Azure and IoT Hub

OzCode
Your Road to Magical Debugging

CODEVALUE

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About Me

- Alex Pshul
  - @AlexPshul
  - www.pshul.com
  - alexp@codevalue.net
- Software Architect & Consultant @CodeValue Ltd.
- More than 8 years of hands on experience
- OzCode Evangelist (www.oz-code.com)
- Talk to me about:
  - Software Development
  - Hardware and Gadgets
  - Gaming
  - Animals

Cloud Computing

Introduction to Cloud Computing

Cloud Computing - A Game Changing Technology

- Infinite shared resources & services
  - Infrastructure is not a limiting factor
  - No need to equip for peak-load requirements
- Elasticity on demand
  - Anytime, anywhere
- Efficient scalability and high availability
- Suitable pricing models
  - Pay for what you use

Cloud Computing

Evolution of Computing - The Next (Current) Big Thing

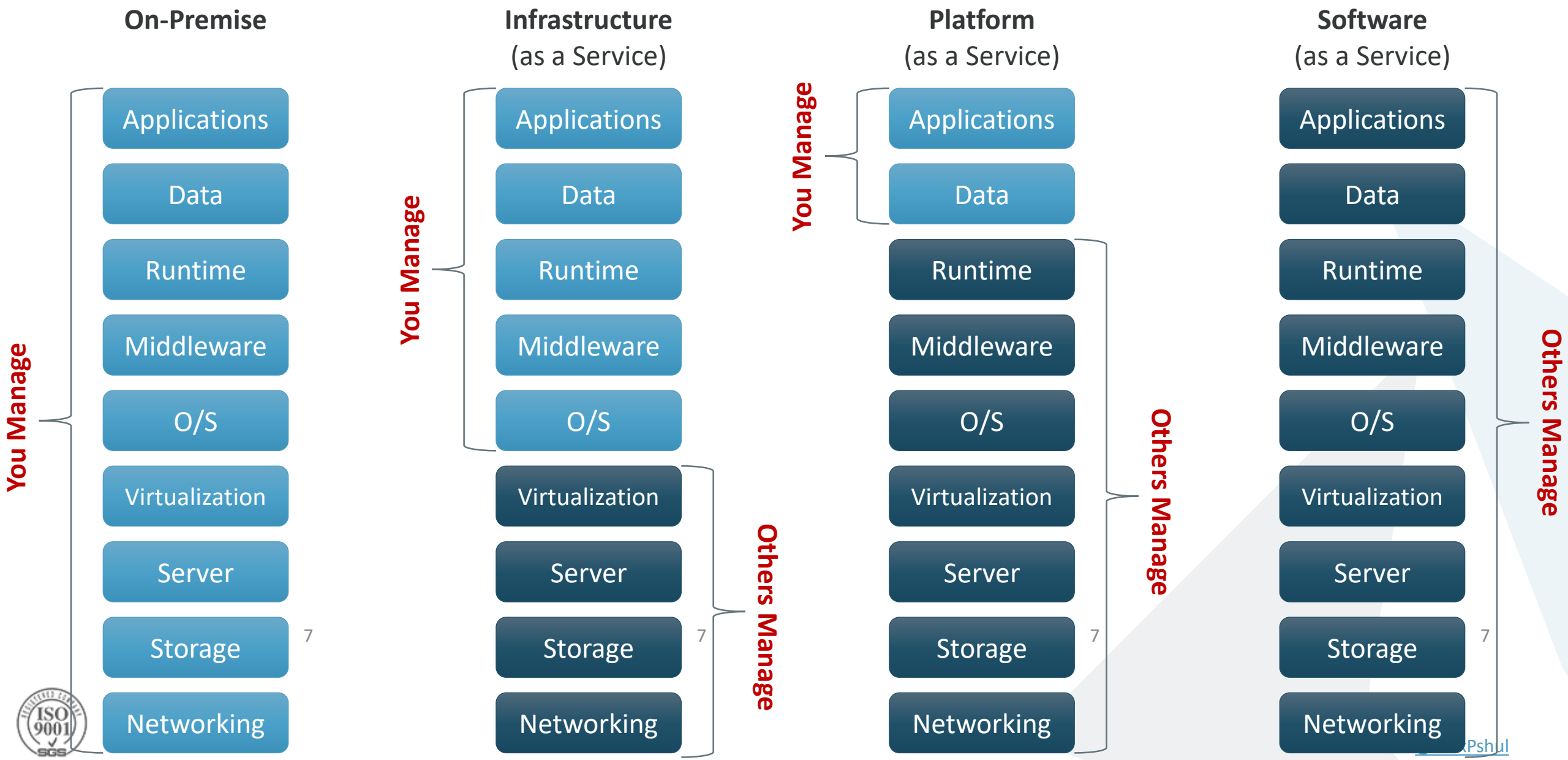
- Virtualization and Abstraction
  - Details are abstracted from consumers
    - Reduces complexity
- Not necessarily the Internet, can be on premises
  - Private cloud
- Automation, Monitoring, Deployment
  - Reduce cost, shift risk, shorten time-to-market, focus on business functionality

Less Worries

Focus on functionality

- Let others take care of:
  - Resource management
  - Security
  - Environments (staging, production)
  - High availability, scalability, load balancing
  - Fault tolerance
  - OS - installation, licensing, updates, patches
  - Network
  - Maintenance

Why the Cloud? - IaaS, PaaS & SaaS



Introduction to Cloud Architecture

Cloud Computing - A Game Changing Technology

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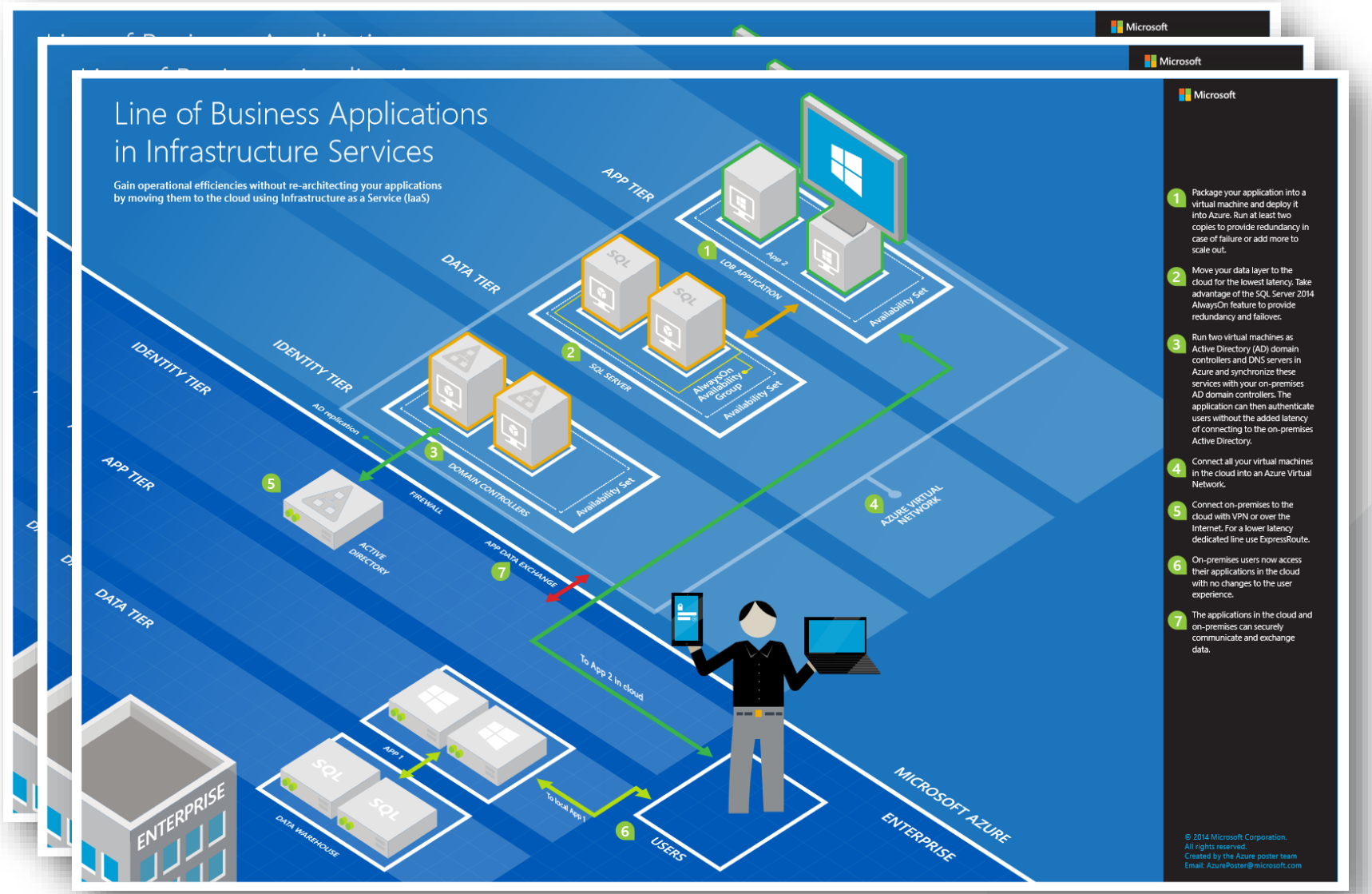
  - Anytime, anywhere
- Efficient scalability and high availability
- Suitable pricing models
  - Pay for what you use
- **Less worries** about the foundation – **Better application quality!!!**

Azure Architecture Blueprints



Microsoft Azure

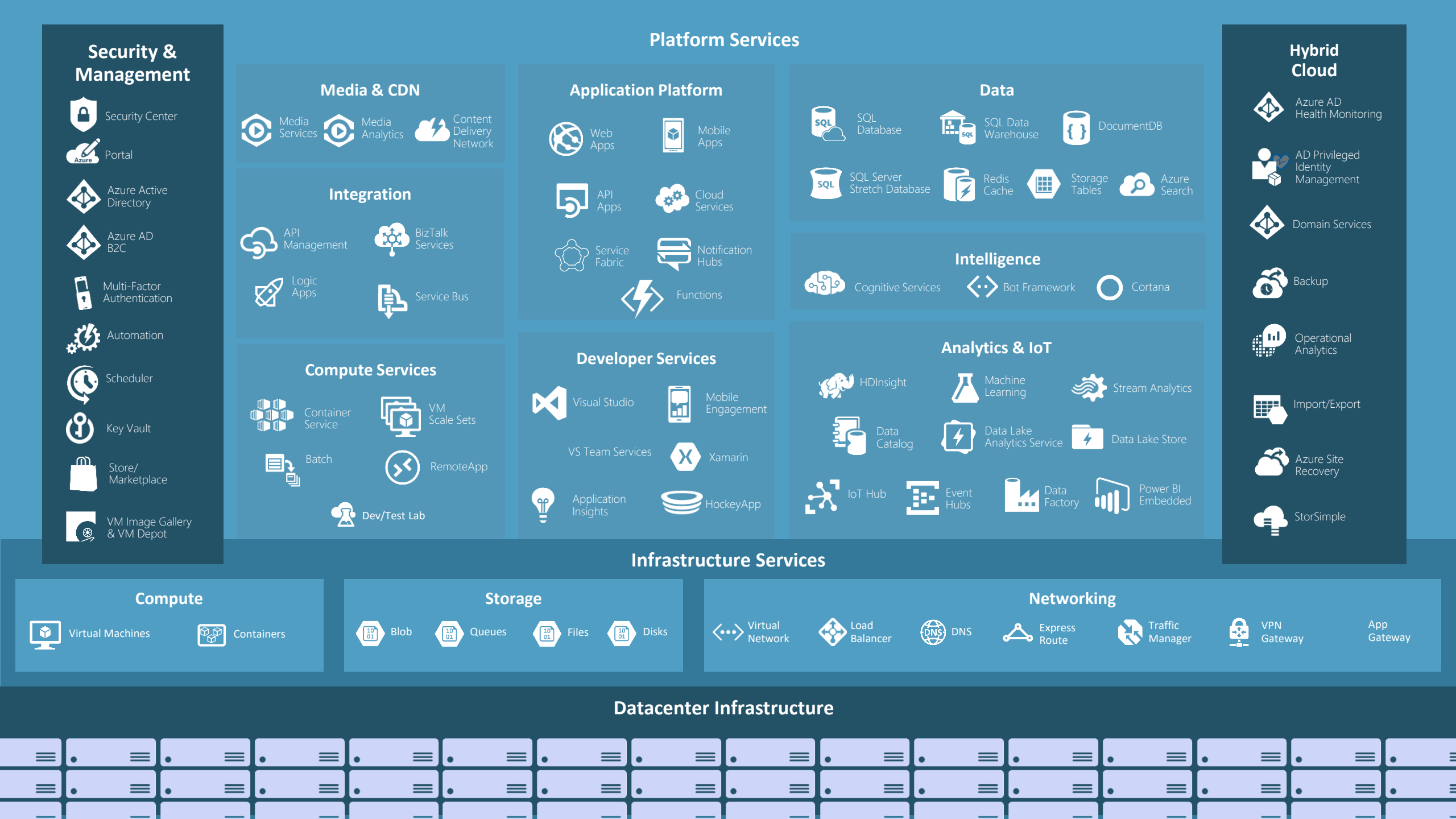
Azure regions

Azure has more global regions than any other cloud provider—offering the scale needed to bring applications closer to users around the world, preserving data residency, and offering comprehensive compliance and resiliency options for customers.

54 regions worldwide

140 available in 140 countries

Project Natick


Security & Management
Security Center
Portal
Azure Active Directory
Azure AD B2C
Multi-Factor Authentication
Automation
Scheduler
Key Vault
Store/ Marketplace
VM Image Gallery & VM Depot
Platform Services
Media & CDN
Media Services
Media Analytics
Content Delivery Network
Integration
API Management
BizTalk Services
Logic Apps
Service Bus
Compute Services
Container Service
VM Scale Sets
Batch
RemoteApp
Dev/Test Lab
Application Platform
Web Apps
Mobile Apps
API Apps
Cloud Services
Service Fabric
Notification Hubs
Functions
Developer Services
Visual Studio
Mobile Engagement
VS Team Services
Xamarin
Application Insights
HockeyApp
Data
SQL Database
SQL Data Warehouse
DocumentDB
SQL Server Stretch Database
Redis Cache
Storage Tables
Azure Search
Intelligence
Cognitive Services
Bot Framework
Cortana
Analytics & IoT
HDInsight
Machine Learning
Stream Analytics
Data Catalog
Data Lake Analytics Service
Data Lake Store
IoT Hub
Event Hubs
Data Factory
Power BI Embedded
Hybrid Cloud
Azure AD Health Monitoring
AD Privileged Identity Management
Domain Services
Backup
Operational Analytics
Import/Export
Azure Site Recovery
StorSimple
Infrastructure Services
Compute
Virtual Machines
Containers
Storage
Blob
Queues
Files
Disks
Networking
Virtual Network
Load Balancer
DNS
Express Route
Traffic Manager
VPN Gateway
App Gateway
Datacenter Infrastructure

Smart Home - Microsoft

Secure | https://portal.azure.com/#@codevalue.onmicrosoft.com/dashboard/private/e0698042-da11-4170-bd65-7a7a2d8ee037

Microsoft Azure

Search resources, services and docs

alonf@codevalue.net
CODEVALUE LTD.

- 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

Smart Home

New dashboard | Upload dashboard | Download dashboard | Edit dashboard | Share | Fullscreen | Clone | Delete

Jerusalem Edit

15:53

WEDNESDAY, MARCH 21, 2018

Pacific Time (US ... Edit

06:53

WEDNESDAY, MARCH 21, 2018

watertank
AZURE IOT HUB

Active

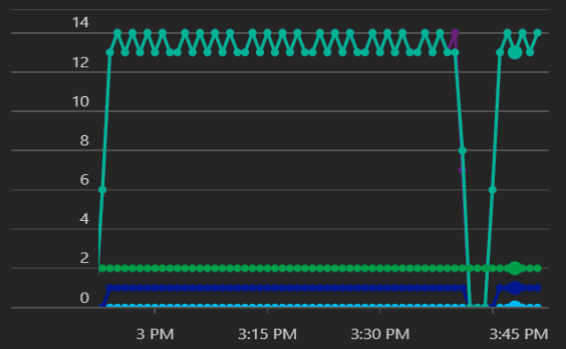
Resource groups
ALL SUBSCRIPTIONS

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...

Commands completed, Connected devices and 3 ...
WATERTANK

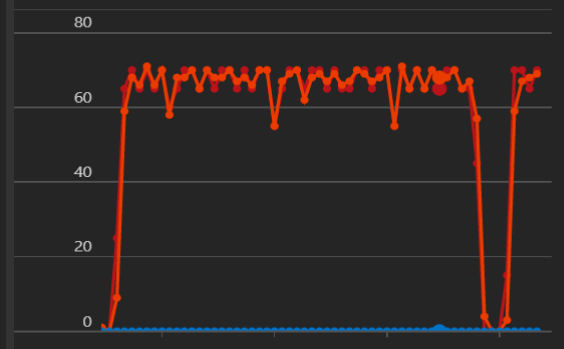


COMMANDS COMPLETED 0

CONNECTED DEVICES 0.9

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

Edit



DATA CONVERSION ERR... 0

INPUT EVENTS 3.52 K

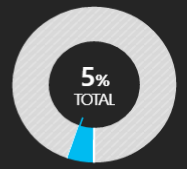
watertankvalues
STREAMING JOB

watertank
FUNCTION APP

Running

watertank
TIMESERIESINSIGHTSENVIRO...

3/21/2018 UTC
WATERTANK



MESSAGES 20661 / 400k

DEVICES 2

eventhubfortimeserie...
EVENTHUB

Active

watertankeventqueue

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

```
prompt> azure   topic          verb          options
```

topic	verb	options
account	download	*username*
account location	import	*password*
account affinity-group	list	*dns-prefix*
vm	show	*vm-name*
vm disk	delete	*lb-port*
vm endpoint	start	*target-image-name*
vm image	restart	*source-path*
service	shutdown	*disk-image-name*
service cert	capture	*size-in-gb*
site	create	*thumbprint*
config	create-from	*value*
	attach	-json
	attach-new	-v
	detach	-vv
	browse	
	set	

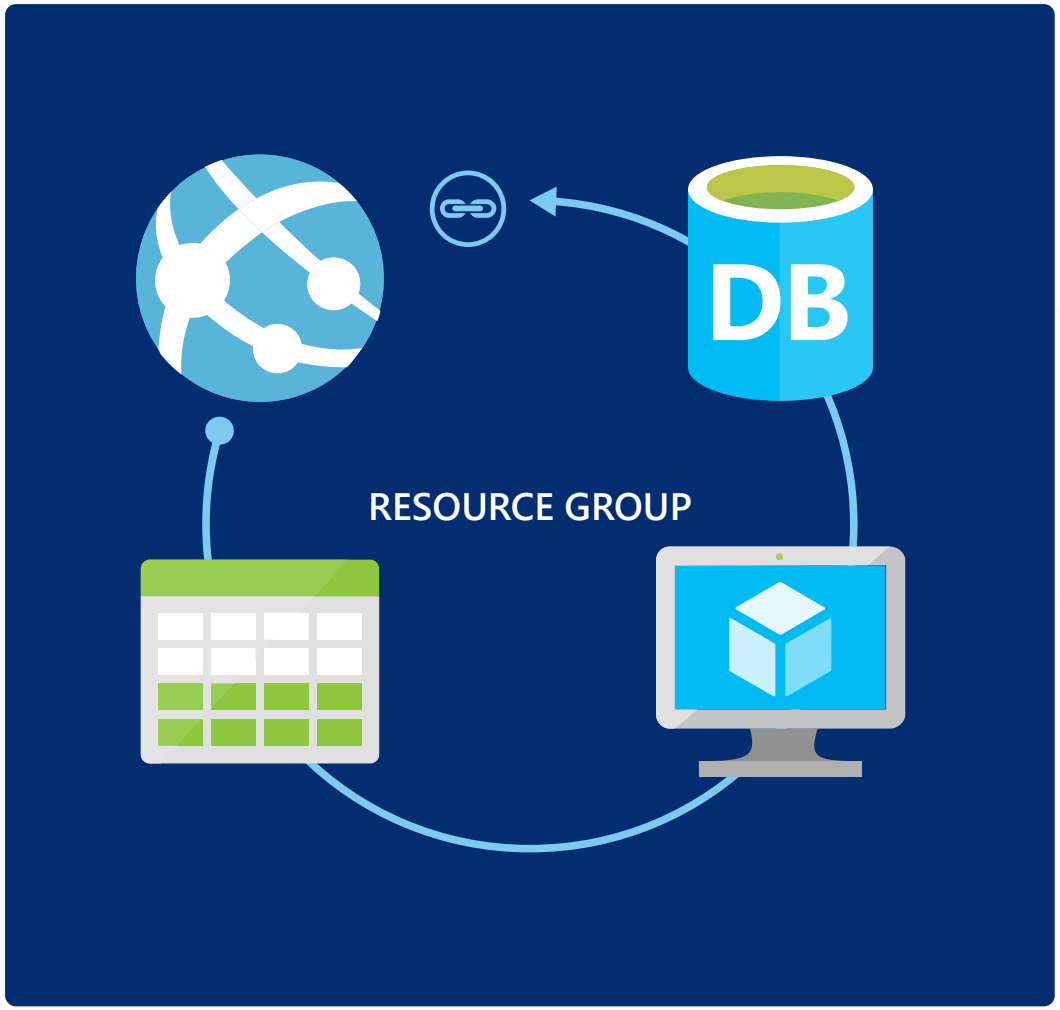
Azure Resource Manager (ARM)

- 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

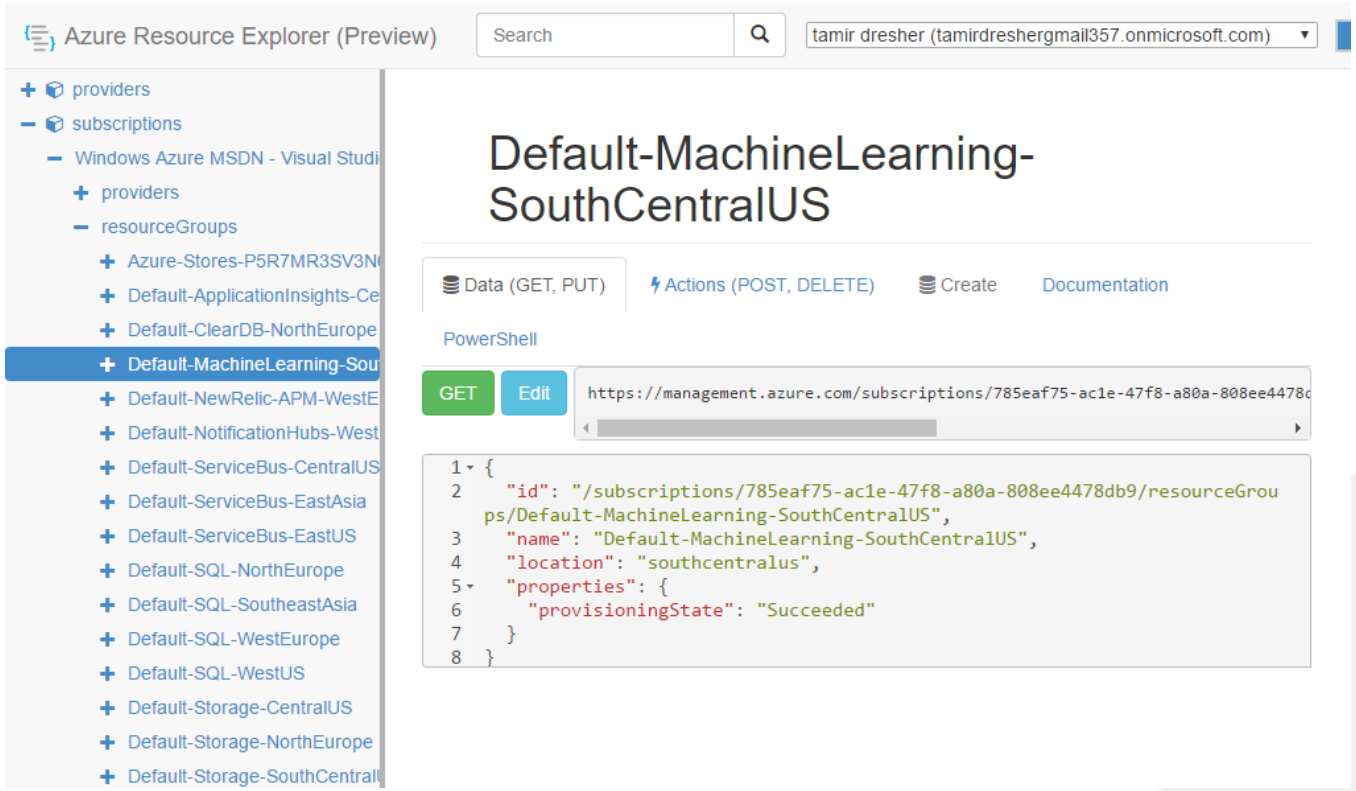
- Tightly coupled containers of multiple resources
- Every resource exist in one (and only one) resource group
- Resource groups can span regions

- 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



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

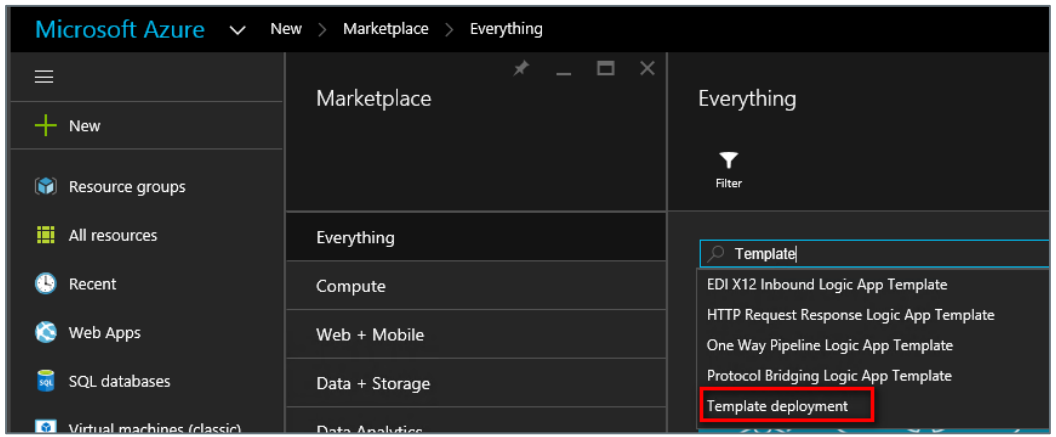
```
New-AzureVM –VM $myVM
New-AzureRmStorageAccount –StorageAccountName $acct
Set-AzureRmVNetConfig –ConfigurationPath –Path
```

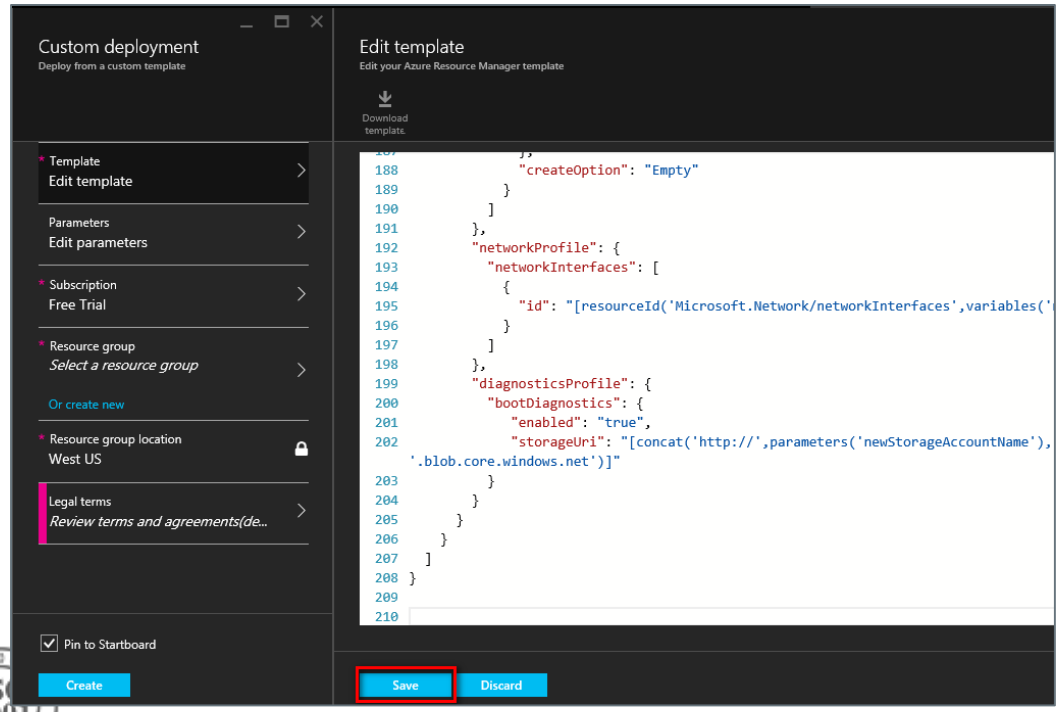
declarative

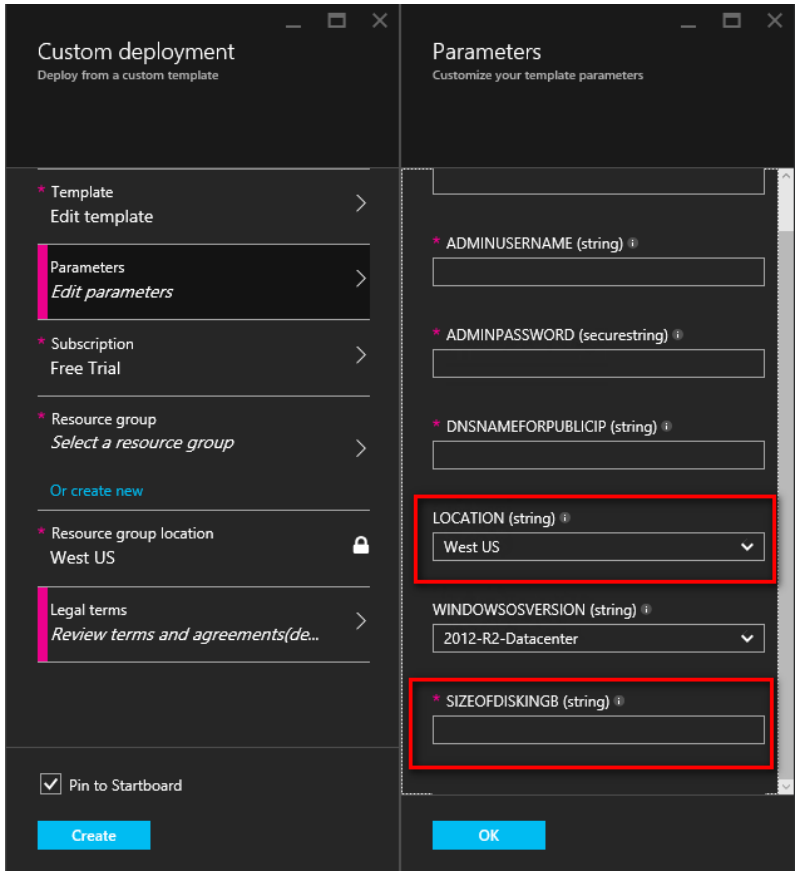
```
{
 "$schema": "https://../deploymentTemplate.json#",
 "contentVersion": "1.0.0.0",
 "parameters": {},
 "variables": {},
 "resources": [],
 "outputs": {}
}
```

Http://github.com/rjmax/ArmExamples

Deploying Templates



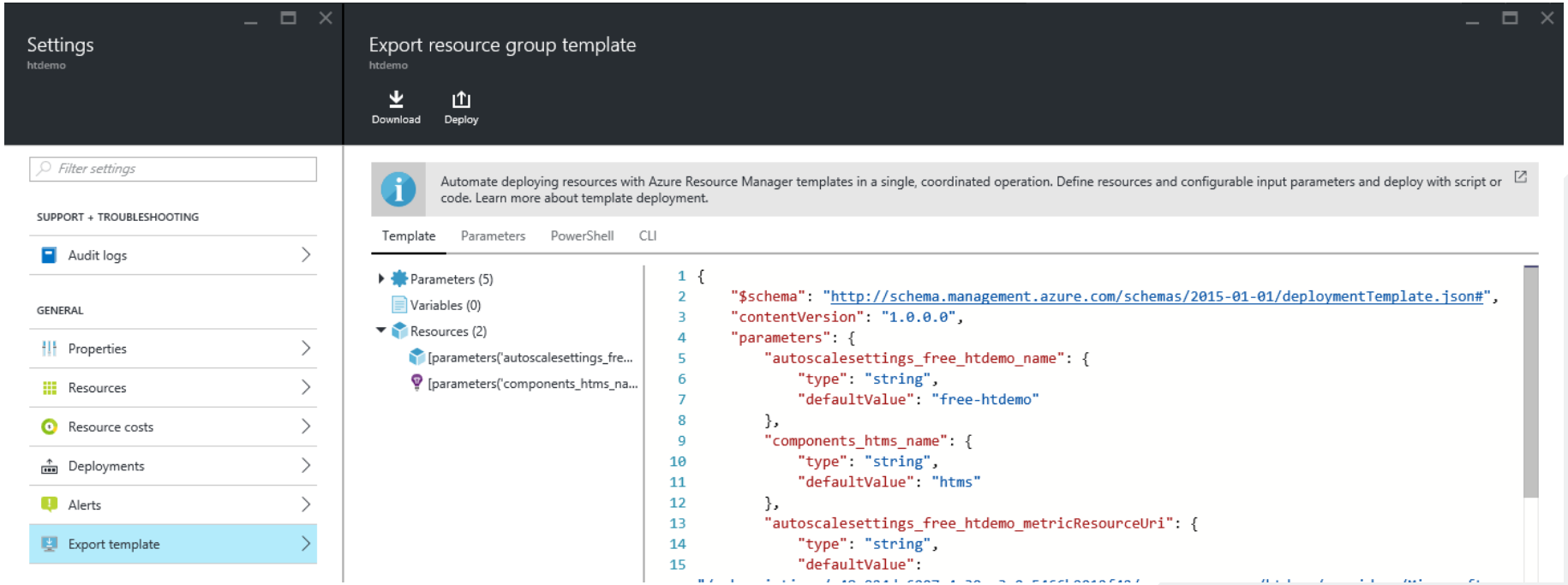




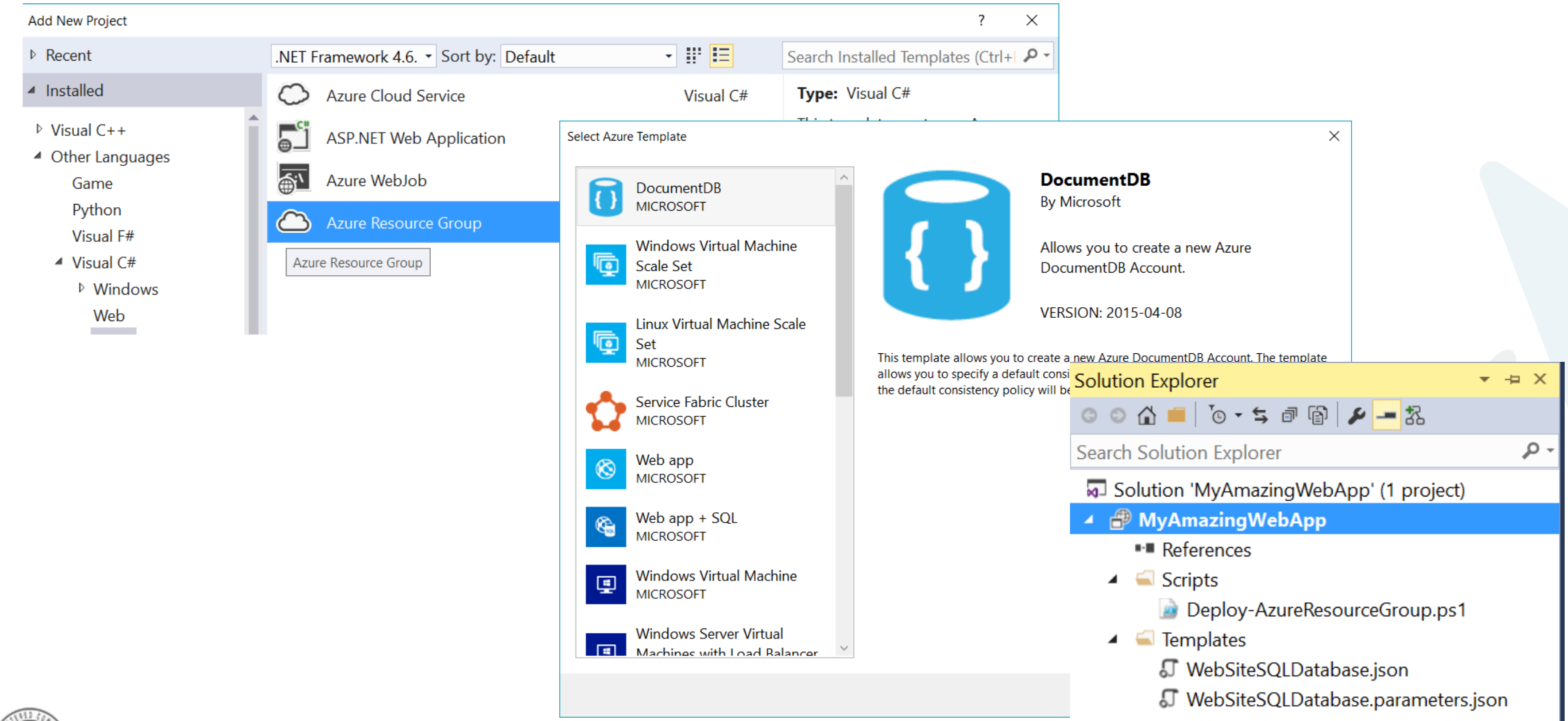

```
New-AzureRmResourceGroupDeployment -DeploymentName
"Simple-VM" -ResourceGroupName
RG-AZITCAMP -TemplateFile "C:\GitHub\Templates\101-
simple-windows-vm\azuredeploy.json
```

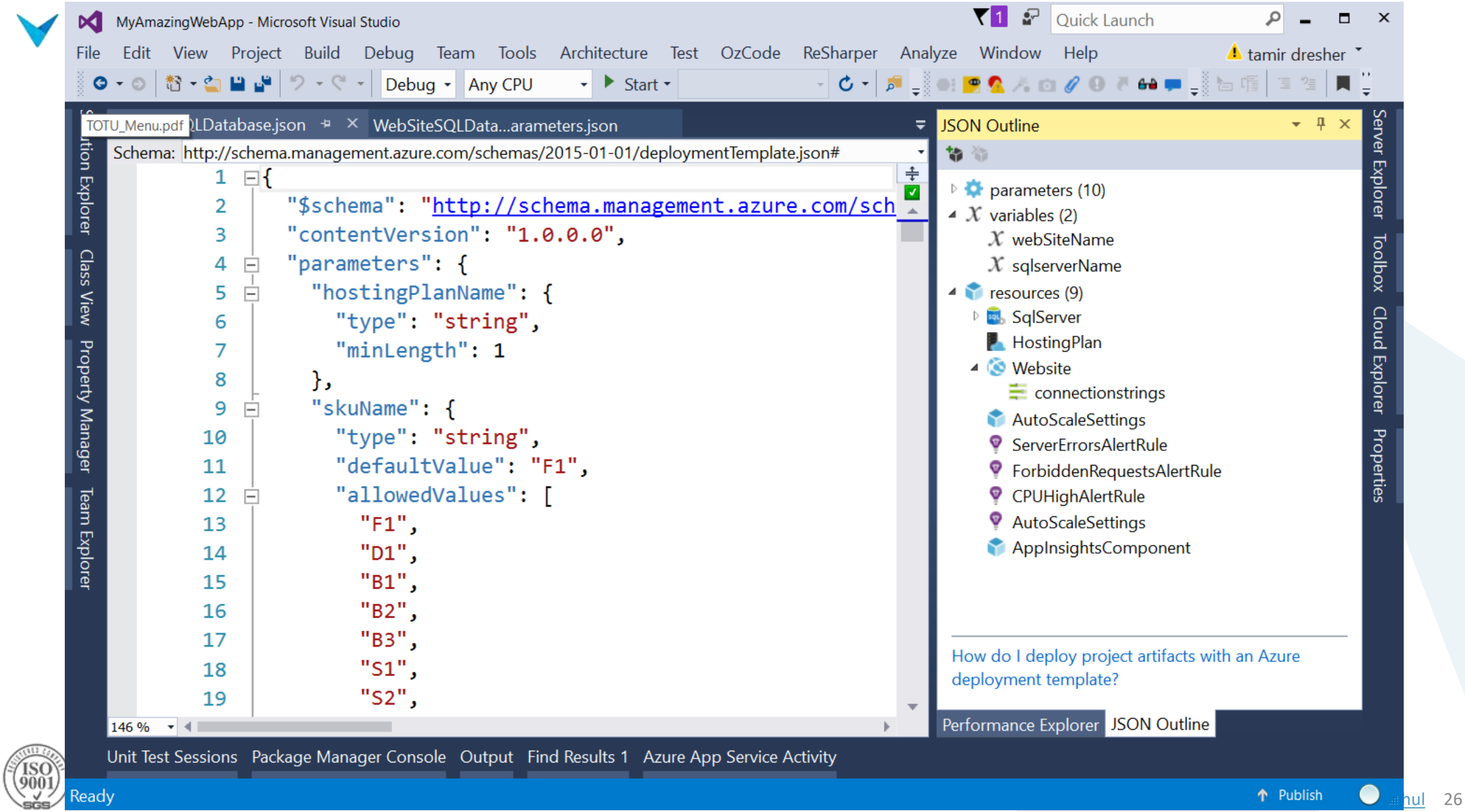
Creating\Editing Templates

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



Azure Resource Group Project




MyAmazingWebApp - Microsoft Visual Studio
Quick Launch
File Edit View Project Build Debug Team Tools Architecture Test OzCode ReSharper Analyze Window Help
tamir dresher
Debug
Any CPU
Start
TOTU_Menu.pdf
WebSiteSQLData...arameters.json
Schema: http://schema.management.azure.com/schemas/2015-01-01/deployment Template.json#
{
"$schema": "http://schema.management.azure.com/sch
"contentVersion": "1.0.0.0",
"parameters": {
"hostingPlanName": {
"type": "string",
"minLength": 1
},
"skuName": {
"type": "string",
"defaultValue": "F1",
"allowedValues": [
"F1",
"D1",
"B1",
"B2",
"B3",
"S1",
"S2",
146 %
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
Server Explorer
Toolbox
Cloud Explorer
Properties
Solution Explorer
Class View
Property Manager
Team Explorer
Unit Test Sessions
Package Manager Console
Output
Find Results 1
Azure App Service Activity
Ready
Publish

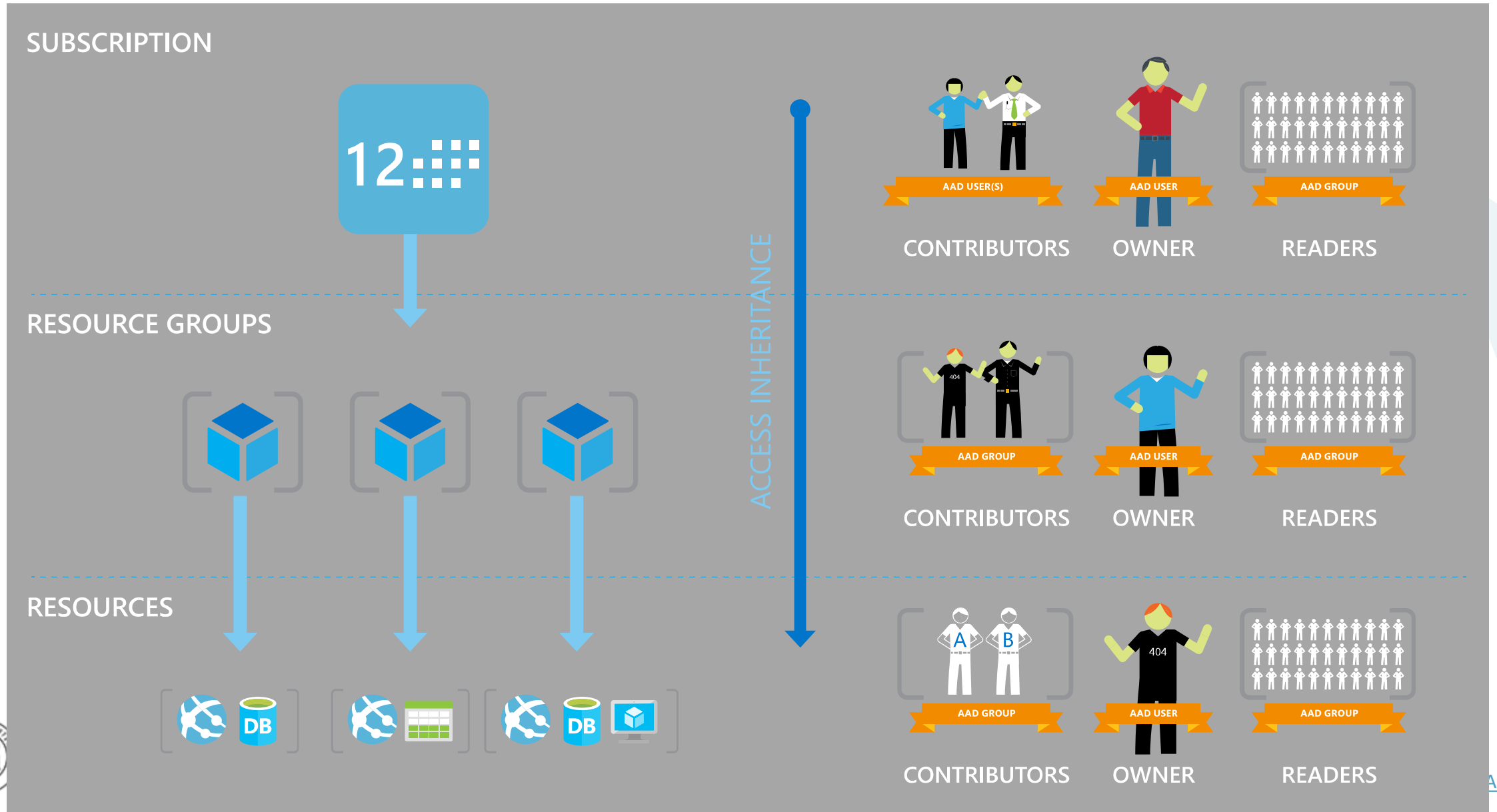
More Azure Deployment Links

- 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
    - Assignemt is per scope (Directory/Subscription/Resource Group/Resource)
    - Inherited – subscription assignments apply to all resources

Role Based Access Control



RBAC Scope

/subscriptions/{id}/resourceGroups/{name}/providers/…/sites/{site}

subscription level – grants permissions to all resources in the sub

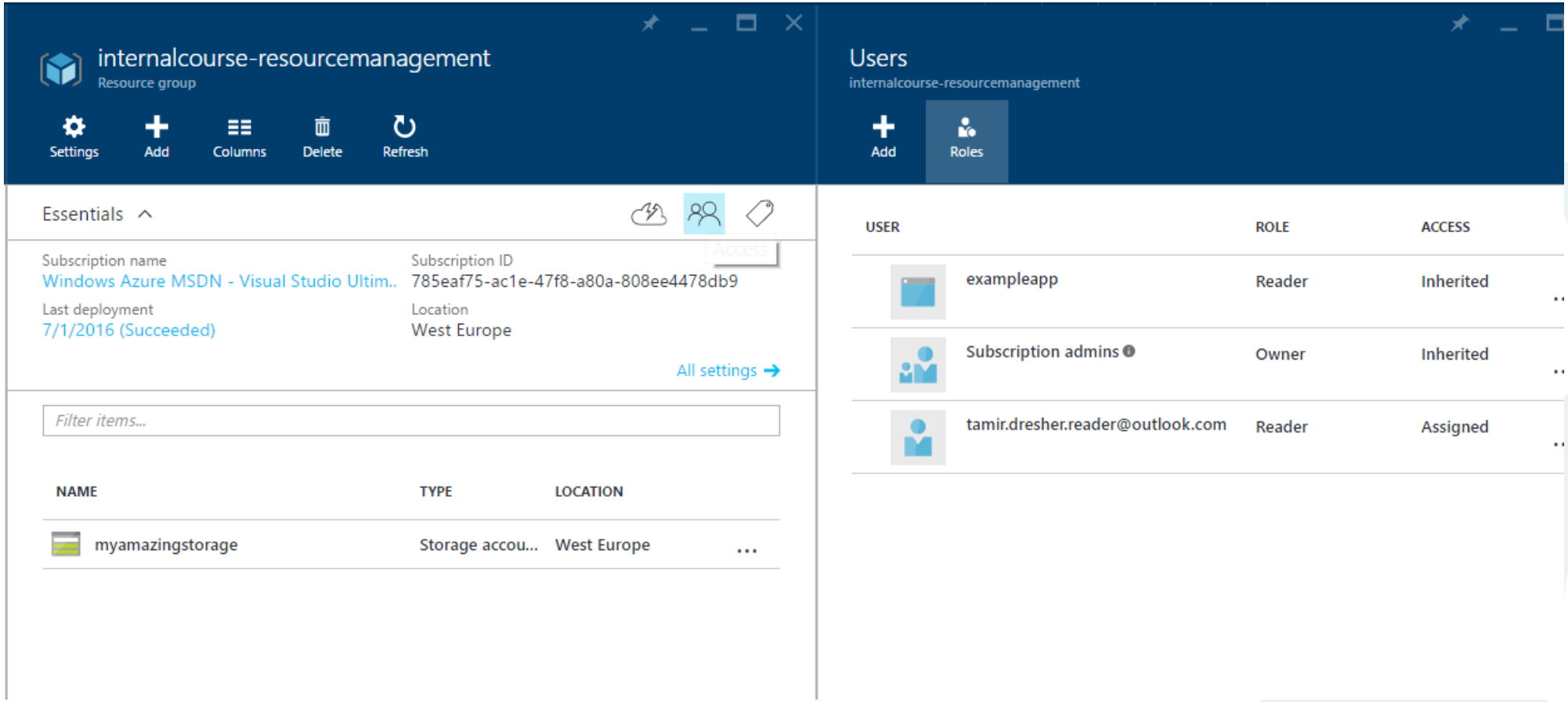
resource group level – grants permissions to all resources in the group

resource level – grants permissions to the specific resource

Built-in Roles

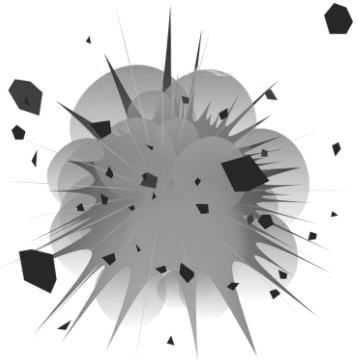
Role name	Permissions
Owner	Full management rights
Contributor	Full management rights except for user management
Reader	View resources and their settings
None	Does not see resources

RBAC in the portal



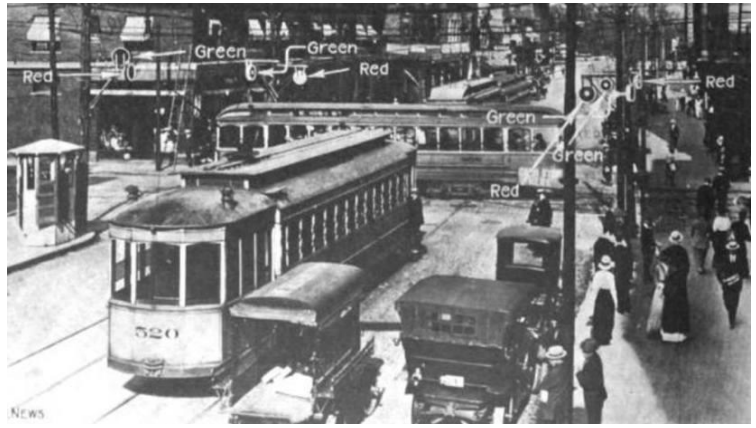
Azure IoT

Traffic Light History Facts

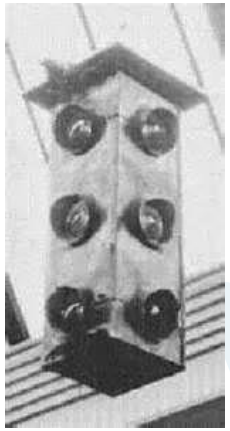


1868
London

1912
SLC



1914
Cleveland



1920
Detroit

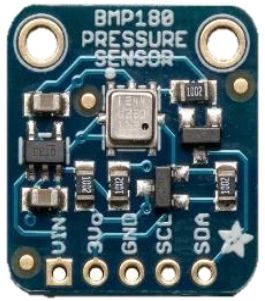
1922
Automatic timer controlled

1950s
Computer Detection

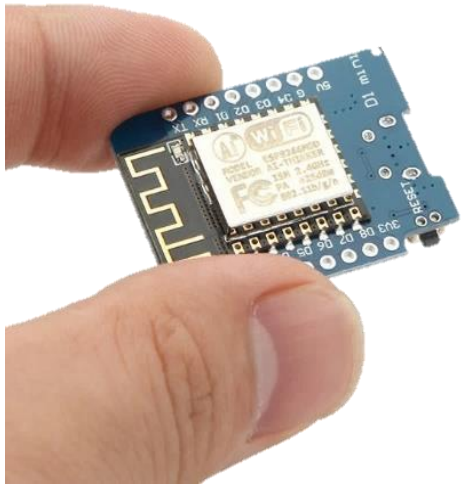
@AlexPshul

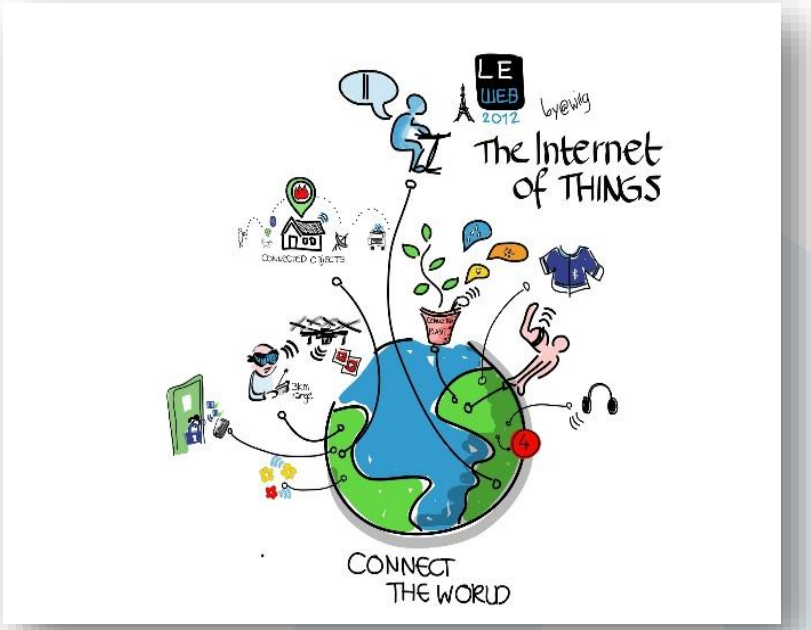
Agenda

- 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 System Basic Components

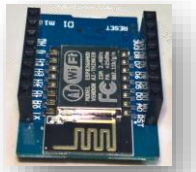




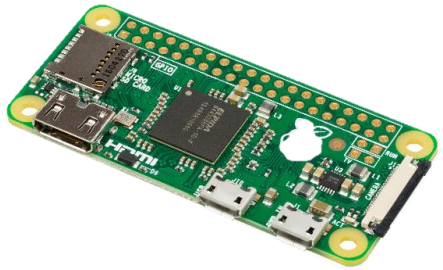

```
var sensorData = await _bmp180.GetSensorDataAsync(Bmp180.UltraHighResolution);
var messageString = JsonConvert.SerializeObject(sensorData);
var message = new
    Microsoft.Azure.Devices.Client.Message(Encoding.ASCII.GetBytes(messageString));
await deviceClient.SendEventAsync(message);
```

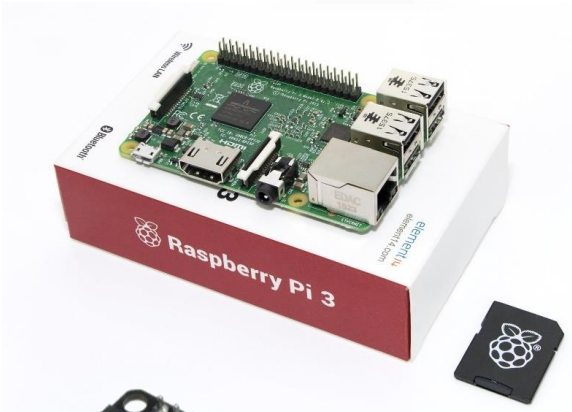
The Device

- There are many System on a Chip (SoC) devices to choose from
- Raspberry Pi family
- Arduino Compatible Family
  - ESP 8266 & ESP 32 based devices
- Microsoft Azure Sphere
- …



Azure Sphere

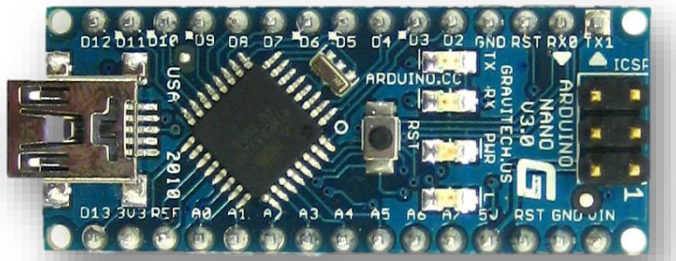


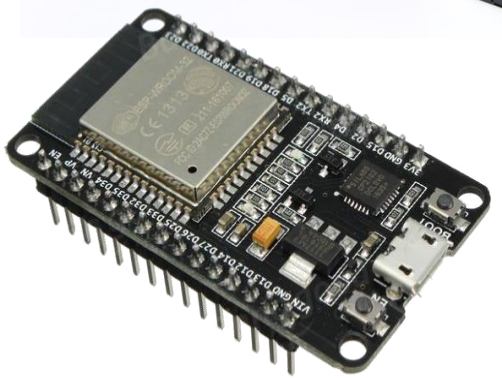


Raspberry Pi 3 Kit

Windows 10 and Raspbian

Samples in C and C#





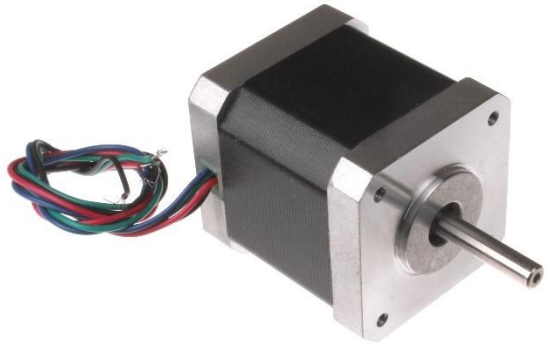
Feather Huzzah ESP8266 Kit

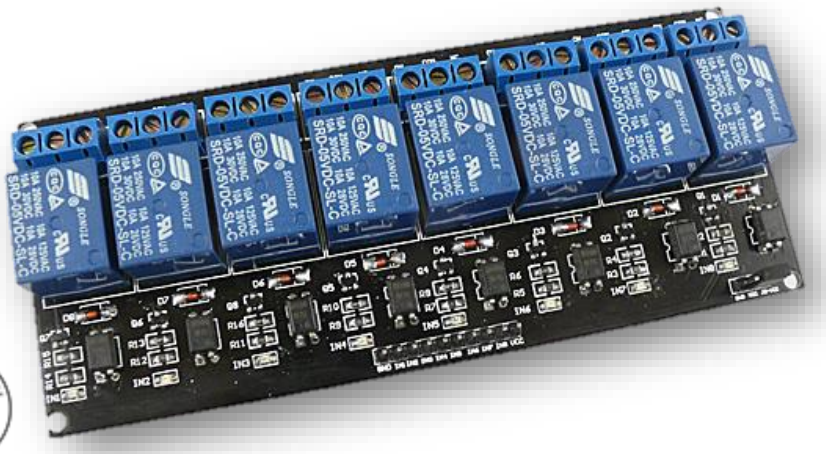
RTOS

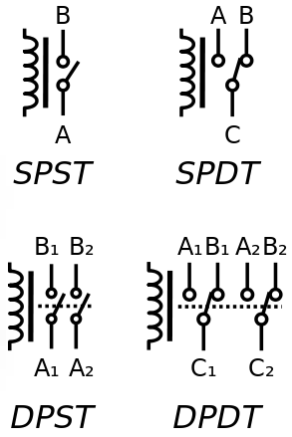
Samples in Arduino IDE and C

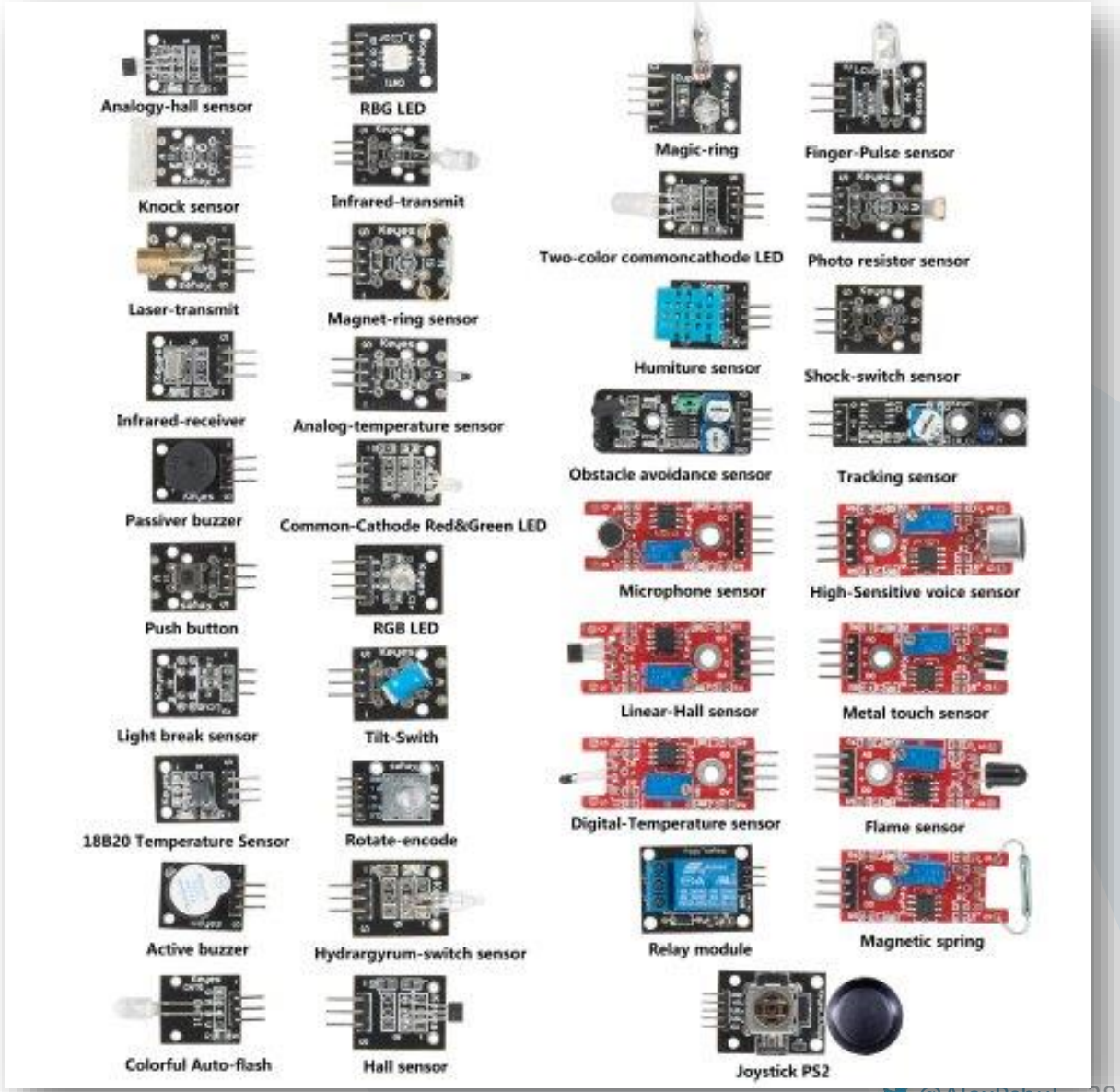
Sensors, Actuators, Motors

- There are plenty of them









How do I play with it?

- Pick your weapon
  - A prototype board that has networking capabilities
    - Raspberry Pi, WeMos, Intel IoT, Tessel, NetDuino
    - The complete list @ Azure IoT hardware catalog
- Some Electronics & Hardware Programming
  - Understand how to connect sensors and communicate with them
- Pick your Cloud Services and technologies
  - Microsoft Azure, AWS
  - Do something with the (Big) data

IoT - More Than The Core Technology

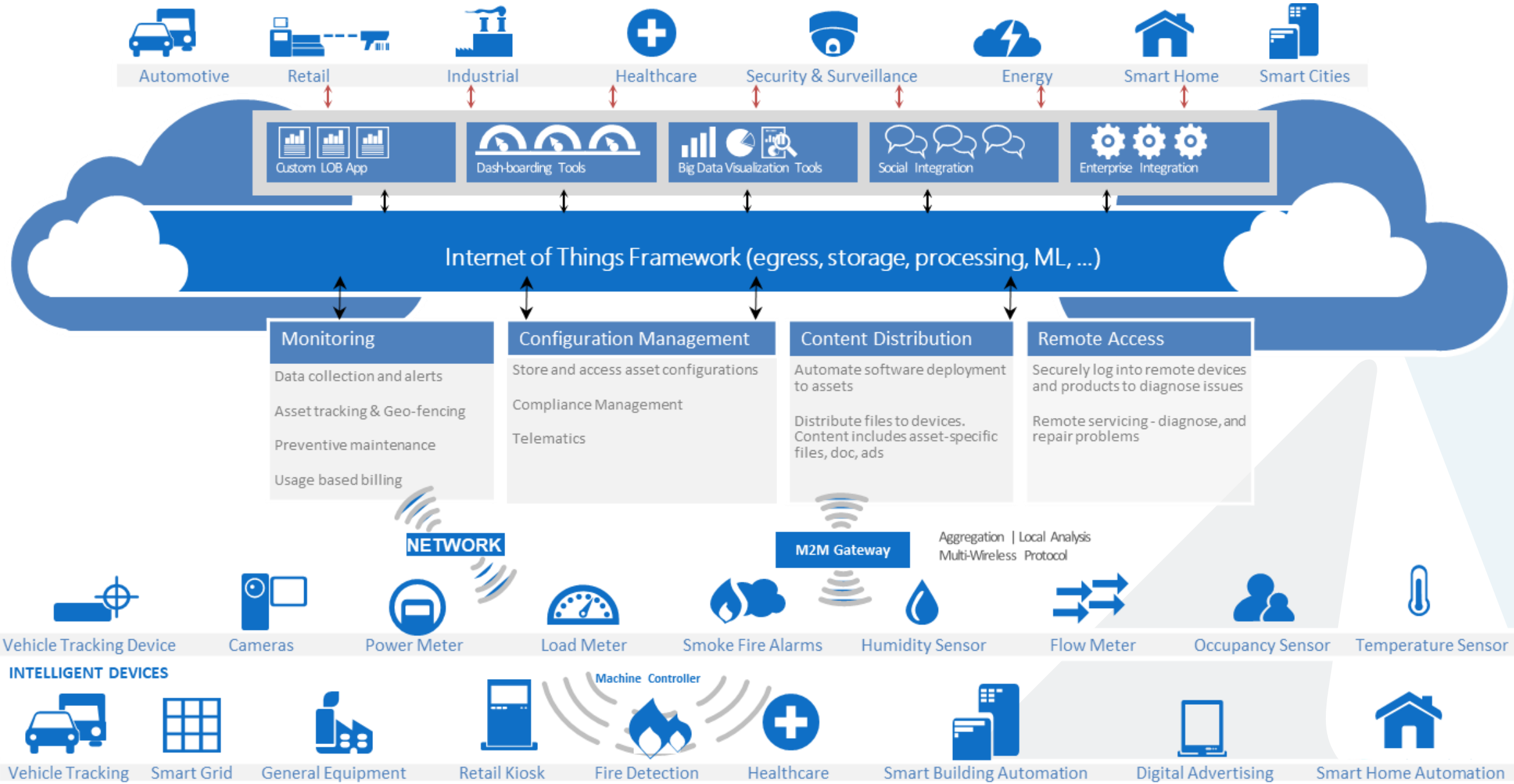
- It is not (just) the technology that makes IoT what it is
- It is the
  - Concepts, perception, commitment and the challenges
  - Facts that the entire industry is dealing with it nowadays
- The IoT Challenge:
  - ***vast*** *amount of* ***devices*** *using different hardware and software technologies, 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?

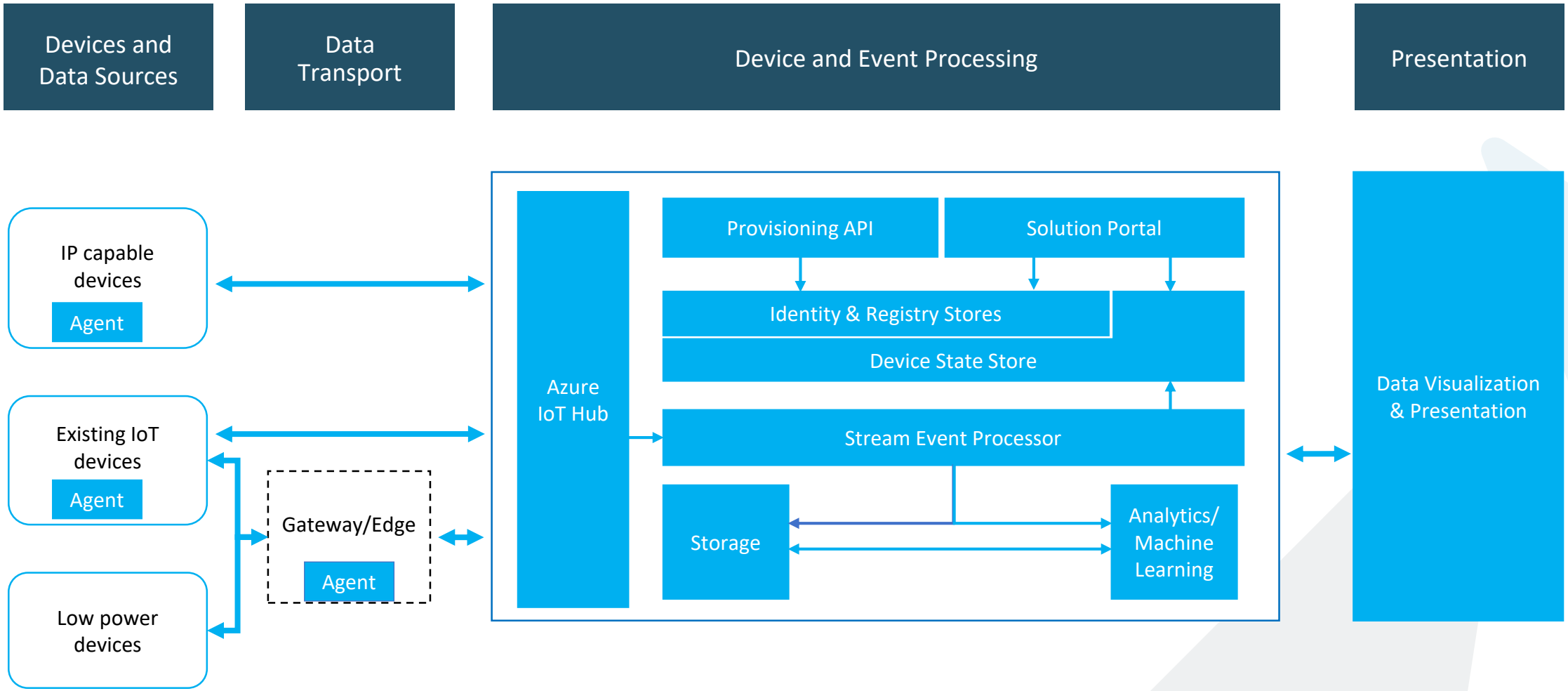
The Modern IoT System

- 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**

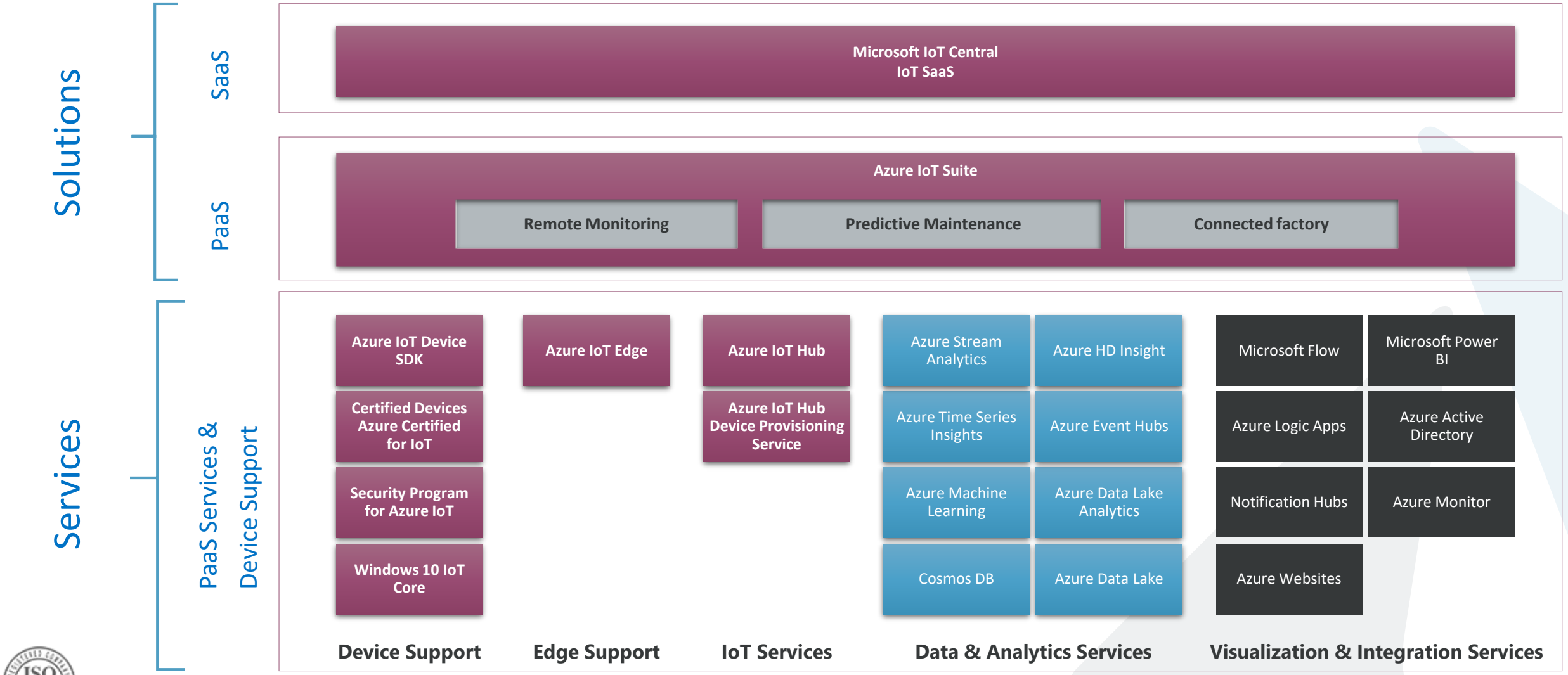
High Level Architecture



Azure IoT Services Reference Architecture

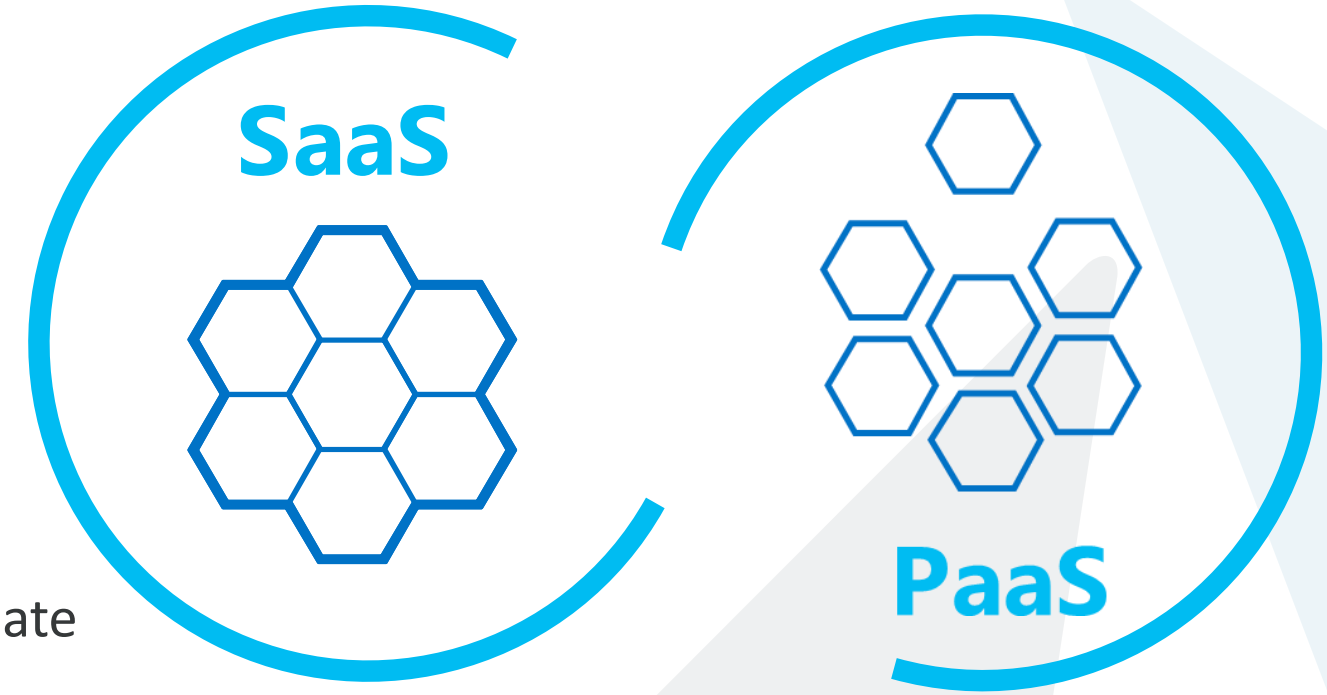


Comprehensive set of capabilities for IoT solutions

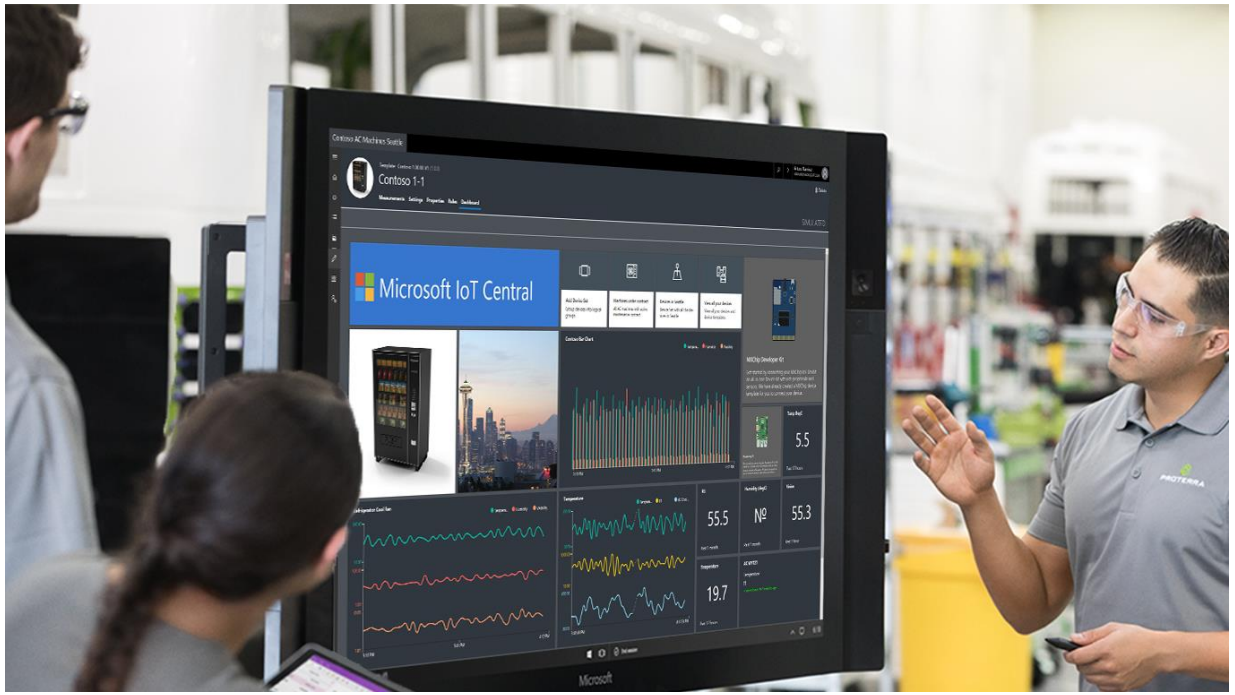


Azure IoT solutions approach

- 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	Sample Contoso	Sample Devkits
Start with a blank template and define your application from scratch.	Get started with a predefined application for a connected device.	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

Delete

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

Installation Date
11/8/2017 7:38:42 AM

Model
Double Zone

Serial Number
SN00001

Maintenance Info

Installation Address

Installation Date
11/8/2017 7:38:42 AM

Maintenance Contract
true

Tampering Threshold
0

Temperature Alert Thres...
0

Customer Info

Customer Address

Customer Contact Email

Customer Contact Name

Customer Contact Phone
(__) ___-____

Customer Name

Max Temperature (de...

22.7

Past 1 week

Max Humidity (%)

58

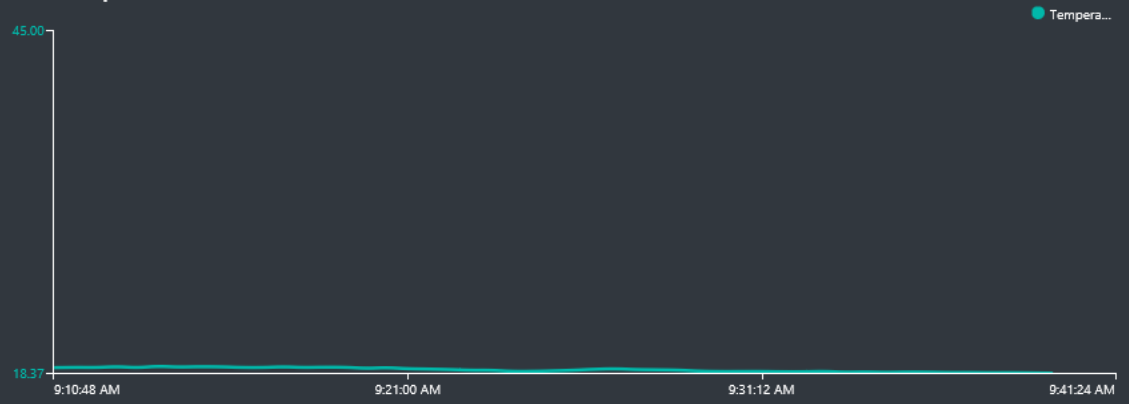
Past 1 week

Average Pressure (hPa)

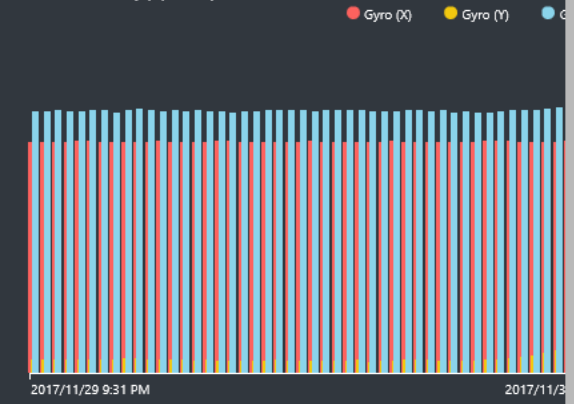
1K

Past 1 week

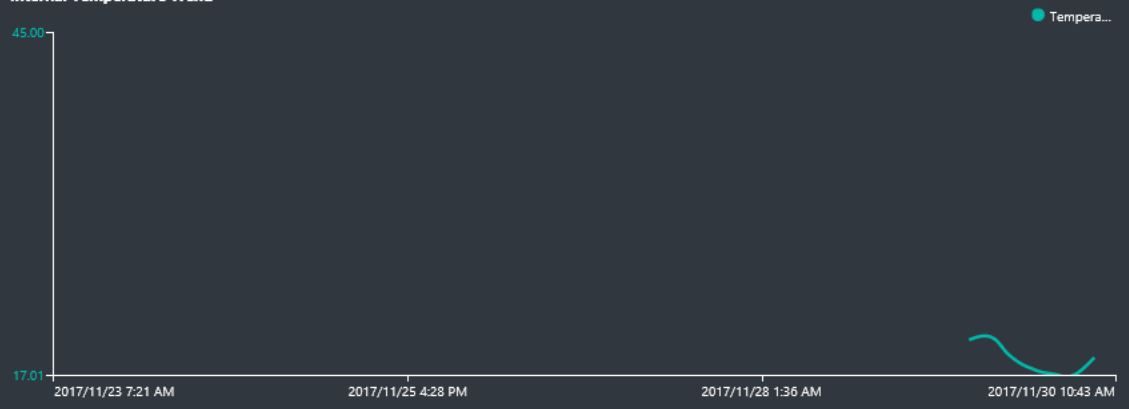
Internal Temperature



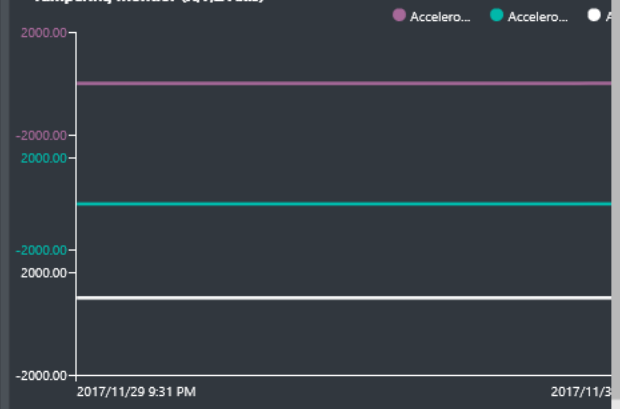
Machie Orientation (X,Y,Z Axis)



Internal Temperature Trend



Tampering Montior (X,Y,Z Axis)



Enviromental 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 Ax

Azure IoT Solution Accelerators

Azure IoT Solution Acce

https://www.azureiotsolutions.com/Accelerators

Microsoft Azure IoT Solution Accelerators

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

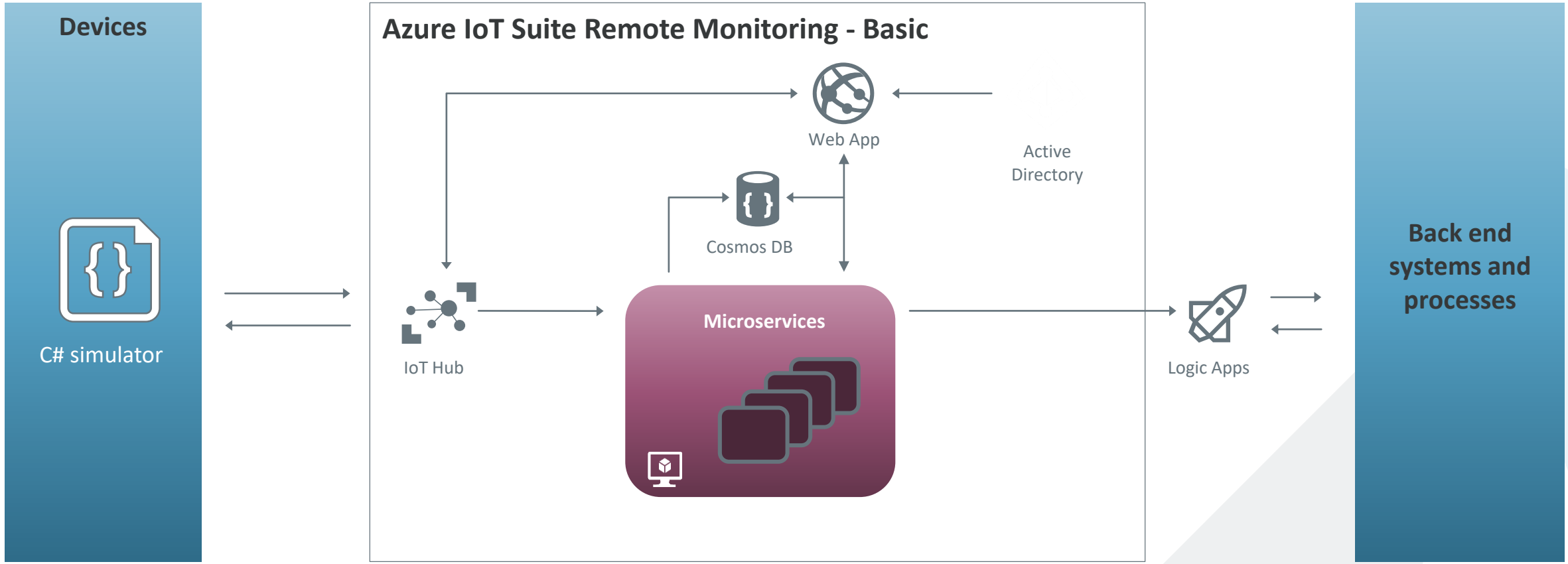
Device Simulation

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



IoT Device Portal - Dashb

https://[redacted].azurewebsites.net/Dashboard/Index

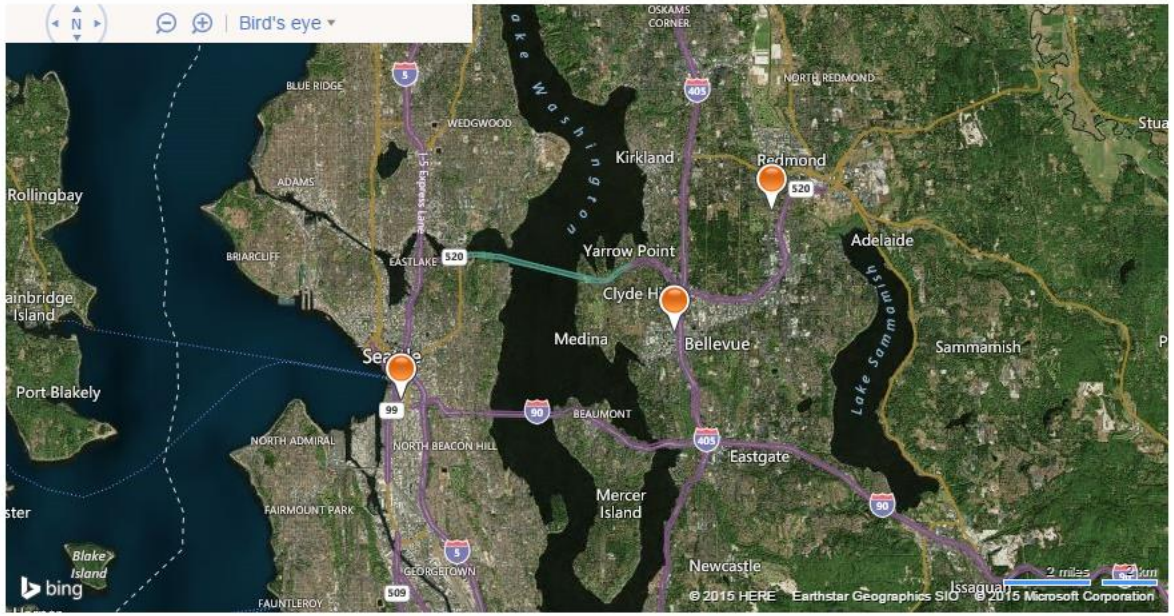
Apps | EA | TASC | Reference | Planning | Stocks | Development | Media | Reddit | Tech | News | Weather | Other Sports | Golf | Hockey | Baseball | Pools | Google | Bookmarks

Microsoft Azure IoT Suite

[redacted]

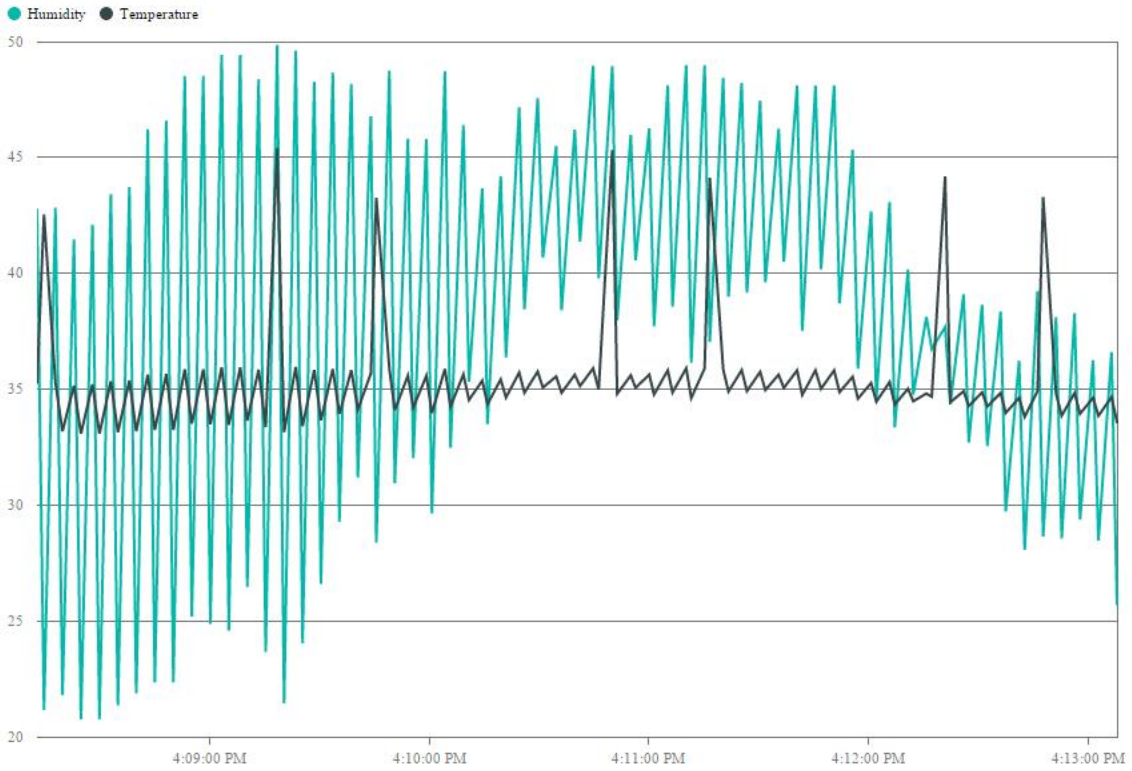
ADMINISTRATOR Sign Out

DASHBOARD
DEVICES
RULES
ACTIONS
ADD A DEVICE



Device to View: SampleDevice001_249

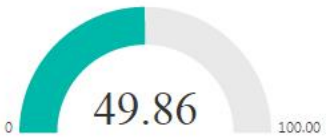
Telemetry History



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

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

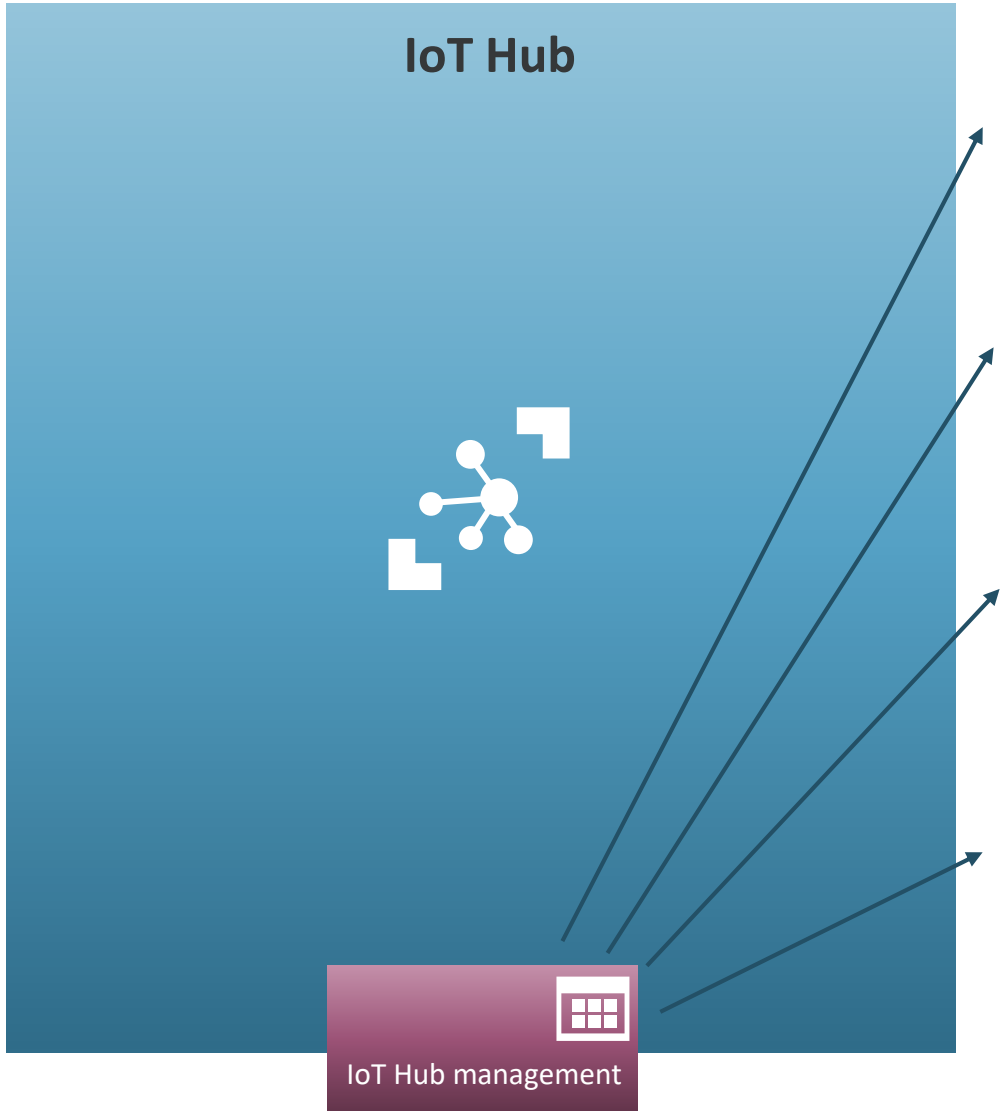
STANDARD TIER	PRICE PER UNIT (PER MONTH)	TOTAL NUMBER OF MESSAGES/DAY PER UNIT	MESSAGE METER SIZE	MAX # OF UNITS
FREE	FREE	8,000	0.5 KB	1
S1	$25	400,000	4 KB	200
S2	$250	6,000,000	4 KB	200
S3	$2,500	300,000,000	4 KB	10

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/

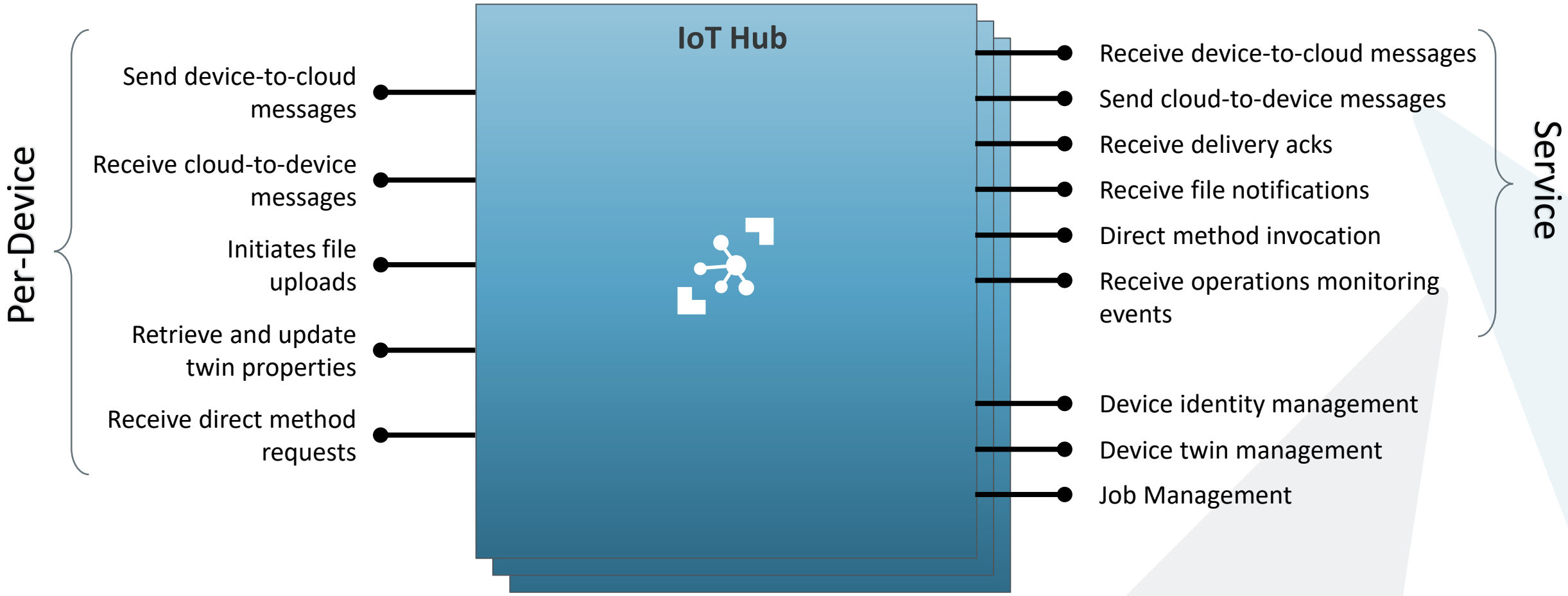
Azure CLI

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

Powershell

https://docs.microsoft.com/en-us/powershell/azureps-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 SKD 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

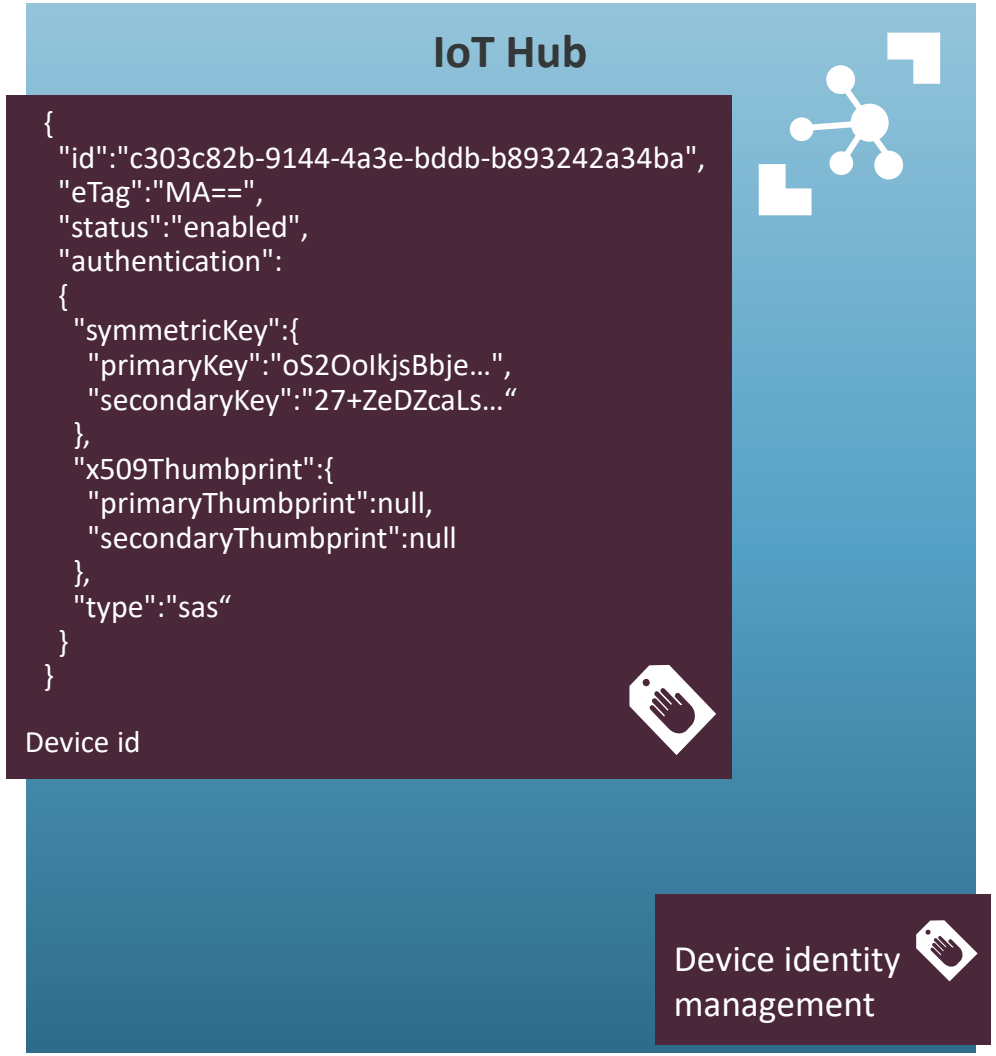
- IoT Hub supports three protocols:
  - HTTP – Use for devices that cannot support other protocols or that are rarely connected
  - AMQP – Use on field and cloud gateways to take advantage of connection multiplexing across devices
  - MQTT – Extremely lightweight, Use on all devices that do not require 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

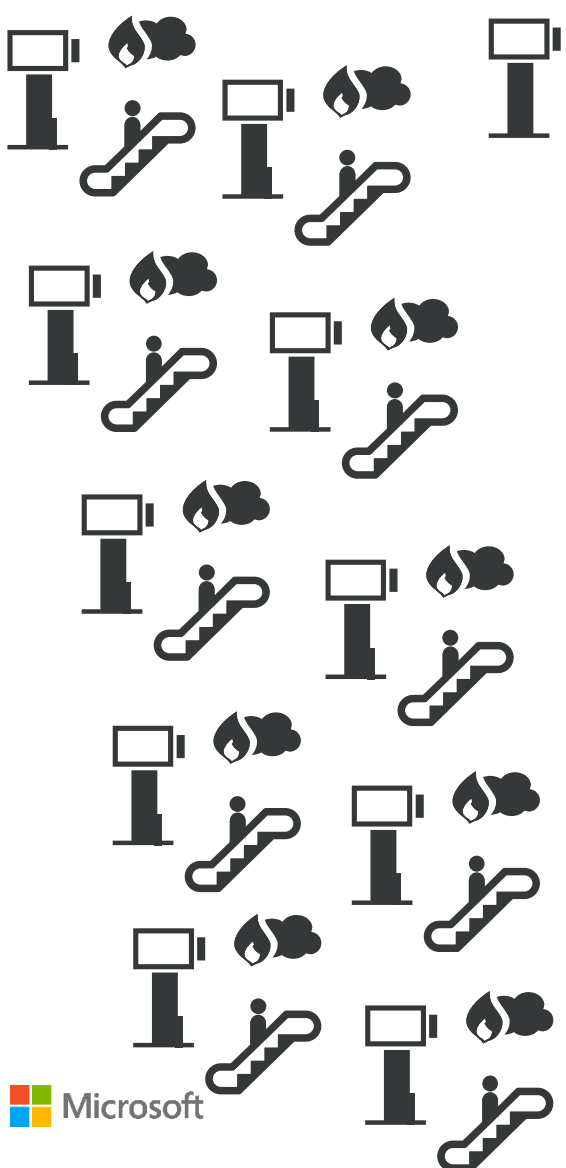
- Unique id for each device
- Unique credentials for authentication
  - Private Key/SAS Token
  - X.509 Certificates
- Device Twin

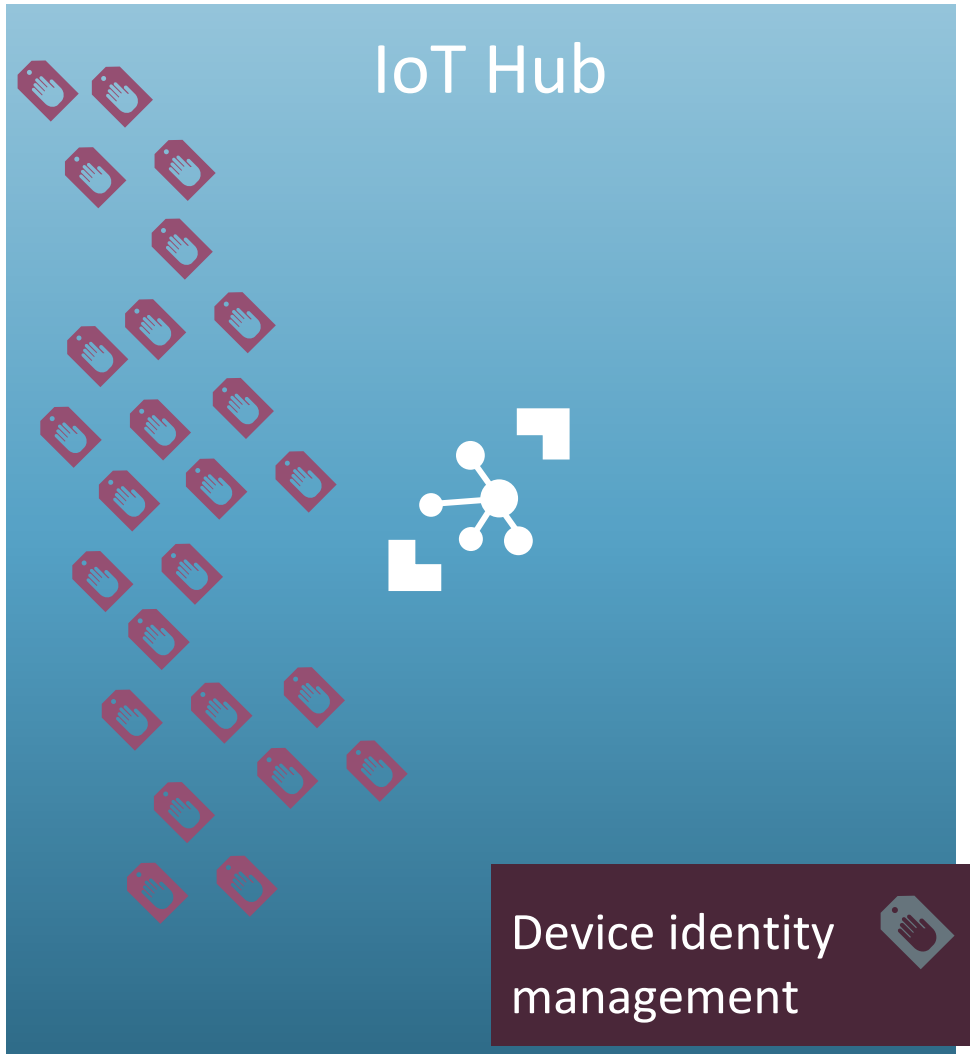


- Azure Portal
- Development tools
  - Azure CLI
  - VSCode extension
- Using a client SDK
  - .Net
  - Node
  - Java
  - Python

Device provisioning and authorization

Provisioning at scale





?!!

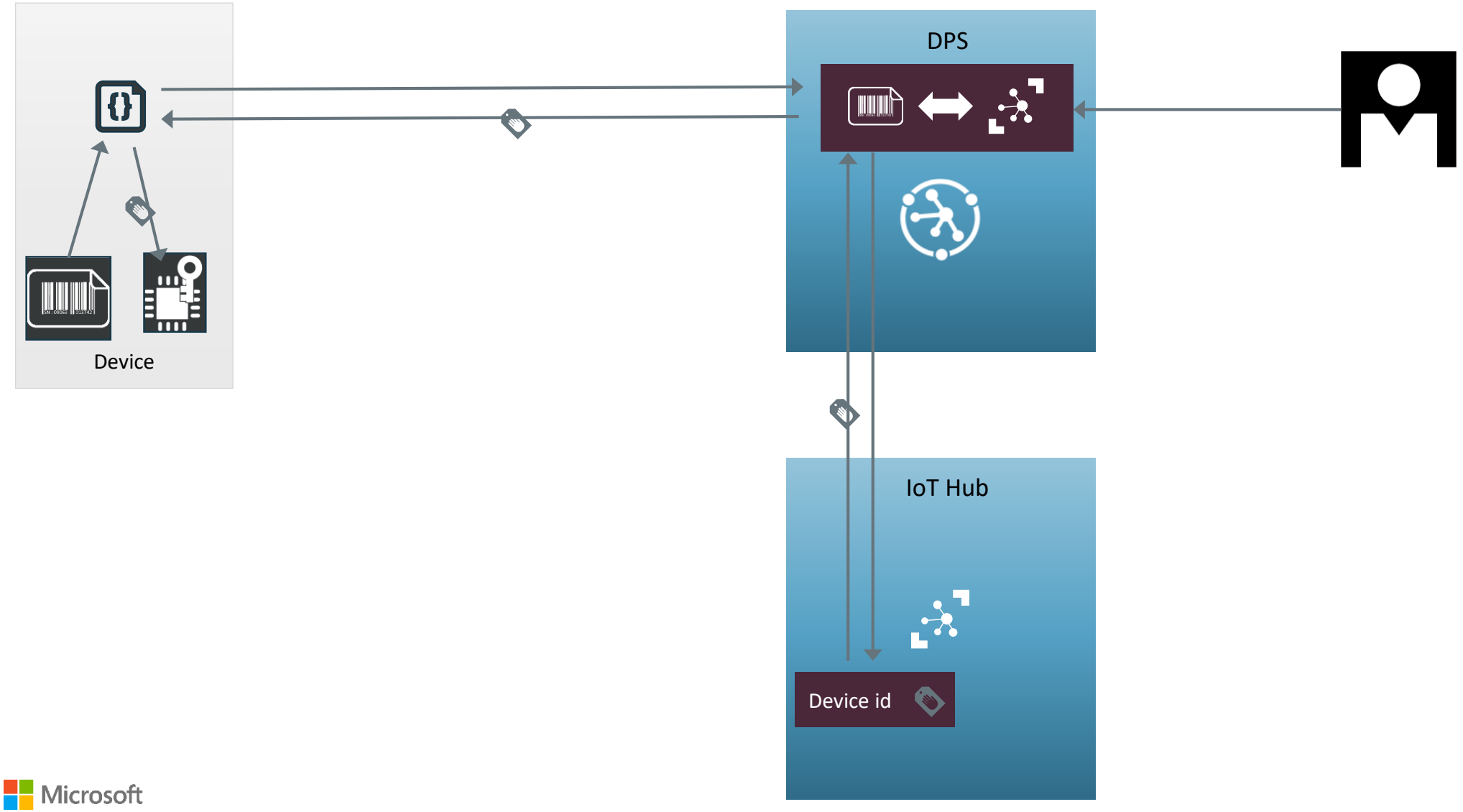
Device identity management

Device provisioning and authorization

Microsoft

@AlexPshul

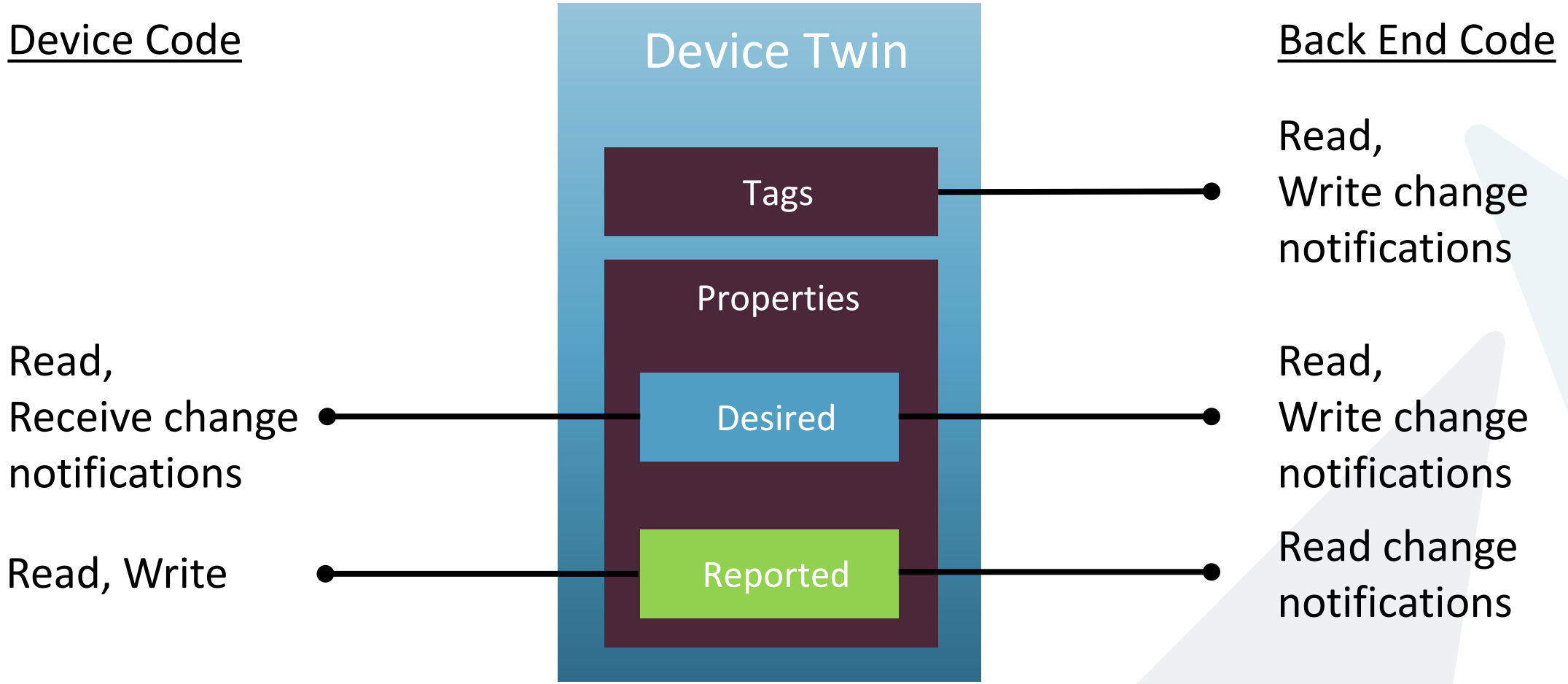
Device Provisioning Service



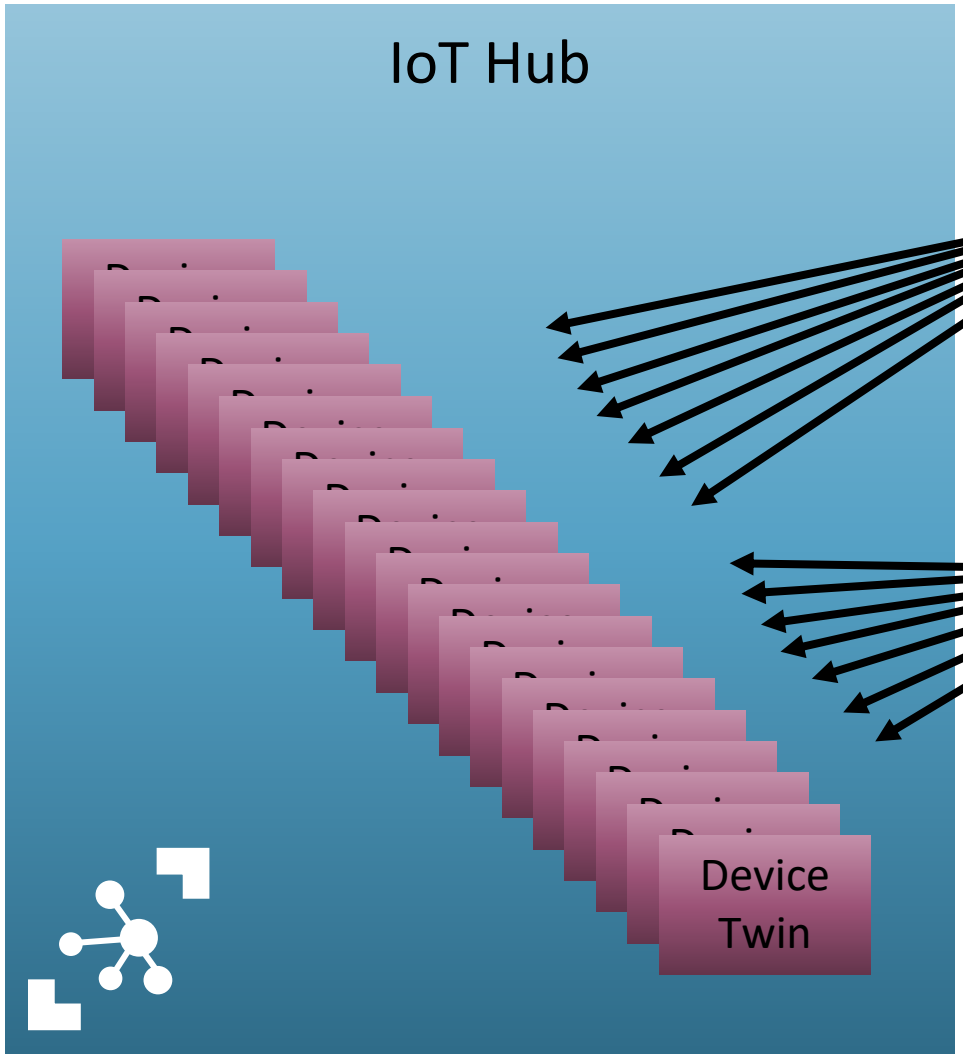
Device Twins

- 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
Device Twin
Back End Code
Tags
Properties
Desired
Reported
Read,
Write change
notifications
Read,
Receive change
notifications
Read,
Write change
notifications
Read, Write
Read change
notifications

Designed for IoT Scale



Jobs

Schedule and Broadcast Device Twin Changes

Set Desired Properties, Tags, Call Methods

Queries

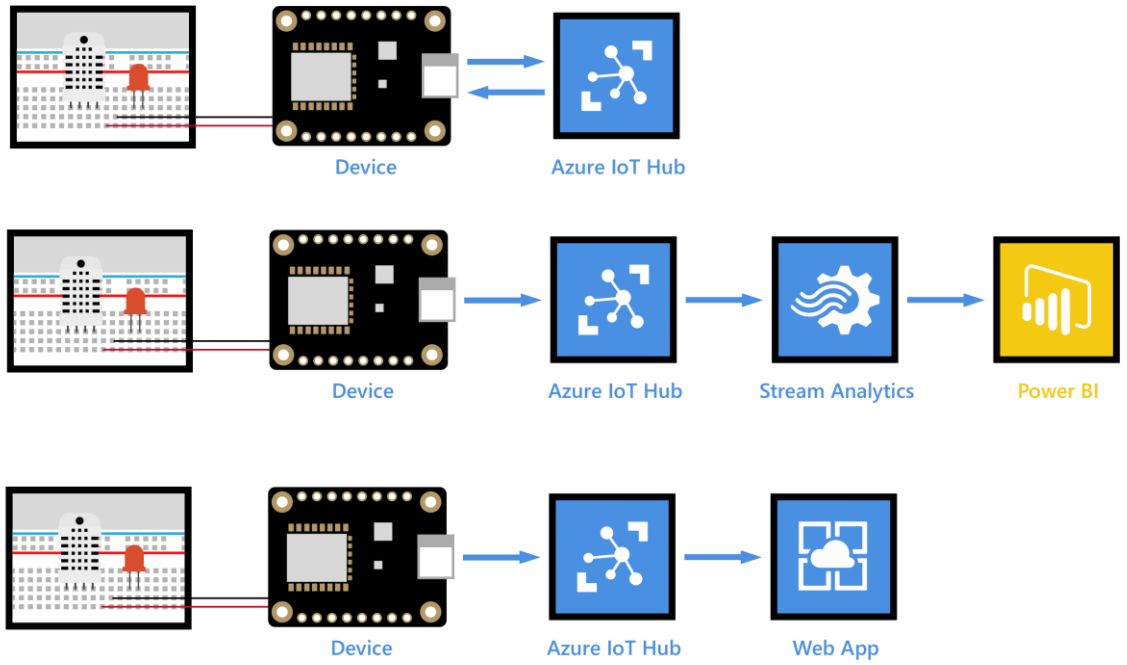
Query Across Device Twin State

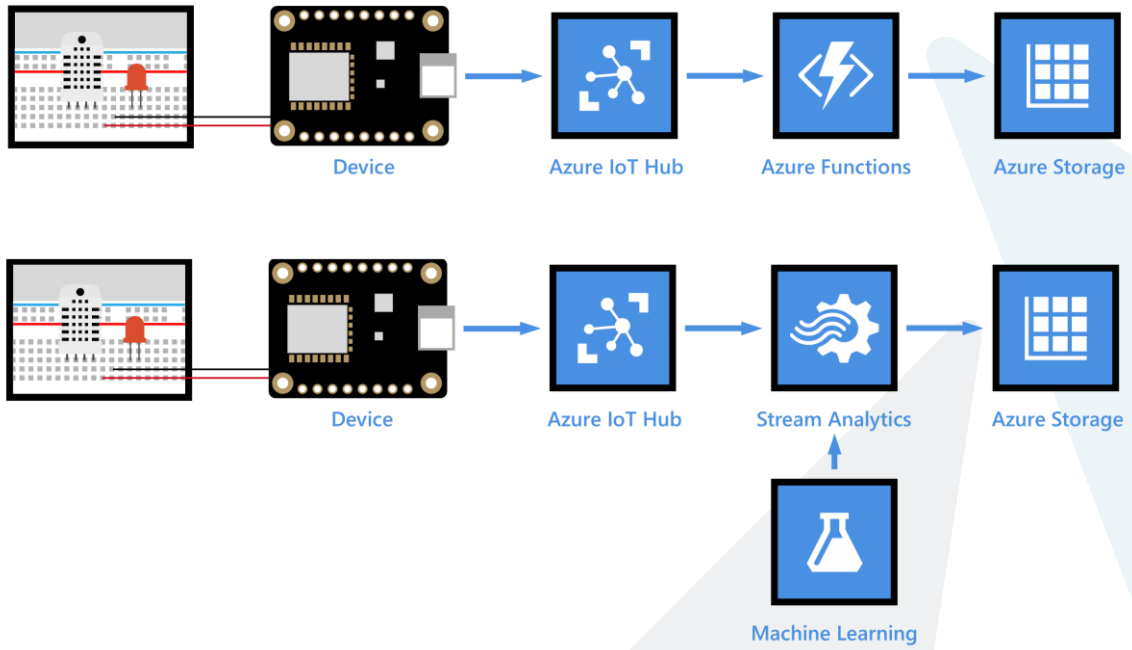
For Business Logic, Reporting and Compliance

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?



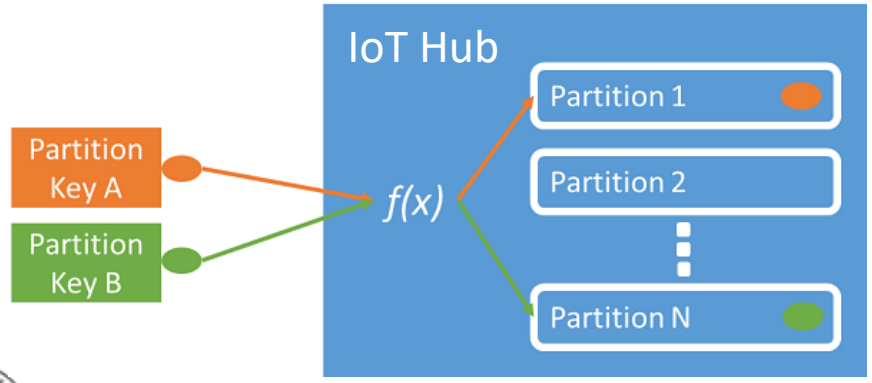


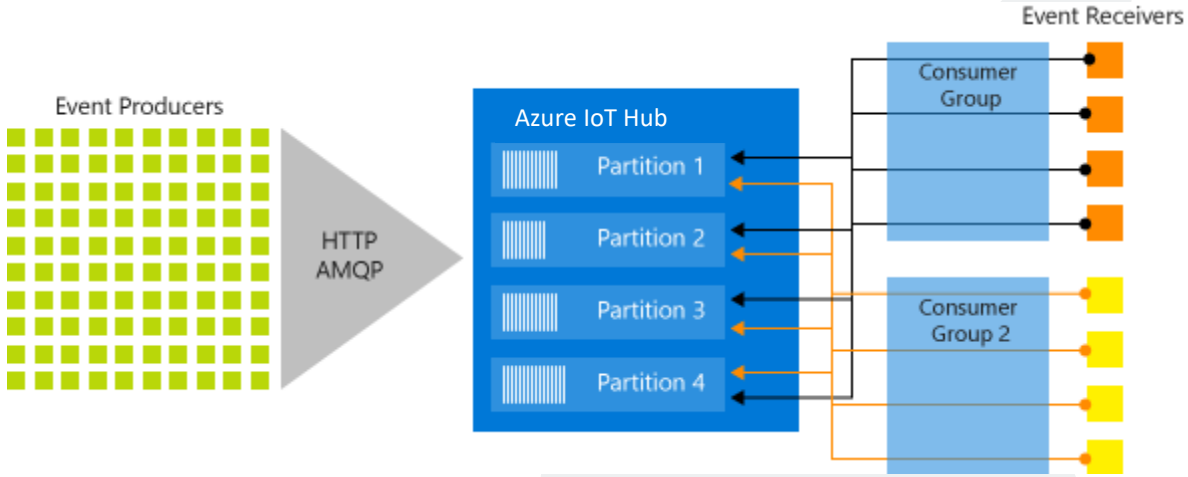
Learn more: https://aka.ms/azureiotgetstarted

@AlexPshul

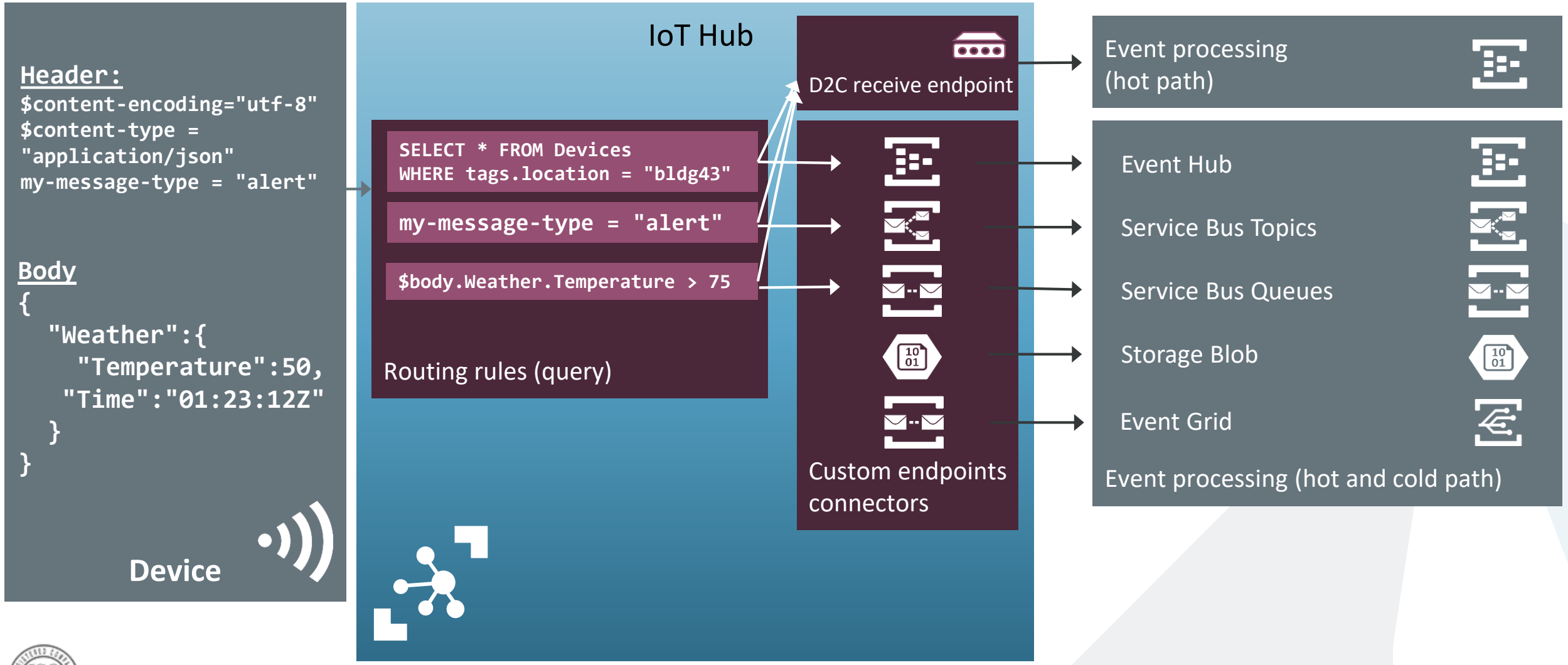
Processing IoT Hub Messages – Event Hub

- 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

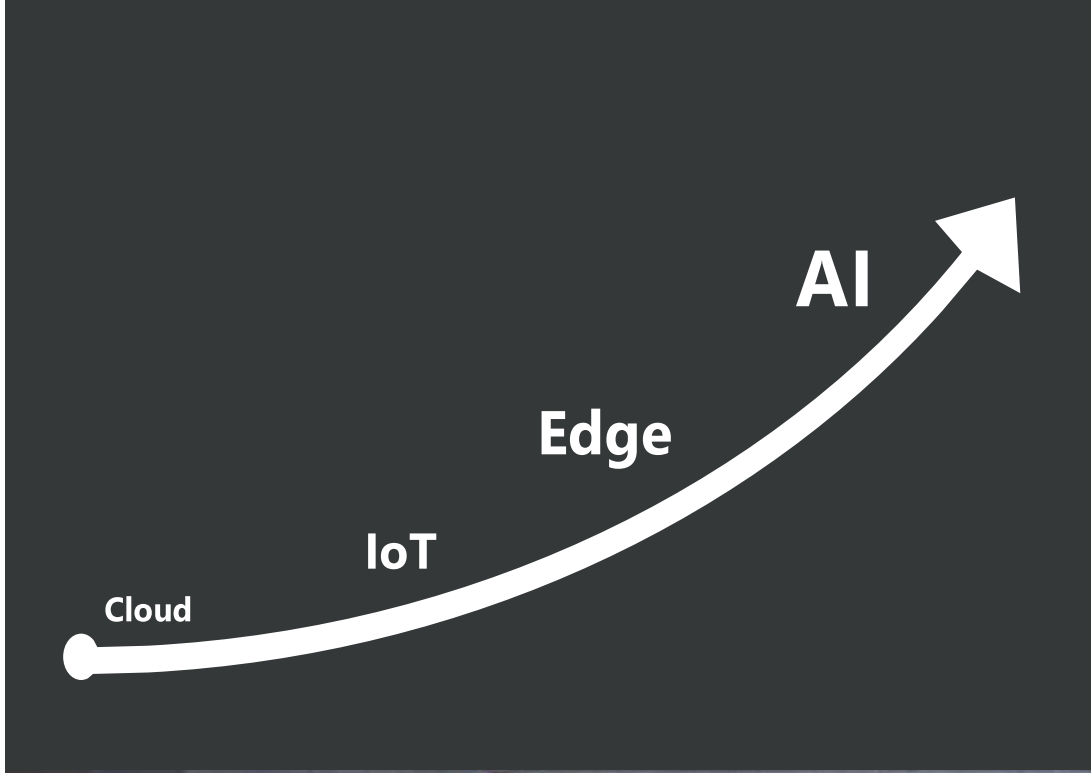
Harnessing signals from sensors and devices, managed centrally by the cloud

Edge

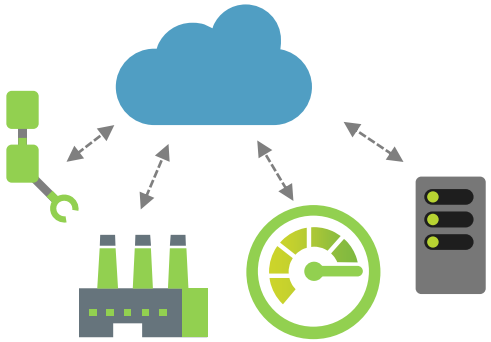
Intelligence offloaded from the cloud to IoT devices

AI

Breakthrough intelligence capabilities



Why the edge?

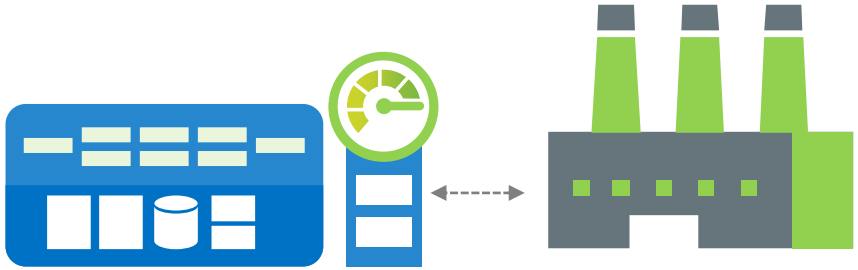


IoT in the Cloud

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



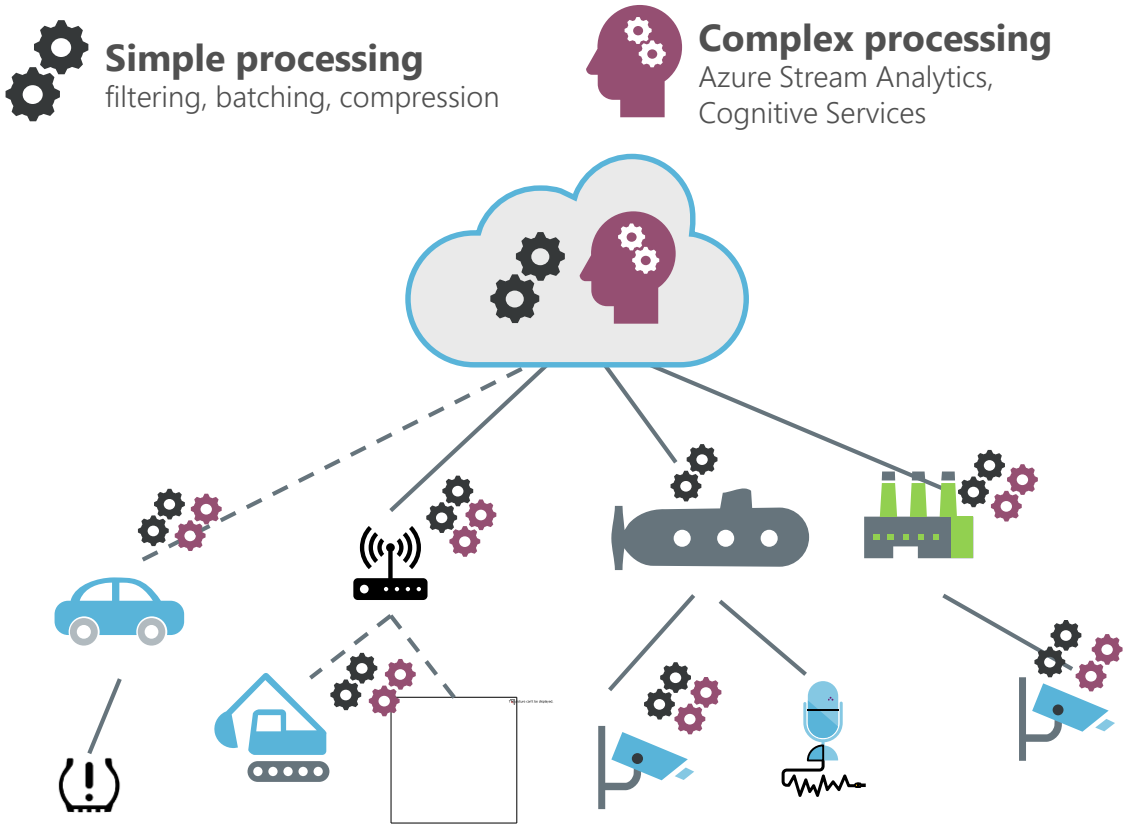
IoT on the Edge

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

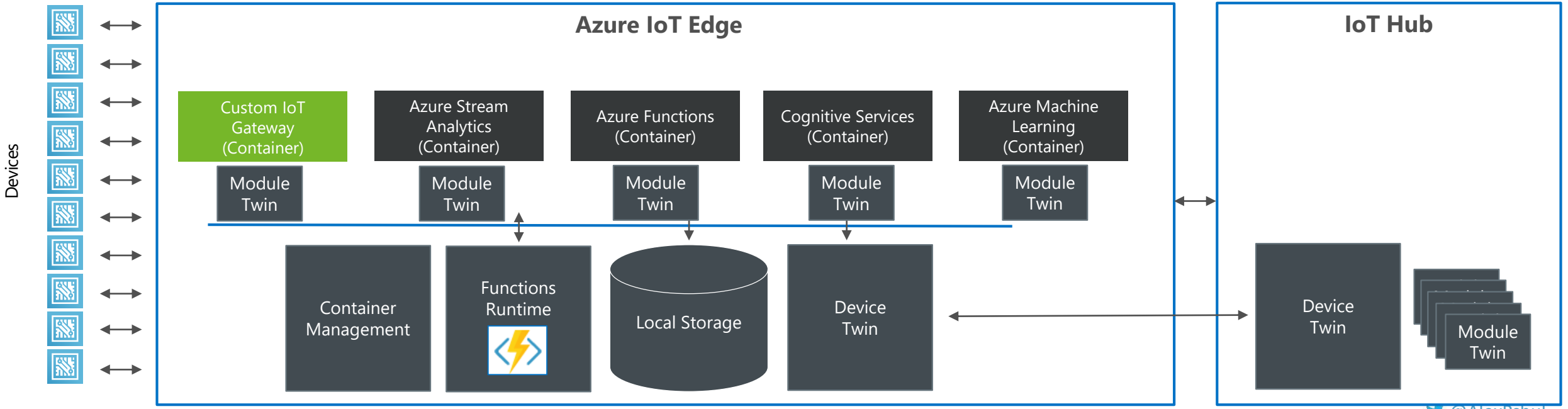
- Enable creating Docker Images that target multiple architecture

Extensible

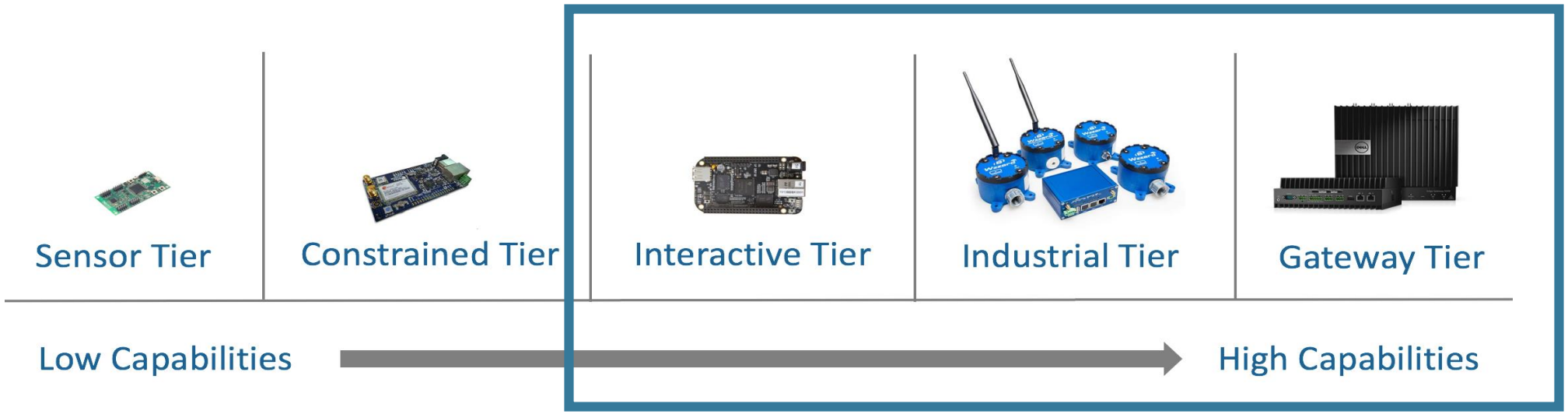
- Enable seamless deployment of advanced capabilities modules such as **AI**, **Azure Function**, **Stream Analytics** and **3rd party**

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

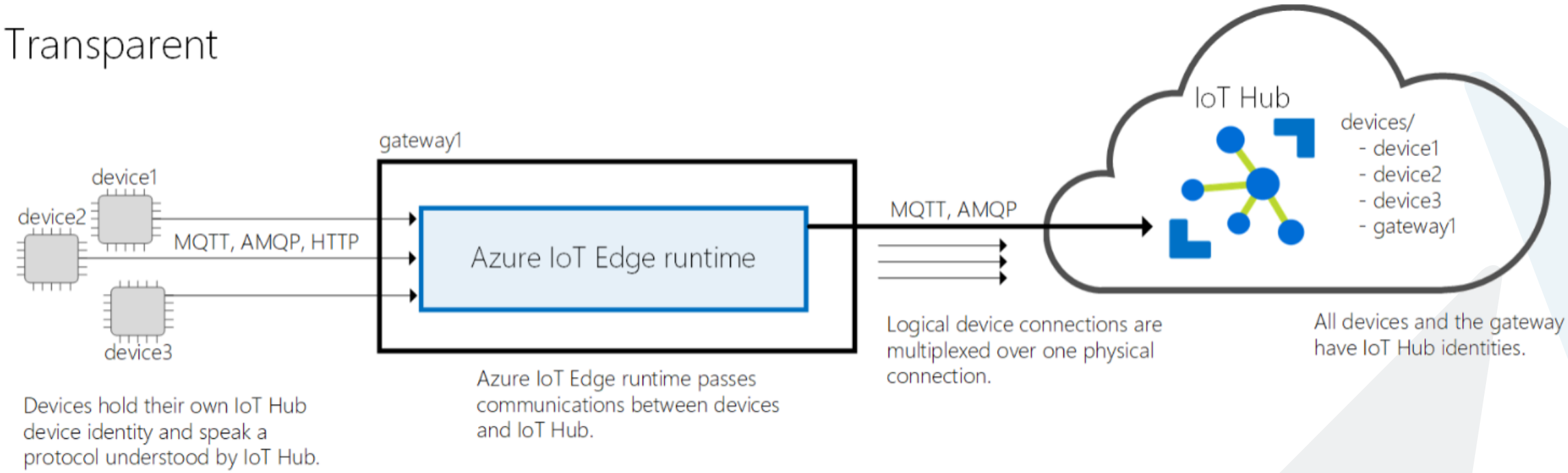


Ability to run on devices smaller than a Raspberry Pi

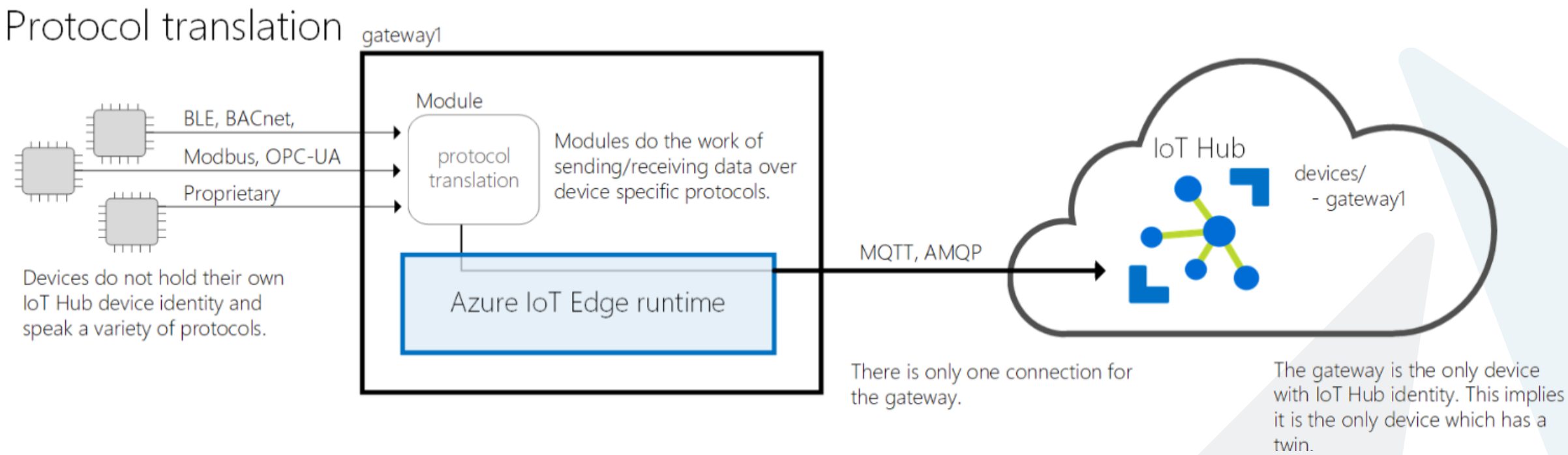
128MB memory

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

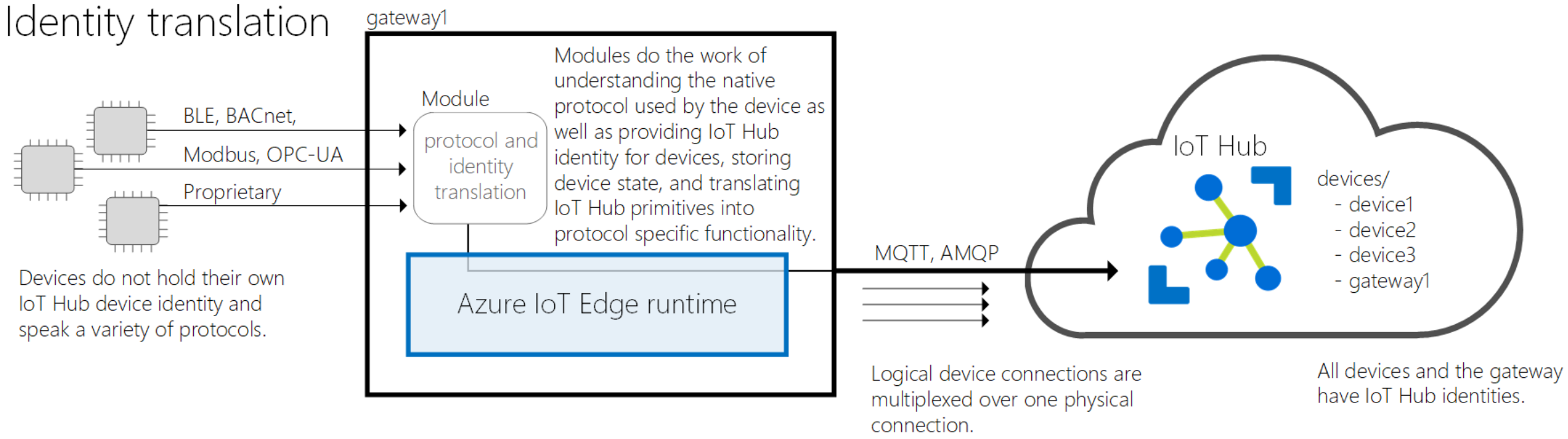
IoT Edge as a Gateway - Transparent



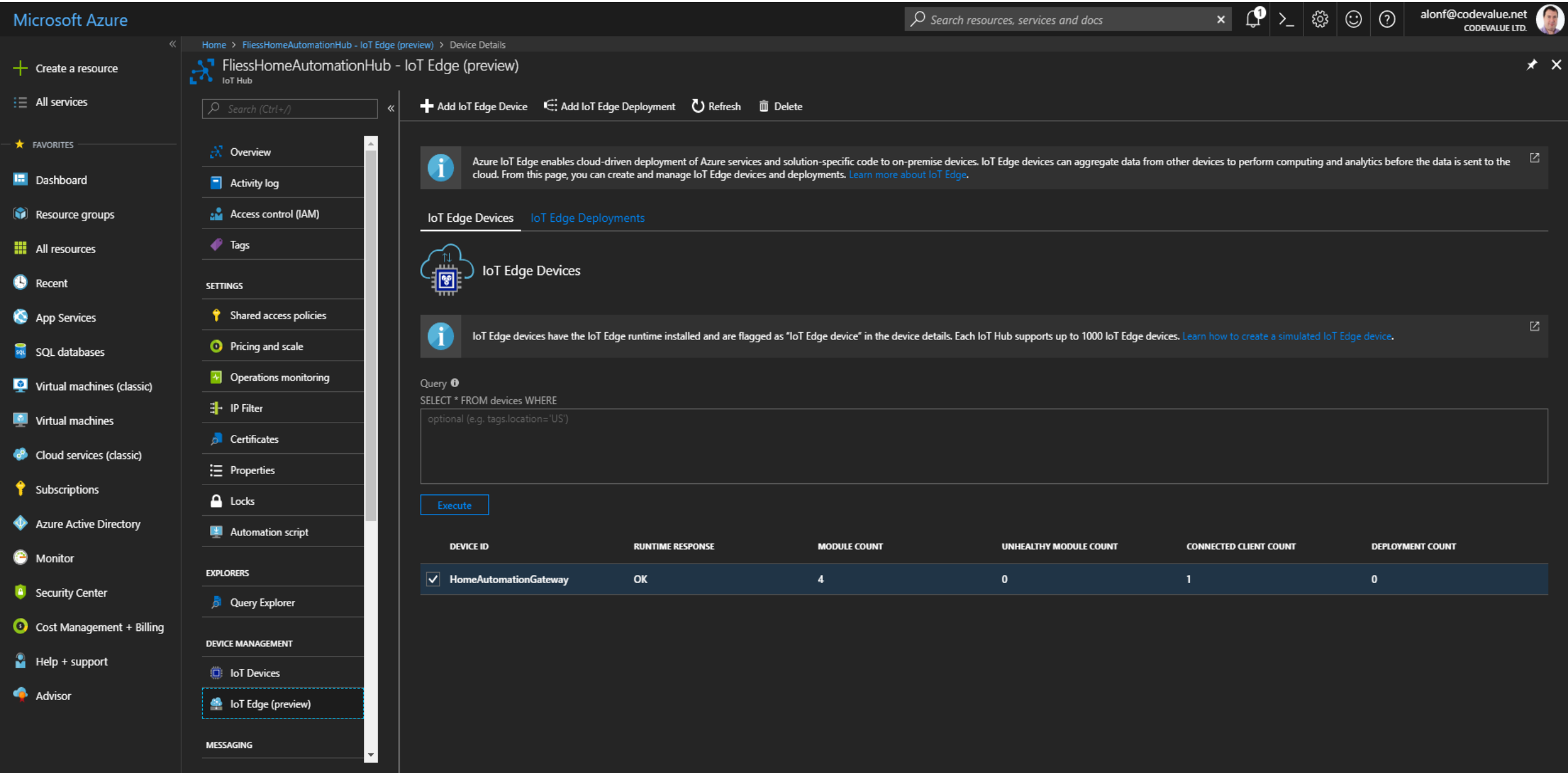
IoT Edge as a Gateway - Protocol Translation



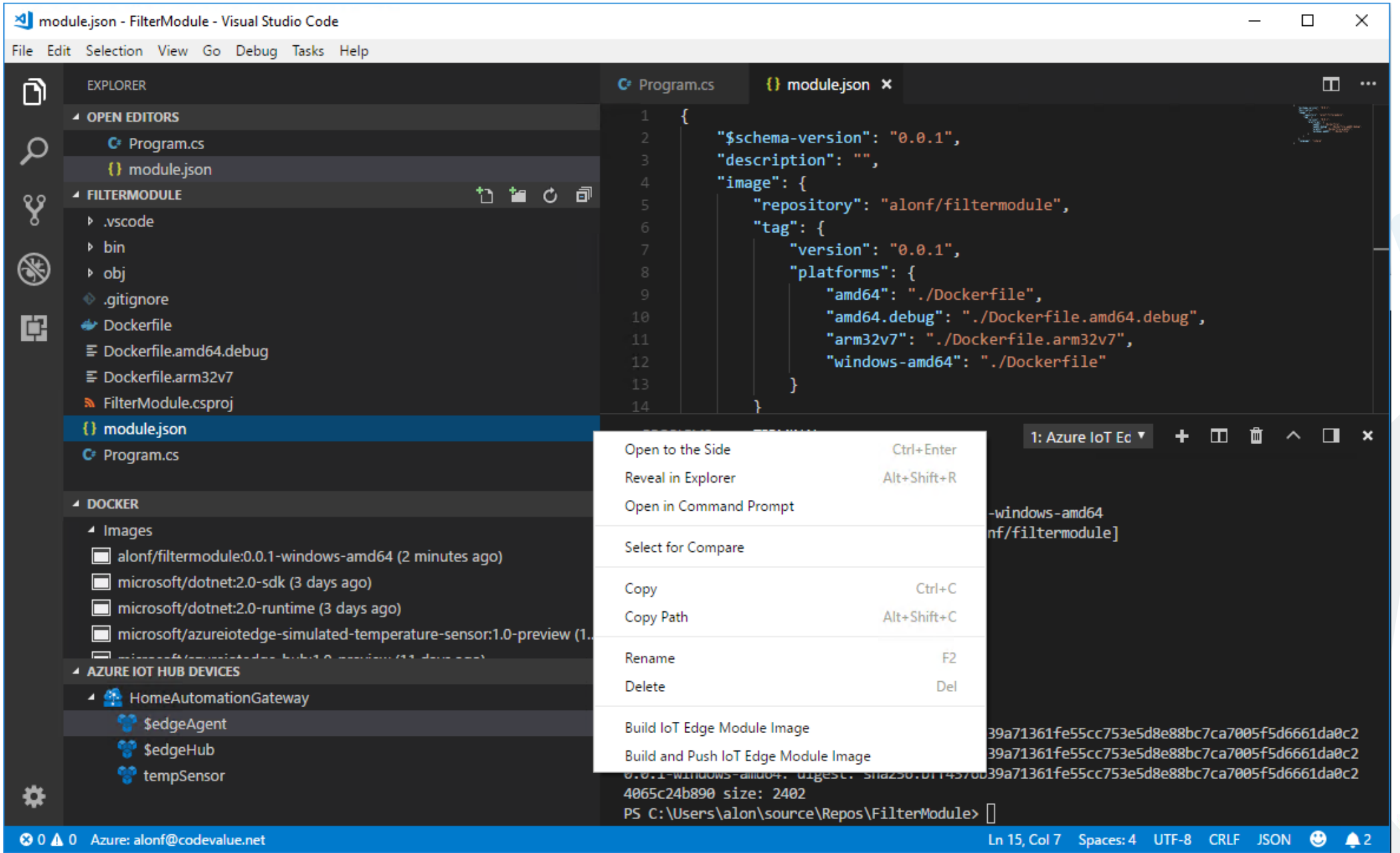
IoT Edge as a Gateway – Identity Translation



IoT Edge Portal Support

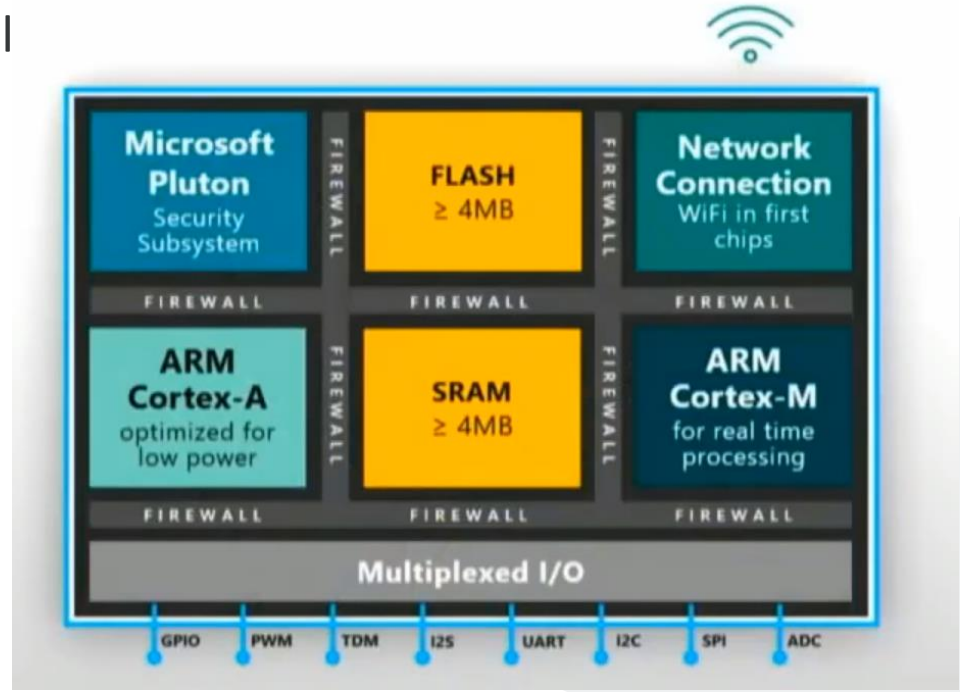


Visual Studio Code IoT Edge Extension



Azure Sphere Device

- Azure Sphere MCU
  - First SoC by MediaTek
  - ARM Cortex-A for low power
  - ARM Cortex-M for real time processing
  - Built-in Wi-Fi
  - Built-in firewall everywhere
    - Secure with built-in silicon technol
- Azure Sphere Linux based OS
  - An OS purpose built for security and agility
- Available Q3 of 2018



Azure IoT Summary

- IoT system architecture is a bit different then 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/