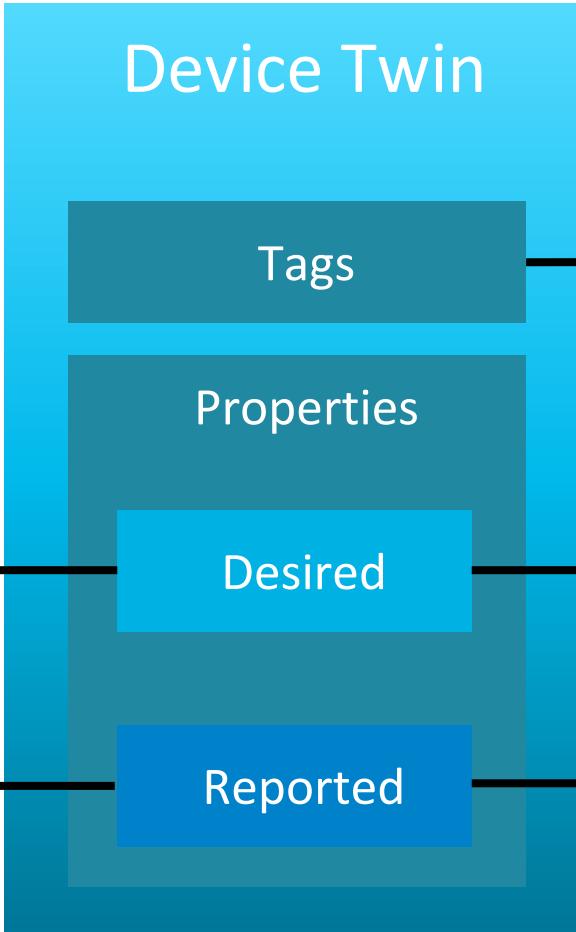
- Device twins are JSON documents that store device state information:
 - metadata, configurations, and conditions
- The IoT Hub persists a device twin for each registered device
- Use device twins to:
 - Store device-specific metadata in the cloud
 - Report current state information such as available capabilities and conditions from your device app
 - Synchronize the state of long-running workflows between device app and cloud app
 - Query your device metadata, configuration, or state
 - Get notified when a twin is modified

Device Twin

Device Code

Read,
Receive change
notifications

Read, Write



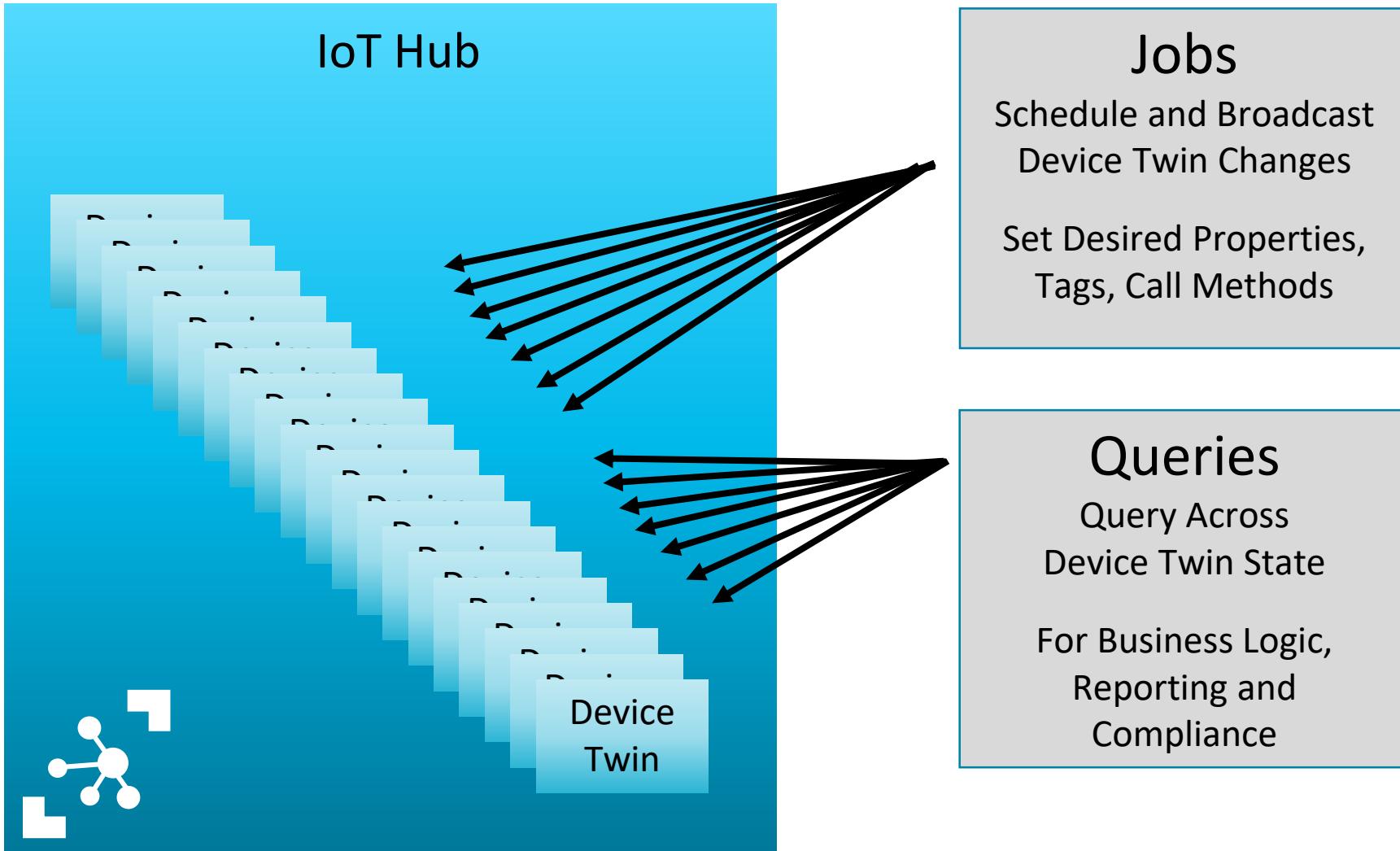
Back End Code

Read,
Write change
notifications

Read,
Write change
notifications

Read change
notifications

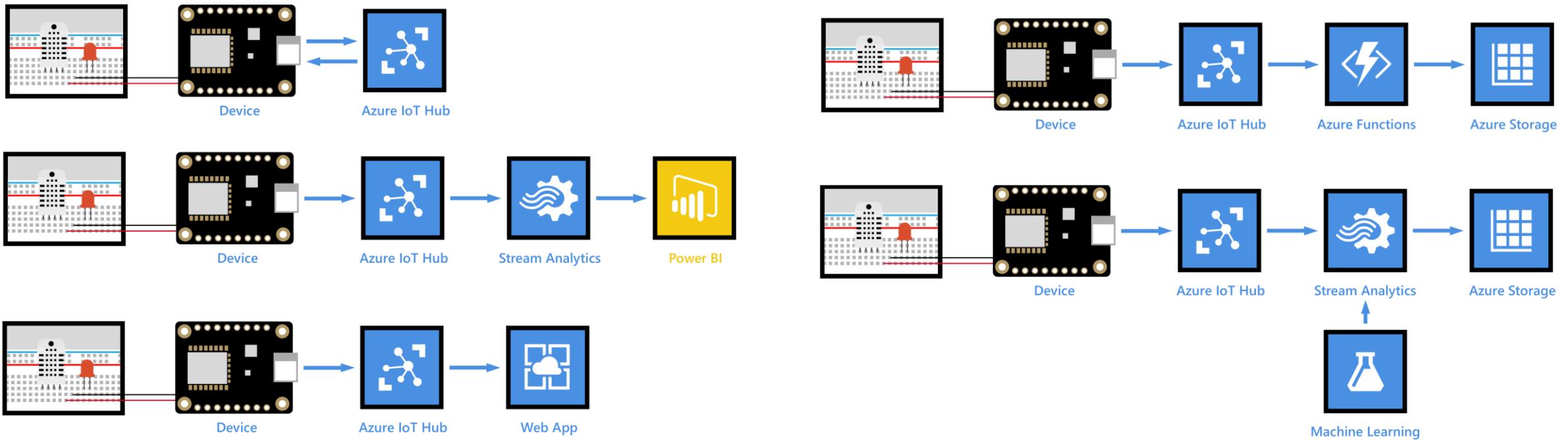
Designed for IoT Scale



Device Jobs

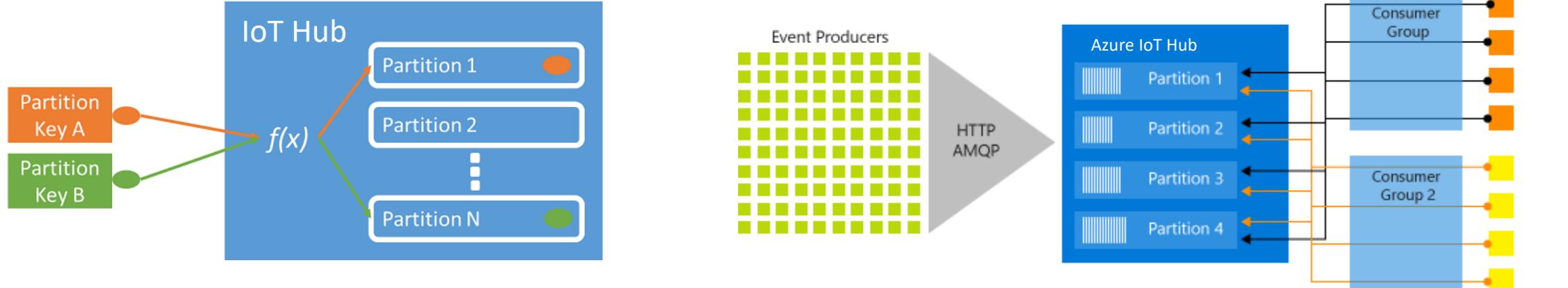
- To handle massive amount of devices and to communicate with offline devices, use Jobs:
 - Jobs encapsulate the execution of device twin updates and direct methods against a set of devices at a schedule time
 - The job is described as a JSON document
- Jobs are initiated by the cloud app and maintained by IoT Hub
 - Once a job is initiated, querying for jobs enables the cloud app to refresh the status of running jobs
- More information

What's next now that I have data flowing in?

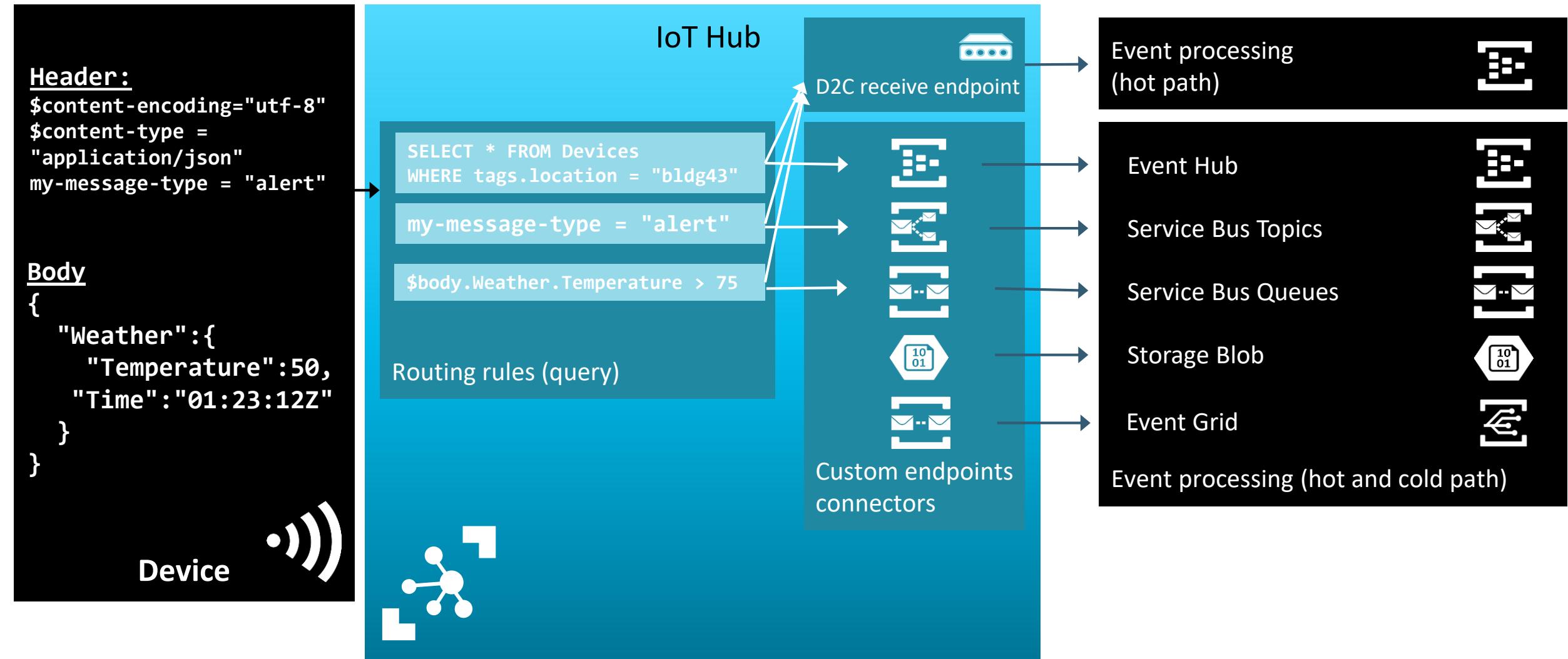


Processing IoT Hub Messages – Event Hub

- You can process IoT Hub device to cloud messages using either:
 - The built-in Event-Hub compatible endpoint
 - Rout the events to an Azure Service Bus queue
- Azure Event Hub is a very powerful telemetry ingestion service that was created by the Service Bus team
 - The key to scale for Event Hubs is the idea of **partitioned consumers**
 - **Partitioned consumers** enables very high scale by removing the contention bottleneck and facilitating end to end parallelism



Routing telemetry data



Direct Method - Calling a function in the device

- As opposed to other IoT Hub message exchange patterns that are one-way, a method call is a request-reply interaction
 - Other cloud to device communication are based on sending messages to the device, or setting desired properties
- Each device method targets a single device
 - Jobs provide a way to invoke direct methods on multiple devices, and schedule method invocation for disconnected devices
- Direct methods are synchronous and either succeed or fail
 - Failure occurs after a timeout period (default: 30 secs, settable up to 1 Hour)
- Great for interactive scenarios such as turning on a light from a phone
- Direct method are HTTP-only from the cloud side, and MQTT-only from the device side
- The payload for method requests and responses is a JSON document up to 8KB

Direct Method

```
private static async Task InvokeMethod()
{
    var methodInvocation = new CloudToDeviceMethod("writeLine") { ResponseTimeout = TimeSpan.FromSeconds(30) };
    methodInvocation.SetPayloadJson("a line to be written");

    var response = await serviceClient.InvokeDeviceMethodAsync("myDeviceId", methodInvocation);

    Console.WriteLine("Response status: {0}, payload:", response.Status);
    Console.WriteLine(response.GetPayloadAsJson());
}

serviceClient = ServiceClient.CreateFromConnectionString(connectionString);
InvokeMethod().Wait();
Console.WriteLine("Press Enter to exit.");
Console.ReadLine();
```

Device Side C SDK – Handling direct method

```
else if (IoTHubClient_LL_SetDeviceMethodCallback(iotHubClientHandle, DeviceMethodCallback, myWeather) != IOTHUB_CLIENT_OK)
{
    (void)printf("Failed on IoTHubClient_SetDeviceMethodCallback\r\n");
}
```

Upload Files

- Use file upload to send media files and large telemetry batches
- You must first link an Azure Storage account to the IoT Hub
 - You can do that using the portal
- The device initiates an upload
- When the upload completes, the device notifies the IoT hub
- See file upload notifications
- The SDK makes it easy: (C#)

```
private static async void SendToBlobAsync()
{
    string fileName = "image.jpg";
    Console.WriteLine("Uploading file: {0}", fileName);
    var watch = System.Diagnostics.Stopwatch.StartNew();

    using (var sourceData = new FileStream(@"image.jpg", FileMode.Open))
    {
        await deviceClient.UploadToBlobAsync(fileName, sourceData);
    }

    watch.Stop();
    Console.WriteLine("Time to upload file: {0}ms\n", watch.ElapsedMilliseconds);
}
```

Waves of Innovation

The smart cloud & Intelligent Edge

Cloud

Globally available, unlimited compute resources

IoT

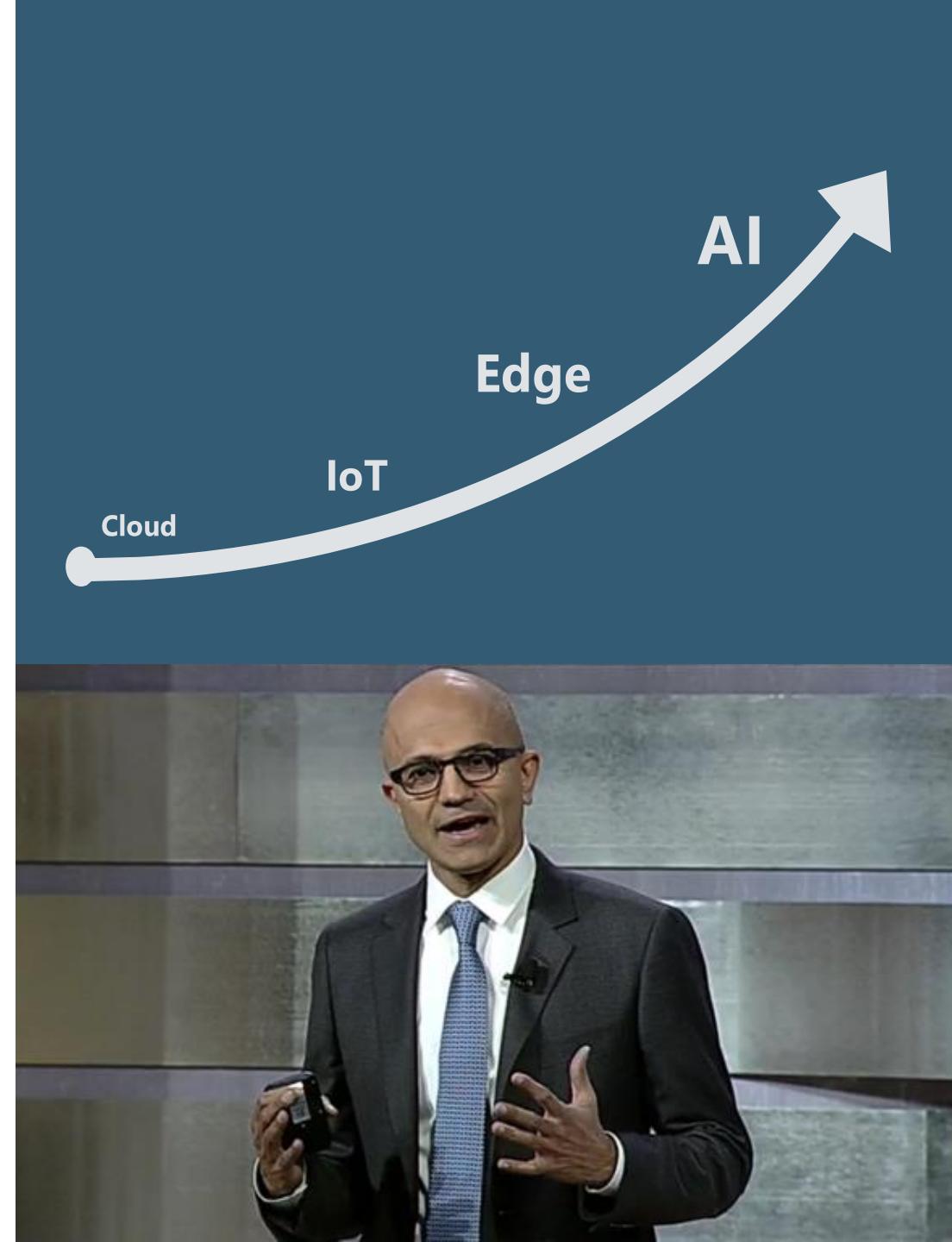
Harnessing signals from sensors and devices, managed centrally by the cloud

Edge

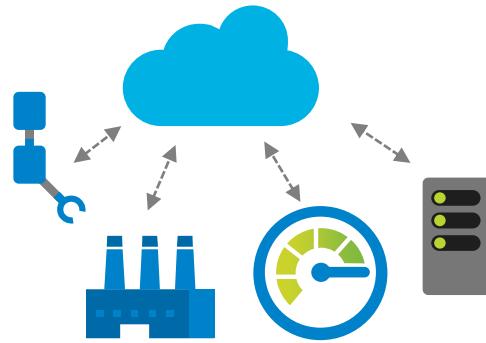
Intelligence offloaded from the cloud to IoT devices

AI

Breakthrough intelligence capabilities



Why the edge?

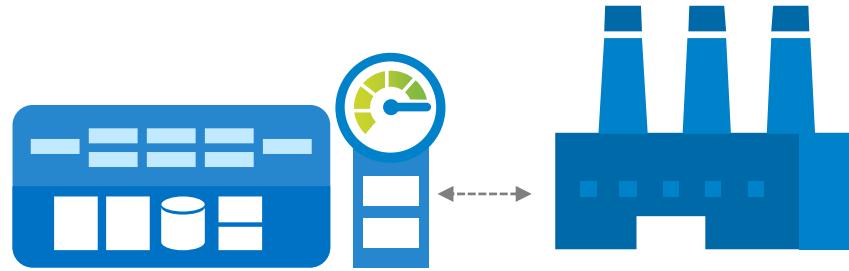


IoT in the Cloud

Remote monitoring and control

Merging remote data from across multiple IoT devices

Near infinite compute and storage to train machine learning and other advanced AI tools



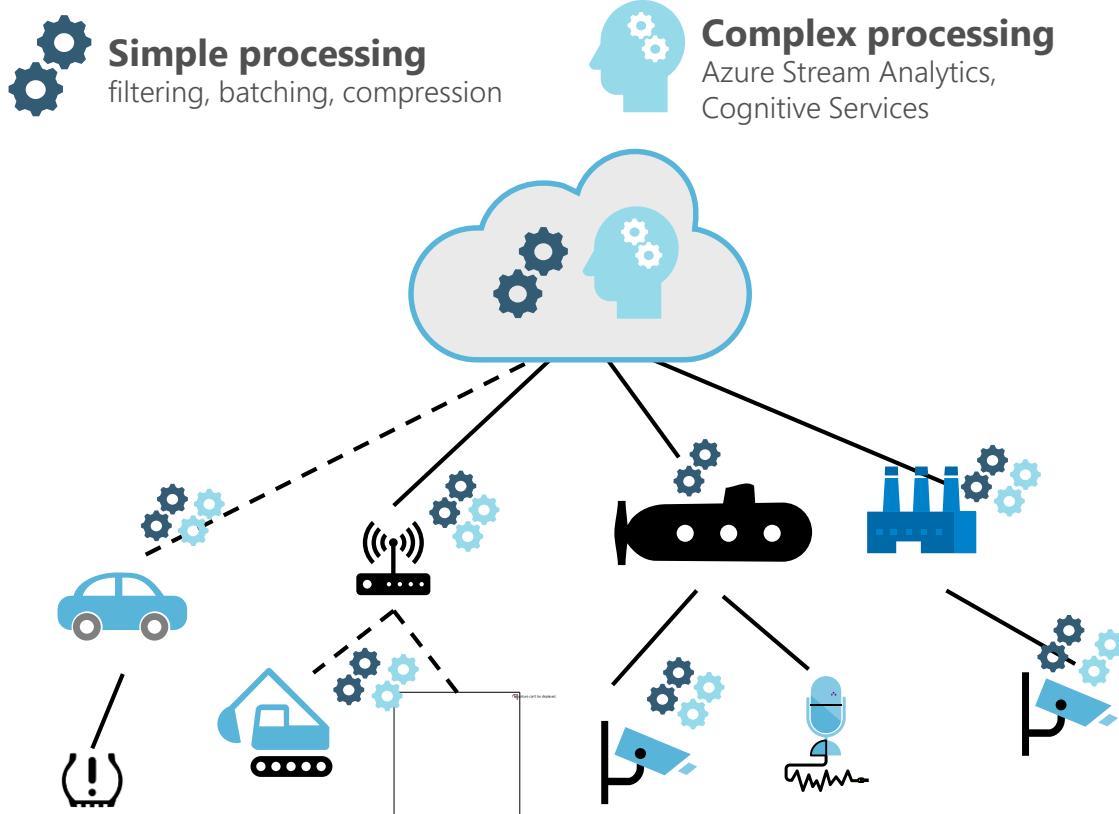
IoT on the Edge

Low latency tight control loops require near real-time response

Public internet inherently unpredictable

Privacy of data and protection of IP

Azure IoT Edge



■ Secure

- A Secure connection to the Azure IoT Edge
- Collect state and telemetry and monitor security of the device

■ Cloud Managed

- Enable rich management from Azure

■ Cross-Platform

- Enable Azure IoT Edge on both Windows and Linux

■ Portable

- Enable creating Docker Images that target multiple architecture

■ Extensible

- Enable seamless deployment of advanced capabilities modules such as **AI**, **Azure Function**, **Stream Analytics** and **3rd party**

Azure IoT Edge

Container based modules

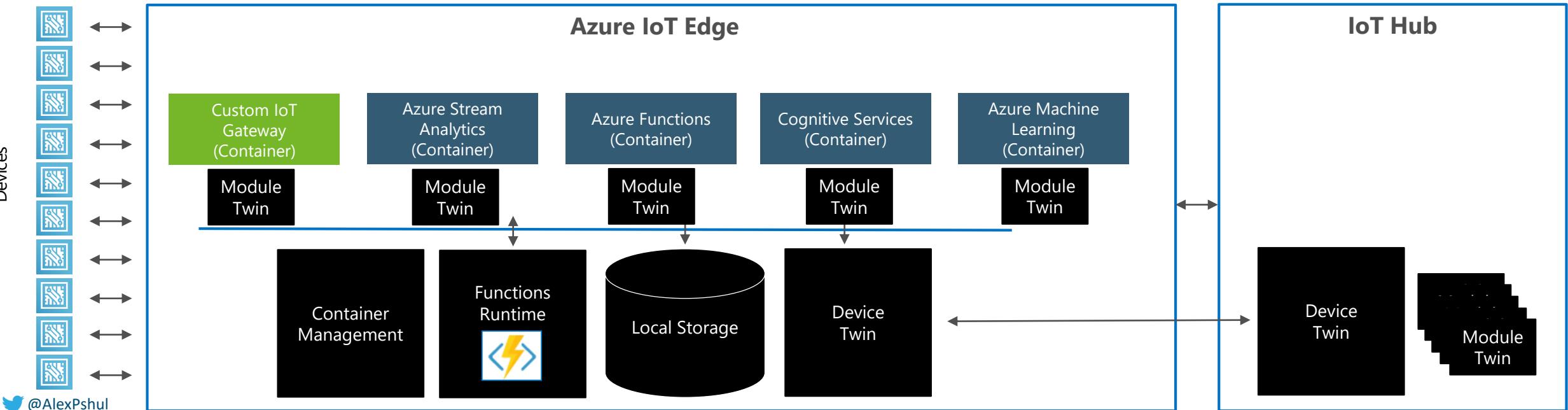
Azure Functions

Azure Stream Analytics

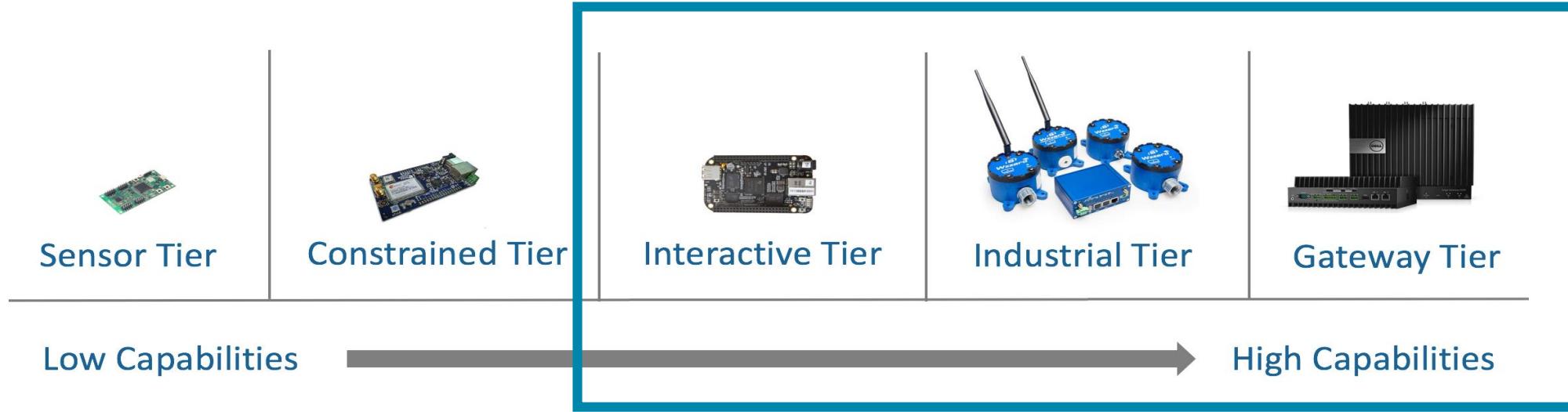
Azure Machine Learning

Cognitive Services

- Offline / Synchronized Device Twins
- Local Storage
- Cloud Management & Deployment
- High Availability / Fault Tolerance
- Cloud Dev/Test Support



Hardware for Azure IoT Edge



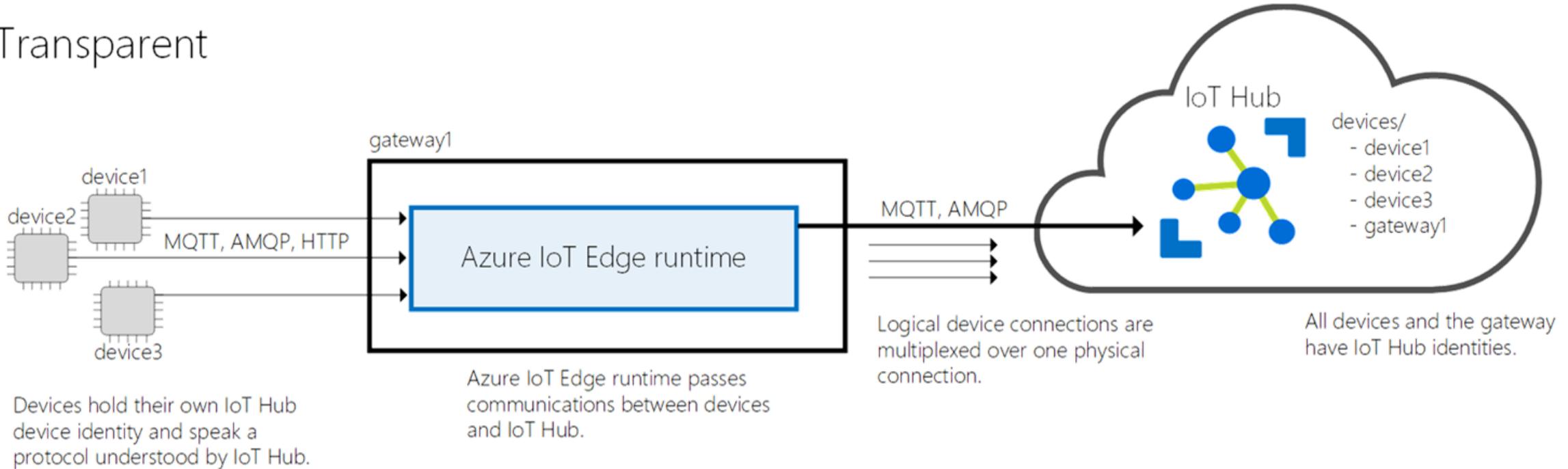
Ability to run on devices smaller than a Raspberry Pi

128MB memory

Support best in class operating systems such as Windows, and Linux

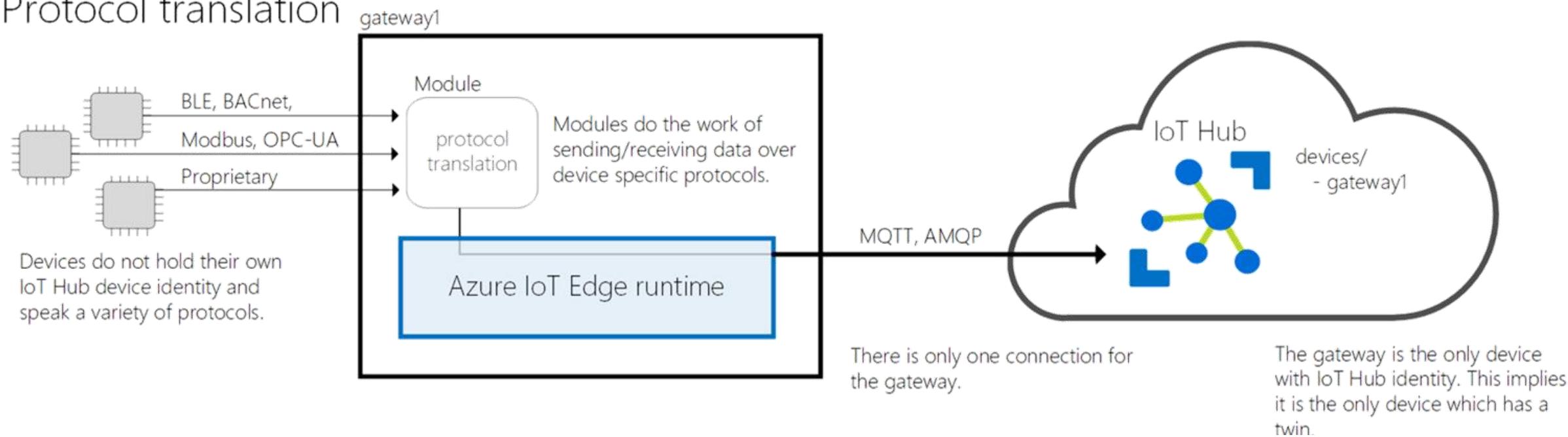
IoT Edge as a Gateway - Transparent

Transparent



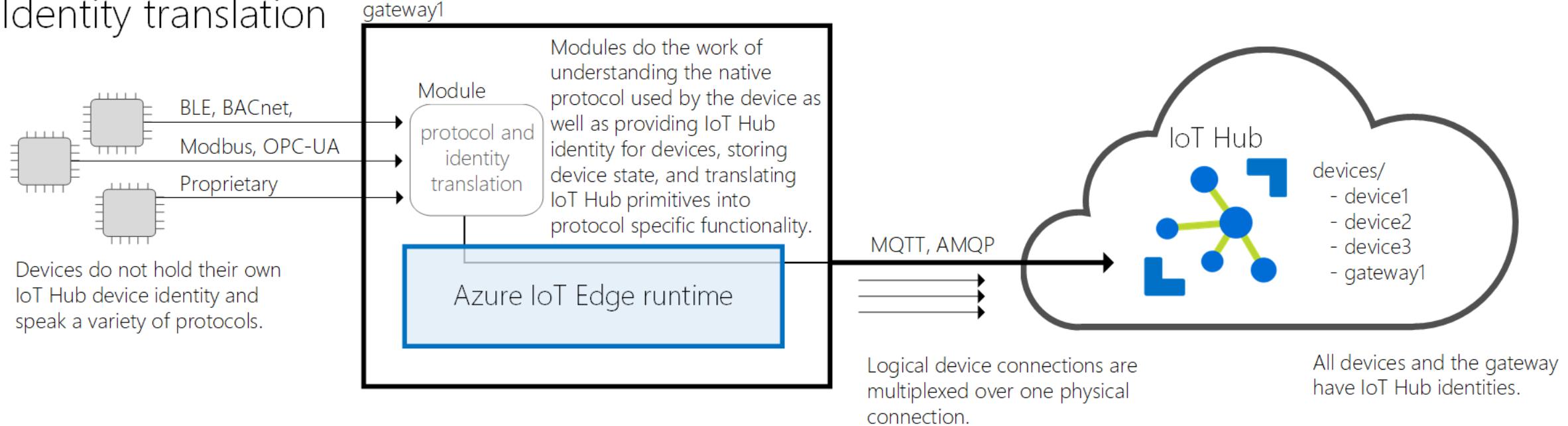
IoT Edge as a Gateway - Protocol Translation

Protocol translation



IoT Edge as a Gateway – Identity Translation

Identity translation



IoT Edge Portal Support

Microsoft Azure

Home > FließHomeAutomationHub - IoT Edge (preview) > Device Details

IoT Hub

Create a resource

All services

Favorites

Dashboard

Resource groups

All resources

Recent

App Services

SQL databases

Virtual machines (classic)

Virtual machines

Cloud services (classic)

Subscriptions

Azure Active Directory

Monitor

Security Center

Cost Management + Billing

Help + support

Advisor

IoT Edge (preview)

Search resources, services and docs

Add IoT Edge Device

Add IoT Edge Deployment

Refresh

Delete

Overview

Activity log

Access control (IAM)

Tags

Shared access policies

Pricing and scale

Operations monitoring

IP Filter

Certificates

Properties

Locks

Automation script

Query

optional (e.g. tags.location='US')

Execute

IoT Edge Devices

IoT Edge Deployments

IoT Edge Devices

IoT Edge devices have the IoT Edge runtime installed and are flagged as "IoT Edge device" in the device details. Each IoT Hub supports up to 1000 IoT Edge devices. Learn how to create a simulated IoT Edge device.

Query

SELECT * FROM devices WHERE optional (e.g. tags.location='US')

Execute

DEVICE ID	RUNTIME RESPONSE	MODULE COUNT	UNHEALTHY MODULE COUNT	CONNECTED CLIENT COUNT	DEPLOYMENT COUNT
HomeAutomationGateway	OK	4	0	1	0

Visual Studio Code IoT Edge Extension

The screenshot shows the Visual Studio Code interface with the IoT Edge extension installed. The Explorer sidebar on the left lists project files and Docker images. The main editor area shows the `module.json` file content:

```
1  {
2   "$schema-version": "0.0.1",
3   "description": "",
4   "image": {
5     "repository": "alonf/filtermodule",
6     "tag": {
7       "version": "0.0.1",
8       "platforms": {
9         "amd64": "./Dockerfile",
10        "amd64.debug": "./Dockerfile.amd64.debug",
11        "arm32v7": "./Dockerfile.arm32v7",
12        "windows-amd64": "./Dockerfile"
13      }
14    }
15 }
```

A context menu is open over the `module.json` file, listing options like Open to the Side, Reveal in Explorer, Open in Command Prompt, Select for Compare, Copy, Copy Path, Rename, Delete, Build IoT Edge Module Image, and Build and Push IoT Edge Module Image.

The status bar at the bottom shows the path `C:\Users\alon\source\Repos\FilterModule>`, the command palette icon, and the message `Azure: alonf@codevalue.net`.

Azure IoT Summary

- IoT system architecture is a bit different than other cloud architecture
 - A “Pettle” – each device count!
- Microsoft provides SaaS and PaaS solutions
 - Azure IoT Central, Azure IoT Suite, Azure IoT Hub and cloud services
- Azure IoT Hub is designed to connect your devices to Azure. It supports:
 - SDKs, Millions of simultaneously connected devices, Per-device authentication, High throughput data ingestion, Scale device management
 - HTTP, MQTT, AMQP communication protocols
 - Cloud to Device and Device to Cloud messaging
 - State transfer with device twins
 - Query language, Job Management, File Upload
- Smart cloud & intelligent Edge

Resources

- Demo code:
 - <https://github.com/alonf/BasicGateController>
 - Setup IoT Hub video: <https://youtu.be/vq5AeLlsWx4>
- My MSDN articles:
 - [Introduction to the Internet of Things – From the Device to Microsoft Azure Cloud](#)
 - https://blogs.msdn.microsoft.com/microsoft_press/2015/04/27/from-the-mvps-introduction-to-the-internet-of-things-from-the-device-to-microsoft-azure-cloud/
 - [Efficient IoT With Azure](#)
 - <https://blogs.msdn.microsoft.com/mvpawardprogram/2016/11/15/efficient-iot-with-azure/>
 - [Secure Provisioning of IoT device using Azure IoT Hub device SDK](#)
 - <https://blogs.msdn.microsoft.com/mvpawardprogram/2017/03/14/provisioning-of-iot-device/>
- Thingiverse
 - <http://www.thingiverse.com/thing:2253418>
- Azure IoT
 - IoT SDKs - <https://docs.microsoft.com/en-us/azure/iot-hub/iot-hub-devguide-sdks>
 - GitHub - <https://github.com/Azure/azure-iot-sdks>
 - Azure IoT Suite - <https://azure.microsoft.com/en-us/suites/iot-suite/>
 - Azure IoT Hub - <https://azure.microsoft.com/en-us/services/iot-hub/>