Internet of Things
with
Microsoft Azure

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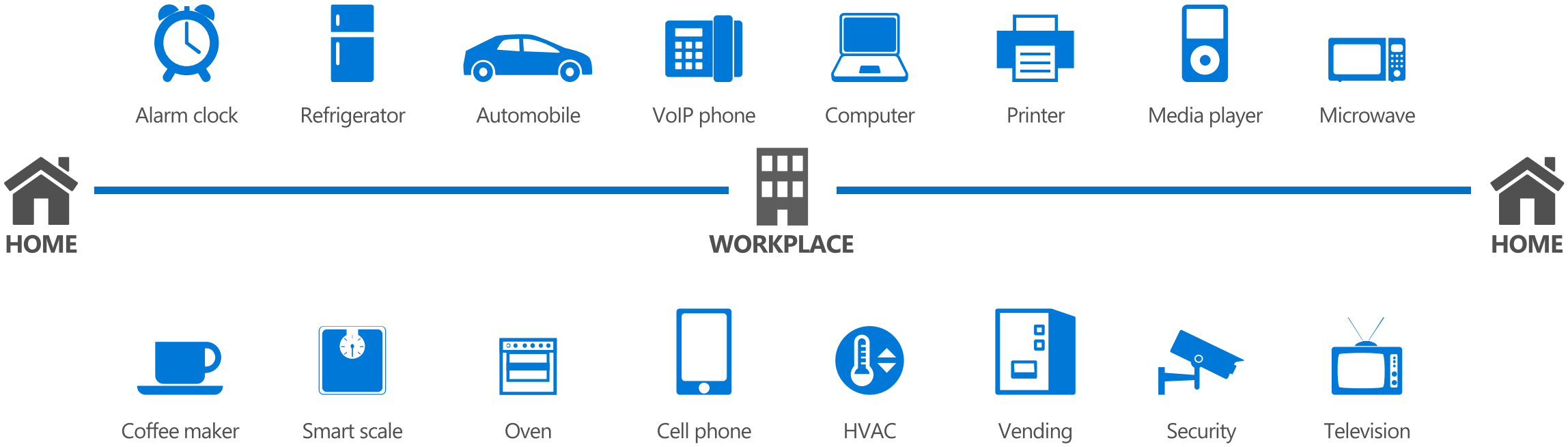
Microsoft

Agenda WIFI: Ecchcmc@2016

09:00	10:30	Introduction to Azure IoT
10:30	10:40	Break
10:40	11:15	Azure Account & Lab
11:15	12:00	Azure IoT and NODE-RED (demo)
12:00	13:00	Lunch
13:00	13:45	Azure IoT Suite – Remote Monitoring
13:45	14:20	Azure Data Factory
14:20	15:00	Break and Hands on Lab Setup
15:00	16:30	Hands on Lab

IoT 2010


Alarm clock
Refrigerator
Automobile
VoIP phone
Computer
Printer
Media player
Microwave
HOME
WORKPLACE
HOME
Coffee maker
Smart scale
Oven
Cell phone
HVAC
Vending
Security
Television

IoT 2016

Medication adherence

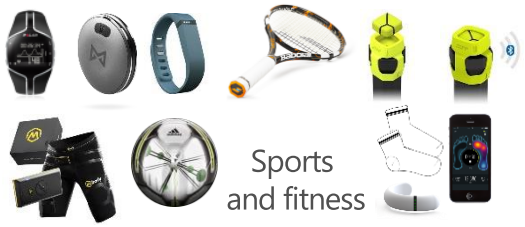
Health monitoring

Pet tracking

Behavior modification

Object tracking

Child and elder monitoring


Sports and fitness

Smart lighting

Indoor navigation

Beacons and proximity

Trip tracking and car health

HOME — **COMMUTE** — **WORKPLACE** — **COMMUTE** — **HOME**

Smart appliances

Food and nutrition tracking

Identity

Office equipment

Smart vending machines

Bike ride stats and protection

Sleep tracking

Air conditioning and temperature control

Environmental sensors

Information capture

Control

Home security

Home automation

Leak detection

Garden, lawn and plant care

New devices and sensors

Entertainment systems

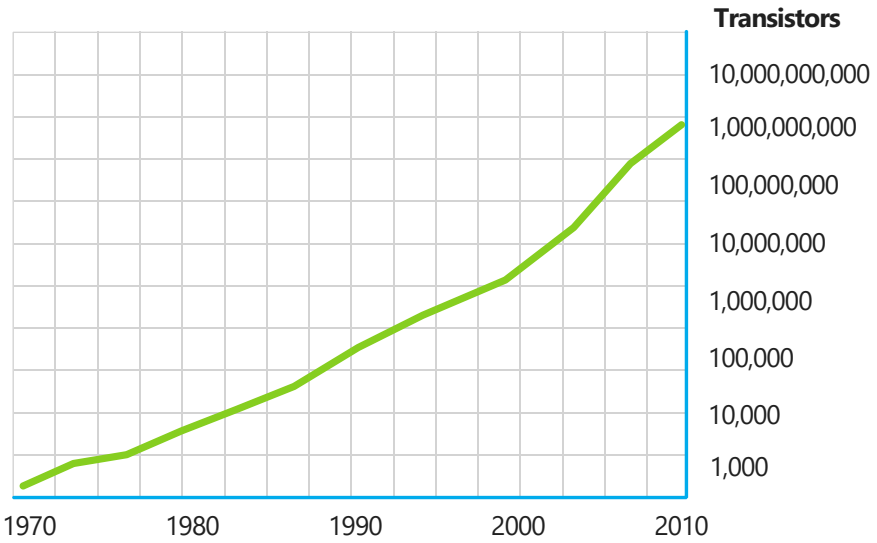
$7.2 TRILLION

worldwide market for IoT solutions by 2020

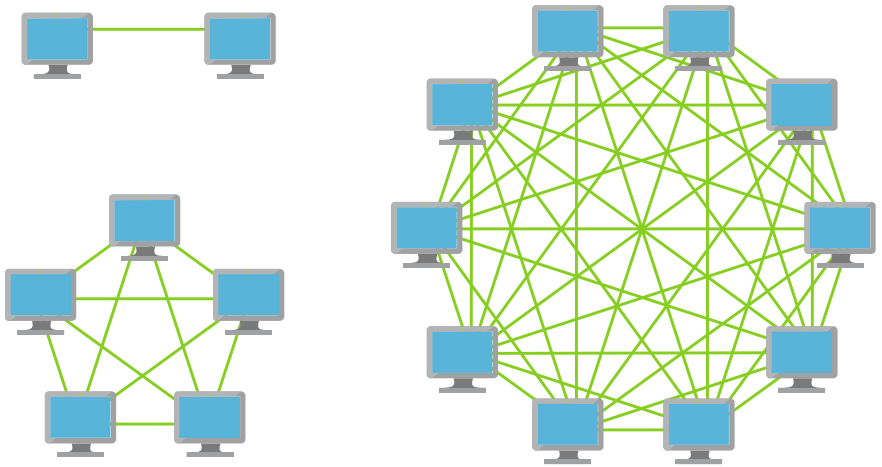
IDC: Worldwide and Regional Internet of Things (IoT) 2014–2020 Forecast

Disruptive Forces

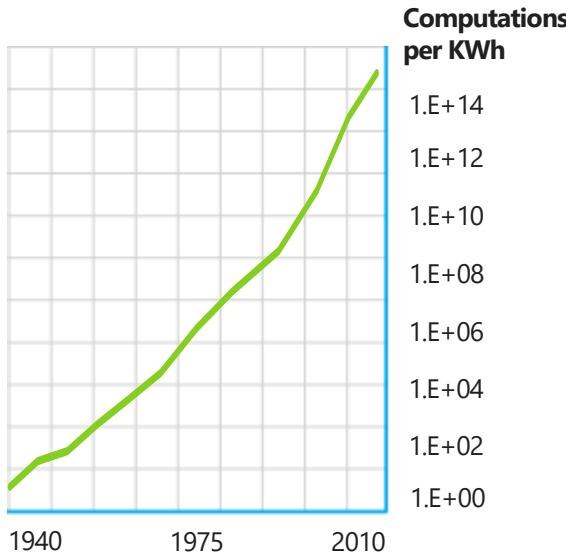
Moore's Law



Metcalf's Law



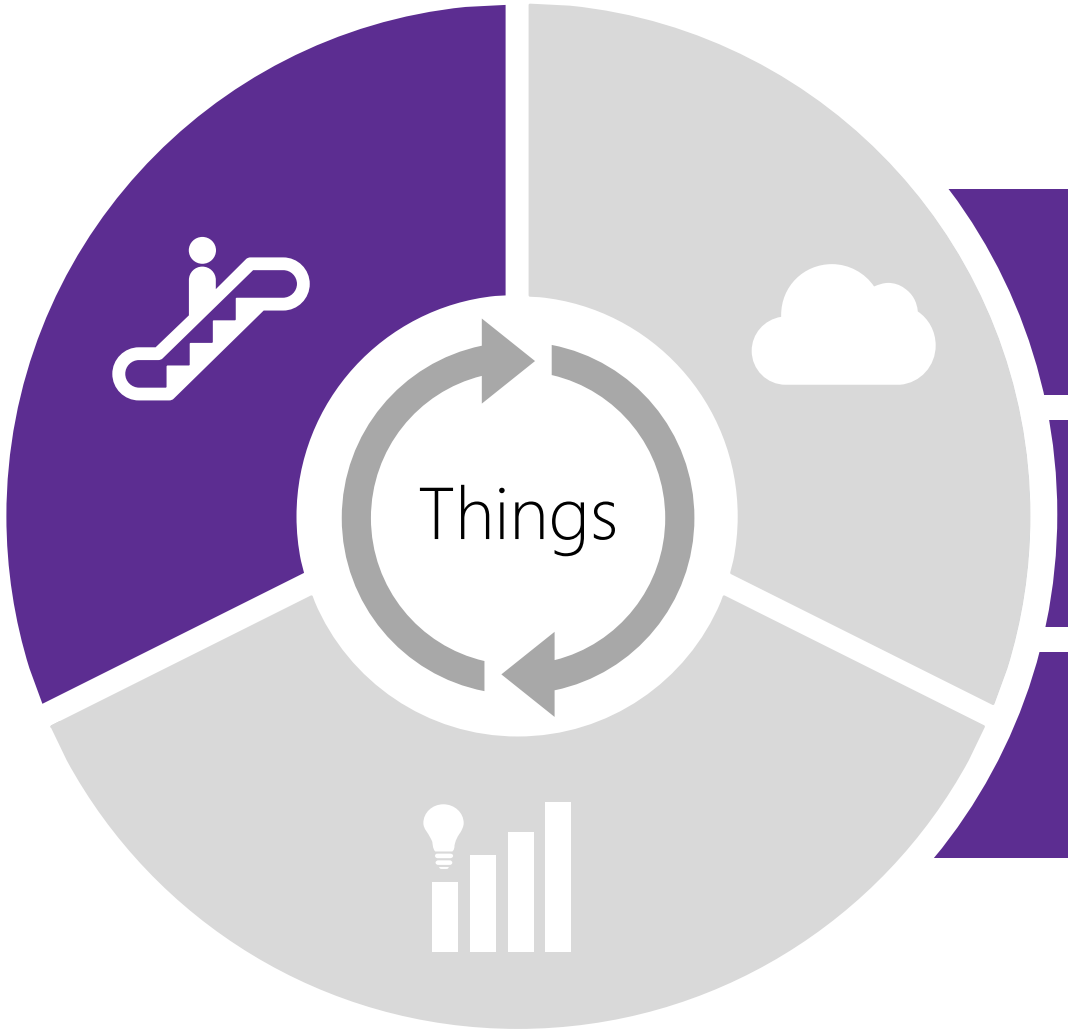
Koomey's Law



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



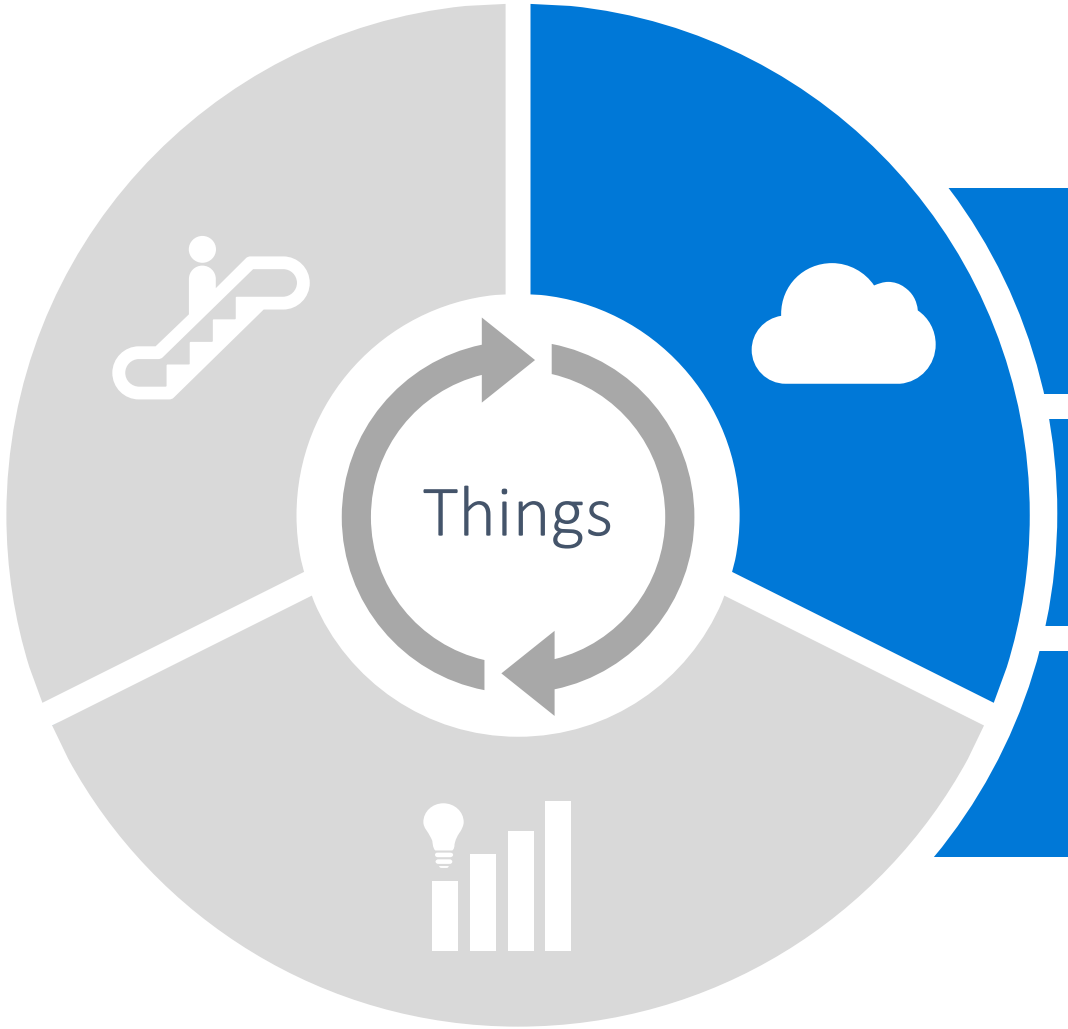
Connect devices and monitor telemetry

Monitor and track device state, location and health

Rules and alerting to improve operational efficiency

IoT Business Maturity Model

2. Business Intelligence



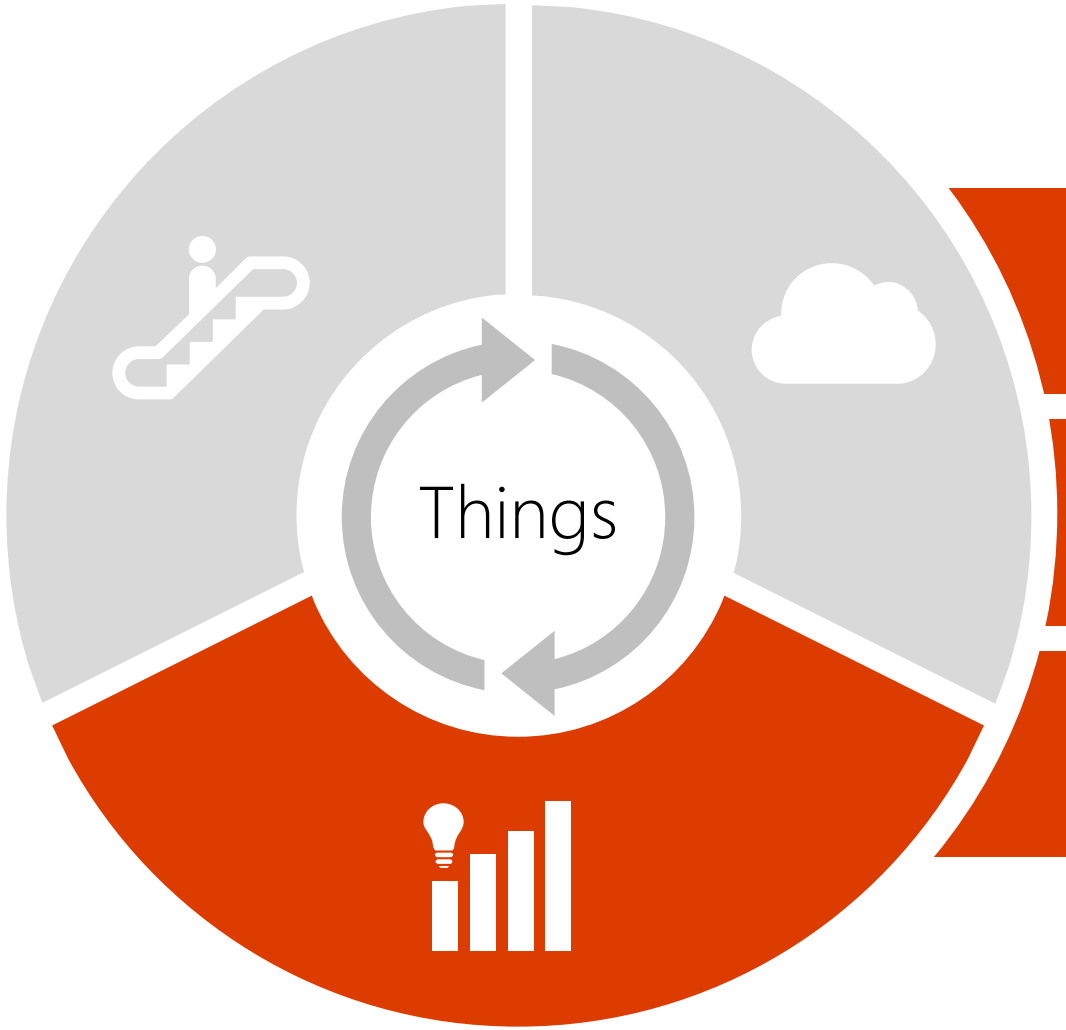
Analyze and visualize data from devices

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



Combine IoT & other data with advanced analytics to power new services and revenue streams

Expand into new adjacent businesses

New partnership opportunities

IoT Device and Cloud Patterns

Microsoft

Cloud Based IoT Solutions

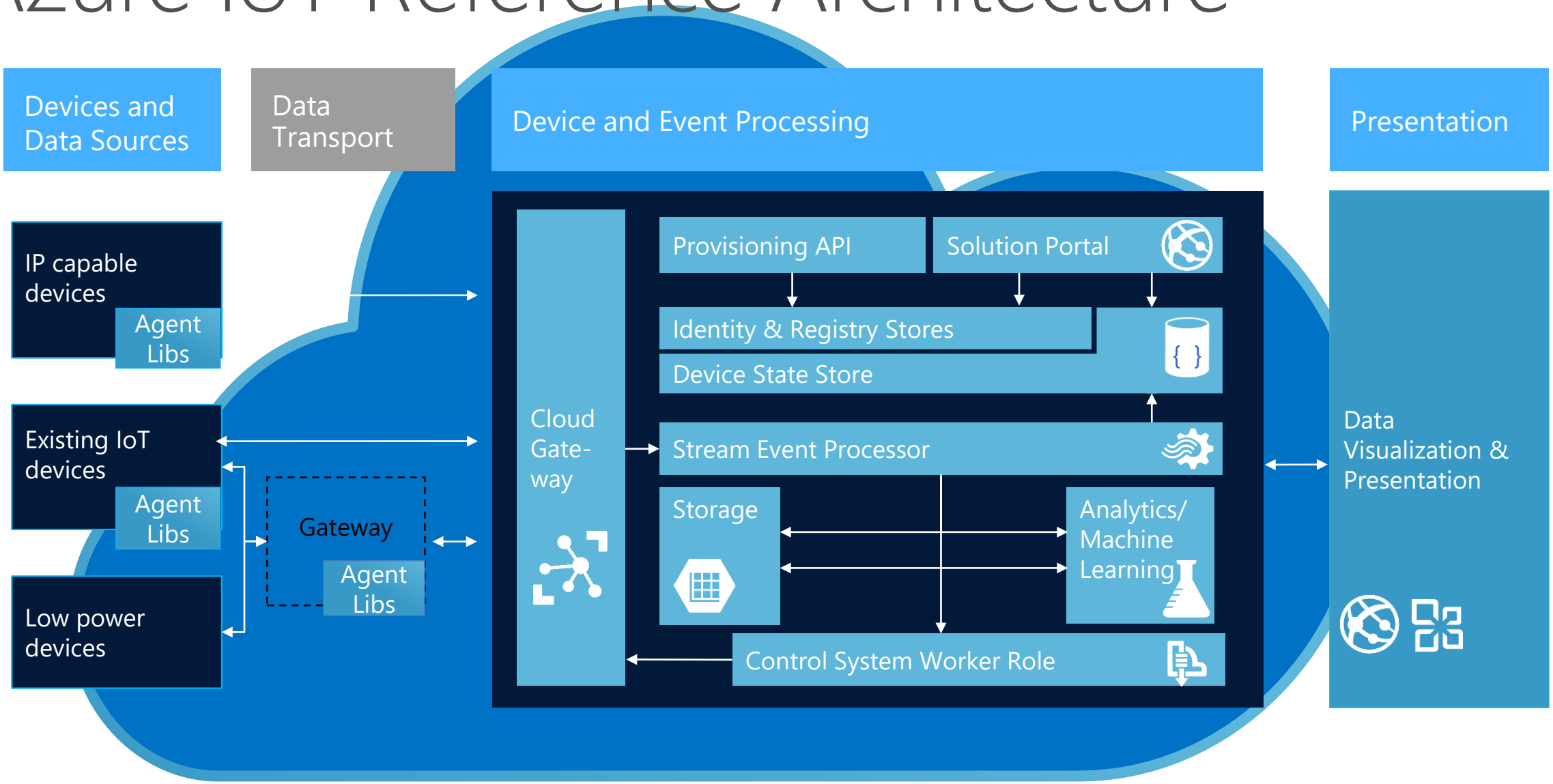
Azure IoT

- Easy to provision, use and manage
- Pay as you go, scale as you need
- Global reach, hyper scale
- End to end security & privacy

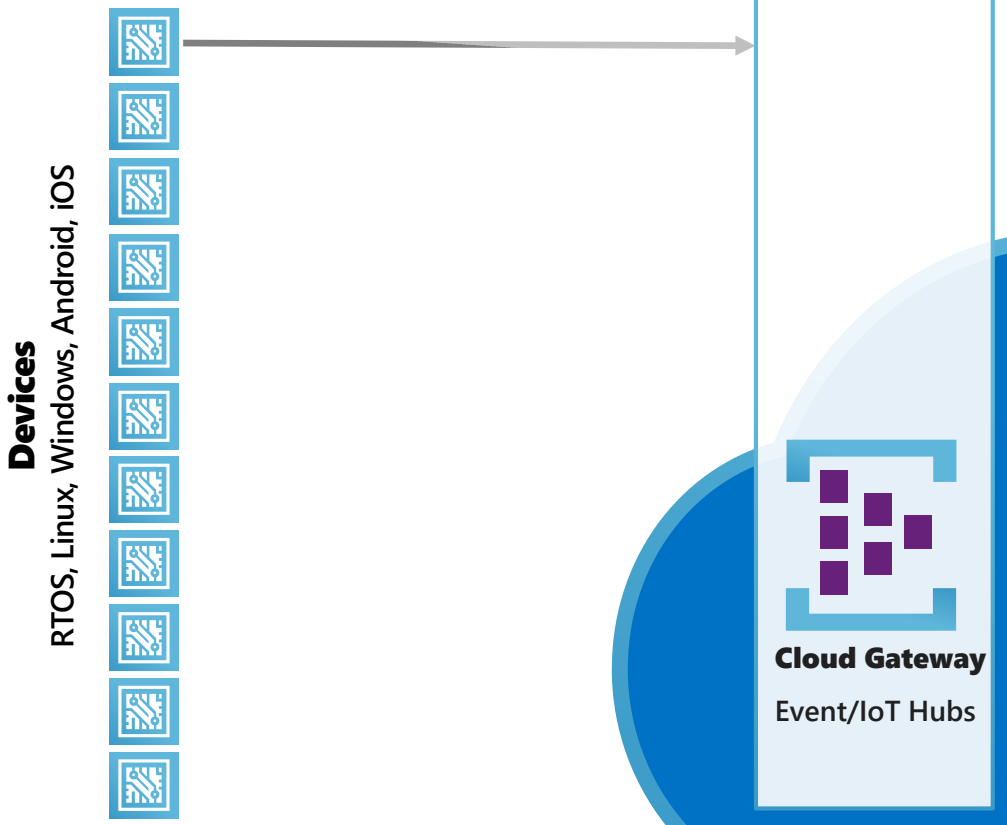
Three parts of an IoT solution

1. Device connectivity & management
2. Analytics & operationalized insights
3. Presentation & business connectivity

Azure IoT Reference Architecture



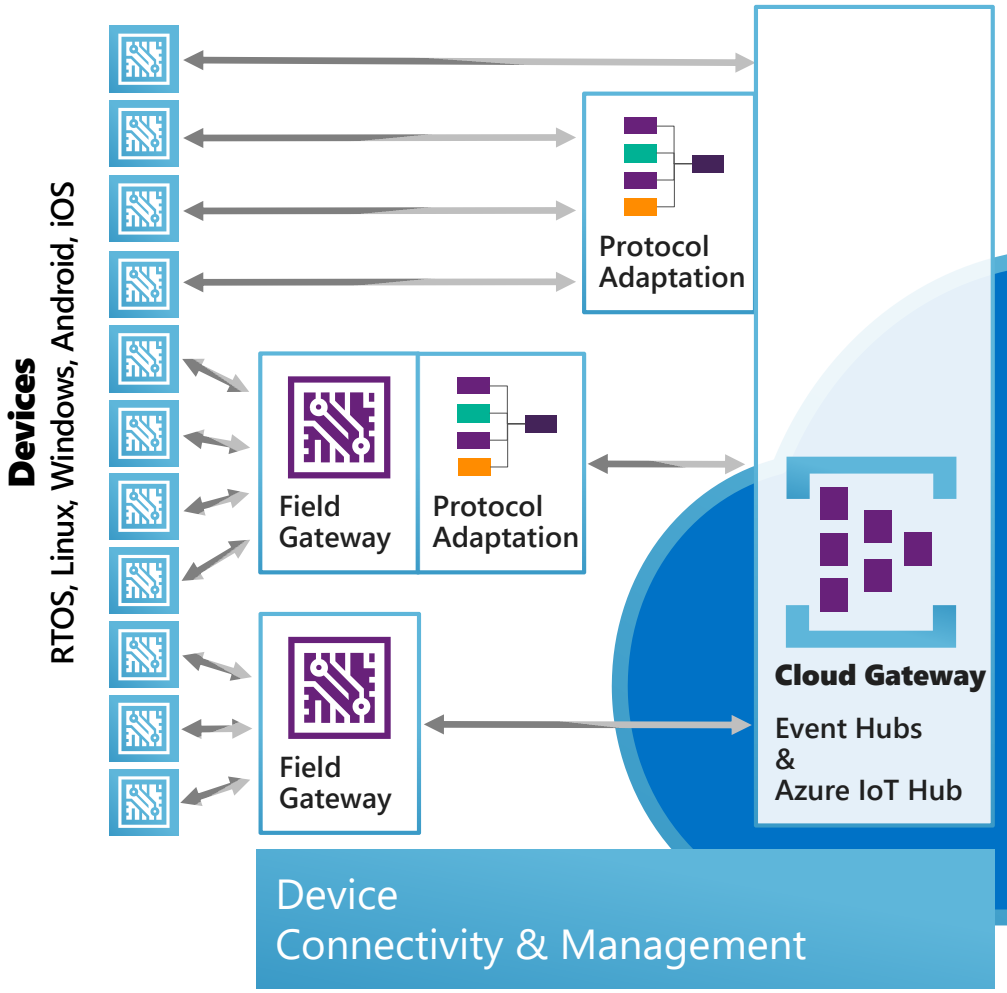
IoT Device & Cloud Patterns



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…

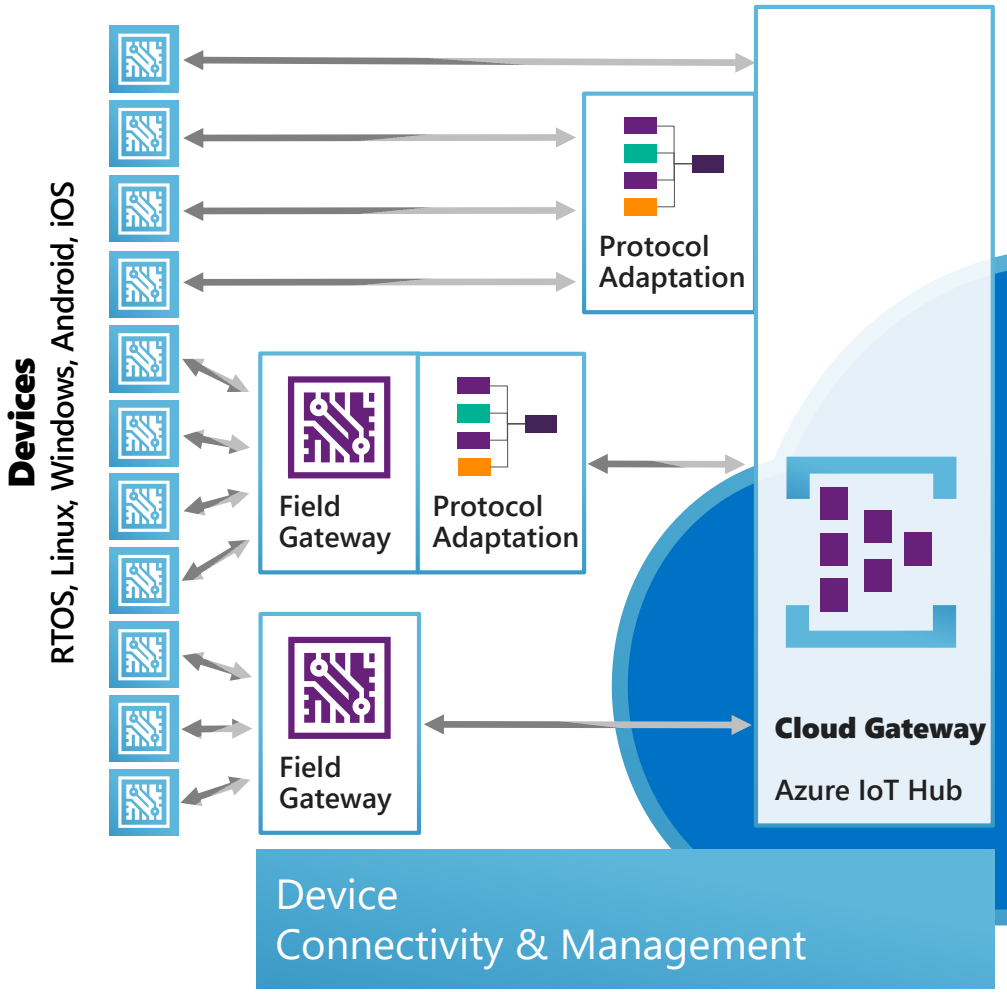
IoT Device & Cloud Patterns



Additional IoT Needs

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

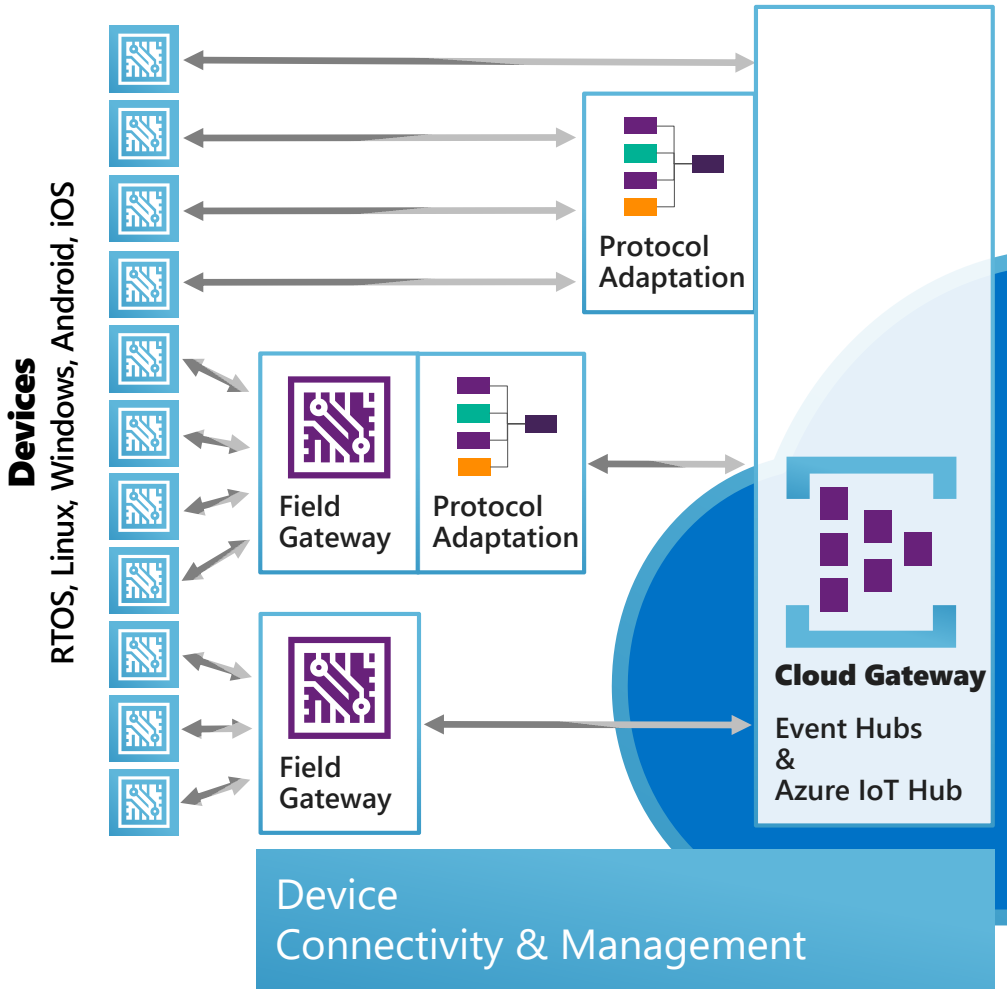
IoT Device & Cloud Patterns



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

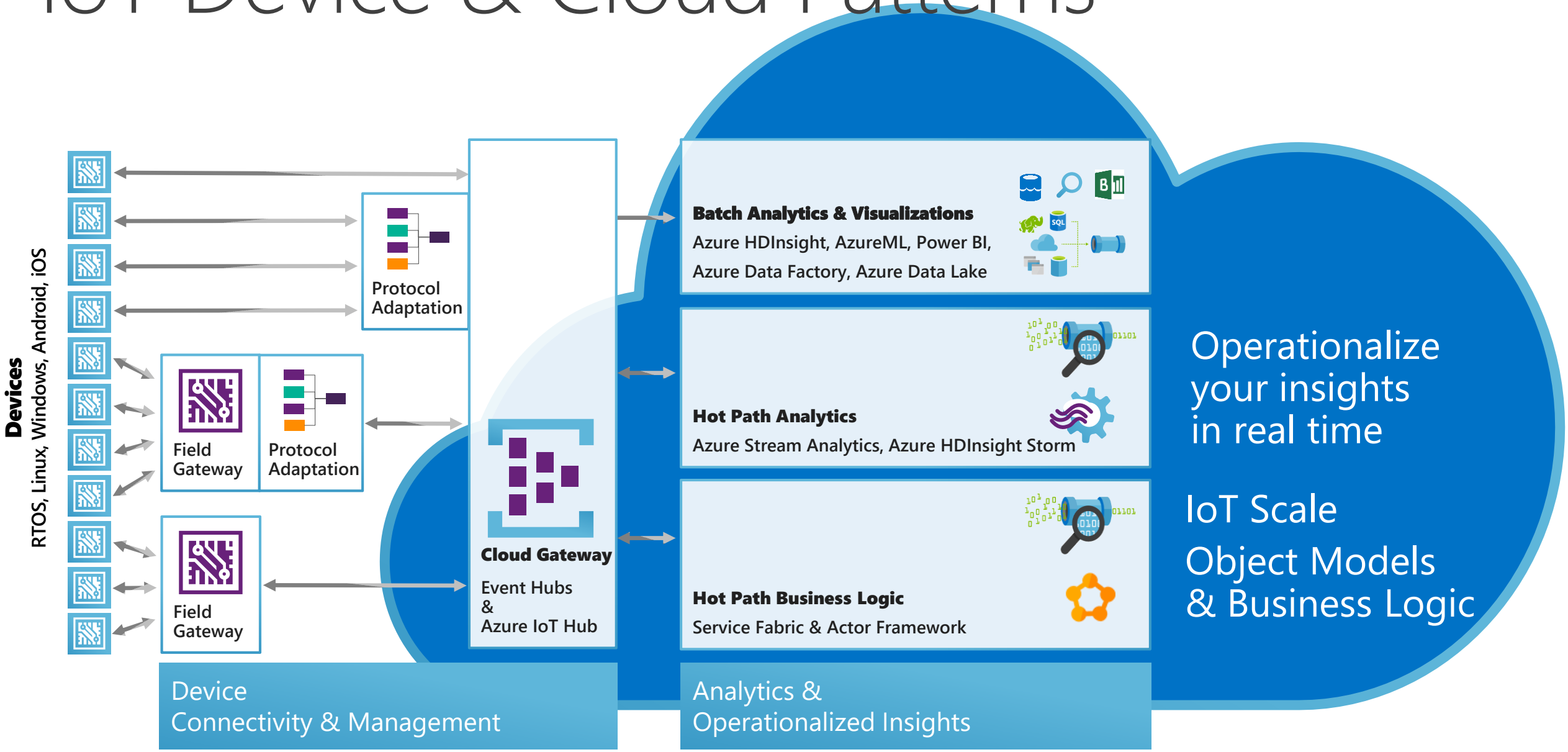
- Open source "agent" framework
- Simple, secure device <-> cloud connectivity & management
- RTOS, Linux, Windows, Android, iOS
- Easy to use, not required

C API	.NET API	Java API	Javascript API

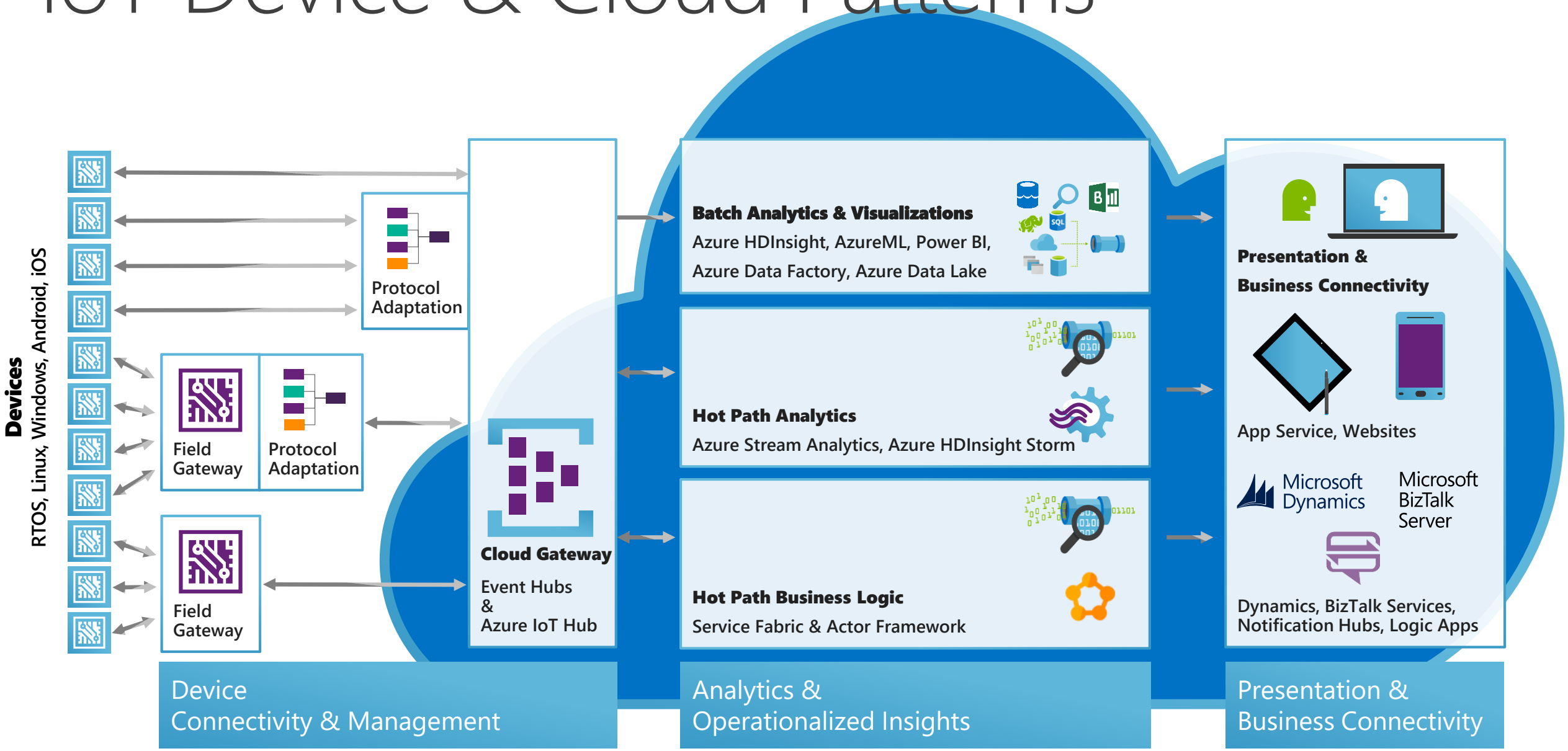
Cross Platform C Code

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

Microsoft

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?

Platforms

- Windows, iOS, Android
- Linux/Unix OS Platforms
- Mbed OS/TI-RTOS/Win Embedded
- …
- …

Protocols

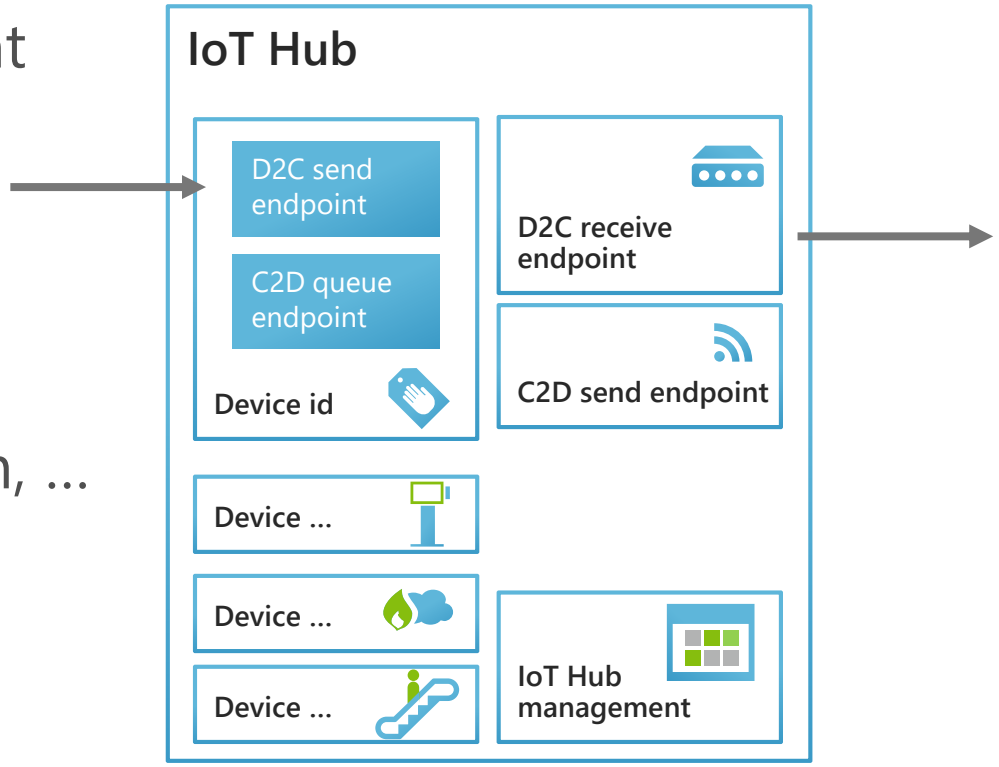
- HTTPS
- AMQP
- MQTT
- CoAP
- OPC

Languages

- .NET
- Java
- Node.js
- C
- Python

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

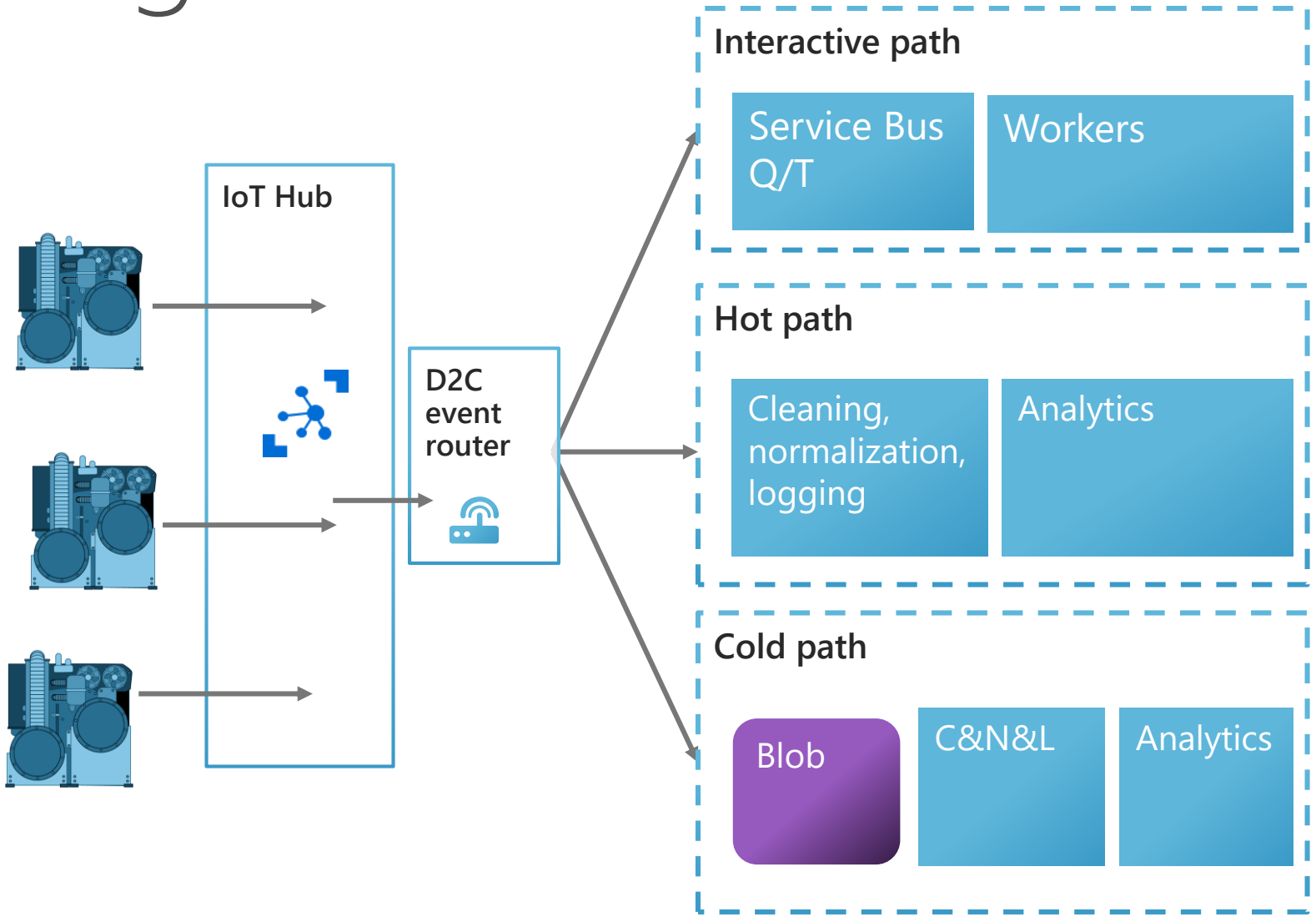
- Easy event processor implementation
- Enable deduplication on Q
- Easy routing to different subcomponents
- Create SB Q/T based on expected throughput

Use any event processor

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

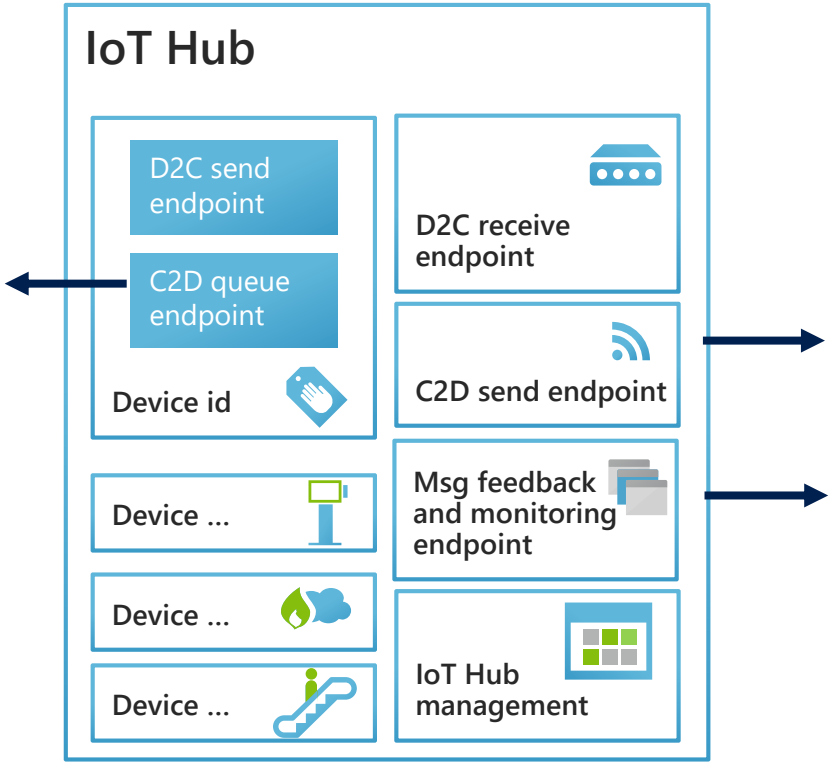
Run batches from blob

- Reuse existing batch code
- Easy with Azure Data Factory



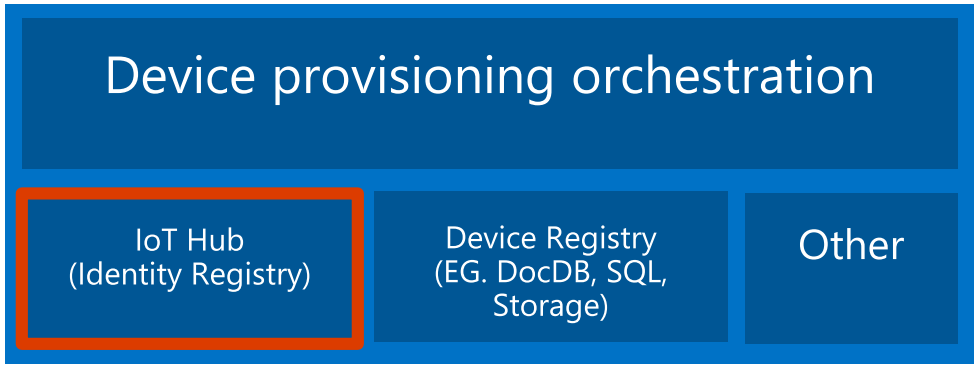
C2D - Messages

- **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



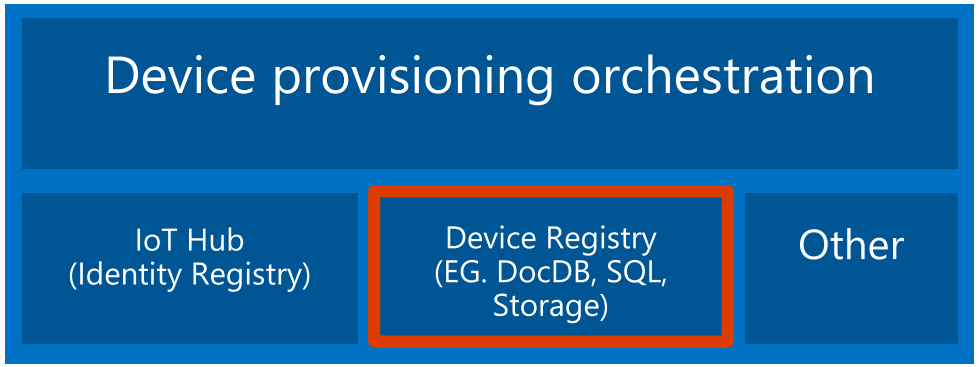
Management - Provisioning

- **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

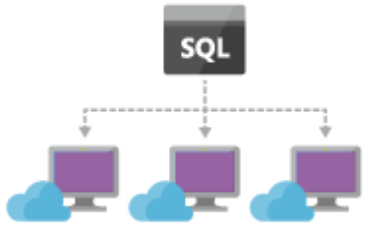
- **Device-side communication**
  - Device Connect - Grants access to device-facing communication endpoints
  - Device Identity Registry - Each device identity has a user-specified deviceId with a set of security credentials and status flag to enable/disable connectivity.

Azure Stream Analytics

Microsoft

ASA – Benefits

- Allows event processing of large volumes of event data at high velocity
- Analysis is done as data arrives
- Declarative ‘SQL like’ query processing support
- High throughput, low latency processing
- Real-time stream computation options
- Enable rapid development



ASA - Inputs

Data stream inputs

- **Event Hub:** Feed events into Azure in real time, and Stream Analytics jobs can process them
- **IoT Hub:** Stream information collected from connected devices directly into a streaming analytics job
- **Blob Storage:** Can be used as an input source for ingesting bulk data

Reference Data

- Static or slow changing used for performing look-ups
- Azure Blob Storage is the only supported reference input
- Source blobs limited to 50MB in size

Input Data Types

- CSV, JSON and Avro Serialized

ASA - Queries

- Performs transformations and computations over streams of events
- Stream Analytics Query Language
  - *Subset of T-SQL syntax*
- Multiple built-in functions
- Supports multiple data types as well as complex
- 3 types of windowing
  - *Tumbling*
  - *Hopping*
  - *Sliding*
- Queries can be created via Azure Portal or via API calls

Save Discard Test

```
WITH [StreamData] AS (SELECT * FROM [IoTHubStream1])

SELECT *
INTO [Telemetry]
FROM [StreamData]

SELECT
    DeviceId,
    AVG (Humidity) AS [AverageHumidity],
    MIN(Humidity) AS [MinimumHumidity],
    MAX(Humidity) AS [MaxHumidity],
    5.0 AS TimeframeMinutes
INTO
    [TelemetrySummary]
FROM
    [StreamData]
WHERE
    [Humidity] IS NOT NULL
GROUP BY
    DeviceId, SlidingWindow (mi, 5)
```

ASA - Outputs

- Multiple options for storing output and viewing analysis results
  Route to one or more outputs
- Flexibility in the consumption and storage of the job output for data warehousing and other purposes

Available Outputs:

- SQL Database
- Blob Storage
- Event Hub
- Power BI
- Table Storage
- Service Bus Queues and Topics
- Document DB

Development SDKs

Microsoft

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)
  - Ubantu 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%

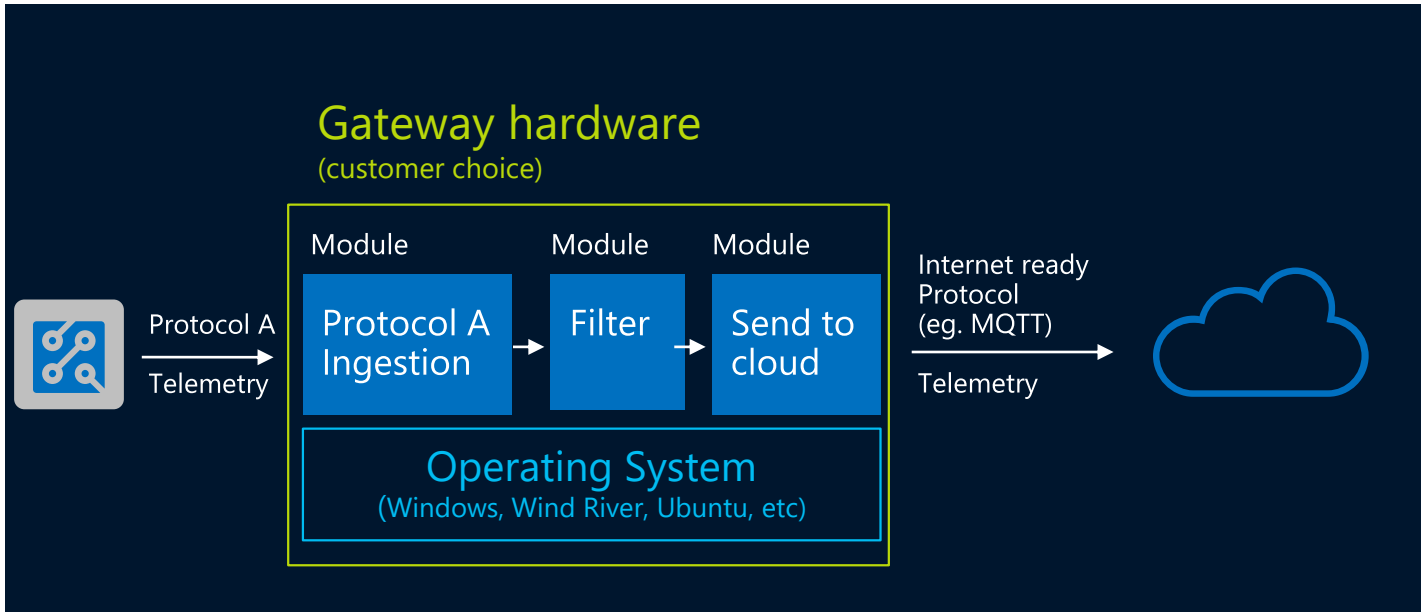
of IoT-created data will be stored, processed, analyzed and acted upon at the edge

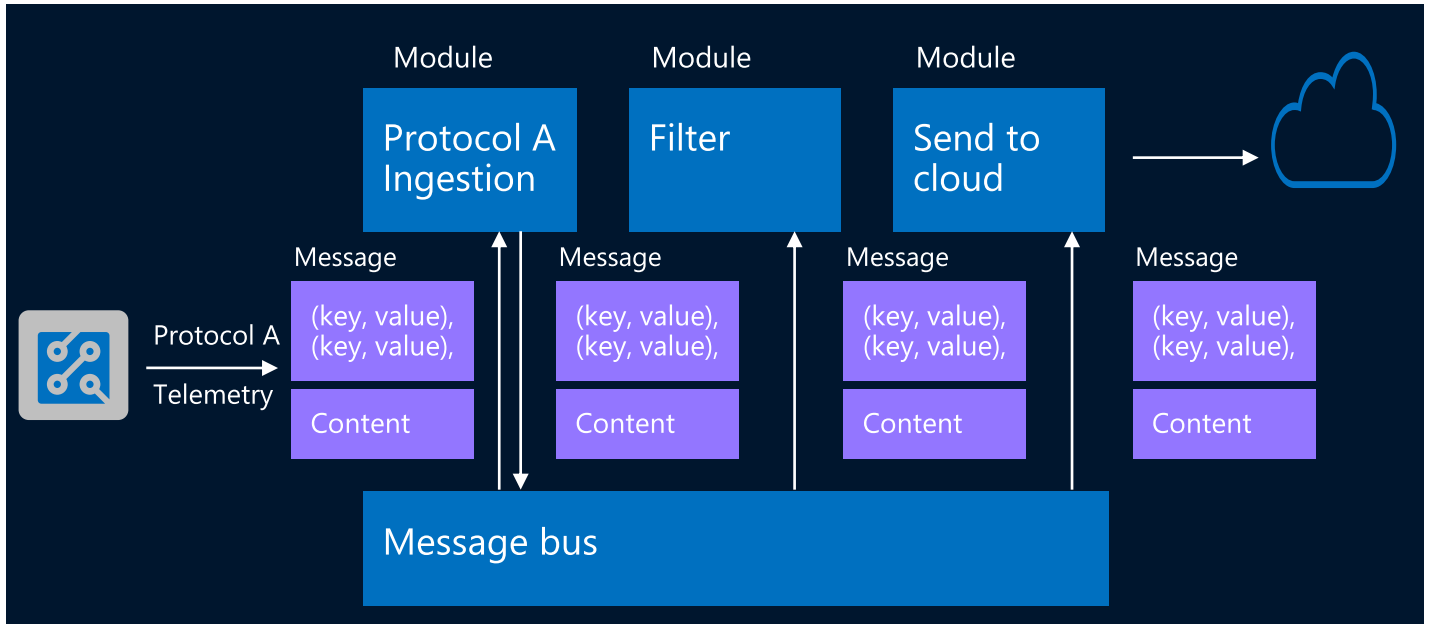
4

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

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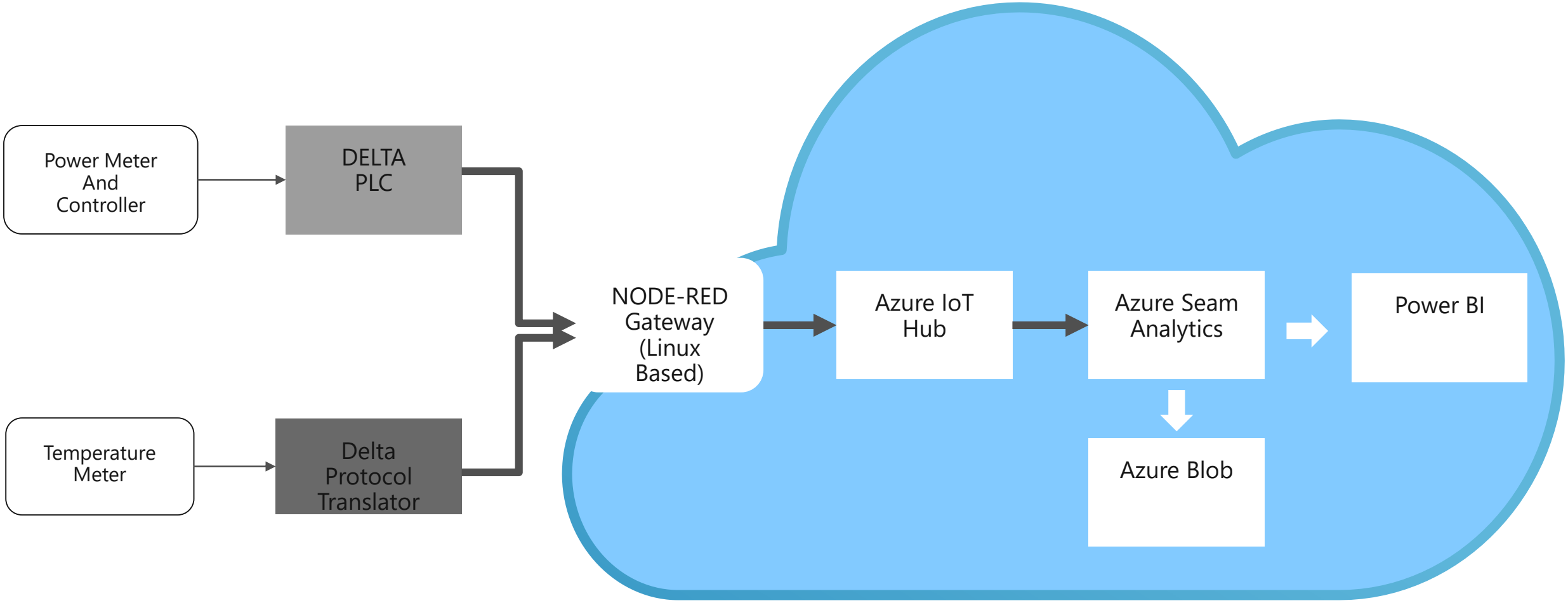
Module 2 (DEMO):
Using Node-RED as Gateway
(Quick Prototyping)

Microsoft

Architecture



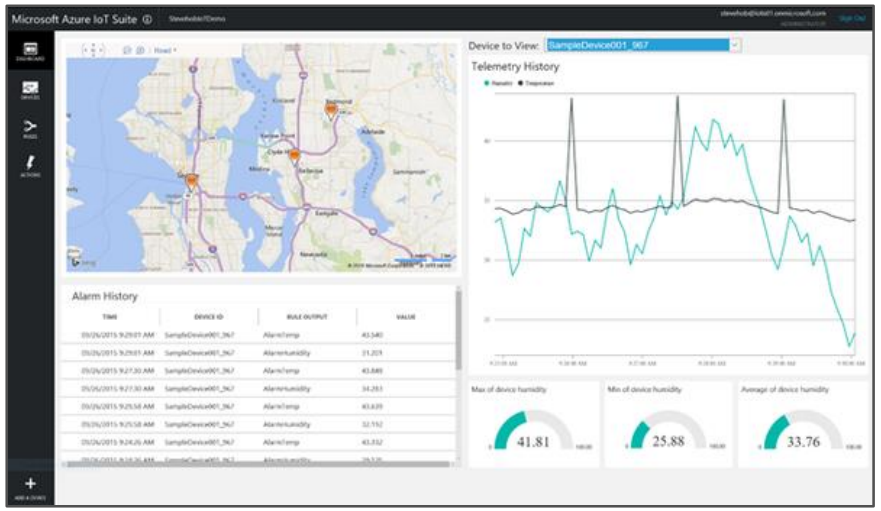
Module 3 (DEMO):
Azure IoT Suite: Remote Monitoring

Microsoft

Preconfigured Solutions

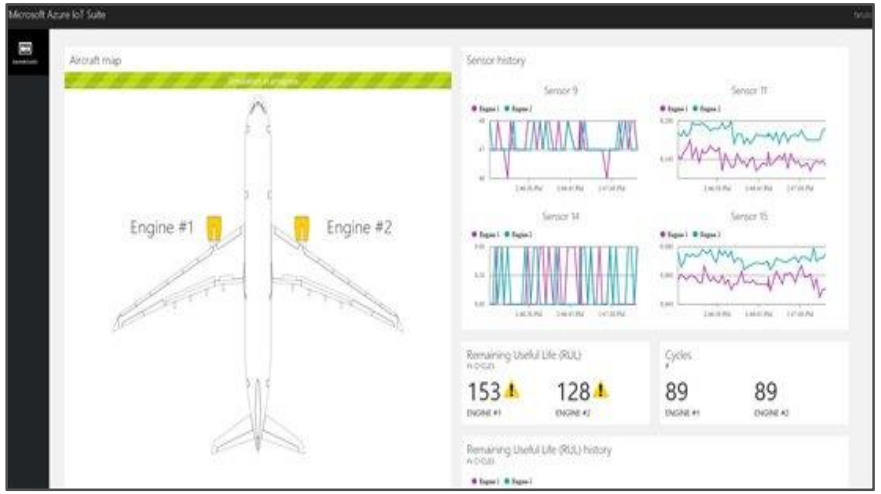
Remote Monitoring

- 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*

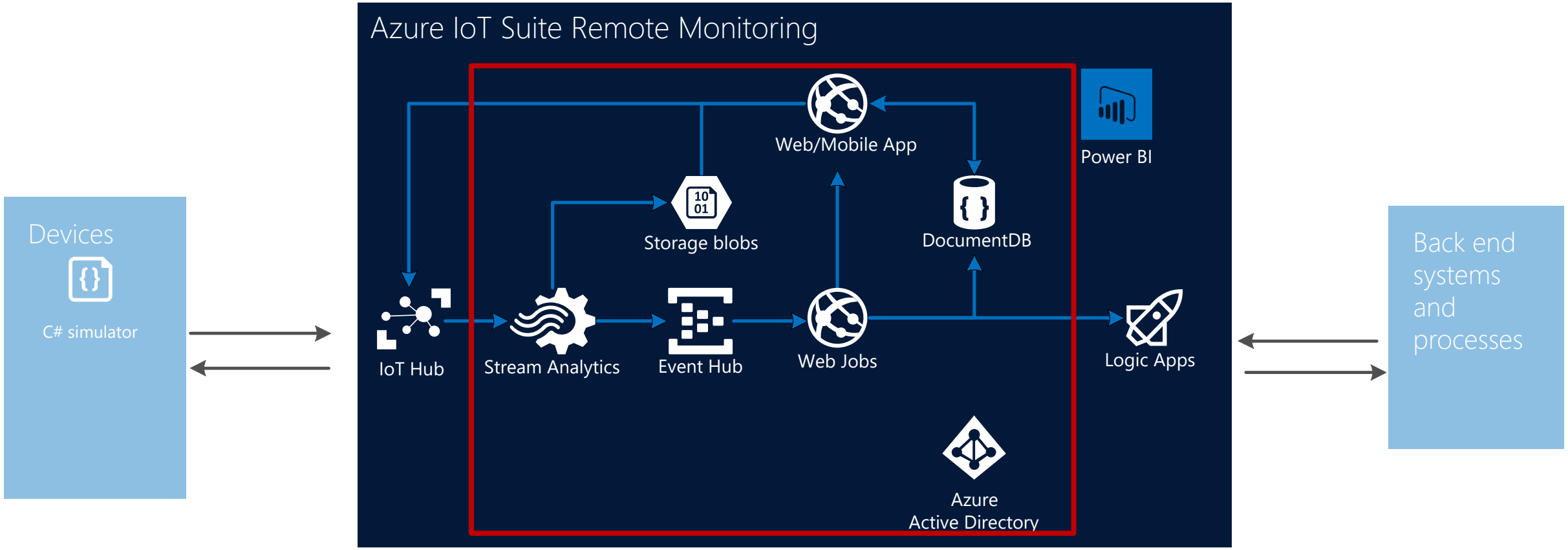


Predictive Maintenance

- 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



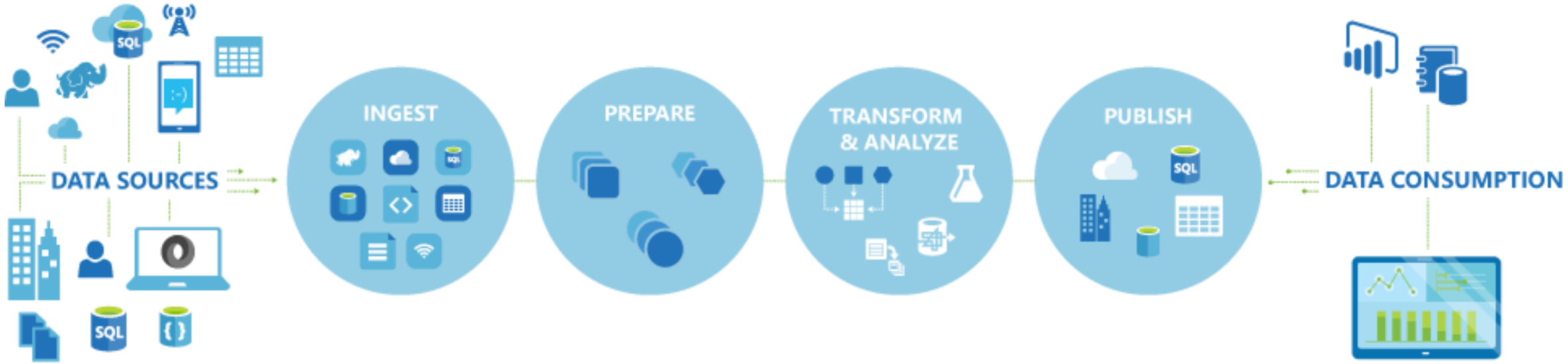
Solution Architecture



Module 4 (DEMO):
Data Management with Azure Data Factory

Microsoft

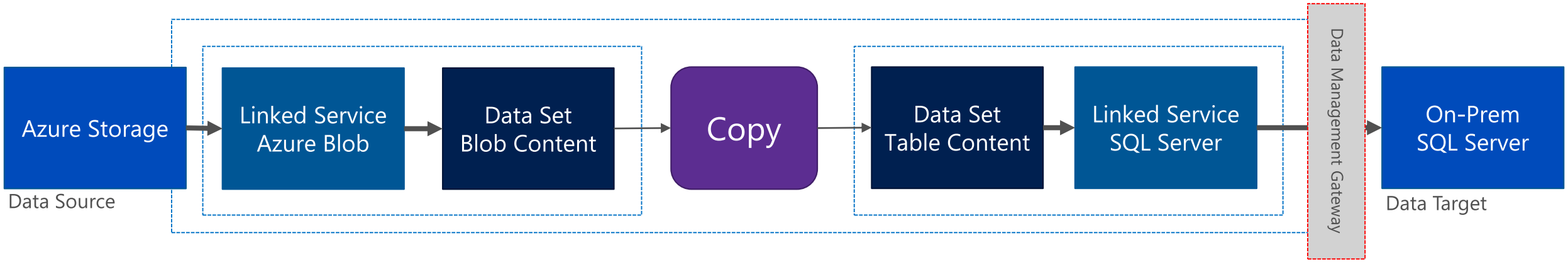
Azure Data Factory



A managed cloud service for building & operating data pipelines

Example (Cloud – OnPrem Scenario)

Copy telemetry data in Azure Blob Storage to SQL server table in on-prem over Data Management Gateway



- 1 x Linked Service to Azure Blob Storage (Source)
- 1 x Linked Service to SQL Server (via Gateway)
- 1 x Data Management Gateway
- 2 x Datasets (one to describe blob table, and the other for SQL table)
- 1 x Pipeline with a copy activity (to copy the data from point A to B)

Hands on Lab

Microsoft

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