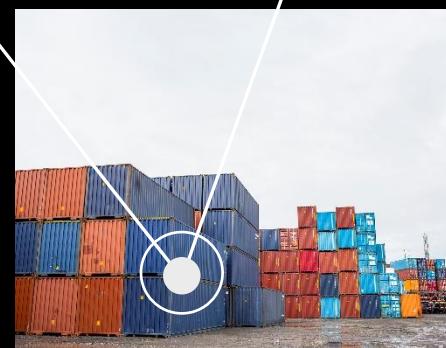
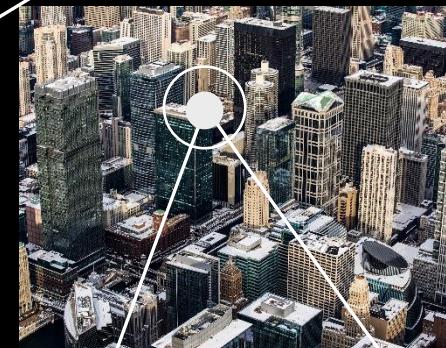
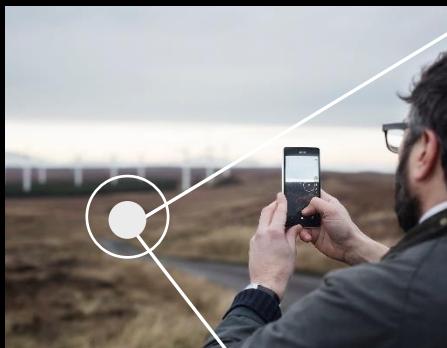


# Build end-to-end IoT solutions Work with Azure IoT Edge

Pamela Cortez  
Azure IoT



# Build end-to-end IoT solutions – Workshop Series

<https://aka.ms/IoT-online-workshop>



Transform your business with IoT



Devices and device communication



Device provisioning at scale



Messaging processing, analytics, and business integration



Work with Azure IoT Edge

# Work with Azure IoT Edge

## IoT Edge Overview & Features

---

AI on the Edge Overview

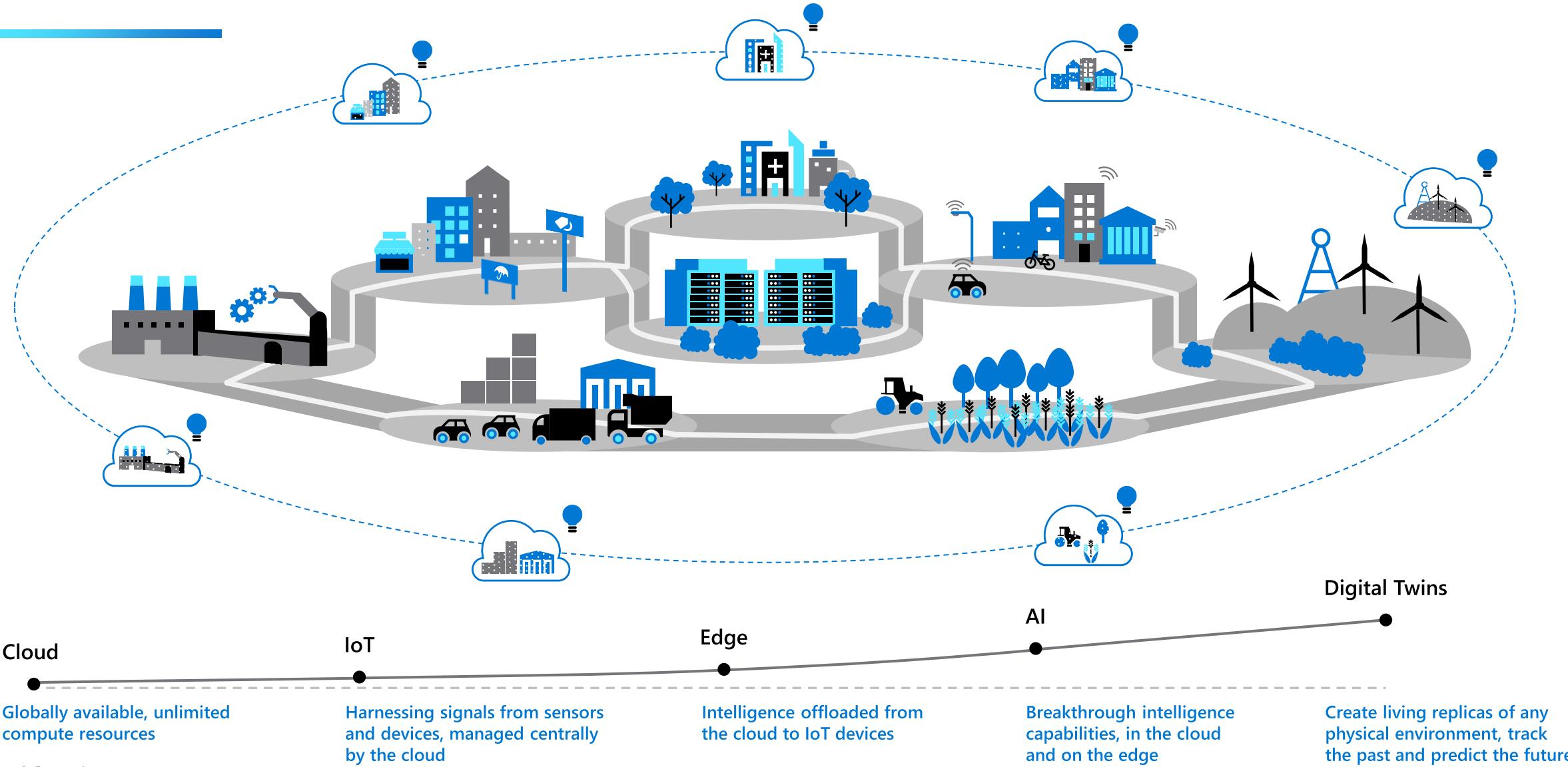
Tooling Support for IoT Edge

Lab:

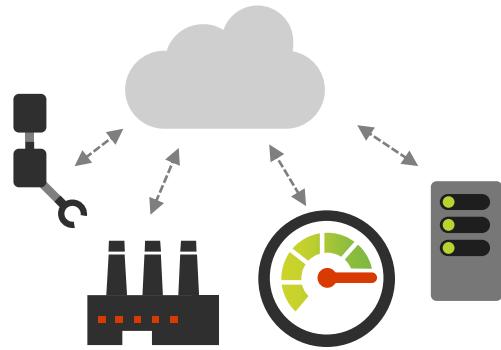
- Set up and deploy an IoT Edge Device
- Developer Modules
- Configure an IoT Edge device

Developer Resources & Getting started

# Innovations enabling new opportunities



# IoT in the Cloud and on the Edge

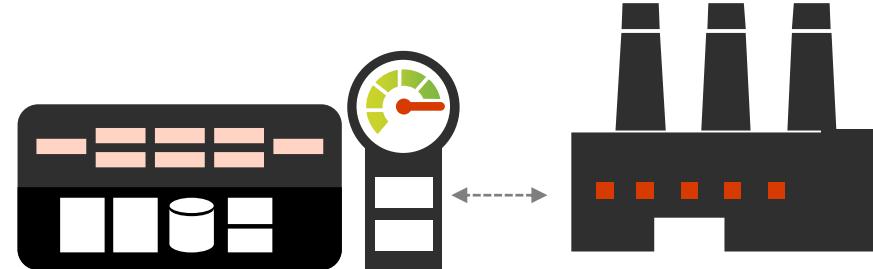


## IoT in the Cloud

Remote monitoring and management

Merging remote data from multiple IoT devices

Infinite compute and storage to *train machine learning* and other advanced AI tools



## IoT on the Edge

Offline operations (short and long term)

Privacy of data and protection of IP

Pre-process data on prem – E.g. video streams

Low latency tight control loops require near real-time response

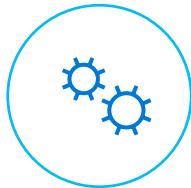
Protocol translation & data normalization

Consistency

# Challenges today create high barriers to entry



## Cloud barriers



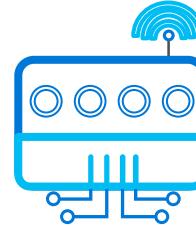
High volume of data collection sources



High cost of transporting data to the cloud



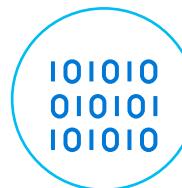
Limits to real-time insights



## Edge barriers



High developer skillset for hardware, cloud, edge

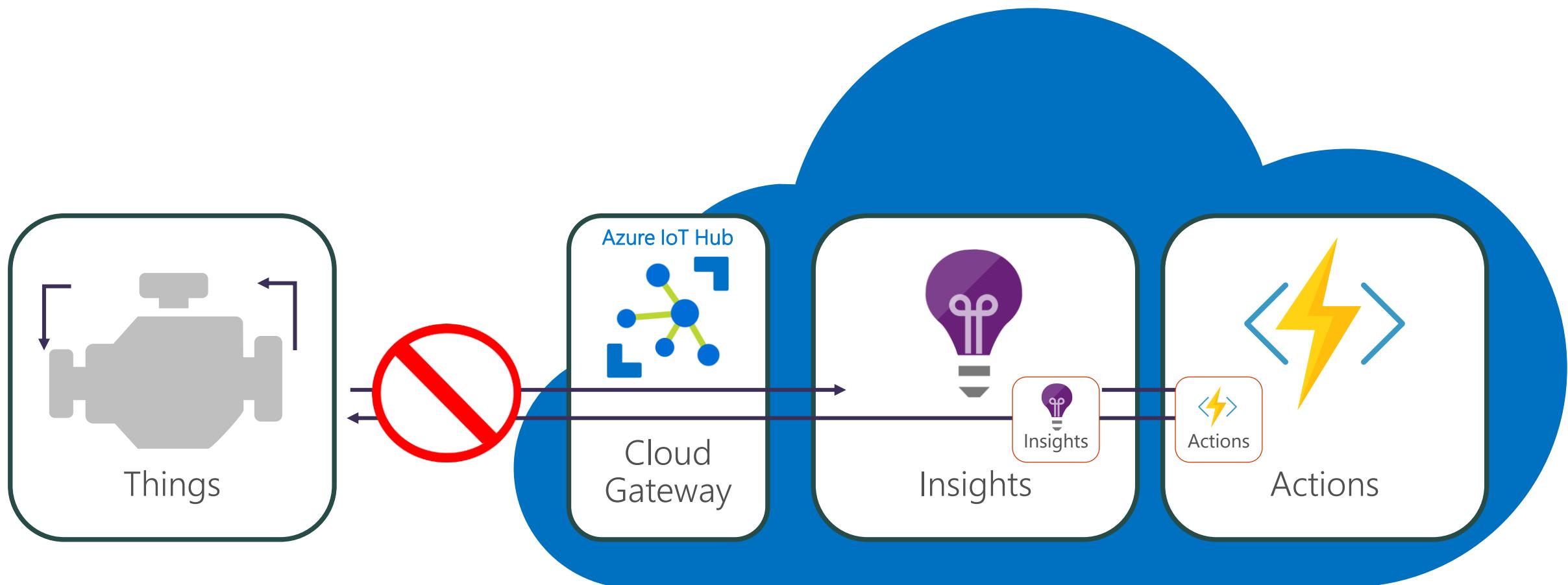


custom code for everything  
= No standardization

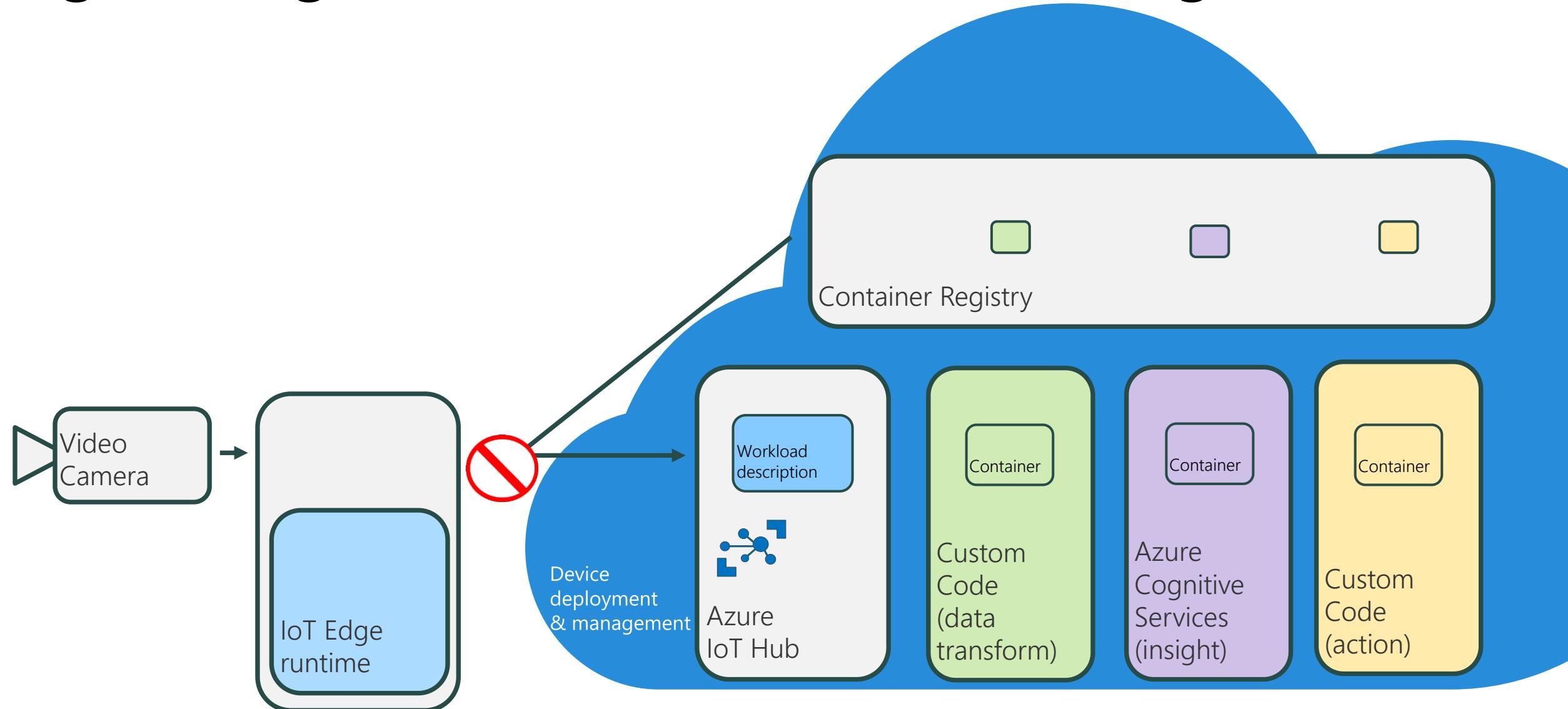


Manual set up and integration  
= Does not scale

# IoT application pattern + edge intelligence



# Edge intelligence enabled with Azure IoT Edge



# Azure IoT Edge features



## Open

Open source

Moby-based container runtime, compatible with Docker containers

Azure IoT Edge Marketplace for Edge modules



## Secure

Zero-touch provisioning of Edge devices at scale with Device Provisioning Service

Security framework provides end to end security and support for variety of hardware-based root of trust

Trusted computing via Open Enclave



## Intelligent

Services onboarded

- Azure Machine Learning
- Azure Stream Analytics
- Custom Vision & more
- Blob storage
- Nvidia Deepstream
- RedisEdge
- SQL Server on Edge
- Alleantia Industrial GW
- Aveva IoT Edge HMI
- Codit Nebulus
- Swim Enterprise
- ... and more in the marketplace



## Enterprise ready

Scaled deployments with Automatic Device Configuration Service

Use existing coding skills (C, C#, Node, Python, Java)

Development tooling in Visual Studio and VSCode

Multi-person development tools for CI/CD using VSTS

IoT Central integration - PP

# Microsoft IoT

Broadest portfolio

Industry Solutions



Manufacturing



Retail



Agriculture



Energy



Smart Cities



Healthcare



Transportation

IoT app services



Azure IoT Central



Dynamics Connected Field Service

Azure services for IoT

Azure IoT Hub

*Azure IoT Hub Device Provisioning Service*

Azure Digital Twins

Azure Time Series Insights

Azure Maps

Azure Security Center for IoT

Azure Stream Analytics

Azure Cosmos DB

Azure AI

Azure Cognitive Services

Azure ML

Azure Logic Apps

Azure Active Directory

Azure Monitor

Azure DevOps

Power BI

Azure Data Share

Azure Spatial Anchors

IoT & Edge Device Support

Azure RTOS

Azure Sphere

Azure IoT Device SDK

Azure IoT Edge

Azure Stack Edge

Windows IoT

Azure Certified for IoT—Device Catalog

Azure Stream Analytics

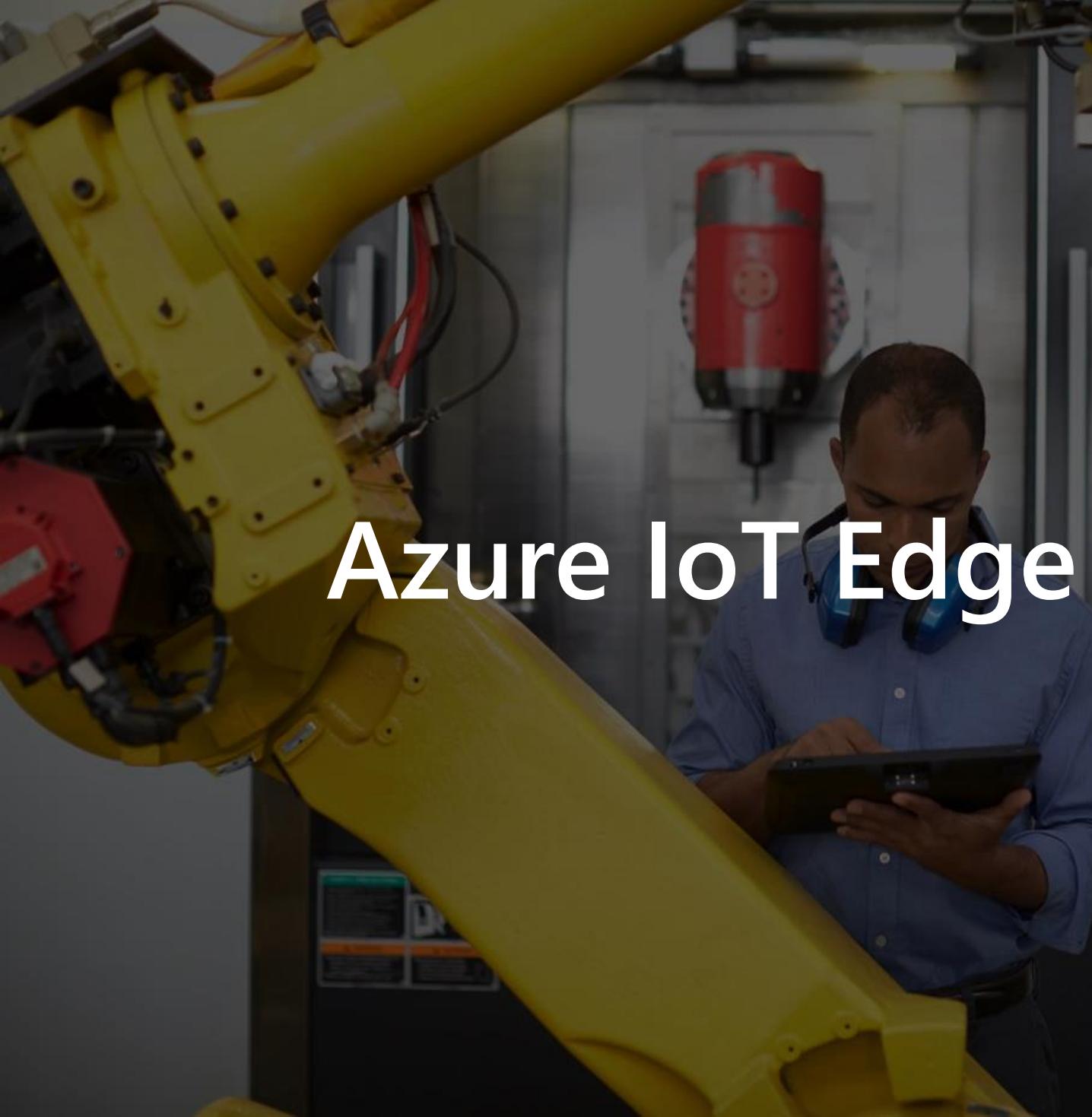
Azure Storage

Azure ML

Azure SQL

Azure Functions

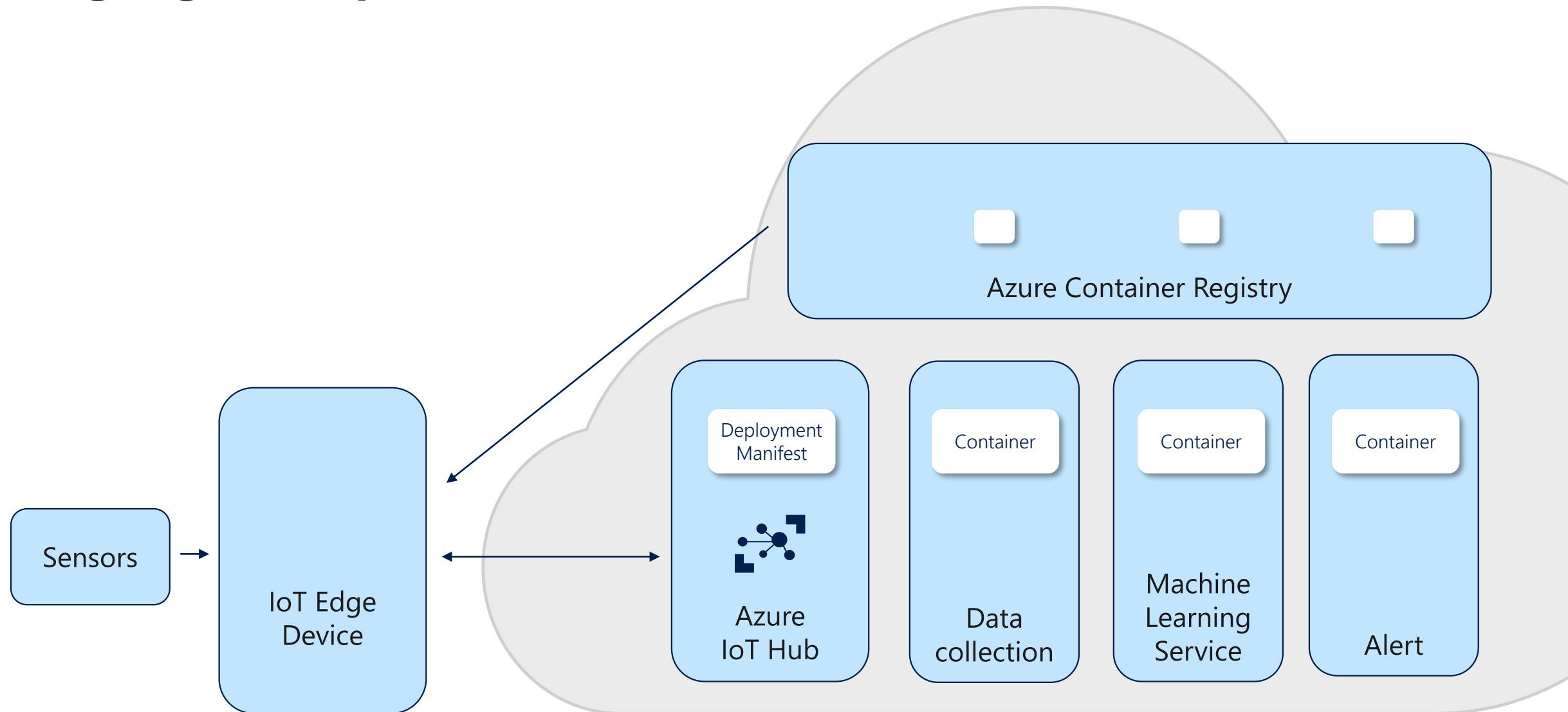
Azure Cognitive Services



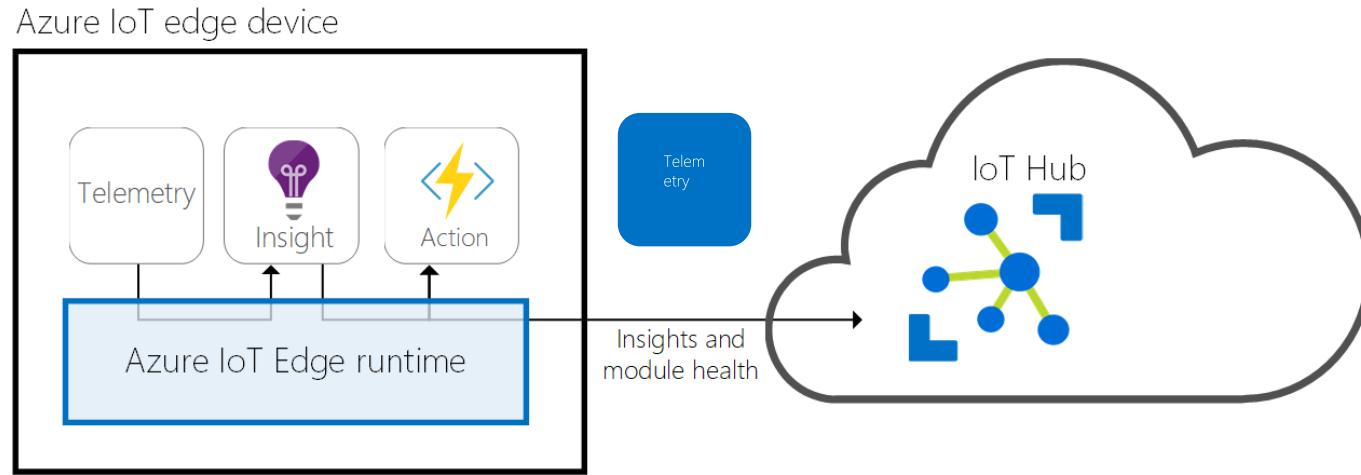
# Azure IoT Edge

- ⬇ Move cloud and custom workloads to the edge, securely
- 🚀 Seamless deployment of AI and advanced analytics
- 📈 Configure, update and monitor from the cloud
- 🎯 Compatible with popular operating systems
- 🔄 Code symmetry between cloud and edge for easy development and testing
- 🔒 Secure solution from chipset to cloud

# Bringing Compute Where The Data Is



# IoT Edge Runtime

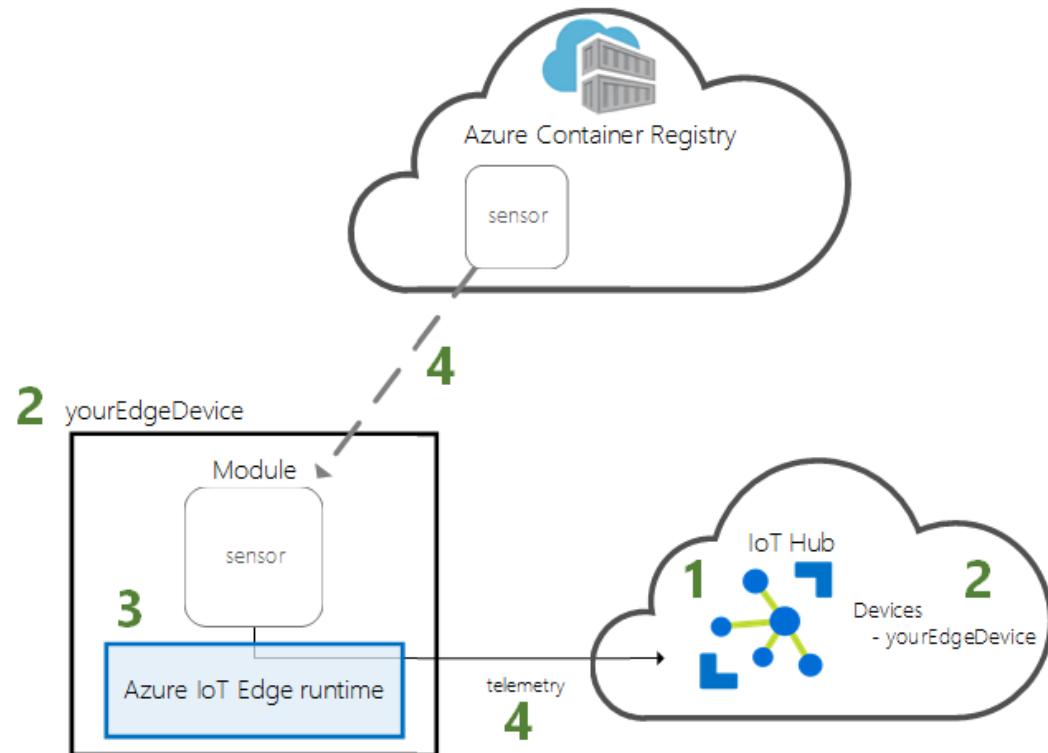


- Installs and updates workloads on the device.
- Maintains Azure IoT Edge security standards on the device.
- Ensures that IoT Edge modules are always running.
- Reports module health to the cloud for remote monitoring.
- Facilitates communication between downstream leaf devices and the IoT Edge device.
- Facilitates communication between modules on the IoT Edge device.
- Facilitates communication between the IoT Edge device and the cloud

# IoT Edge Runtime: System Modules

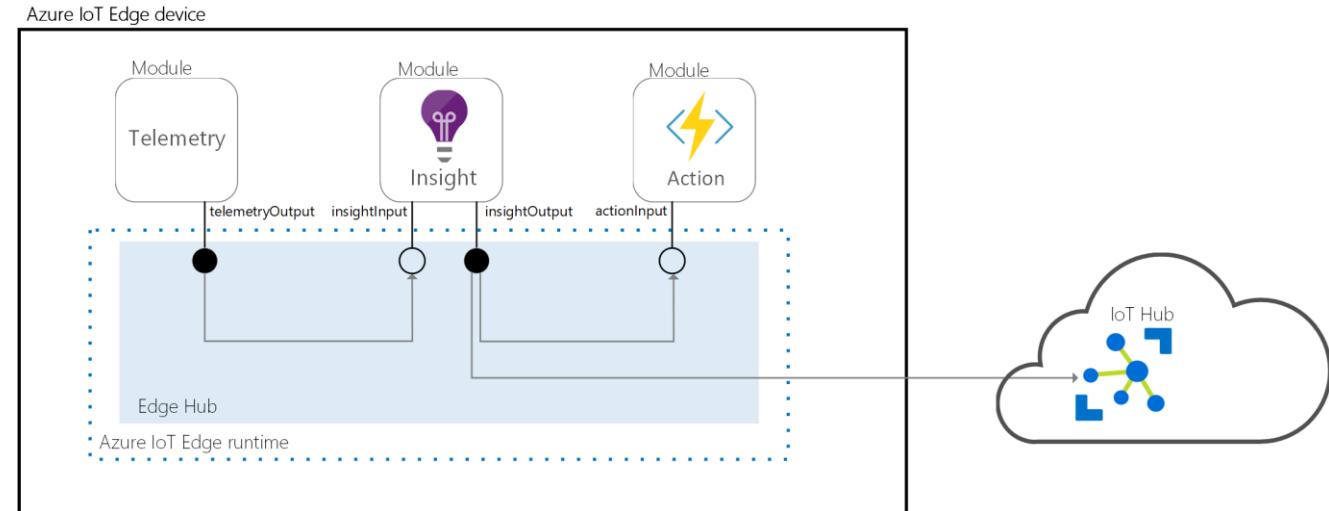
edge-agent:

Deployment & Container orchestration  
Ensures module uptime

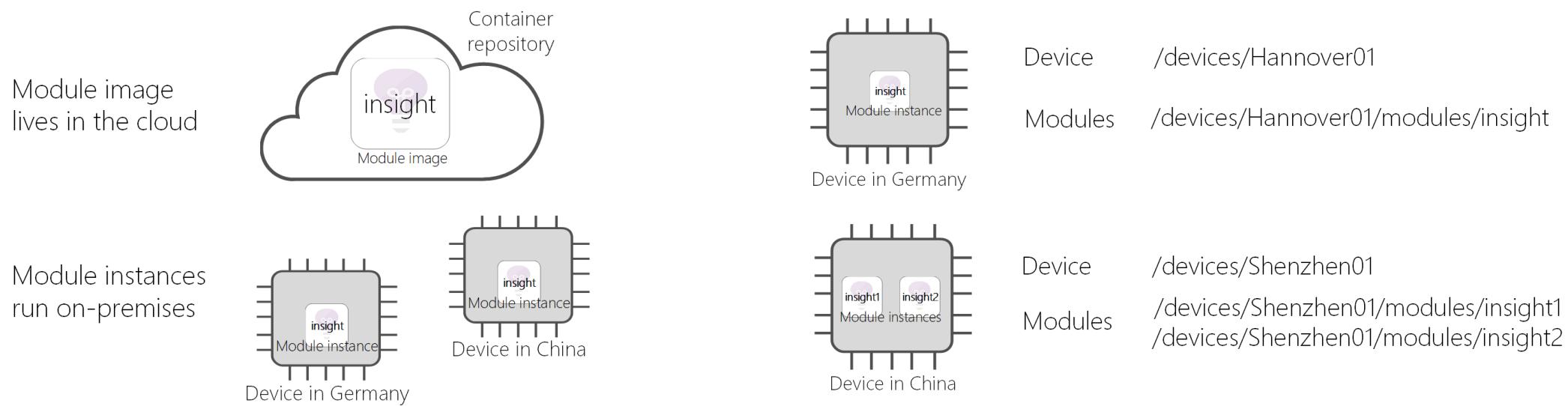


edge-hub:

Communication to/from Azure IoT Hub  
Inter-module communication



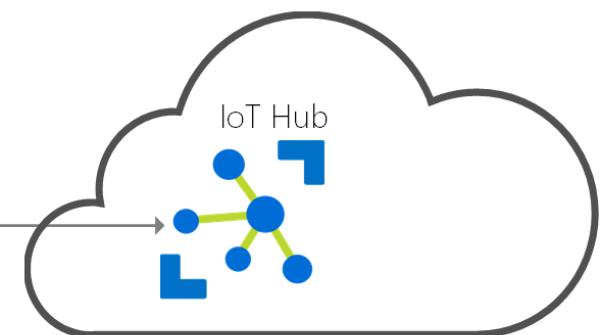
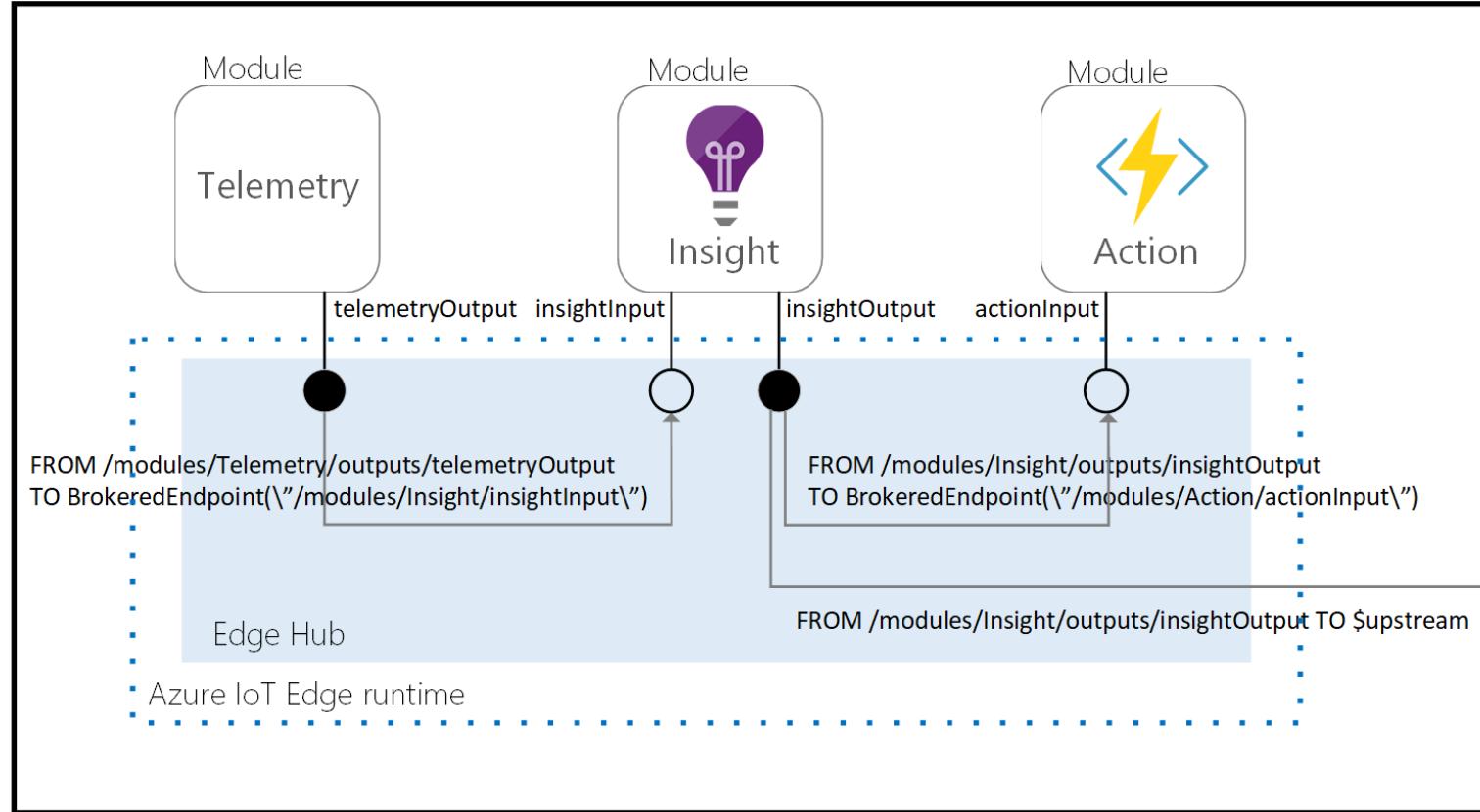
# Concept – Module



- A **module image** is a package containing the software that defines a module.
- A **module instance** is the specific unit of computation running the module image on an IoT Edge device. The module instance is started by the IoT Edge runtime.
- A **module identity** is a piece of information (including security credentials) stored in IoT Hub, that is associated to each module instance.
- A **module twin** is a JSON document stored in IoT Hub, that contains state information for a module instance, including metadata, configurations, and conditions.
- SDKs to develop custom modules in multiple languages (C#, C, Python, Java, Node.JS)

# Communication Patterns - Routing

Azure IoT Edge device



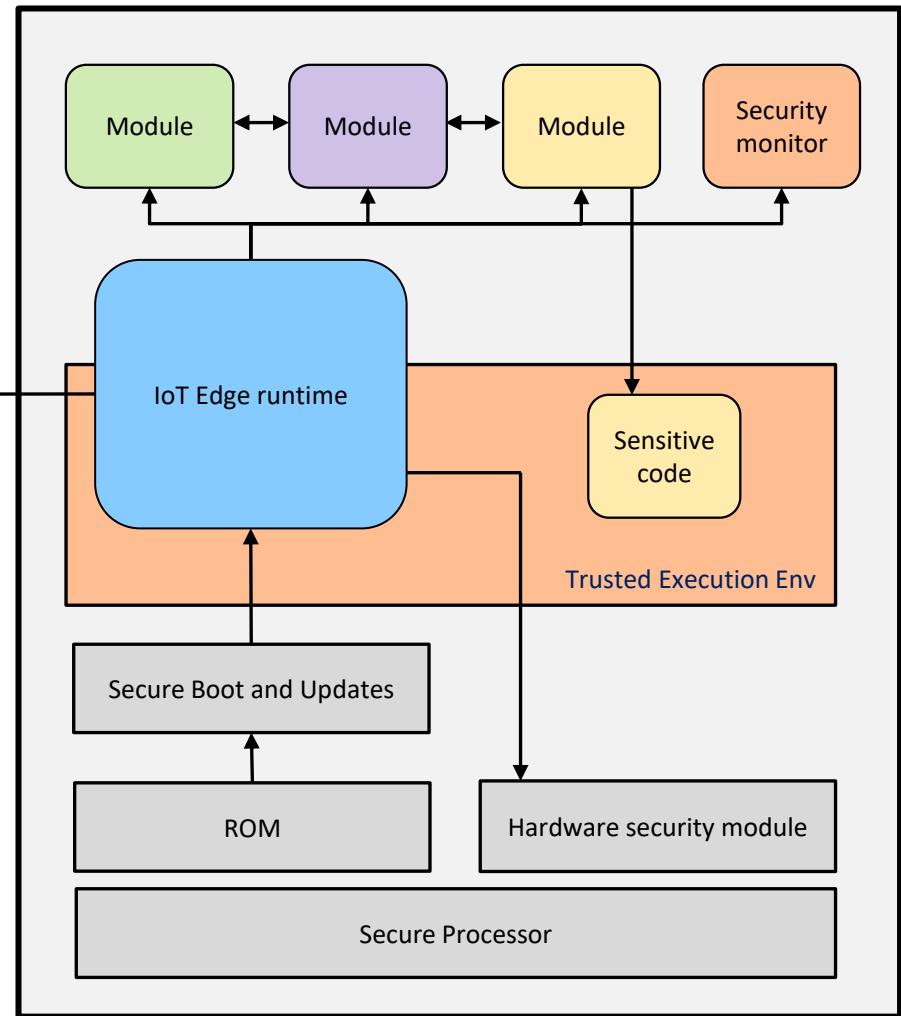
`FROM <source> WHERE <condition> INTO <sink>`

# Azure IoT Edge security

Security is critical for IoT devices

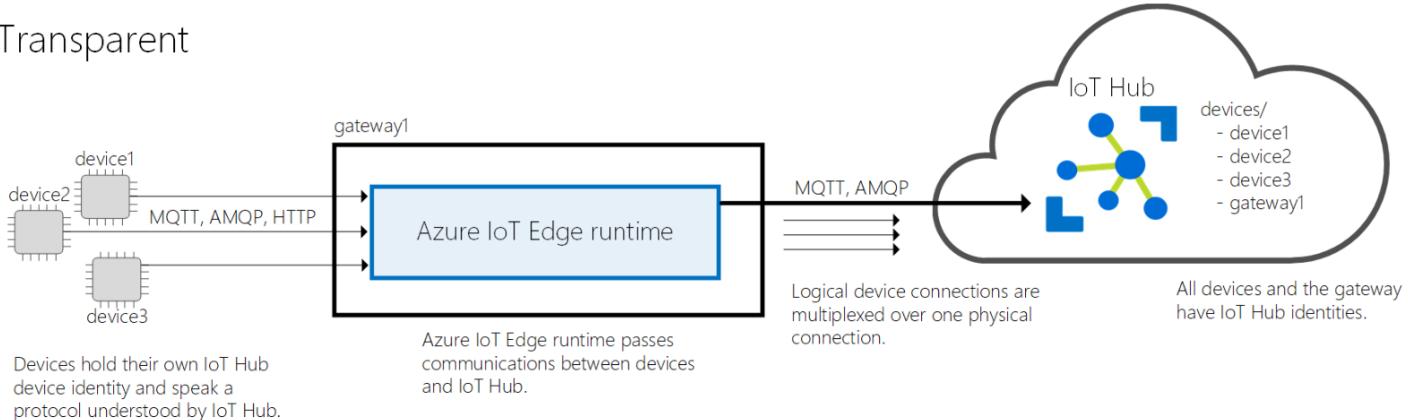
Azure IoT Edge has an industry leading security framework

- Secure boot
- Secret storage
- Correct workload
- Encrypted communication
- Secure execution (public preview)
- Security monitoring

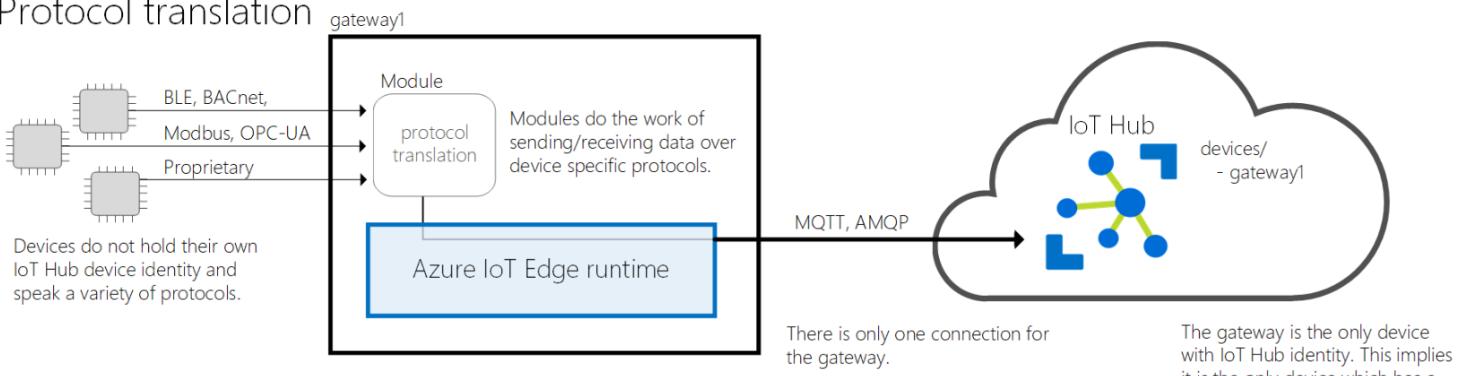


# Azure IoT Edge as a Gateway (Patterns)

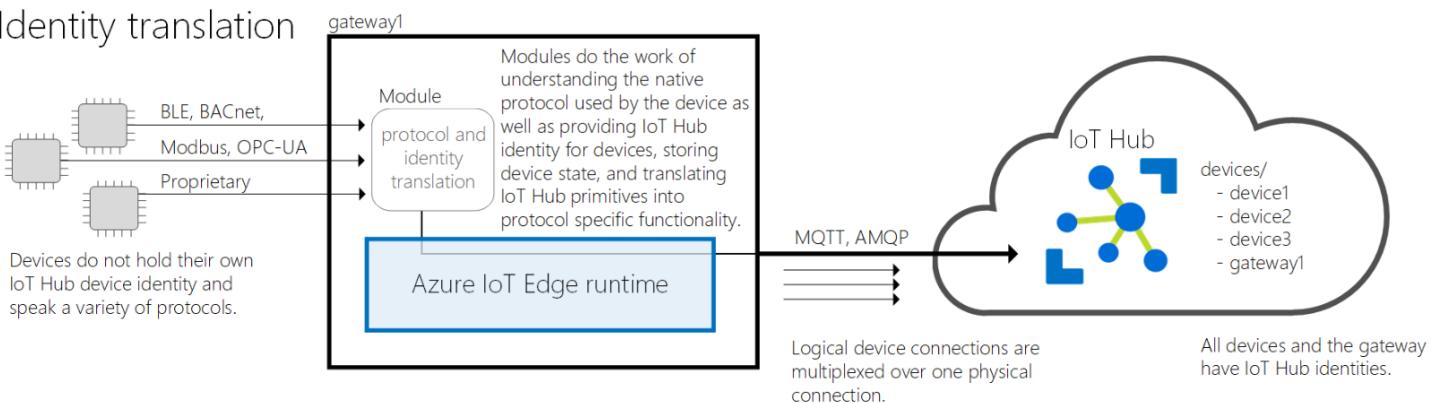
Transparent



Protocol translation



Identity translation



# Enabling intelligent edge spectrum



## Azure IoT Edge requirements

Hardware sizing depends on workload

Flexible architecture – ARM or AMD64

Linux and Windows

- Moby-compatible container runtime

# Two ecosystem programs

For ISVs: module marketplace

The screenshot shows the Microsoft Azure Marketplace interface. At the top, there's a navigation bar with links like Overview, Solutions, Products, Documentation, Pricing, Training, Marketplace, Partners, Support, Blog, and More. Below the navigation is a search bar labeled "Search Marketplace". The main area is titled "Browse apps" and features a grid of module cards. One card for "Sentiment Analysis Container – Azure Cognitive Services" is highlighted. Other cards include "Unsupervised Anomaly Detection Module", "AI Vision Dev Kit Get Started Module", "Nebulus UDP Receiver", "Azure Security Center for IoT", "NVIDIA DeepStream SDK", "RedisEdge", and "Simulated Temperature Sensor". Each card includes a "Get it now" button and a heart icon.

For ODMs: device catalog

The screenshot shows the Microsoft Azure Certified for IoT device catalog. The top header says "Azure Certified for IoT device catalog - Preview" and features a "Certified" badge. Below the header is a banner with the text "Find your IoT device" and "Certified IoT devices and starter kits tailored to your needs". There's a search bar and buttons for "Become a Partner" and "Learn More". The main content area displays a grid of certified IoT devices and starter kits. The grid includes columns for device type, name, and manufacturer. Examples shown include the Azure IoT Edge (Edge Certified/Edge Capable), Azure IoT Starter Kit (CEC1x02DevBoard), Azure IoT Starter Kit (Industrial IoT Starter Kit), Azure IoT Starter Kit (Grove Starter Kit for Azure IoT Edge), Azure IoT Starter Kit (teXXmo IoT Button), Azure IoT Starter Kit (ARK-1123H), Azure IoT Starter Kit (M5Stack IoT kit), and Azure IoT Starter Kit (MXChip IoT DevKit). Each item has a small image and some descriptive text.

# Azure IoT Central Edge Features

Manage IoT Edge devices, deploy edge software modules, publish insights, and take actions at-scale – all from within IoT Central



## Azure IoT Edge device provisioning & connectivity

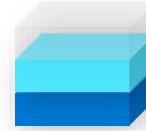
Group Enrollments

Symmetric Key  
X.509 Certs



Individual Enrollments

Symmetric Key  
X.509 Certs  
TPM



## Azure IoT Edge Device Management



Module Management and Edge deployments



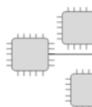
Module Telemetry ingestion and command & control



Per Module visualization & insights



Module based rules & triggered actions

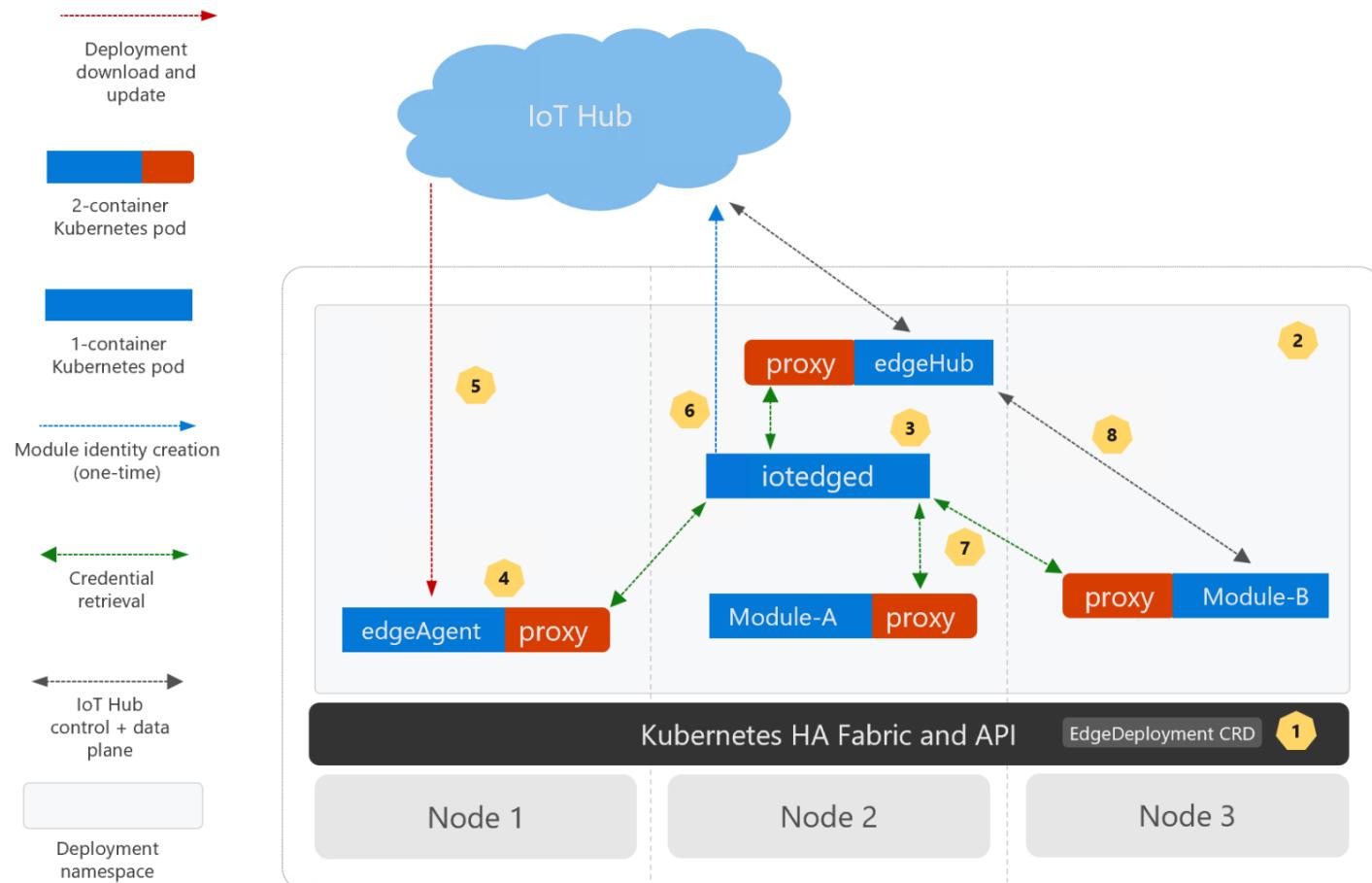


Device Relationships

*Public preview feature:*

# Deploy IoT Edge workloads on Kubernetes

- Adds hardware failure resilience to IoT Edge deployments by leveraging Kubernetes platform features
- Manage applications from IoT Hub with the same familiar app model
- Automatic translation to Kubernetes native application model (pods, services, deployments...)
- Cluster can be shared by the multiple edge devices



Learn more: [aka.ms/iotedge-on-kubernetes](http://aka.ms/iotedge-on-kubernetes)

# Built-in troubleshooting tool

```
[osboxes@osboxes ~]$ sudo iotedge check
Configuration checks
✓ config.yaml is well-formed
✓ config.yaml has well-formed connection string
✓ container engine is installed and functional
✓ config.yaml has correct hostname
✓ config.yaml has correct URIs for daemon mgmt endpoint
✓ latest security daemon
✓ host time is close to real time
✓ container time is close to host time
!! DNS server
    Container engine is not configured with DNS server setting, which may impact connectivity to IoT Hub.
    Please see https://aka.ms/iotedge-prod-checklist-dns for best practices.
    You can ignore this warning if you are setting DNS server per module in the Edge deployment.
!! production readiness: certificates
    Device is using self-signed, automatically generated certs.
    Please see https://aka.ms/iotedge-prod-checklist-certs for best practices.
✓ production readiness: certificates expiry
✓ production readiness: container engine
!! production readiness: logs policy
    Container engine is not configured to rotate module logs which may cause it run out of disk space.
    Please see https://aka.ms/iotedge-prod-checklist-logs for best practices.
    You can ignore this warning if you are setting log policy per module in the Edge deployment.

Connectivity checks
✓ host can connect to and perform TLS handshake with IoT Hub AMQP port
✓ host can connect to and perform TLS handshake with IoT Hub HTTPS port
✓ host can connect to and perform TLS handshake with IoT Hub MQTT port
✓ container on the default network can connect to IoT Hub AMQP port
✓ container on the default network can connect to IoT Hub HTTPS port
✓ container on the default network can connect to IoT Hub MQTT port
✓ container on the IoT Edge module network can connect to IoT Hub AMQP port
✓ container on the IoT Edge module network can connect to IoT Hub HTTPS port
✓ container on the IoT Edge module network can connect to IoT Hub MQTT port
✓ Edge Hub can bind to ports on host

One or more checks raised warnings. Re-run with --verbose for more details.
[osboxes@osboxes ~]$
```

Configuration checks

Production readiness

Connectivity checks

# Work with Azure IoT Edge

**IoT Edge Overview & Features**

**AI on the Edge Overview**

---

**Tooling Support for IoT Edge**

**Lab:**

- Set up and deploy an IoT Edge Device
- Developer Modules
- Configure an IoT Edge device

**Developer Resources & Getting started**

# Time Series

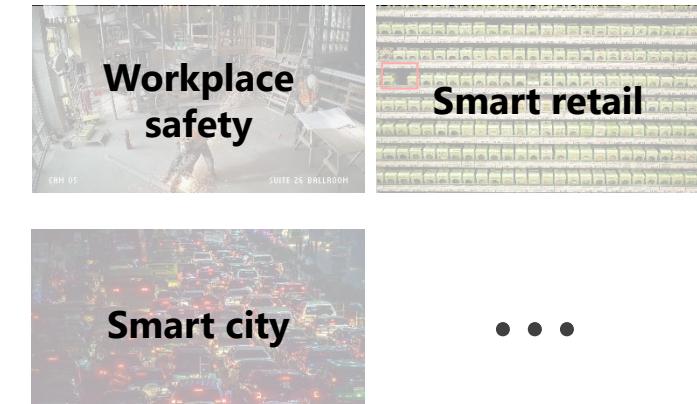
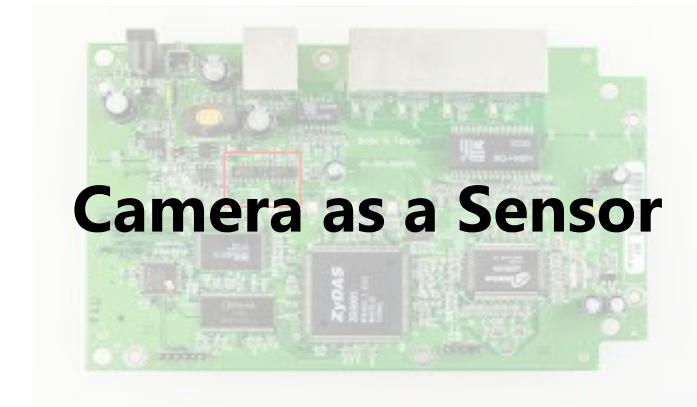


**Asset configuration**

# Sound



# Vision



• • •

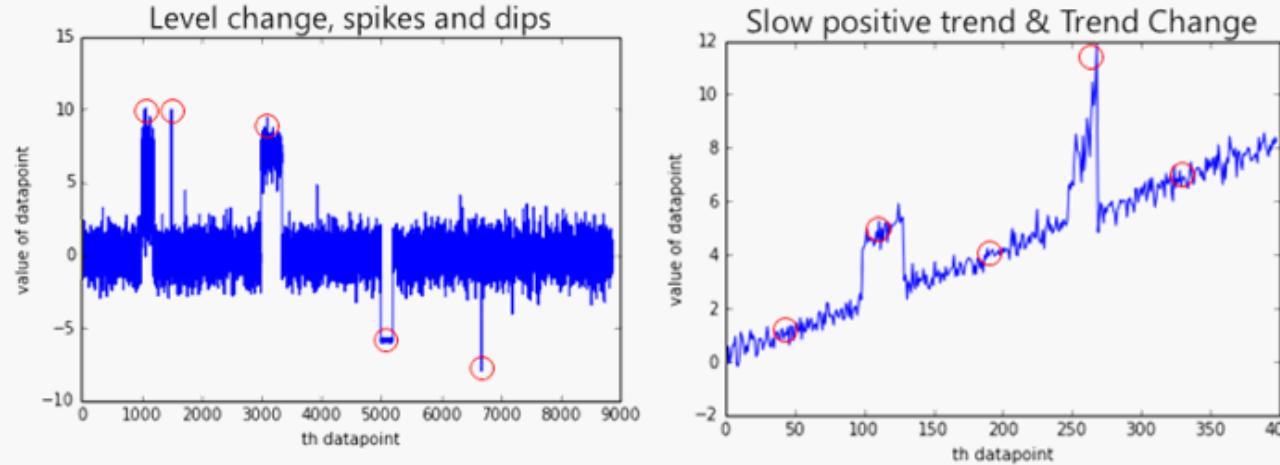
# Time Series AI



# Use ASA / SQL DB Edge for out-of-the-box time series AI

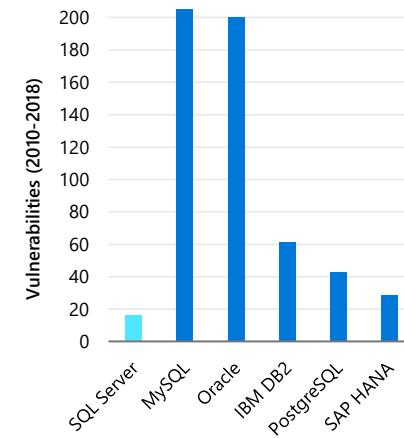
## Azure Stream Analytics

- Unsupervised models for inline learning and real-time scoring
- Easily invoked with simple function calls within query language
- 5 types of anomalies detected: Spikes and Dips, Slow positive/negative trend, Bi-level change



## SQL Database Edge - Preview

- Choice of platform (Linux, Windows on ARM64, x64)
- Time-series built-in
- AI built-in (Python, R, Spark, Java)
- Turn-key management
- Unparalleled performances and security



Vision AI



# In IoT Computer Vision is about converting Cameras into Sensors

## Retail



## Industrial



## Smart spaces



# Worker Health and Safety for Construction and Manufacturing

## Challenge

Difficult to enforce worker safety protocols leading to avoidable injuries and deaths

## Solution

People detection and tracking combined with object detection identify unsafe conditions to enable better enforcement of safety protocols



# Several pre-built AI containers from Cognitive Services



Custom Vision

*Image Classification  
+ Object Detection*



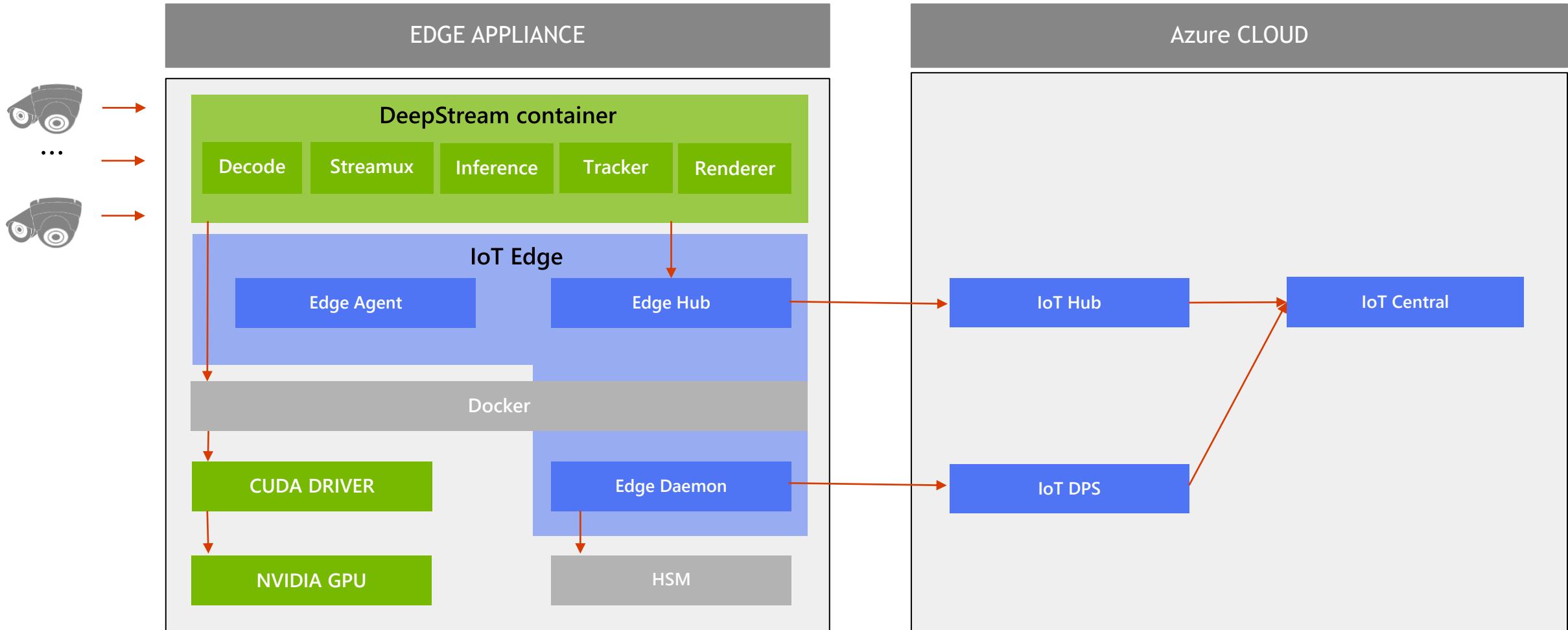
Face detection  
& Face recognition



Text recognition

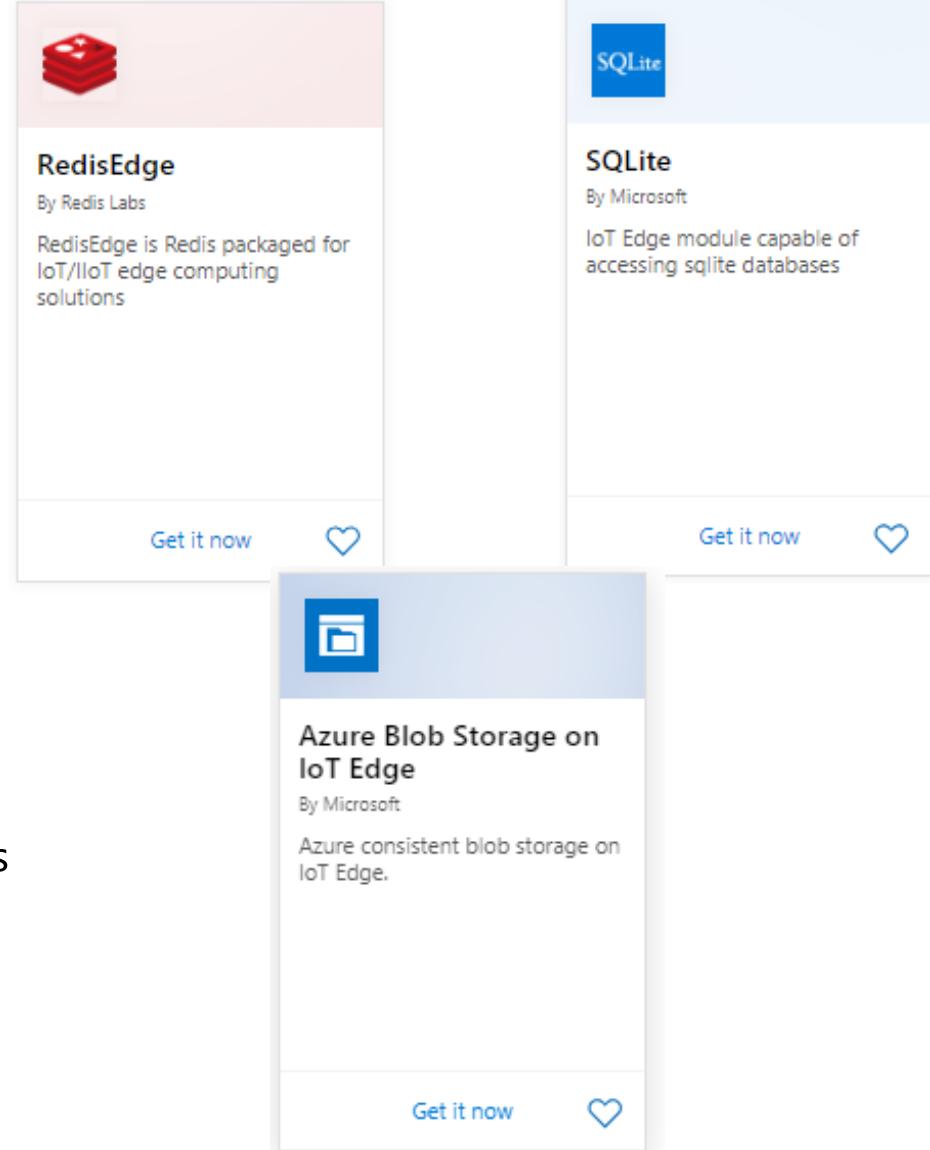
<http://aka.ms/visioncontainerspreview>

# Azure IoT Edge + NVIDIA DeepStream



# Managing your data

- Telemetry (AI model output):
  - Store and forward upstream via the IoT Edge runtime
  - Store and query locally with a database from the Azure IoT Edge marketplace. For instance, Redis, SQLite or SQL server.
- Large files (images, videos):
  - Use a local blob store (same REST API as the cloud)
    - Blob store has auto-tiering and auto-purging capabilities
    - Blob store includes store and forward for intermittent connections
  - Use a storage gateway like Databox Edge
    - It already syncs your data



# Work with Azure IoT Edge

**IoT Edge Overview & Features**

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---

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# Azure IoT Tooling support



## Visual Studio

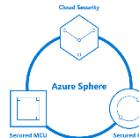


### Azure IoT Hub support in Cloud Explorer



### Azure IoT Edge Tools - Preview

Microsoft | 942 installs | 1.646 downloads | ★★★★★ (2)  
Support to develop, debug and deploy Azure IoT Edge Modules.



### Azure Sphere Tools for VS



### Connected Service for Azure IoT Hub

Microsoft | 6,616 installs | 10,847 downloads | ★★★★★ (1)  
Allows developers to connect to Azure IoT Hub easily and with step-by-step guid.



## Visual Studio Code



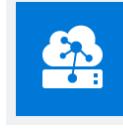
### Azure IoT Tools

Microsoft | 984 installs | 990 downloads | ★★★★★ (1)  
The ultimate collection of extensions for working with Azure IoT in VS Code!



### Azure IoT Hub Toolkit

Microsoft | 58,176 installs | 280,343 downloads | ★★★★★ (5)  
Interact with Azure IoT Hub, IoT Device Management, IoT Edge Management, IoT Hub Simulation, IoT Hub Code Generation



### Azure IoT Edge

Microsoft | 28,756 installs | 145,630 downloads | ★★★★★ (6)  
Develop, deploy, debug, and manage your IoT Edge solution



### Azure IoT Device Workbench

Microsoft | 7,429 installs | 25,104 downloads | ★★★★★ (3)  
Integrated environment to enable easy development on IoT prototype devices (e.g. DevKit, teXXmo IoT Button, ESP32 and Raspberry Pi) with multiple Azure services.



### Arduino

Microsoft | 203,980 installs | 766,018 downloads | ★★★★★ (33)  
Arduino for Visual Studio Code

## IoT DevOps



### IoT Edge tasks for Azure Pipelines



### IoT Edge Jenkins plugin



### Azure DevOps project for IoT Edge

## Azure IoT CLI Extension

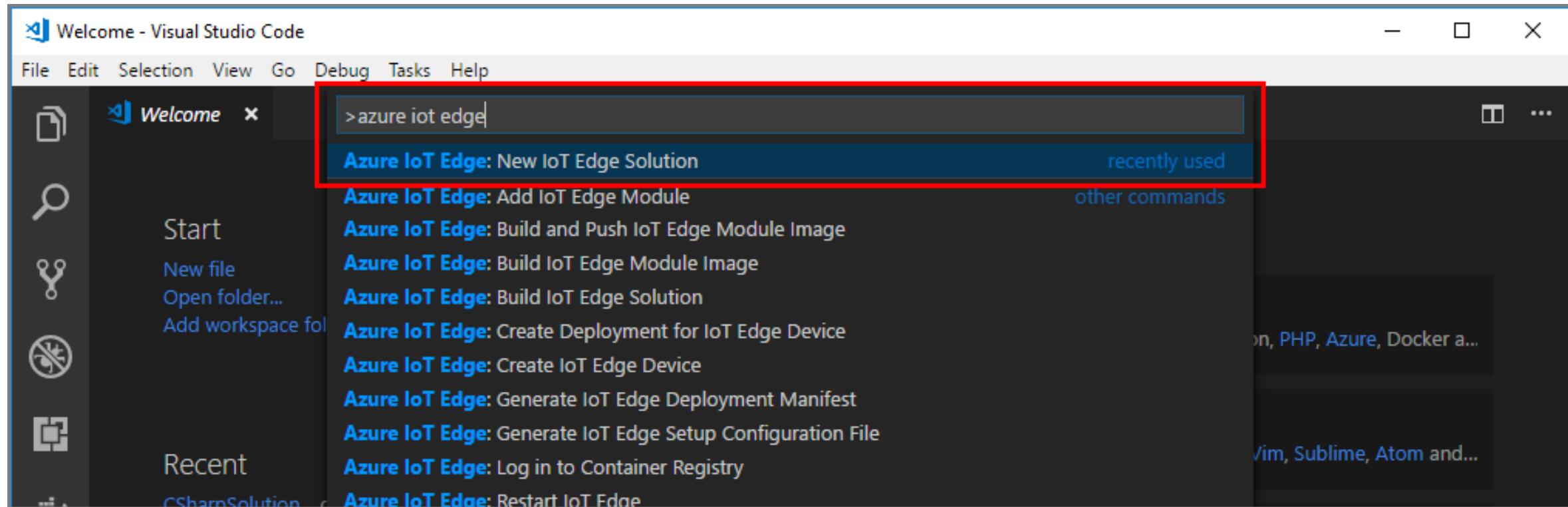


### iotedgedev CLI Tool



### iotz

# Develop Custom Modules with VS Code



# Work with Azure IoT Edge

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**Lab:**

---

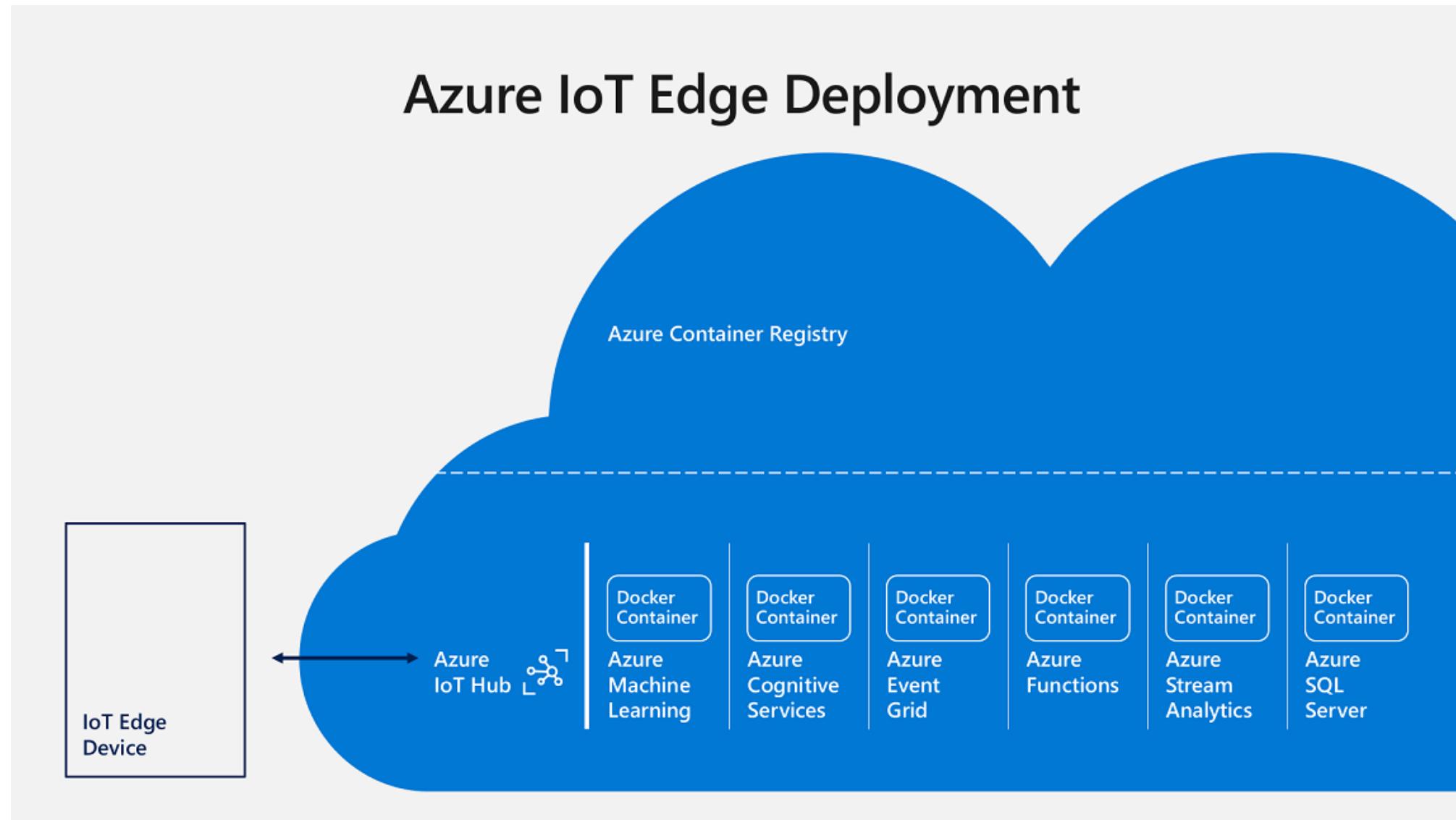
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**Developer Resources & Getting started**

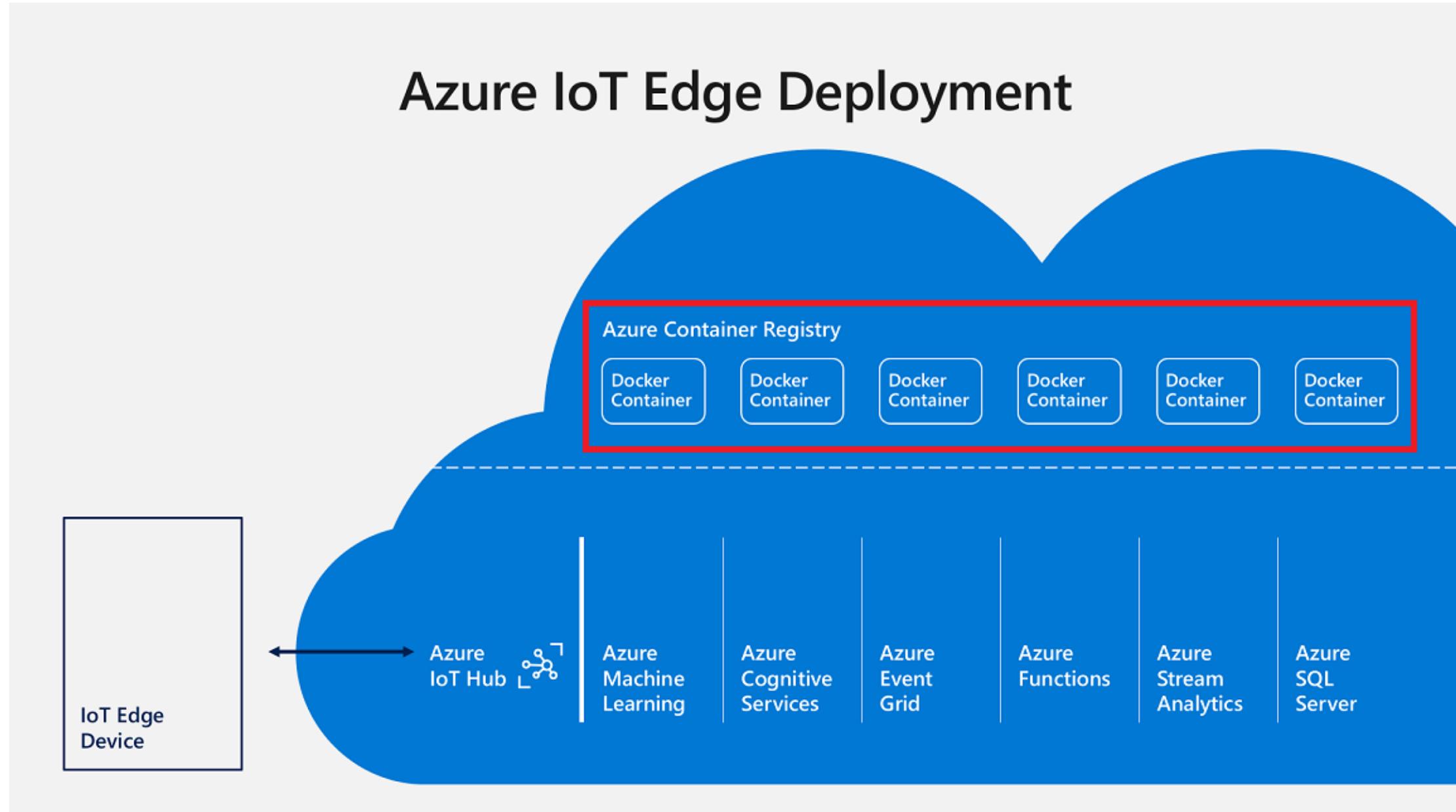
# Azure IoT Edge Deployment



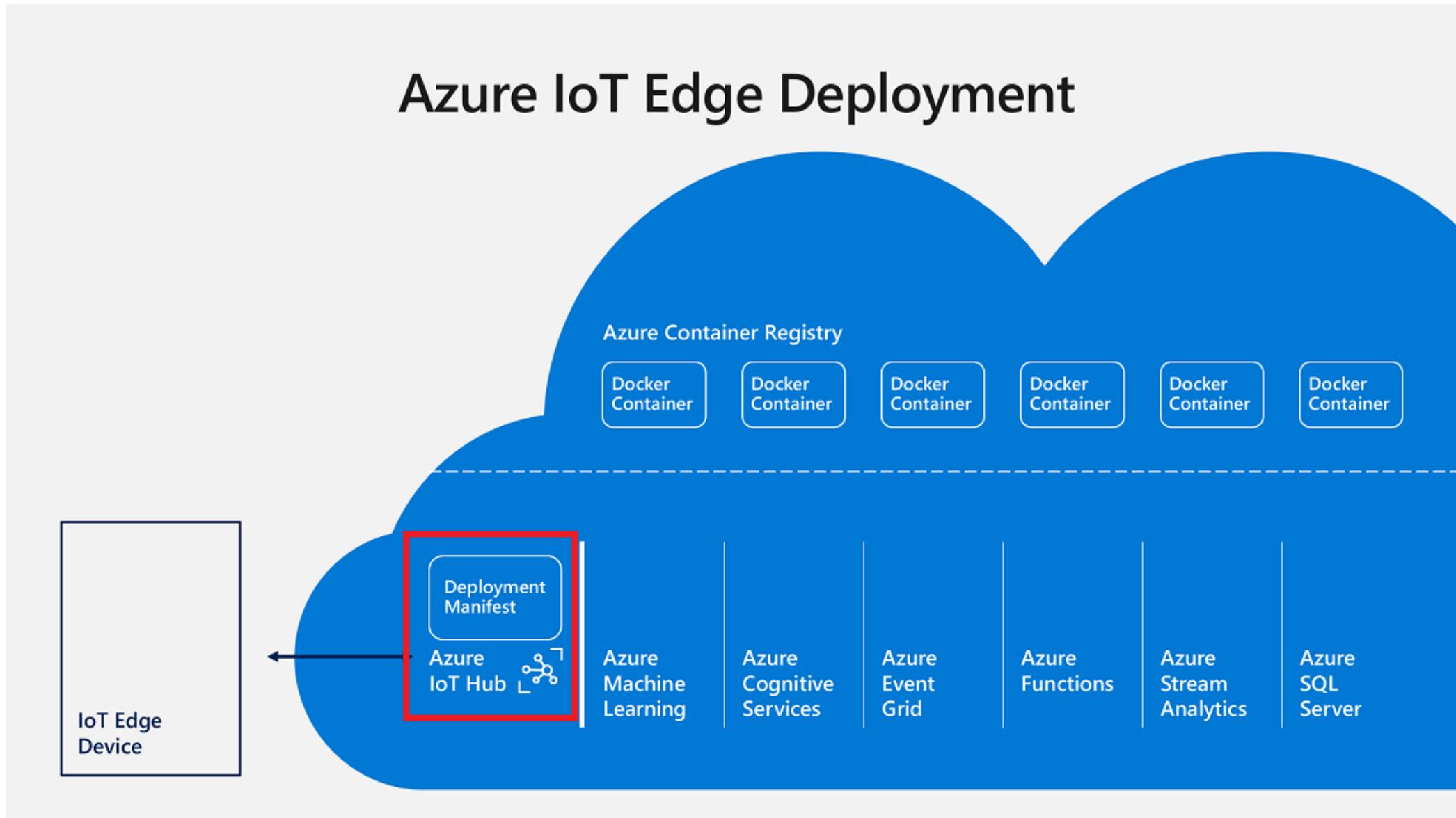
# Create Azure Services and solutions to be deployed on the Edge



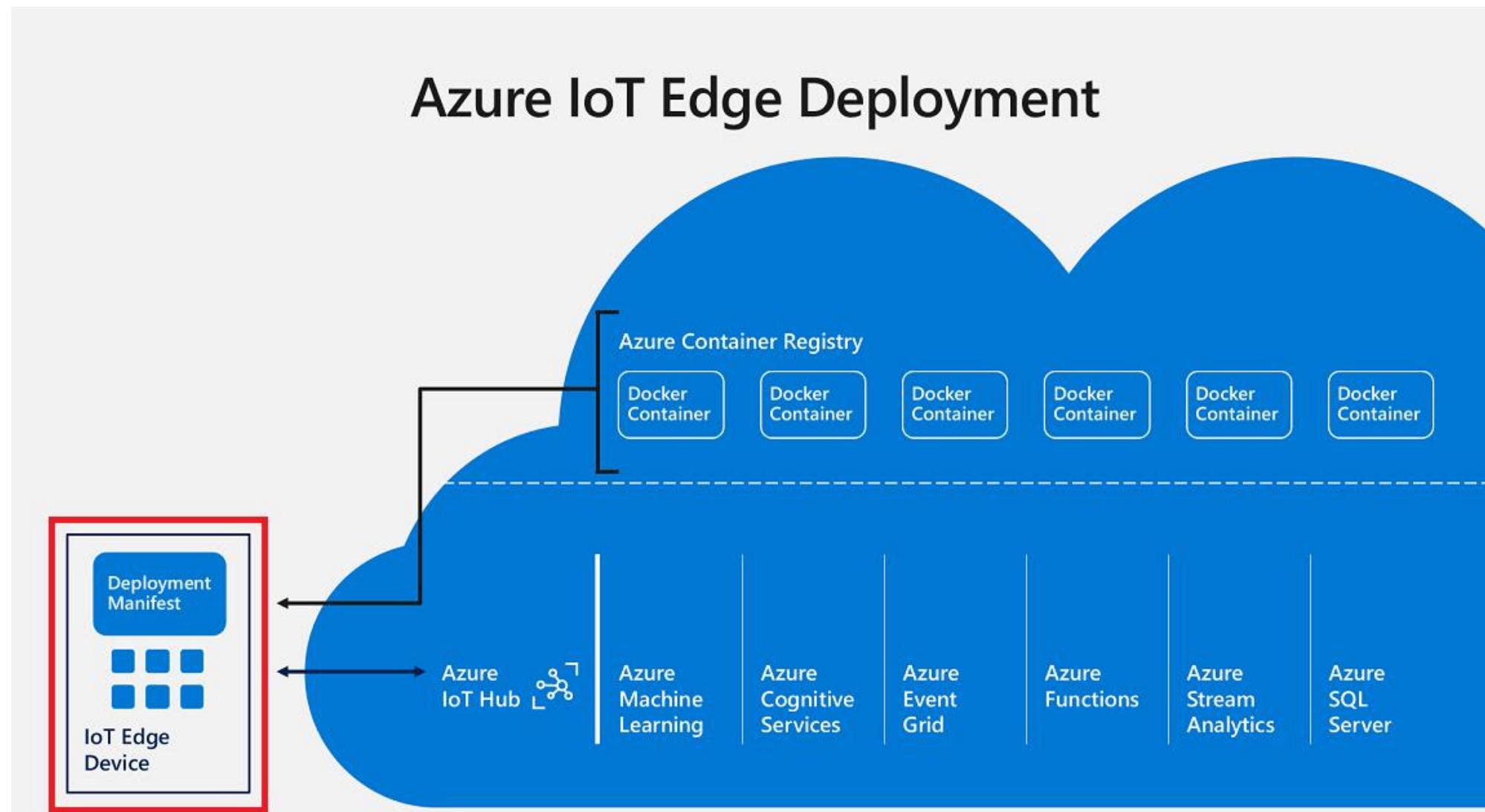
Create containers and store them in a container registry like Azure Container Registry



# Create a deployment manifest with Azure IoT Hub

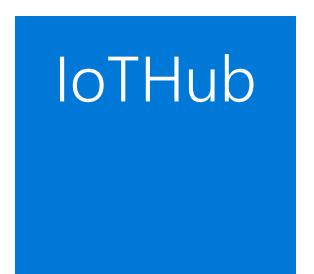


# Create a deployment manifest with Azure IoT Hub



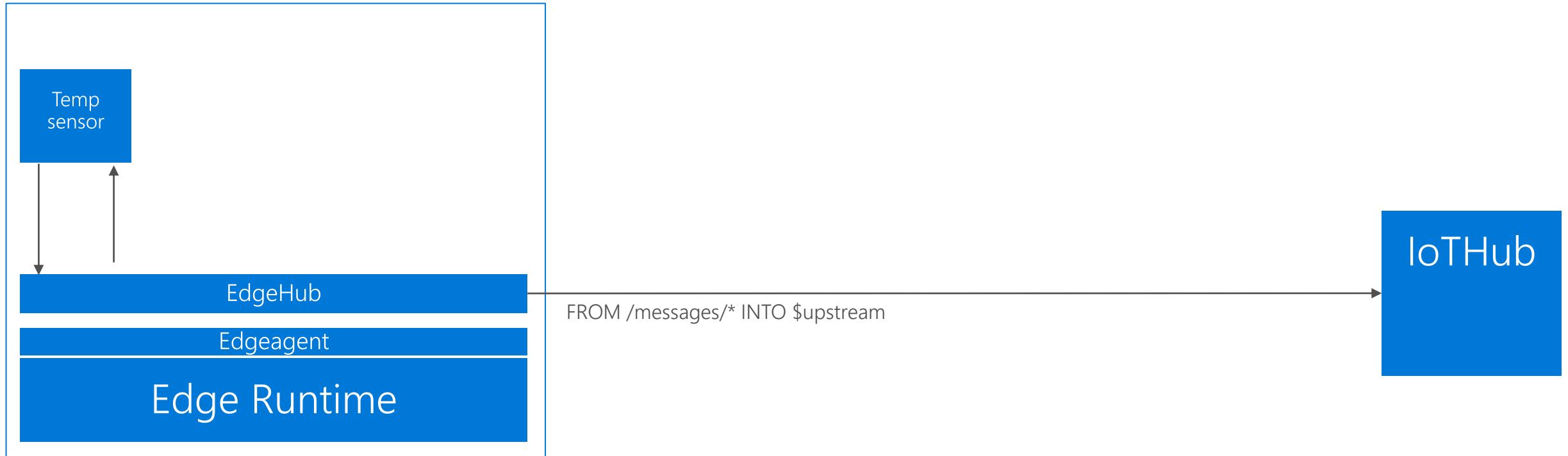
# Deploy Azure IoT Edge Enabled Linux VM

Linux VM



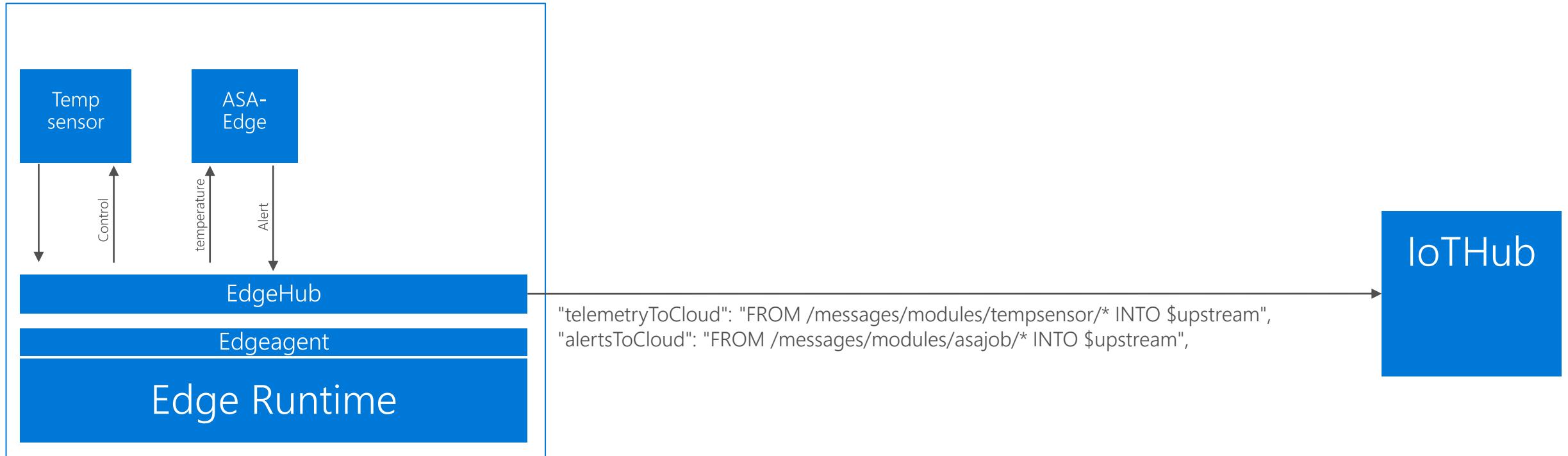
# Add an Edge Module and Deploy to Edge Device

Linux VM



# Deploy Azure Stream Analytics on Edge

Linux VM



"alertsToReset": "FROM /messages/modules/asajob/\* INTO BrokeredEndpoint(\"/modules/tempsensor/inputs/control\")",  
"telemetryToAsa": "FROM /messages/modules/tempsensor/\* INTO BrokeredEndpoint(\"/modules/asajob/inputs/temperature\")"

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---

Learn more  
[aka.ms/azure-iot-edge](https://aka.ms/azure-iot-edge)

Get started  
[docs.microsoft.com/azure/  
iot-edge](https://docs.microsoft.com/azure/iot-edge)



# IoT Edge Workshops

Visual Anomaly Detection over  
multiple cameras with NVIDIA  
Jetson Nano devices

<https://aka.ms/iotedge-iva-workshop>

A collection of resources for  
connecting NVIDIA Jetson devices to  
Microsoft Azure  
<http://aka.ms/jetson-on-azure>



# Get Started Now!

## Microsoft Learn learning paths

<http://aka.ms/mslearniot>



<https://aka.ms/SecurelyConnectDevicesLearningPath>



<https://aka.ms/IntroAzureIoTLearningPath>

## Sign-up for Build end-to-end IoT solutions – Workshop Series

<https://aka.ms/IoT-online-workshop>

- Transform your business with IoT
- Devices and device communication – *IoT Hub*
- Device provisioning at scale – *Device Provisioning Service*
- Messaging processing, analytics, & business integration – *Time Series Insights, Event Grid, Azure Stream Analytics*
- Work with Azure IoT Edge – *IoT Edge*

Remotely monitor and control devices with Azure IoT Hub

56 min • Module • 9 Units

★★★★★ 4.7 (60)

Create an IoT Hub device app, and a back-end service app. As a scenario, we use the monitoring, and controlling, of the temperature and humidity of a cheese cave.

1100 XP

Build the intelligent edge with Azure IoT Edge

1 hr 47 min remaining • Learning Path • 1 of 3 modules completed

Beginner Intermediate Advanced Developer Solutions Architect Azure IoT Azure Portal Storage IoT Hub IoT Central IoT Edge Time Series Insights Cosmos DB Blob Storage Event Grid Machine Learning Service Azure Resource Manager Virtual Machines Azure Notebooks Cloud Shell Container Instances Container Registry

Interested in running cloud intelligence on edge devices? This path is the place to start to learn how to use Azure IoT Edge to build IoT solutions that require having cloud intelligence deployed locally on IoT Edge devices. Azure IoT Edge is a fully managed service built on Azure IoT Hub. Deploy your cloud workloads—artificial intelligence, Azure and third-party services, or your own business logic—to run on Internet of Things (IoT) edge devices via standard containers. By moving certain workloads to the edge of the network, your devices spend less time communicating with the cloud, react more quickly to local changes, and operate reliably even in extended offline periods.

In this learning path, you will:

- Learn more about how intelligent edge can unblock new scenarios
- Learn how to deploy a prebuilt modules to the Edge device
- Learn how an IoT Edge device can be used as a gateway

Skills Learned in the learning path:

- Set up and deploy an IoT Edge device
- Develop Modules
- Configure an IoT Edge device

2700 XP

# Learn how to get started with IoT

# **Building IoT solutions with Azure Developer Guide**

<https://discover.microsoft.com/azure-iot-building-solutions-dev-guide/>

## Microsoft Learn learning paths

<http://aka.ms/mslearniot>

Microsoft Learn is a newer learning platform that offers sandbox online training

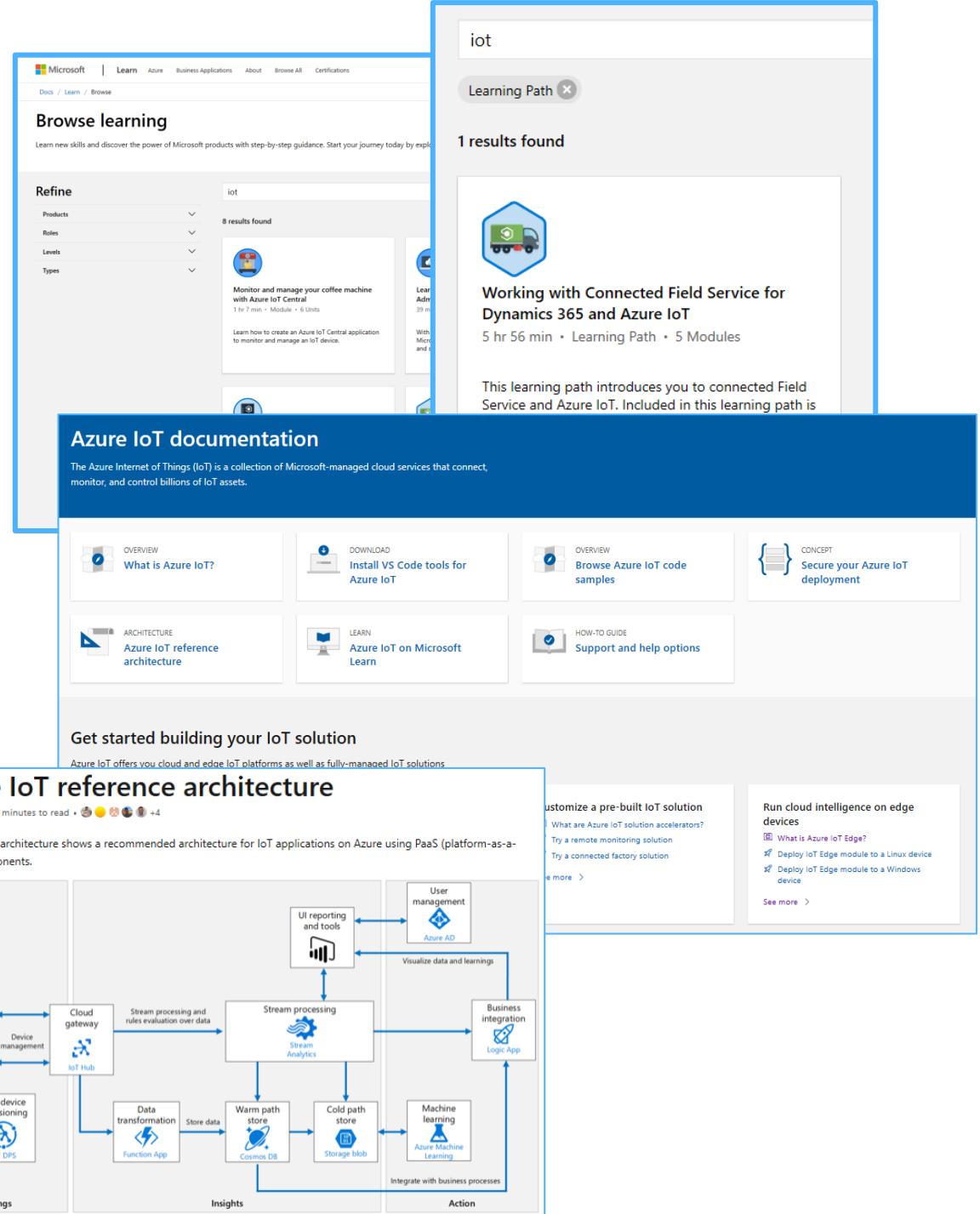
Azure IoT Reference Architecture Guide

<https://docs.microsoft.com/azure/architecture/reference-architectures/iot/>

This reference architecture shows a recommended architecture for IoT applications on Azure using PaaS (platform-as-a-service) components.

Azure IoT Docs

Getting Started, Tutorials, How-to guides, reference, whitepapers



# IoT Show

New video every Monday (Deep Dives on Wednesdays!) Subscribe to stay up-to-date with latest Microsoft IoT announcements, product and features demos, customer and partner spotlights, top industry talks, and technical deep dives with IoT Show! [aka.ms/IoTShow](https://aka.ms/IoTShow)



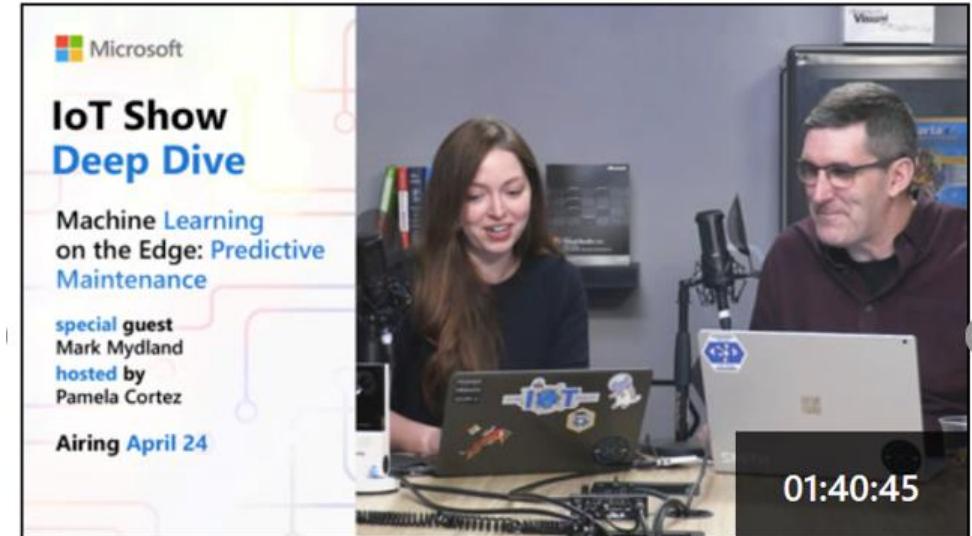
<https://aka.ms/iotshow/deepdive>



Deep Dive: Building IoT Solutions with IoT Central



Deep Dive: Using CI/CD to Deploy IoT Edge Modules with Confidence



# IoT Tech Community

Community forum to stay to update on latest announcements, connect with other developers, share your projects, and ask questions!

Fast growing vibrant community

One Microsoft IoT voice

<http://aka.ms/iottechcommunity>

The screenshot shows the homepage of the IoT Tech Community forum. At the top, there is a banner with the text "Internet of Things (IoT)" and "The space to share experiences, engage and learn from experts." Below the banner, it displays "10,128 Members" and a "Join" button. The main content area is titled "Select a Conversation Space" and features a grid of six conversation spaces: Azure IoT, Windows 10 IoT, IoT Devices, Robotics, Makers, Azure Security Center for IoT, Azure Maps, and Azure Sphere AMA. Each space has a small icon, the name, and the number of unread posts (e.g., 278 Unread posts for Azure IoT). There are also "Conversations" and "Blogs" tabs at the top right.

# Nvidia IoT Edge device spectrum



Azure IoT Edge



Nano

TX2

Xavier

T4

JETSON (arm64)

8

14

49

68

TESLA (amd64)

# streams

(1080p 30fps h265 resnet10)