Build end-to-end IoT solutions

Work with Azure IoT Edge

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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

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, in the cloud and on the edge

Digital Twins
- Create living replicas of any physical environment, track the past and predict the future
**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

- Things
- Cloud Gateway
- Insights
- Actions

Azure IoT Hub
Edge intelligence enabled with Azure IoT Edge

Video Camera → IoT Edge runtime → Azure IoT Hub

- Workload description
- Custom Code (data transform)
- Azure Cognitive Services (insight)
- Custom Code (action)

Device deployment & management

Container Registry
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

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#### IoT app services

- **Azure IoT Central**
- **Dynamics Connected Field Service**

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#### Azure services for IoT

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#### IoT & Edge Device Support

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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 As
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
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)
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)
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 

For ODMs: device catalog
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
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
Built-in troubleshooting tool

Configuration checks
- config.yml is well-formed
- config.yml has well-formed connection string
- container engine is installed and functional
- config.yml has correct hostname
- config.yml 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
- 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.
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 MQTT port
- container on the default network can connect to IoT Hub HTTPS 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 ~)$ sudo iotedge check
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Developer Resources & Getting started
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**
- Shopper analytics
- Loss prevention
- Shelf availability

**Industrial**
- Workplace safety
- Quality control
- Infrastructure inspection

**Smart spaces**
- Traffic
- Access control
- Public safety
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*
  - [http://aka.ms/visioncontainerspreview](http://aka.ms/visioncontainerspreview)

- **Face detection & Face recognition**

- **Text recognition**
Azure IoT Edge + NVIDIA DeepStream

**EDGE APPLIANCE**

- **DeepStream container**
  - Decode
  - Streamux
  - Inference
  - Tracker
  - Renderer

- **IoT Edge**
  - Edge Agent
  - Edge Hub

- **Docker**
  - CUDA DRIVER
  - NVIDIA GPU
  - Edge Daemon
  - HSM

**Azure CLOUD**

- **IoT Hub**
- **IoT Central**
- **IoT DPS**
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
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Developer Resources & Getting started
Azure IoT Tooling support

**Visual Studio**

- **Azure IoT Hub support in Cloud Explorer**
- **Azure IoT Edge Tools - Preview**
- **Azure Sphere Tools for VS**

**Visual Studio Code**

- **Azure IoT Tools**
- **Azure IoT Hub Toolkit**
- **Azure IoT Edge**
- **Azure IoT Device Workbench**

**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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Developer Resources & Getting started
Azure IoT Edge Deployment
Create Azure Services and solutions to be deployed on the Edge

Azure IoT Edge Deployment

Azure IoT Hub → Azure Machine Learning → Docker Container

Azure Cognitive Services → Docker Container

Azure Event Grid → Docker Container

Azure Functions → Docker Container

Azure Stream Analytics → Docker Container

Azure SQL Server → Docker Container
Create containers and store them in a container registry like Azure Container Registry

Azure IoT Edge Deployment

IoT Edge Device

Azure IoT Hub

Azure Container Registry
- Docker Container
- Docker Container
- Docker Container
- Docker Container
- Docker Container
- Docker Container

Azure Machine Learning
Azure Cognitive Services
Azure Event Grid
Azure Functions
Azure Stream Analytics
Azure SQL Server
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

IoTHub

Edgeagent

Edge Runtime
Add an Edge Module and Deploy to Edge Device

FROM /messages/* INTO $upstream
Deploy Azure Stream Analytics on Edge

```
"telemetryToCloud": "FROM /messages/modules/tempSensor/* INTO $upstream",
"alertsToCloud": "FROM /messages/modules/asajob/* INTO $upstream",
"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

Get started
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
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- Work with Azure IoT Edge – IoT Edge
Learn how to get started with IoT

Building IoT solutions with Azure Developer 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/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
Nvidia IoT Edge device spectrum

- Nano (JETSON, arm64): 8 streams
- TX2 (JETSON, arm64): 14 streams
- Xavier (JETSON, arm64): 49 streams
- T4 (TELSA, amd64): 68 streams

# streams: (1080p 30fps h265 resnet10)