

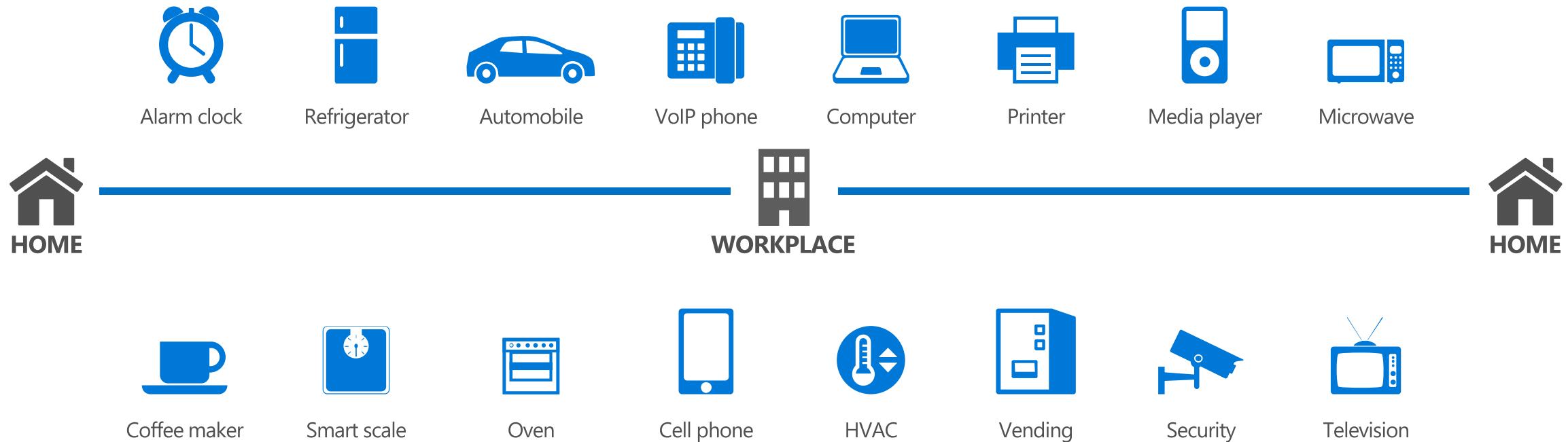
The background of the slide features a nighttime aerial photograph of a dense cluster of skyscrapers. The buildings are illuminated from within, creating a grid of light against the dark sky. The perspective is from above, looking down the length of the city's skyline.

Internet of Your Things with Microsoft Azure

Martin Abbott
Microsoft Azure MVP



IoT 2010



IoT 2016



Medication adherence



Health monitoring



Pet tracking



Behavior modification



Child and elder monitoring



Sports and fitness



Smart lighting



Object tracking



Trip tracking and car health



Indoor navigation



Beacons and proximity



HOME



Smart appliances



Food and nutrition tracking



WORKPLACE



Office equipment



Smart vending machines



HOME



Bike ride stats and protection



Control



Sleep tracking



Air conditioning and temperature control



Identity



Environmental sensors



Information capture



Home security



Home automation



Leak detection



Garden, lawn and plant care



New devices and sensors



Entertainment systems

COMMUTE

COMMUTE

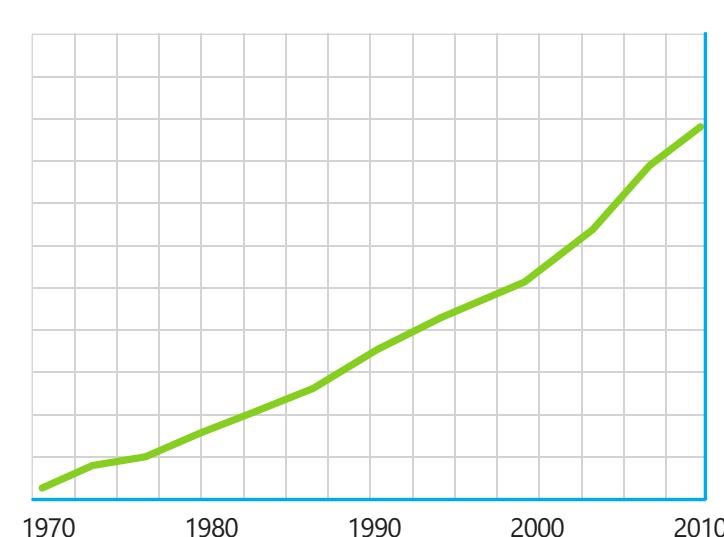
\$7.2 TRILLION

worldwide market for IoT solutions
by 2020

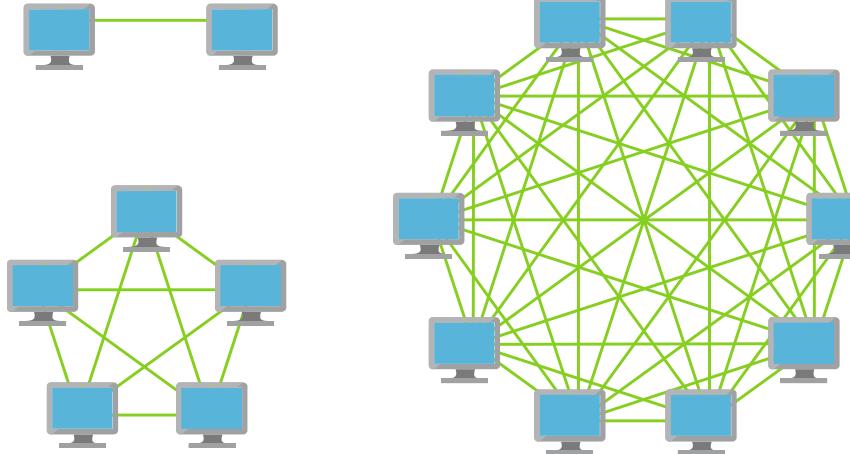
IDC: Worldwide and Regional Internet of Things (IoT) 2014–2020 Forecast

Disruptive Forces

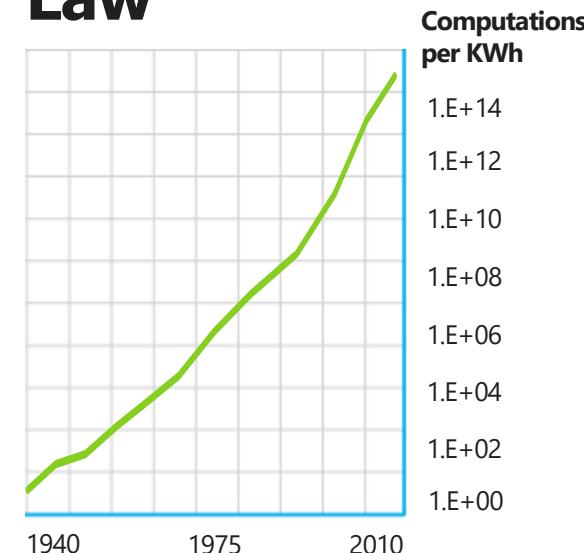
Moore's Law



Metcalf's Law



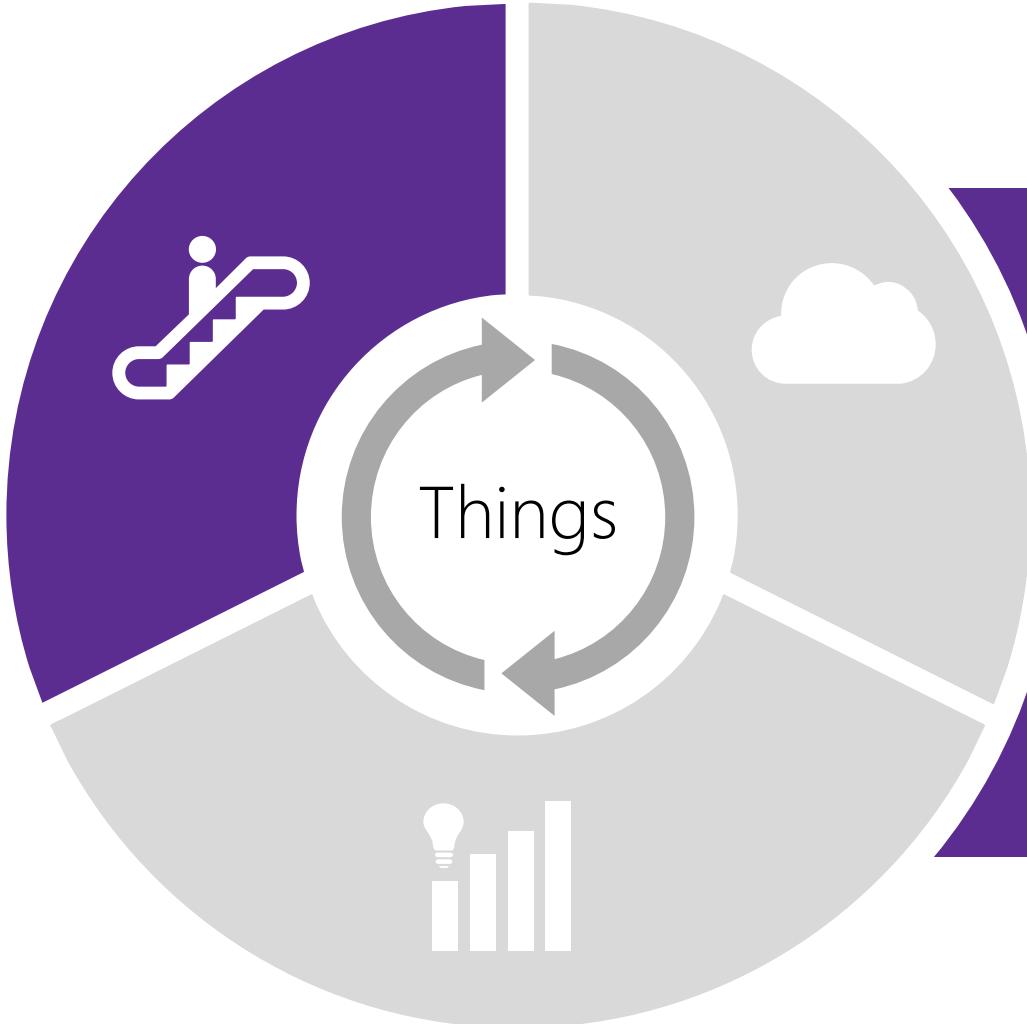
Koomey's Law



And more importantly:
what can you do by combining and analyzing signals from all of these IoT devices?

IoT Business Maturity Model

1. Operational efficiency



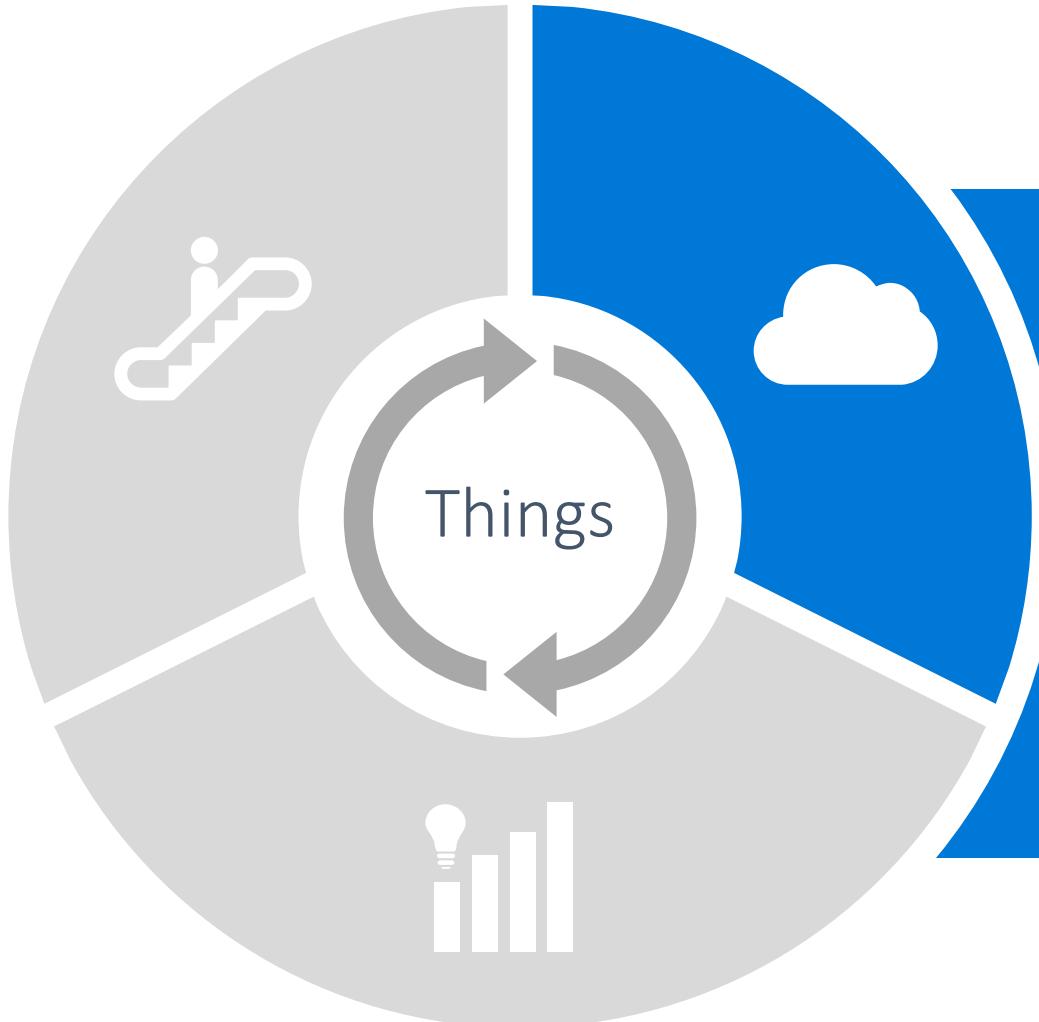
Connect devices and monitor telemetry

Monitor and track device state, location and health

Rules and alerting to improve operational efficiency

IoT Business Maturity Model

2. Business Intelligence



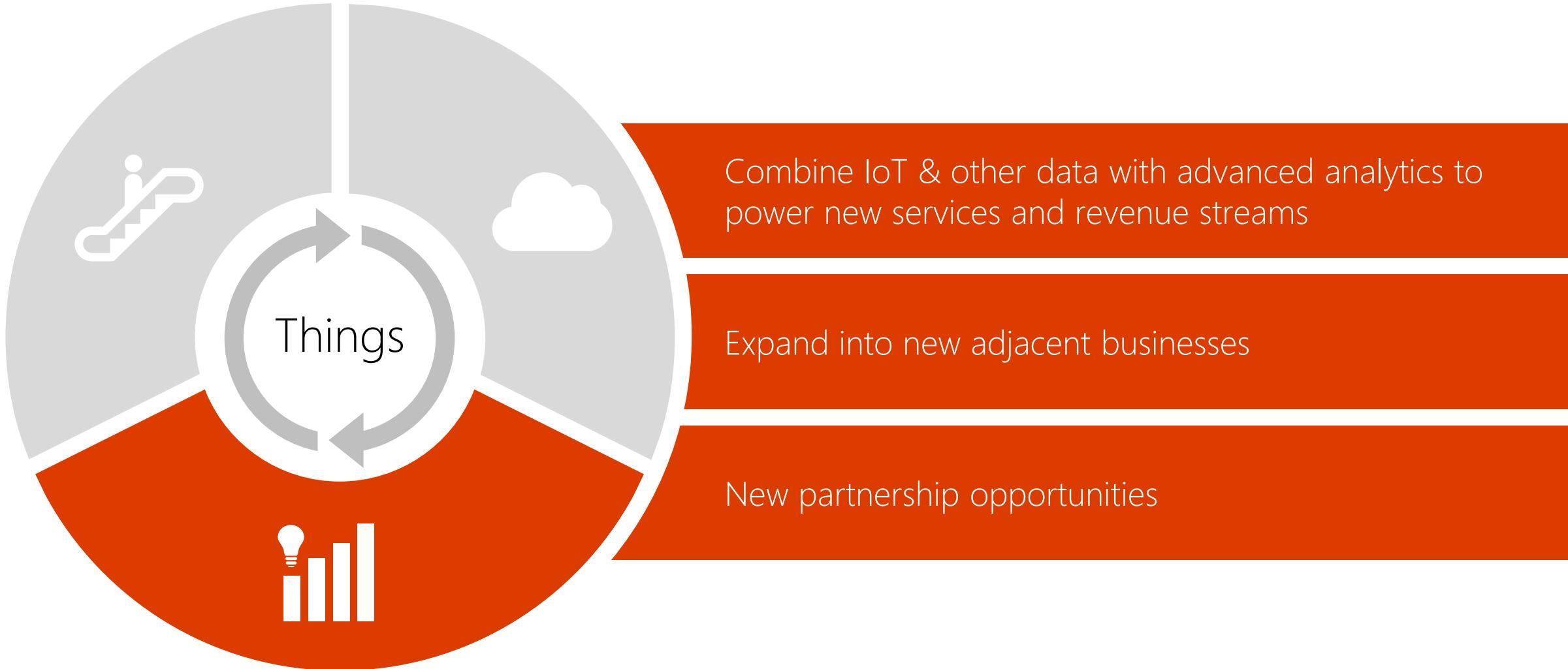
Analyze and visualize data from devices

Discover patterns in device data using predictive analytics

Operationalize insights to improve things and processes in real time

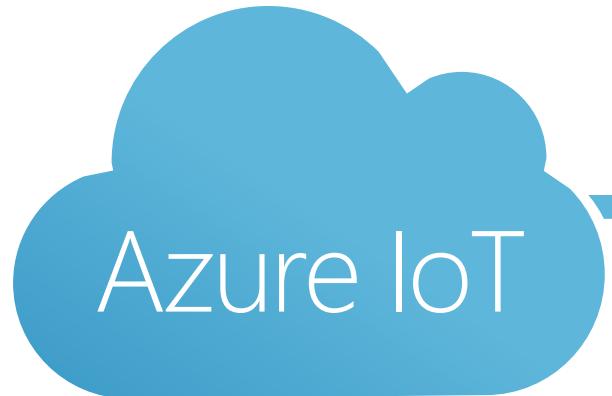
IoT Business Maturity Model

3. Business Transformation



IoT Device and Cloud Patterns

Cloud Based IoT Solutions



Easy to provision, use and manage

Pay as you go, scale as you need

Global reach, hyper scale

End to end security & privacy

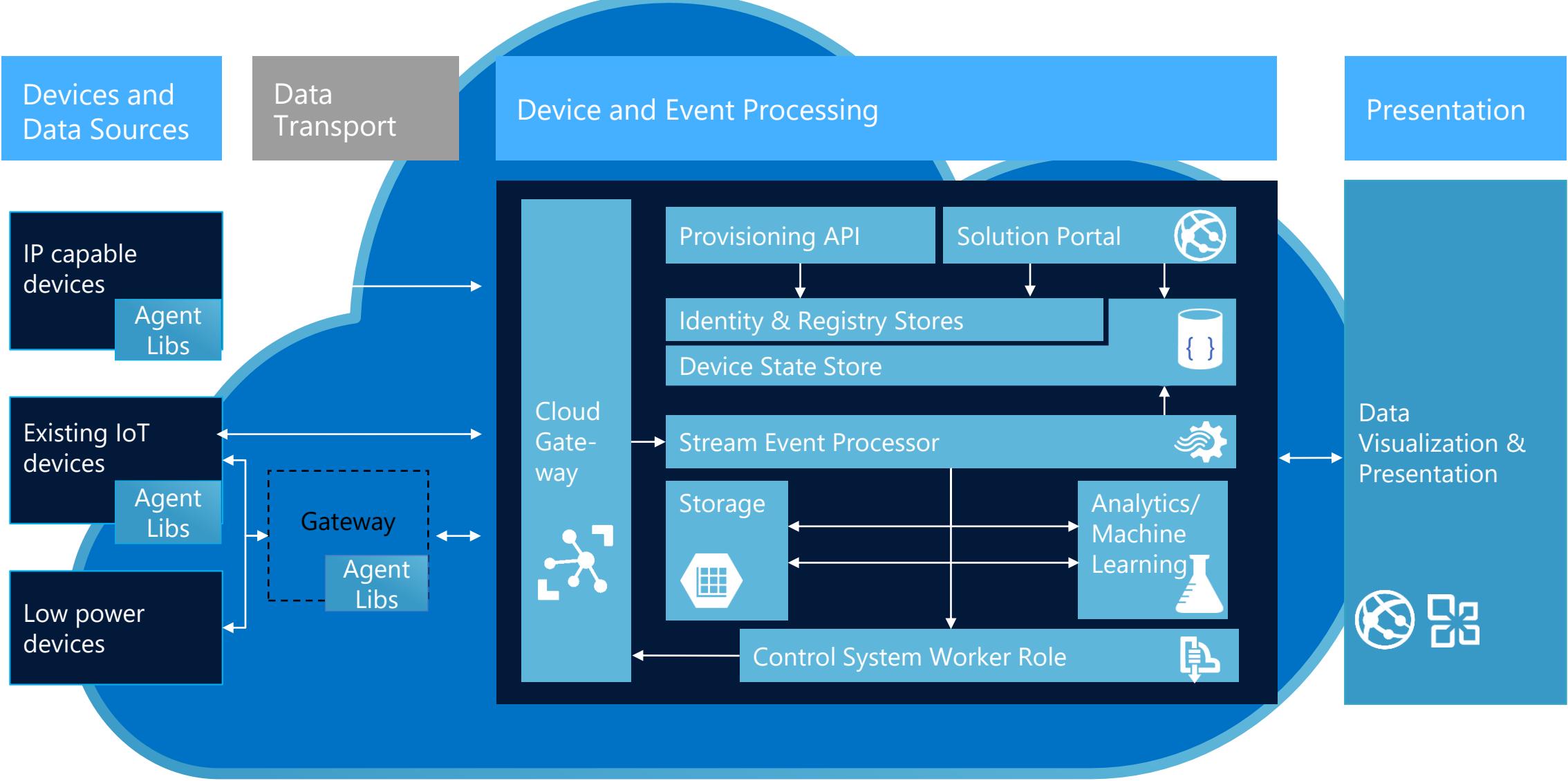
Three parts of an IoT solution

1 Device connectivity & management

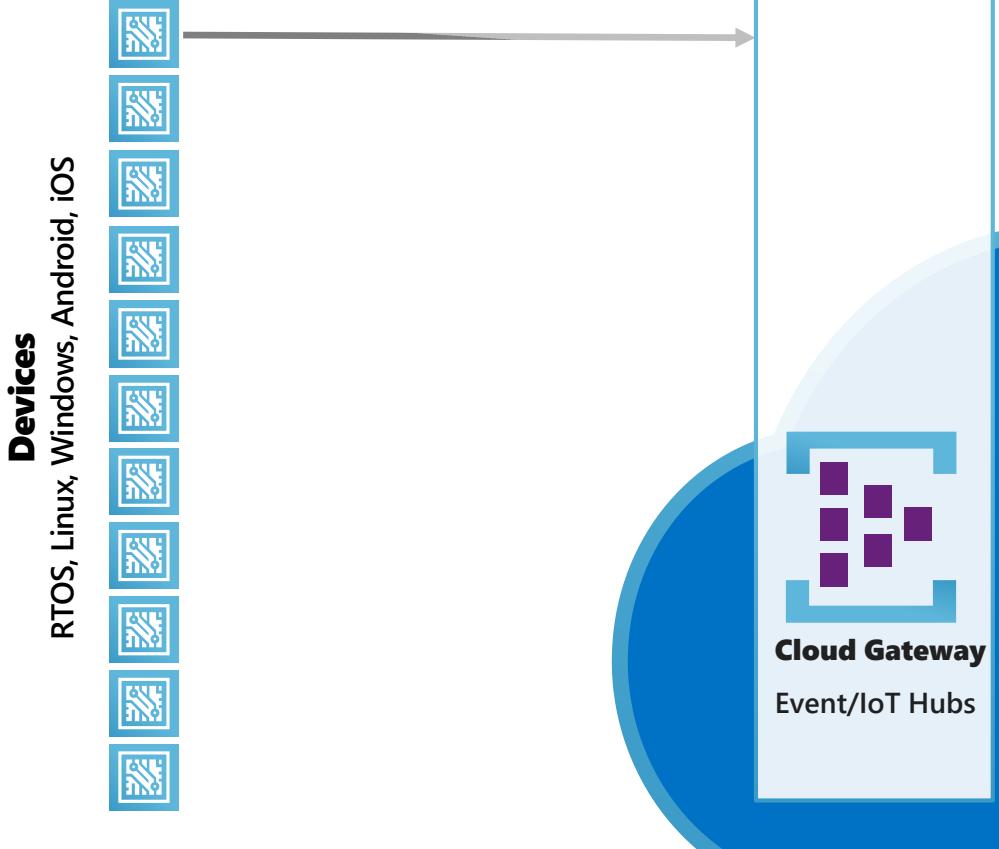
2 Analytics & operationalized insights

3 Presentation & business connectivity

Azure IoT Reference Architecture



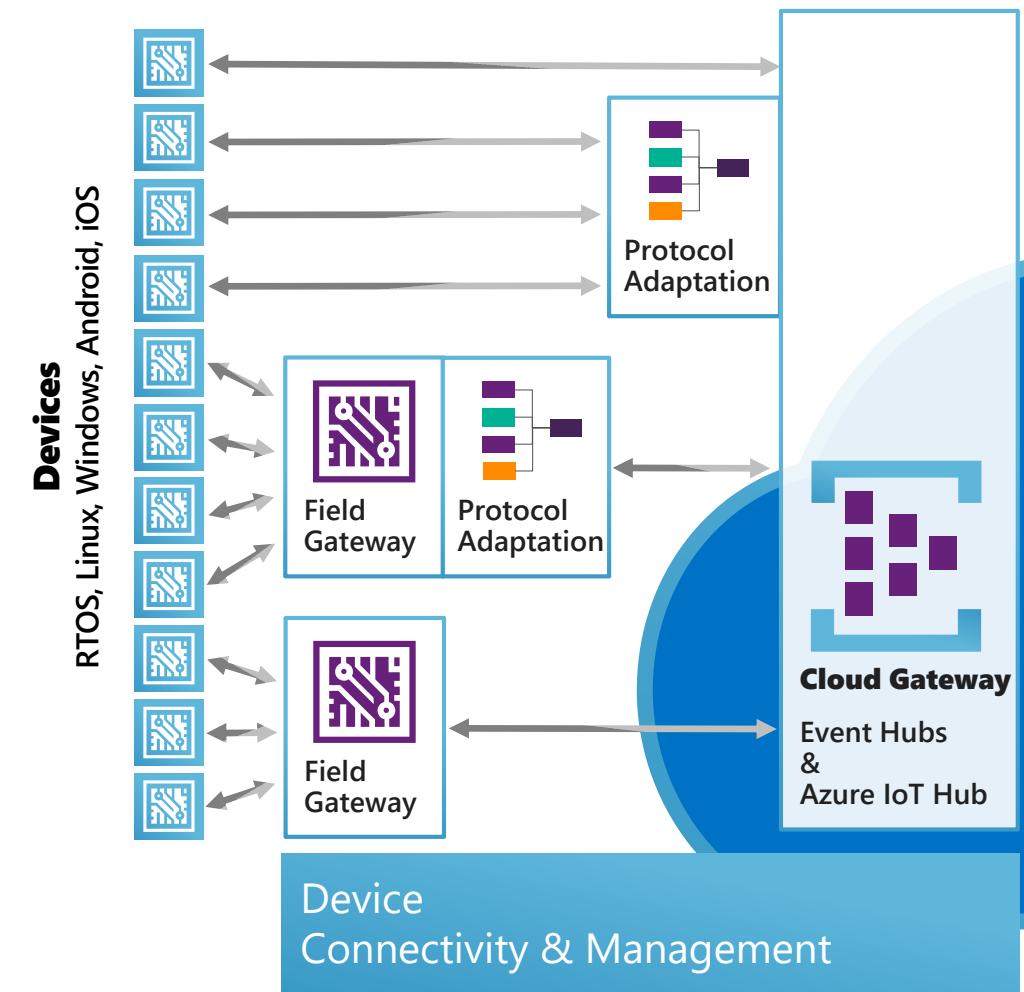
IoT Device & Cloud Patterns



Event Hubs

- High scale telemetry ingestion service
- HTTP/AMQP protocol support
- Each Event Hub supports
 - 1 million publishers
 - 1GB/s ingress
- Generally available worldwide
 - Tens of Billions of messages per day
 - Tens of TB ingested per day
 - And rising...

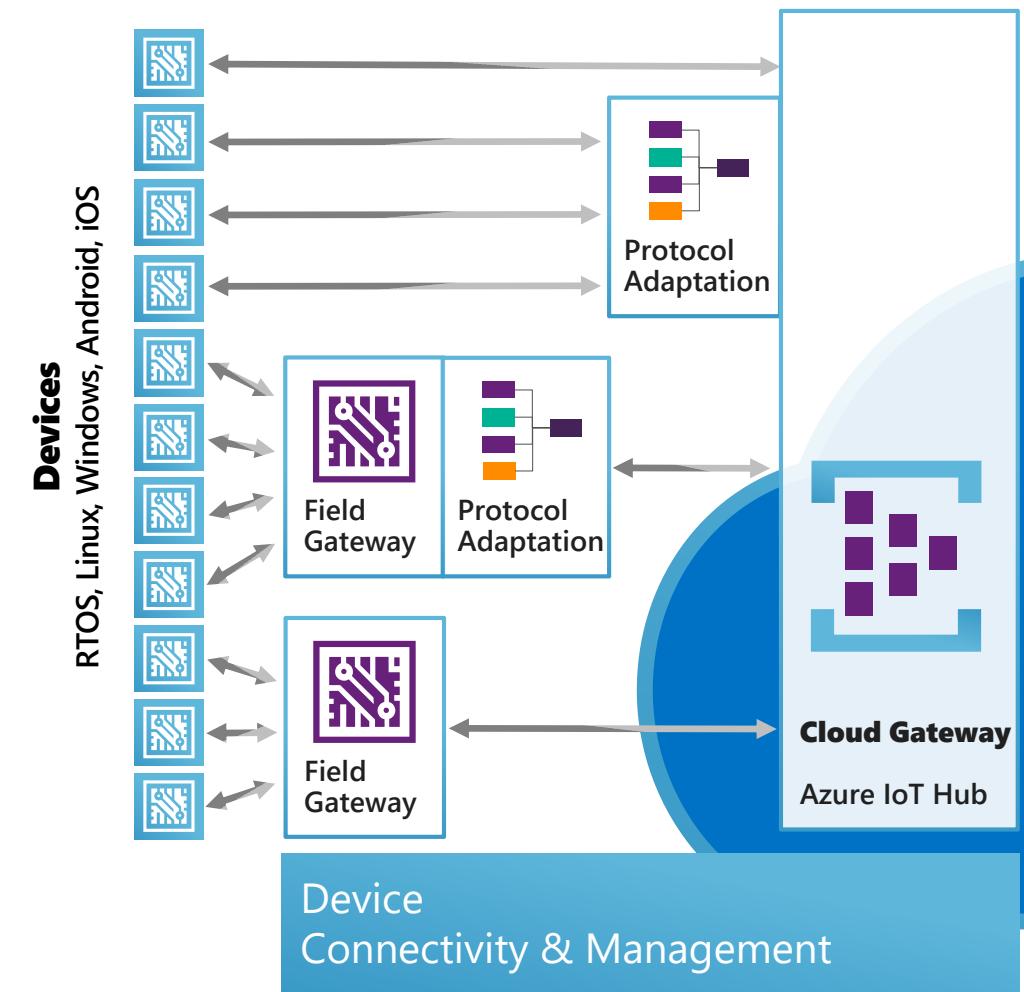
IoT Device & Cloud Patterns



Additional IoT Needs

- Command & control
- Device identity
- Device registry
- Device and State management
- Protocol translation and gateways

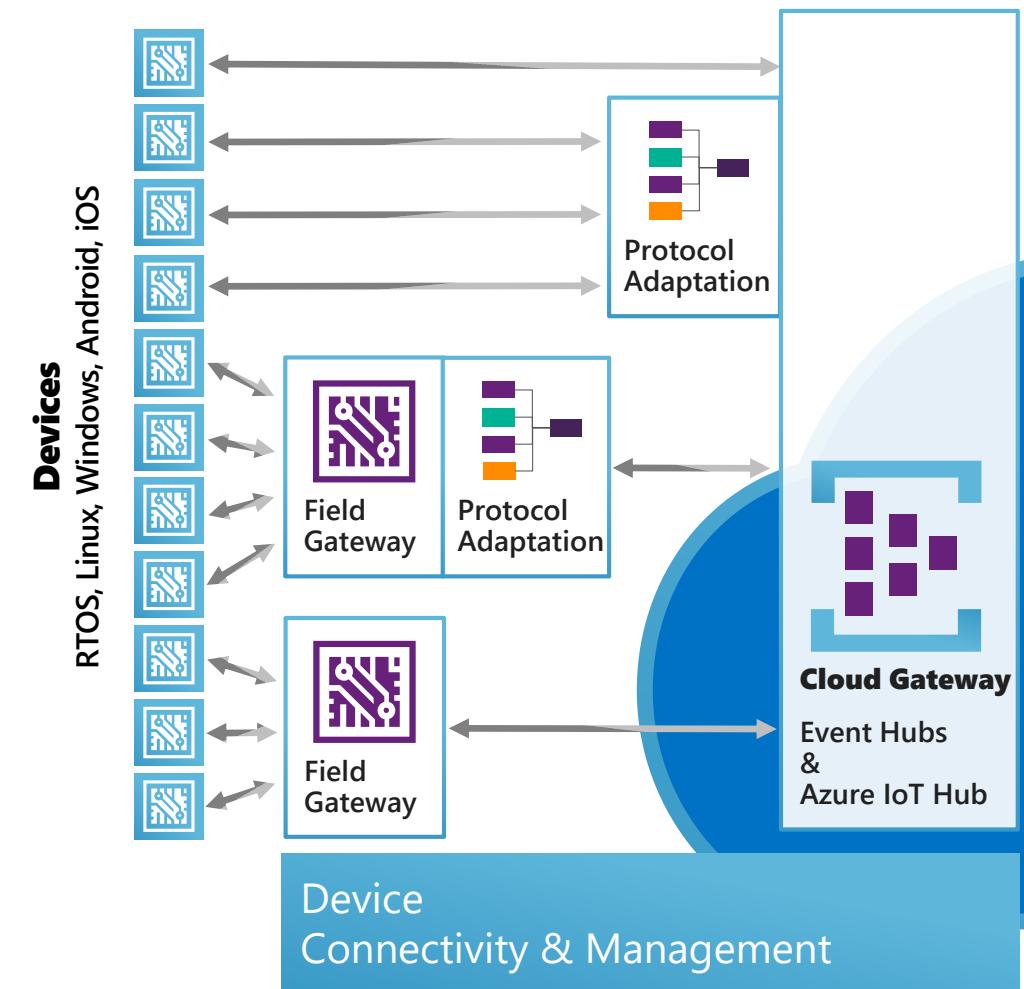
IoT Device & Cloud Patterns



Azure IoT Hub

- Bi-directional device <-> cloud
- Up to 10 million devices
- Telemetry ingestion
- Command & control
- Device registry & identity
- Bulk import/export of device identities
- Device Management
- HTTP/AMQP/AMQP-WS/MQTT
- Extensible protocol support
- Operations Monitoring

IoT Device & Cloud Patterns



Cross-Platform Device Support

- Open source "agent" framework
- Simple, secure device <-> cloud connectivity & management
- RTOS, Linux, Windows, Android, iOS
- Easy to use, not required

C API

.NET API

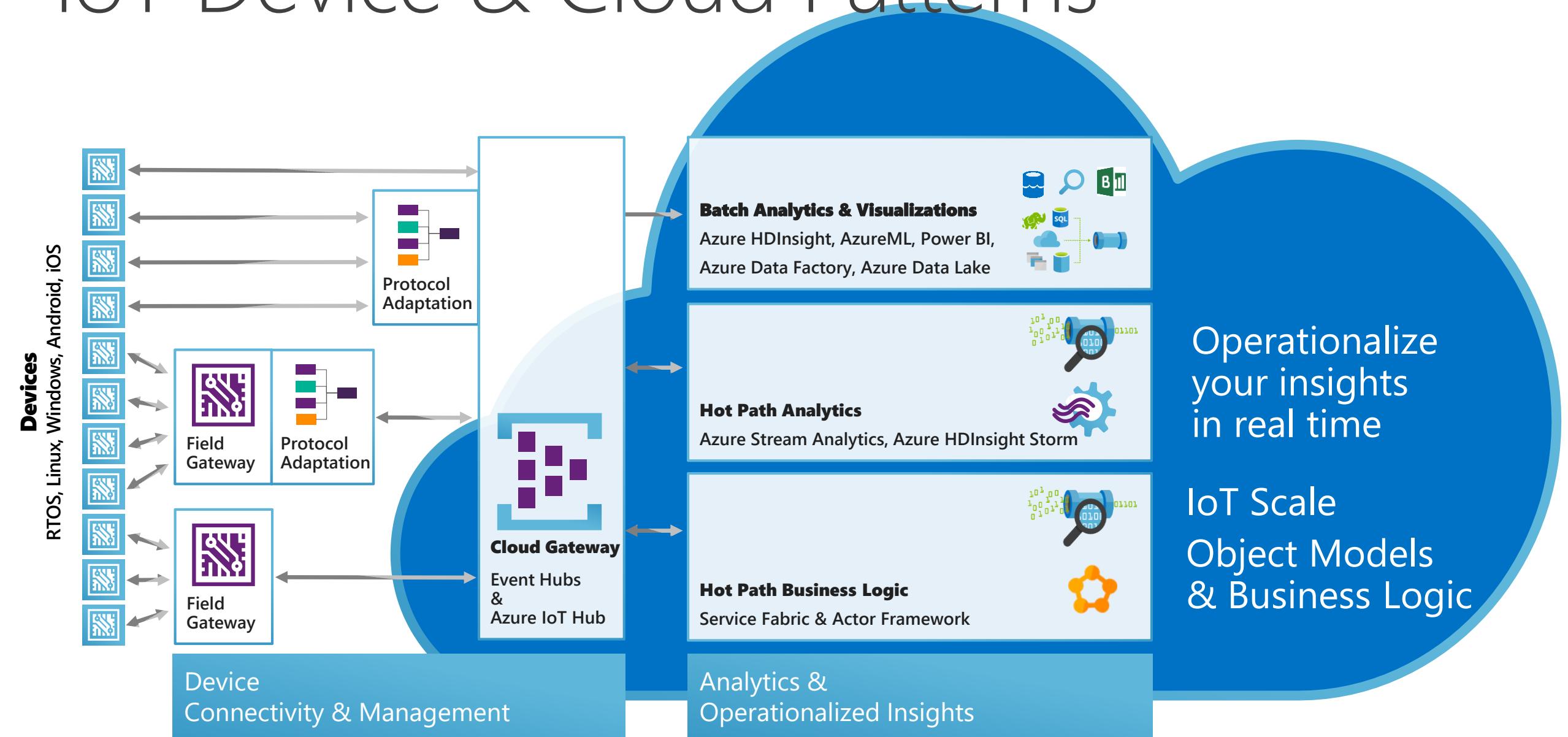
Java API

Javascript API

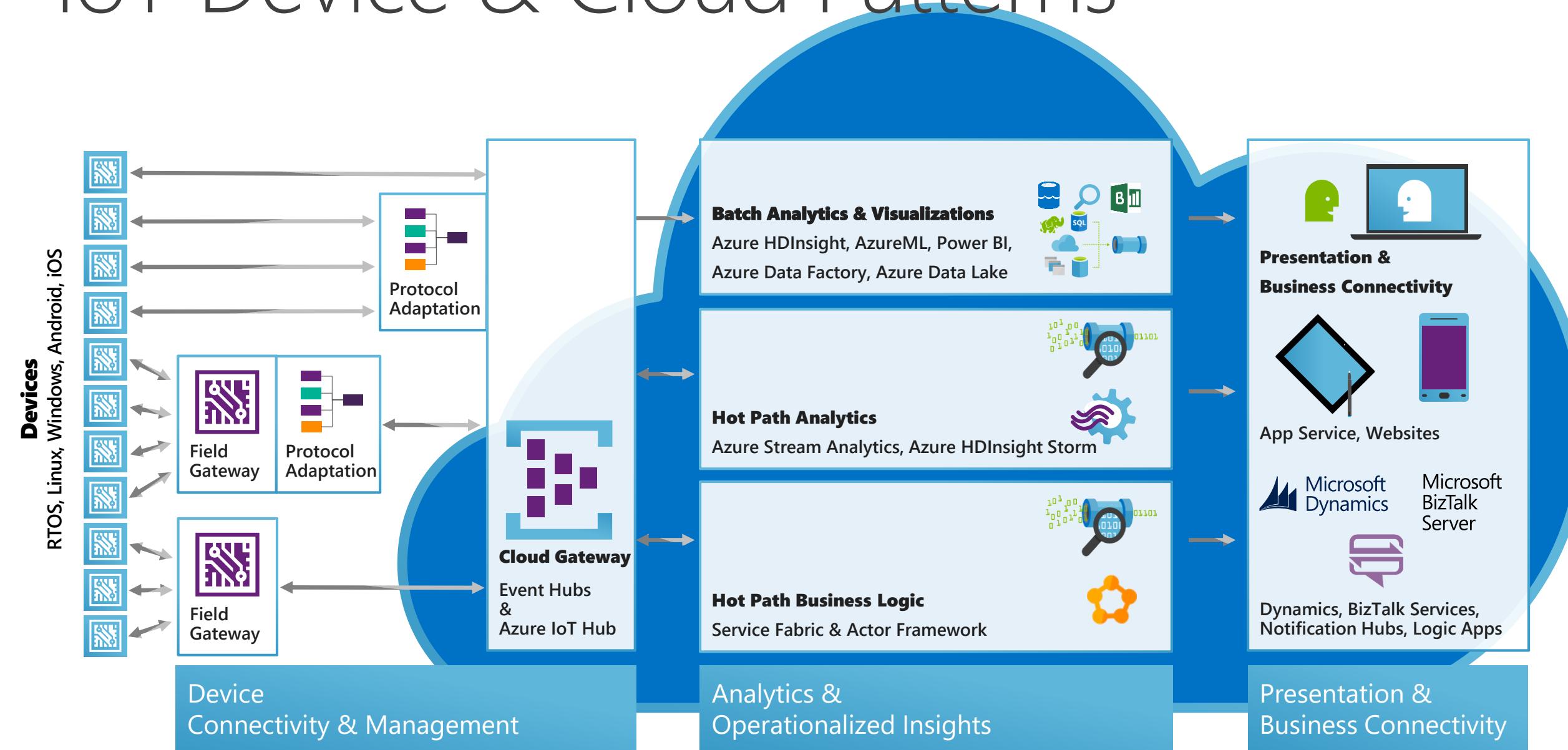
Cross Platform C Code

OS Abstraction Layer / OS Bindings

IoT Device & Cloud Patterns



IoT Device & Cloud Patterns



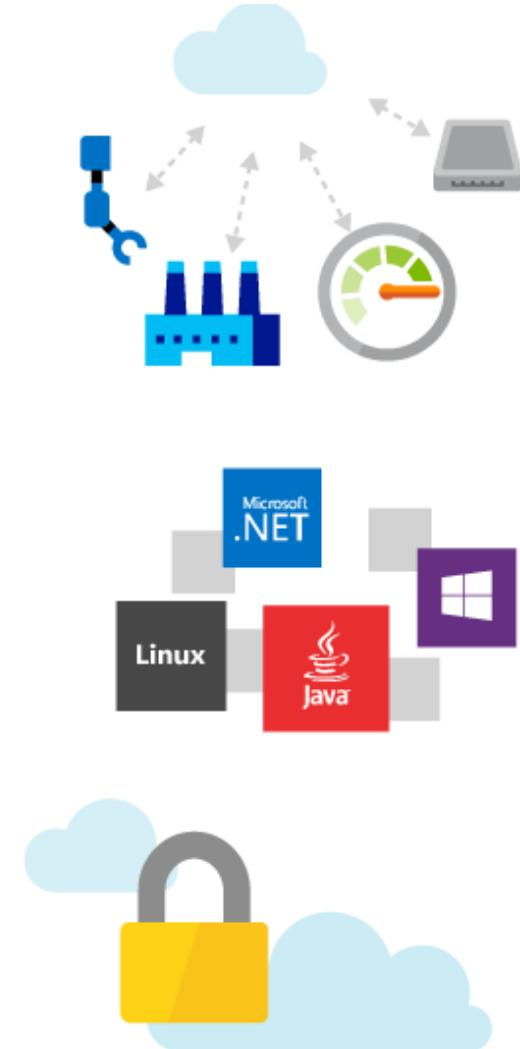
Microsoft Azure IoT services

Devices	Device Connectivity	Storage	Analytics	Presentation & Action
	 Event Hubs	 SQL Database	 Machine Learning	 App Service
	 IoT Hubs	 Table/Blob Storage	 Stream Analytics	 Power BI
	 Service Bus	 DocumentDB	 HDInsight	 Notification Hubs
	 External Data Sources	 External Data Sources	 Data Factory	 Mobile Services
				 BizTalk Services

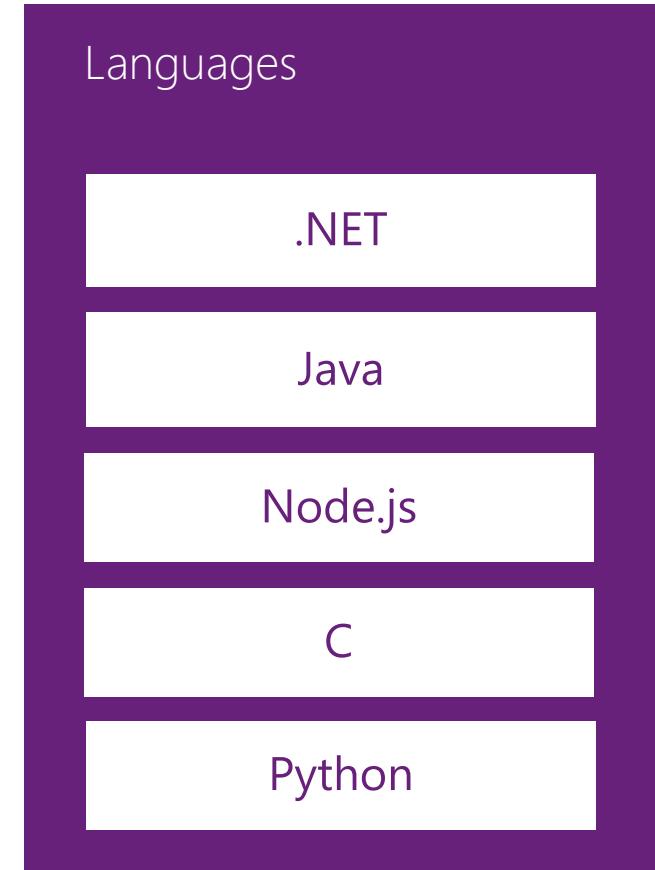
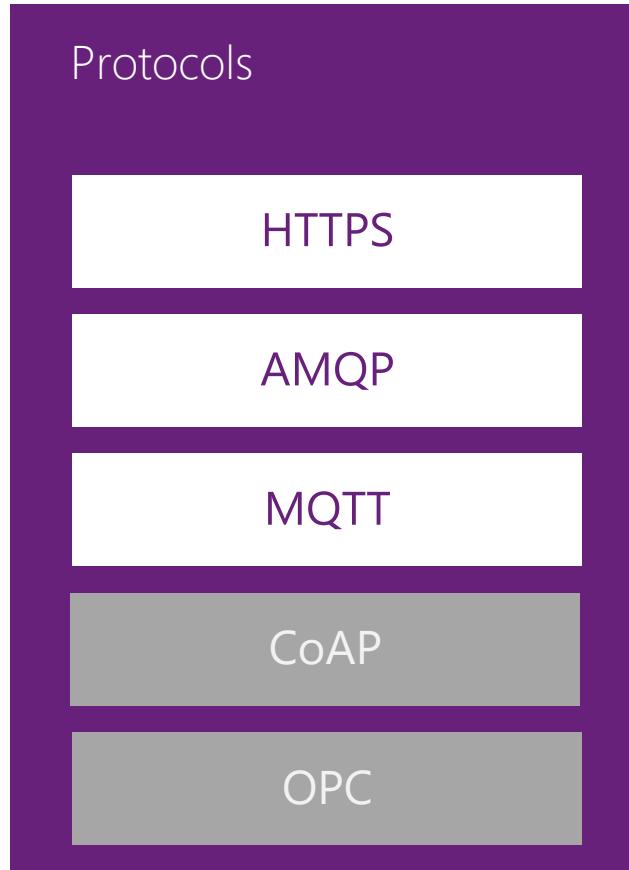
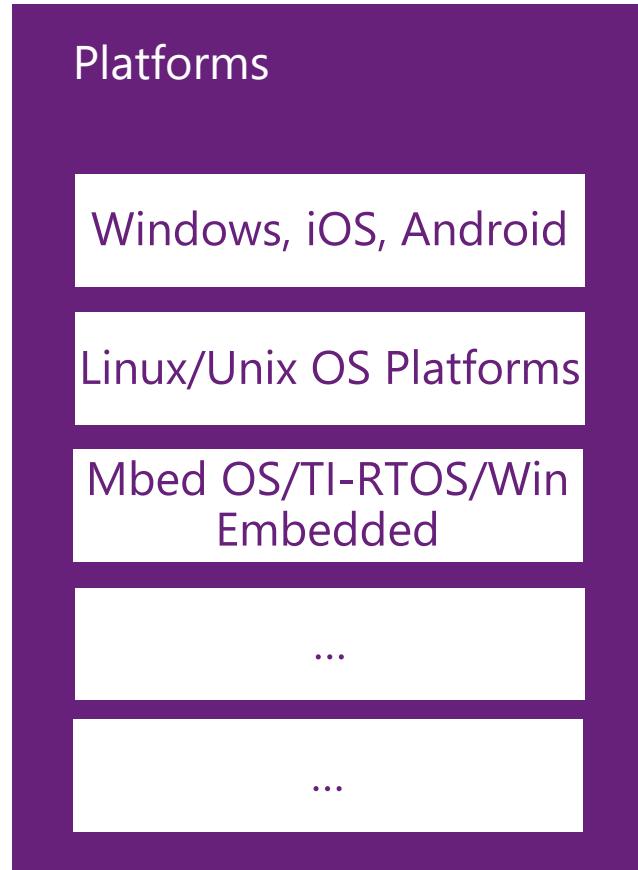
Azure IoT Hub

IoT Hub at a glance

- Establish bi-directional communication with millions of IoT devices
- Work with platforms and protocols that you know
- Authenticate per device for security-enhanced IoT solutions
- Based on Azure Event Hubs technology; delivering tens of billions of messages per day

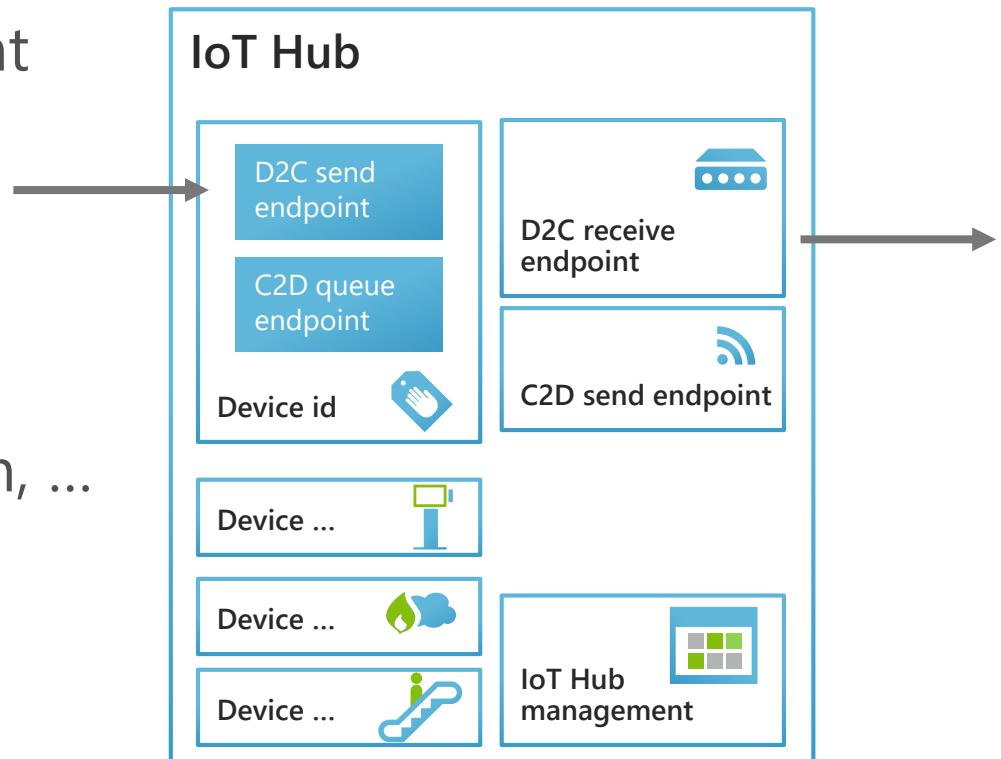


What's supported?



D2C – Messages

- **Interface**
 - AMQP / MQTT and HTTPS device-side endpoint
 - AMQP service-side endpoint
 - Device and service SDKs
- **Compatible with Event Hubs**
 - Partitioned receiver, client check-pointing
 - Integrations with Azure Stream Analytics, Storm, ...
 - 100% compatible with Event Hubs receivers
- **IoT Hub services for D2C**
 - Millions of simultaneously connected devices
 - Per-device authentication
 - Connection-multiplexing



D2C – Consuming Events

Code against SB msg API

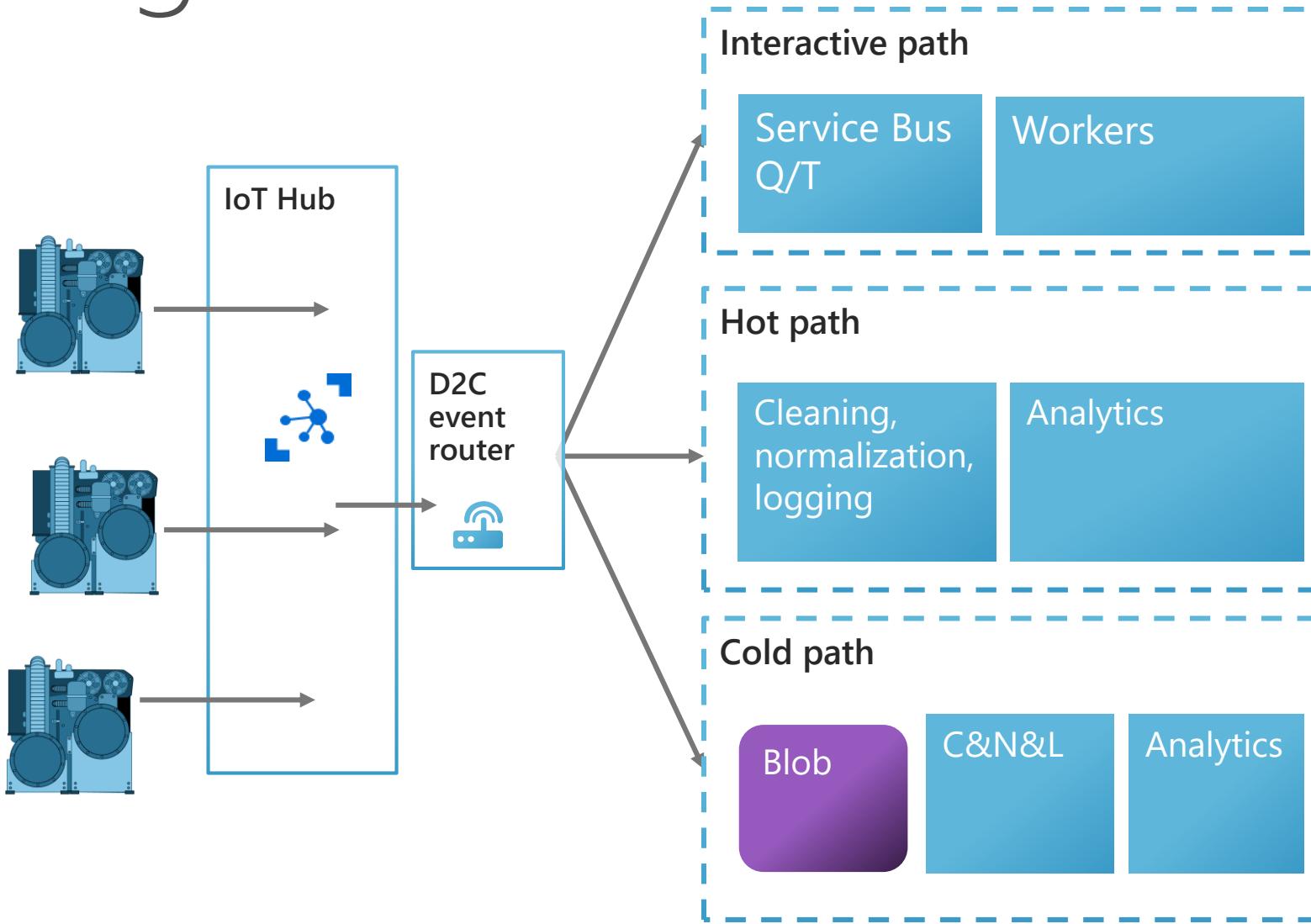
- Easy event processor implementation
- Enable deduplication on Q
- Easy routing to different subcomponents
- Create SB Q/T based on expected throughput

Use any event processor

- Easy to select only “real-time” data.
- Storm / Spark
- Custom code
- Azure Stream Analytics

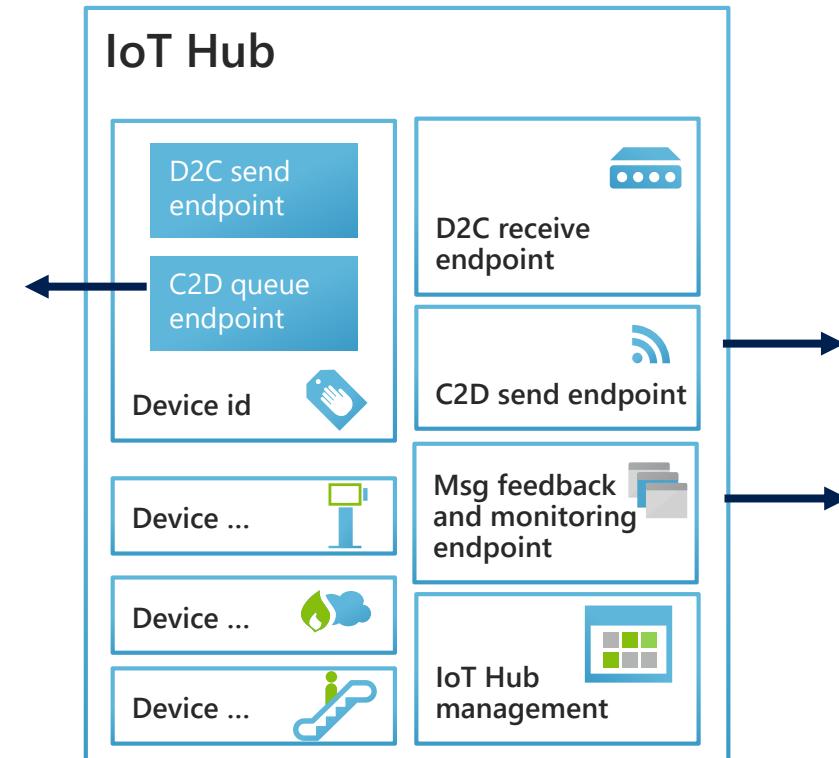
Run batches from blob

- Reuse existing batch code
- Easy with Azure Data Factory



C2D - Messages

- **Interface**
 - AMQP, MQTT, HTTPS device-side endpoint
 - AMQP service-side endpoint
- **At-least-once semantics**
 - Durable queued messages (TTL up to 2 days)
 - Device acknowledges receipt
(Send - Receive - Abandon OR Complete)
- **TTL and receipts**
 - Per-message TTL
 - Per-message positive and negative receipts
- **Command lifecycle pattern**
 - Use correlated D2C for responses
 - Use feedback information to retry
 - Store command state in command registry



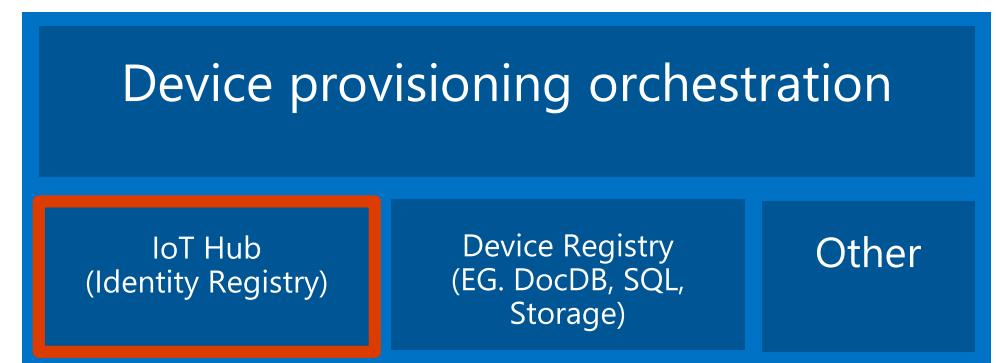
Management - Provisioning

- **Identity Registry**

- Each IoT hub has a device identity registry that you can use to create per-device resources in the service
- Does not contain any application metadata
- Can be accessed like a dictionary using the **deviceId** as the key
- Does not support expressive queries

- **Operations:**

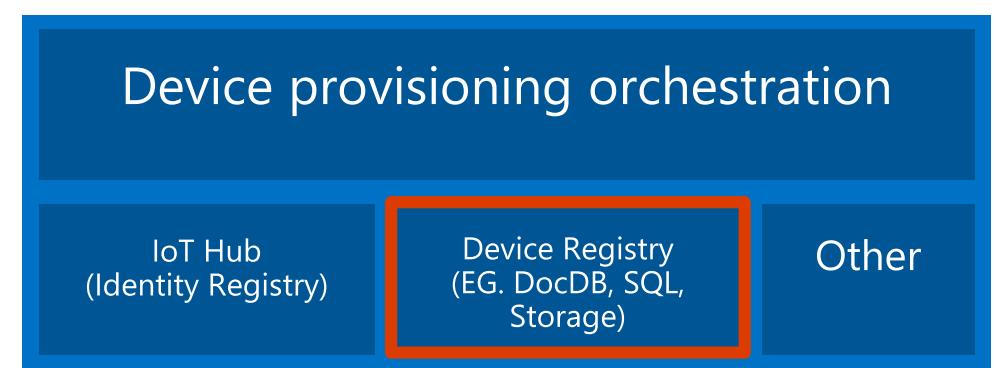
- *Create device identity*
- *Update device identity*
- *Retrieve device identity by ID*
- *Delete device identity*
- *List up to 1000 identities*



Management - Provisioning

- **Device Registry**

- Provides the ability to add application-specific metadata to your devices
- Use a per-device authentication model
- The device registry serves as a consistent view of device data
- Typically stored in DocDB, SQL DB, or similar



Management - Provisioning

- **Disabling devices**
 - You can disable devices by updating the **status** property of an identity in the registry
 - You would typically do this in two scenarios:
 - *For any reason, you consider a device is compromised or has become unauthorized*
 - *During a provisioning orchestration process or decommissioning process*
- **Batch Operations**
 - Imports / Exports at scale are long-running jobs that use a customer-supplied blob container to read and write device identity data
 - You are able to export device identities in bulk from the IoT hubs registry

Management - Security (Transport)

- **Transport Security & Authentication**
 - Various AuthN options including certificates and pre-shared keys
 - The connection established between devices and IoT Hub is TLS (Transport Layer Security) based
 - Communication is encrypted
 - Server is authenticated using its own X.509 certificate sent to the device during hand shaking
 - Security keys are never sent over the wire - always token/signature based
- **Custom Authentication Options**
 - Multi-factor Authentication
 - Active Directory

Management – (Access Policies)

- **Service-side Communication**
 - RegistryRead and RegistryReadWrite - Grant permissions to the Identity registry
 - Service connect - Grants access to service-facing communication and monitoring endpoints
- **Device-side communication**
 - Device Connect - Grants access to device-facing communication endpoints
 - Device Identity Registry - Each device identity has a user-specified deviceId with a set of security credentials and status flag to enable/disable connectivity.

Development SDKs

SDK

- SDK and agent libraries easily accessible in GitHub
- Cross platform support – choose OS, platform and language
- Device support with IP and access control capabilities
- Connect IP and non-IP devices via gateway and field protocols
- Open source framework to accommodate development of custom agents for devices
- Simple and secure D2C and C2D connectivity for messaging, device management and command and control
- Multiple OS support - RTOS, Linux, Windows, Android, iOS etc

SDKs - Device

- **Operating Systems Supported**

- Debian Linux (v 7.5)
- Fedora Linux (v 20)
- mbed OS (v 2.0)
- Raspbian Linux (v 3.18)
- Ubuntu Linux (v 14.04)
- Windows Desktop (7, 8, 10)
- Windows IoT Core (v 10)
- Windows Server (v 2012 R2)
- Yocto Linux (v 2.1)

- **C Libraries Supported**

- Debian Linux (v 7.5) HTTPS, AMQP, MQTT
- Fedora Linux (v 20) HTTPS, AMQP, MQTT
- mbed OS (v 2.0) HTTPS, AMQP
- Ubuntu Linux (v 14.04) HTTPS, AMQP, MQTT
- Windows Desktop (7,8,10) HTTPS, AMQP, MQTT
- Yocto Linux (v 2.1) HTTPS, AMQP

SDKs – Device (Registry Manager)

- **Name Space: Microsoft.Azure.Devices**
- **RegistryManager**
- RegistryManager.CreateFromConnectionString()
- RegistryManager.OpenAsync()
- RegistryManager.AddDeviceAsync()
- RegistryManager.GetDevicesAsync()
- RegistryManager.RemoveDeviceAsync()

SDKs – Device Client

- **Name Space: Microsoft.Azure.Devices.Client**
- **Key Object: DeviceClient**
- **DeviceClient.CreateFromConnectionString()**
- **DeviceClient.OpenAsync()**
- **DeviceClient.SendEventAsync()**
- **DeviceClient.ReceiveAsync()**
- **DeviceClient.UploadToBlob()**

SDKs – Service Client

- **Name Space: Microsoft.Azure.Devices**
- **Key Object: ServiceClient**
- **ServiceClient.CreateFromConnectionString()**
- **ServiceClient.OpenAsync()**
- **ServiceClient. SendCloudToDeviceMessageAsync()**
- **ServiceClient. ReceiveFeedbackAsync()**

SDKs – Gateway

**1
85%**

of existing 'things' were never designed to be connected to the internet/cloud

**2
Avg. 60%**

cost-savings by processing data at the edge

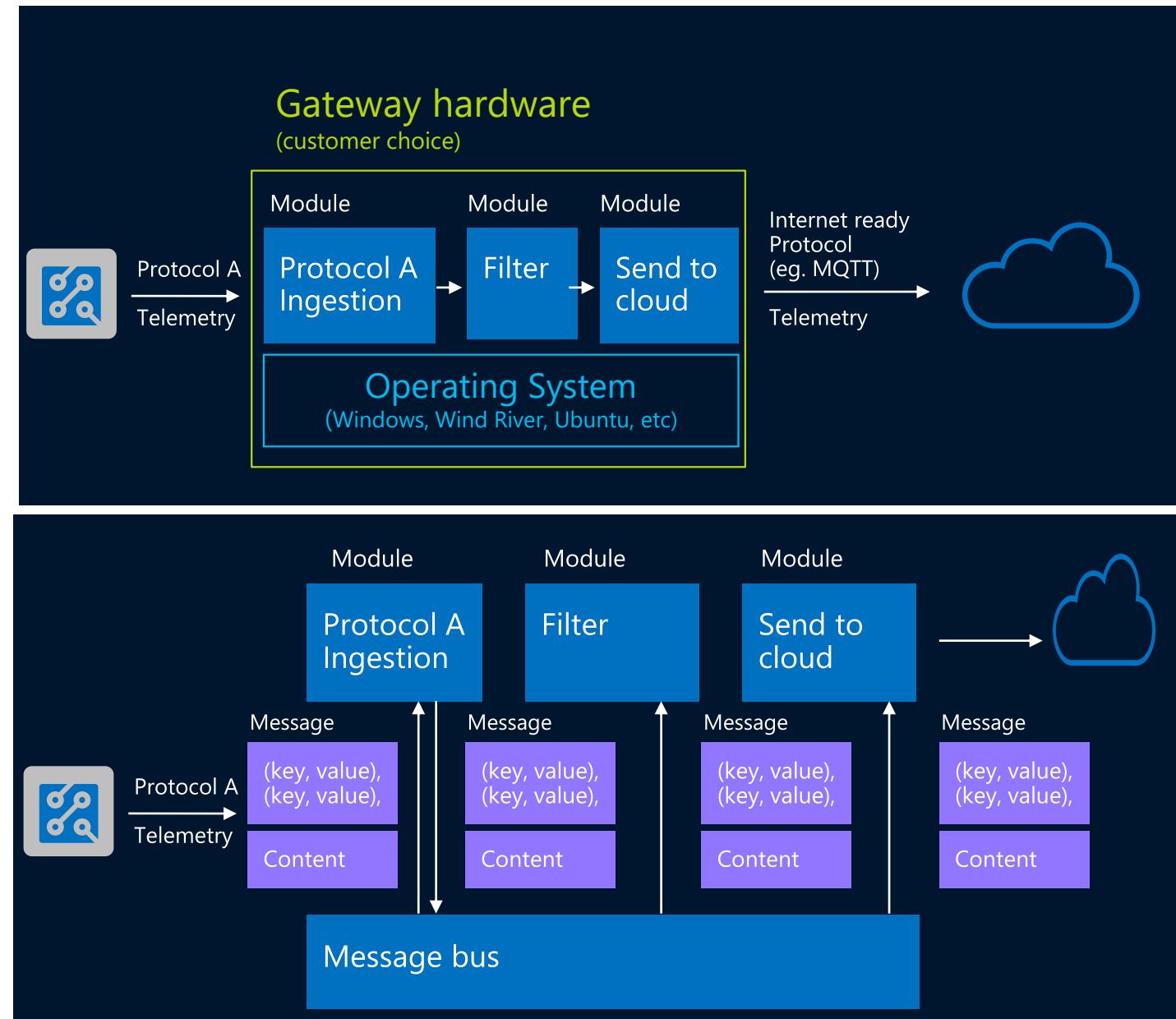
**3
40%**

of IoT-created data will be stored, processed, analyzed and acted upon at the edge

**4
5x–Growth**

of data by 2020, 50% IT networks constrained

- SDK allows customers to choose OS and hardware
- SDK abstraction layer allows gateways to run on Windows AND Linux be powered by many different types of hardware
- Modules are the brains of a gateway
- Each module performs an action
- Chain of modules can be thought of as a data processing pipeline, solving an end to end scenario



Tools and Demo

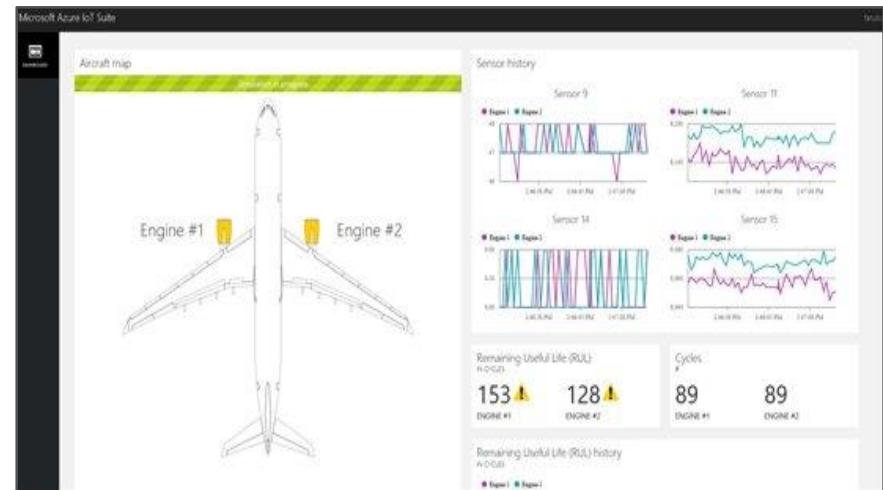
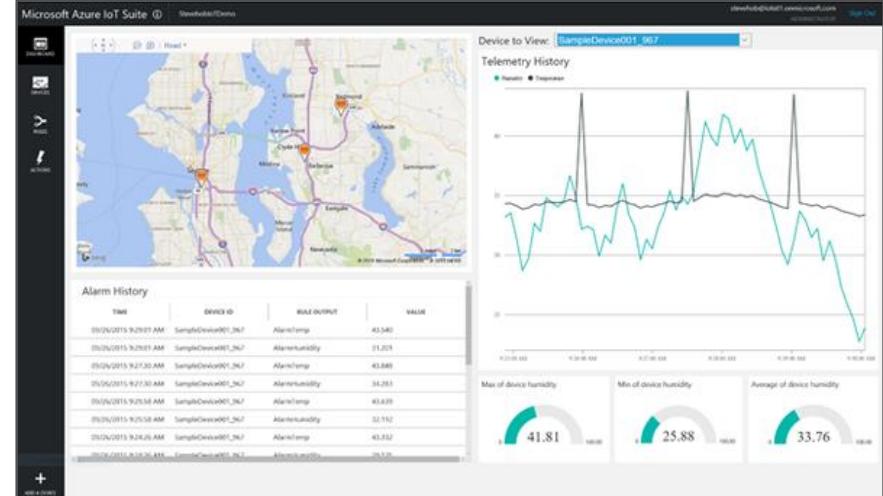
Preconfigured Solutions

Remote Monitoring

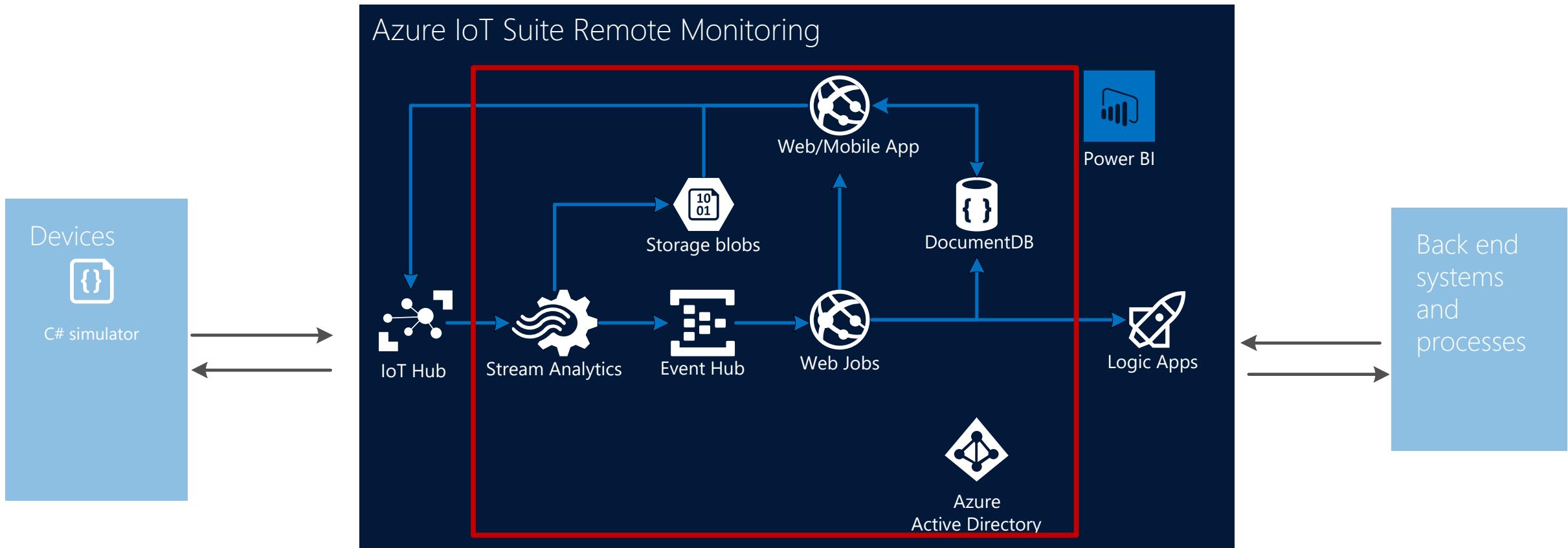
- Complete solution template that can be deployed via cloud or locally
- To be modified to suit custom scenarios
- Illustrates how you can perform end-to-end monitoring of your devices
- Key Services:
 - *Data Ingestion, Device identify, Command and Control*
 - *Rules, Actions*

Predictive Maintenance

- Complete solution template that can be deployed via cloud or locally
- To be modified to suit custom scenarios
- Illustrates how you can predict the point when failure is likely to occur
- Includes key Azure IoT Suite Services
- Has ML workspace for predicting RUL (Remaining useful Life) of Aircraft Engines as an example



Solution Architecture





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