Build end-to-end IoT solutions
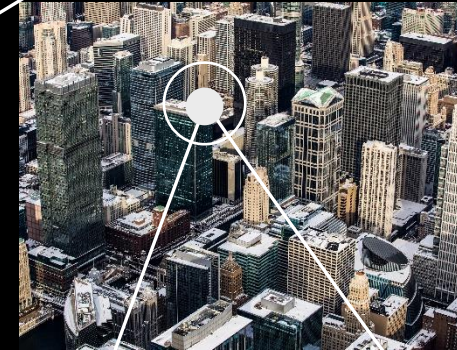## Devices and Device Communication

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

Devices and Device Communication
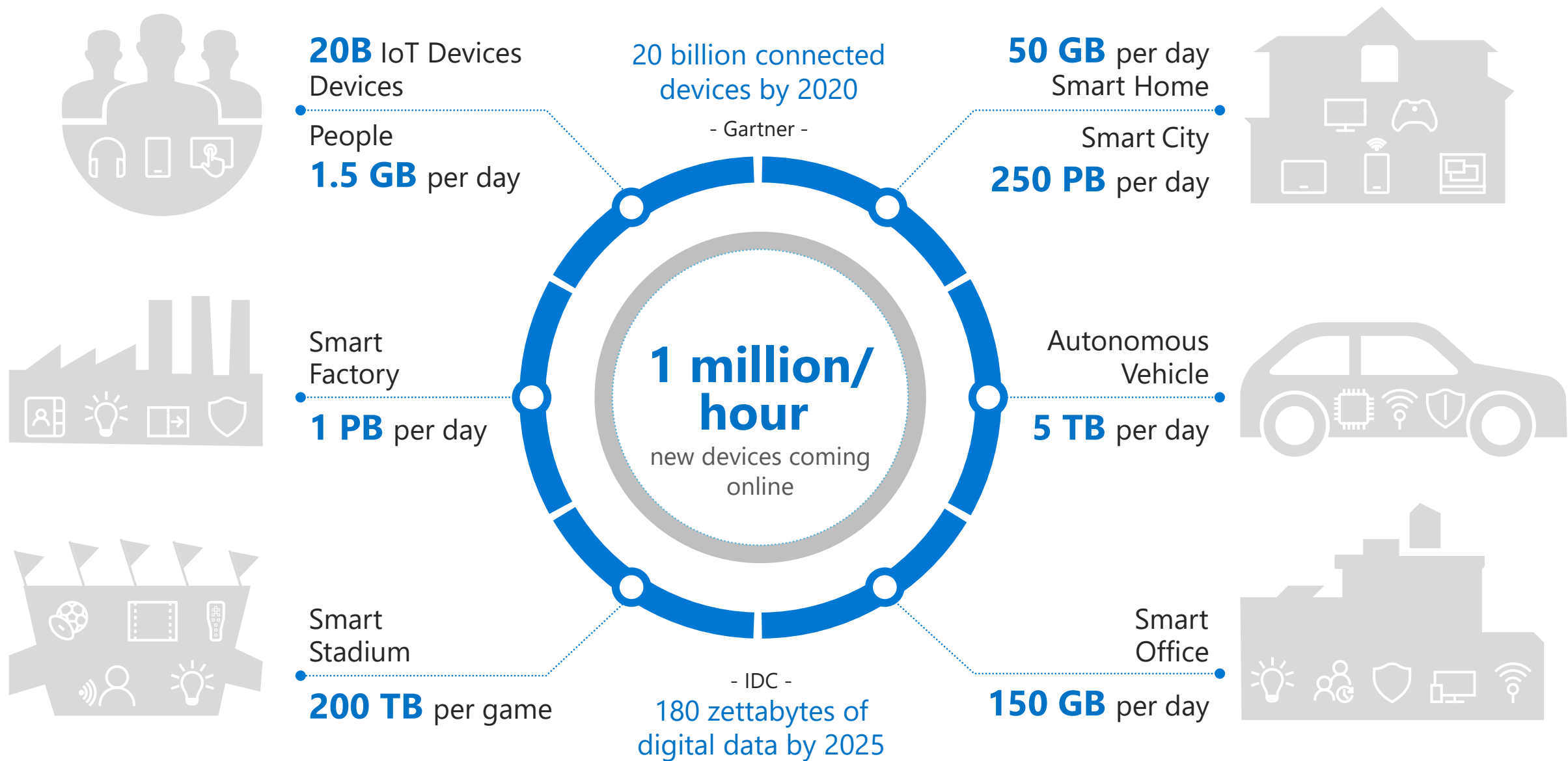
Overview of IoT Hub Features

Developer Tools
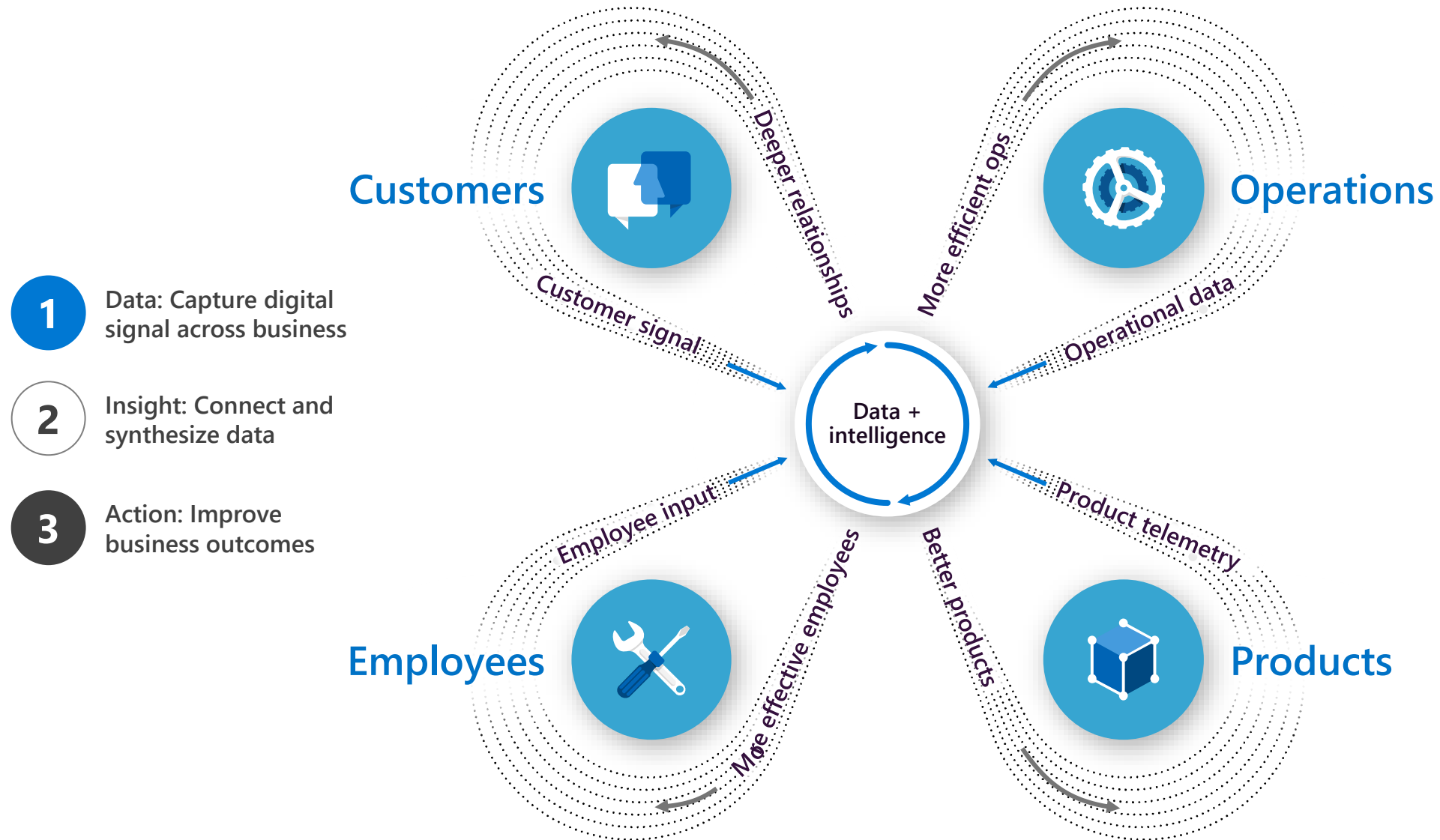
Lab: Connecting Simulated Device

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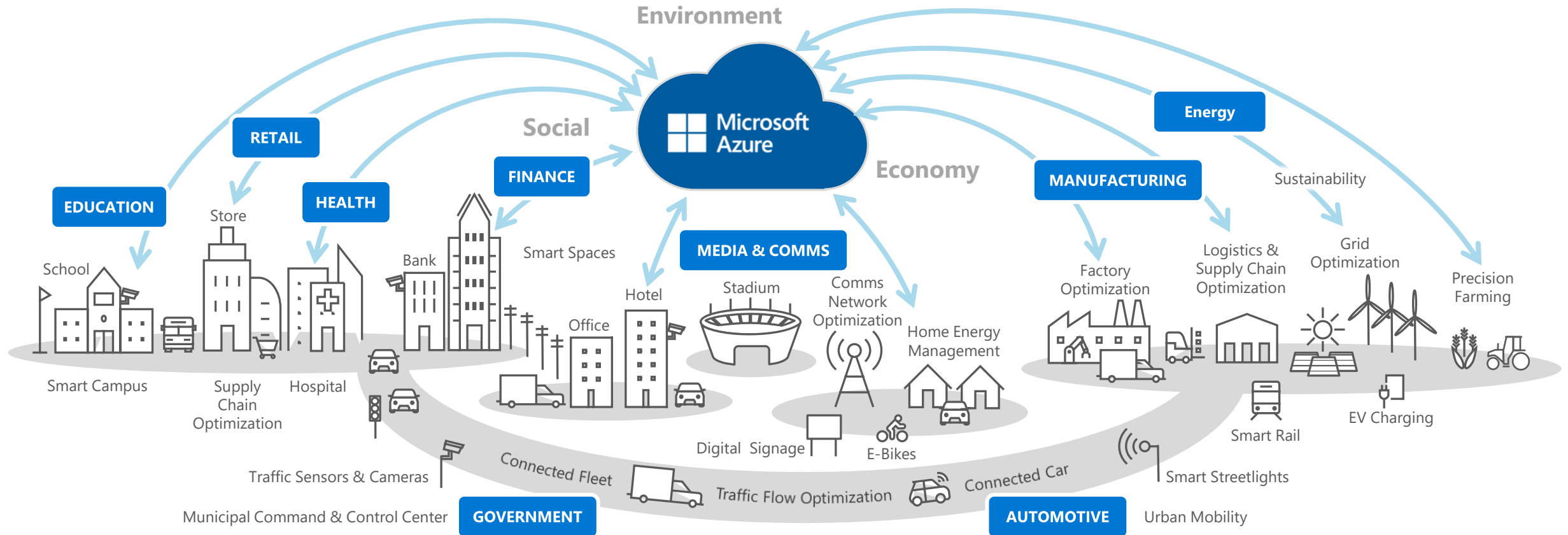## Developer Resources & Getting started

IoT fuels digital transformation

20B IoT Devices
Devices

People
1.5 GB per day

Smart
Factory

1 PB per day

Smart
Stadium

200 TB per game

20 billion connected
devices by 2020
- Gartner -

1 million/ hour

new devices coming
online

- IDC -
180 zettabytes of
digital data by 2025

50 GB per day
Smart Home

Smart City
250 PB per day

Autonomous
Vehicle

5 TB per day

Smart
Office

150 GB per day

IoT enables a digital feedback loop

1 Data: Capture digital signal across business

2 Insight: Connect and synthesize data

3 Action: Improve business outcomes

Customers

Operations

Employees

Products

Data + intelligence

Deeper relationships

Customer signal

More efficient ops.

Operational data

Employee input

More effective employees

Better products

Product telemetry

Microsoft invests $5 billion in IoT

Our goal is to give every customer the ability to transform their businesses, and the world at large, with connected solutions

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
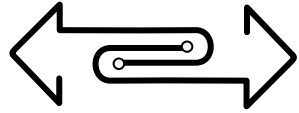Azure Stream Analytics
Azure Storage
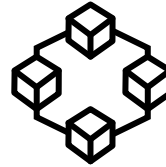
Azure ML
Azure SQL
Azure Functions
Azure Cognitive Services

Azure IoT Hub

Bi-directional communication

Millions of Devices

Multi-language, open source SDKs

HTTPS/AMQP/MQTT

Send Telemetry

Receive Commands

Device Management

Device Twins

Queries & Jobs

Enterprise scale & integration

Billions of messages

Scale up and down

Declarative Message Routes

File Upload

WebSockets & Multiplexing

Azure Monitor

Azure Resource Health

Configuration Management

End-to-end security

Per Device Certificates

Per Device Enable/Disable

TLS Security

X.509 Support

IP Whitelisting/Blacklisting

Shared Access Polices

Firmware/Software Updates

IoT Hub Offerings

Basic tier

EDITION TYPE	PRICE PER IOT HUB UNIT (PER MONTH)	TOTAL NUMBER OF MESSAGES/DAY PER IOT HUB UNIT	MESSAGE METER SIZE
B1	$10	400,000	4 KB
B2	$50	6,000,000	4 KB
B3	$500	300,000,000	4 KB

Standard tier

EDITION TYPE	PRICE PER IOT HUB UNIT (PER MONTH)	TOTAL NUMBER OF MESSAGES/DAY PER IOT HUB UNIT	MESSAGE METER SIZE
Free	Free	8,000	0.5 KB
S1	$25	400,000	4 KB
S2	$250	6,000,000	4 KB
S3	$2,500	300,000,000	4 KB

- Easy upgrade from basic to standard tier.
- Only standard allows cloud-to-device commands, device twin operations and IoT Edge

- Learn about IoT Hub scaling

IoT Hub and Event Hub Comparison

IoT Capability	IoT Hub standard tier	IoT Hub basic tier	Event Hubs
Device-to-cloud messaging	✓	✓	✓
Protocols: HTTPS, AMQP, AMQP over webSockets	✓	✓	✓
Protocols: MQTT, MQTT over webSockets	✓	✓	
Per-device identity	✓	✓	
File upload from devices	✓	✓	
Device Provisioning Service	✓	✓	
Cloud-to-device messaging	✓		
Device twin and device management	✓		
Device streams (preview)	✓		
IoT Edge	✓		

IoT Hub: Core Platform Capabilities

1. Telemetry (D2C): async messaging from devices

2. C2D commands: async messaging to devices

3. Device/module twin: state document exchange

4. Direct methods: RPC (synchronous)

5. File upload: storage blob-based

6. Endpoints and routes

7. Device streams: streams-based, not message-based
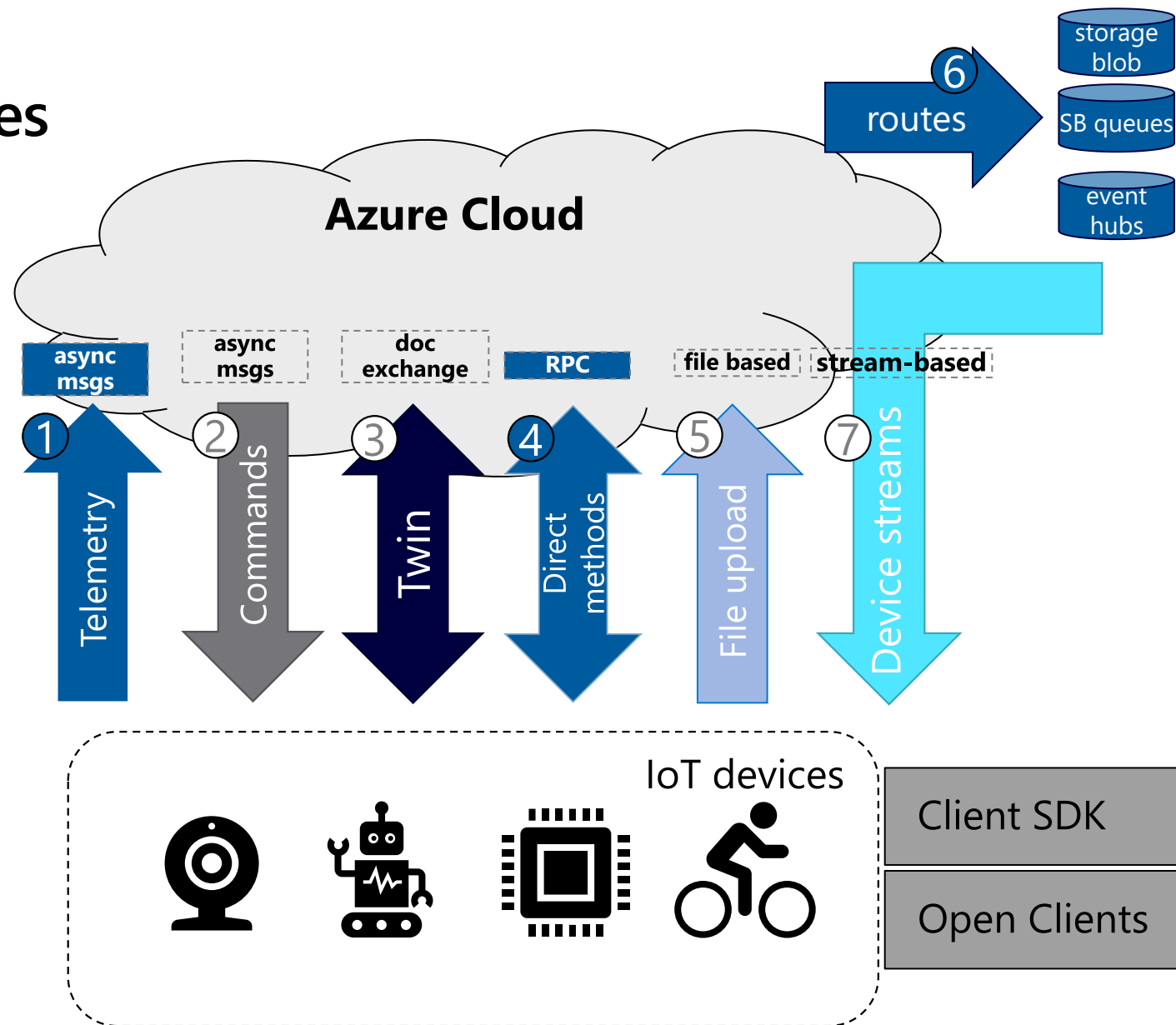
Device Streams (Preview)

Scenarios

- How to connect to devices inside private networks, or behind firewalls
- Applications: RDP/SSH, access devices' diagnostic portals

What?

- A mechanism to establish secure TCP connections to/from devices in secure/private networks
- Device streams are mediated by IoT Hub's streaming endpoint
- General-purpose and application/protocol agnostic

IoT Hub mediates device streams traffic

Azure IoT Hub

Device stream

IoT Devices

Secure/private network

Service endpoints

Public network or a separate private network
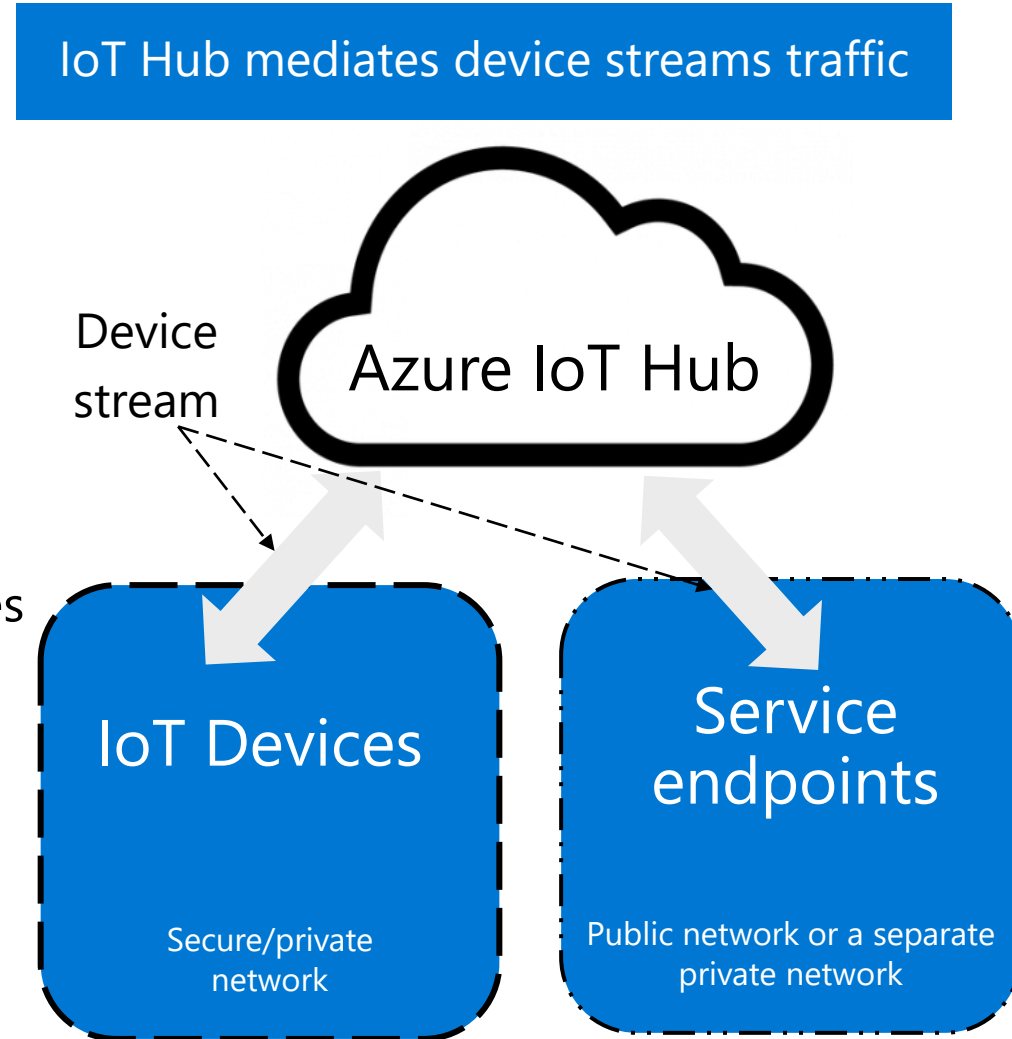
Device Streams Advantages

Firewall-friendly end-to-end connectivity

No need to open inbound ports on device or its network (only outbound port 443 is used)

Authentication enforcement

Both device and service authenticate using their IoT Hub credentials

Encryption enforcement

Traffic sent over device stream is always encrypted using TLS

Compatibility with TCP/IP stack

Ability to integrate into proprietary device applications or off-the-shelf TCP/IP applications including SSH/RDP, Web, File transfer, etc
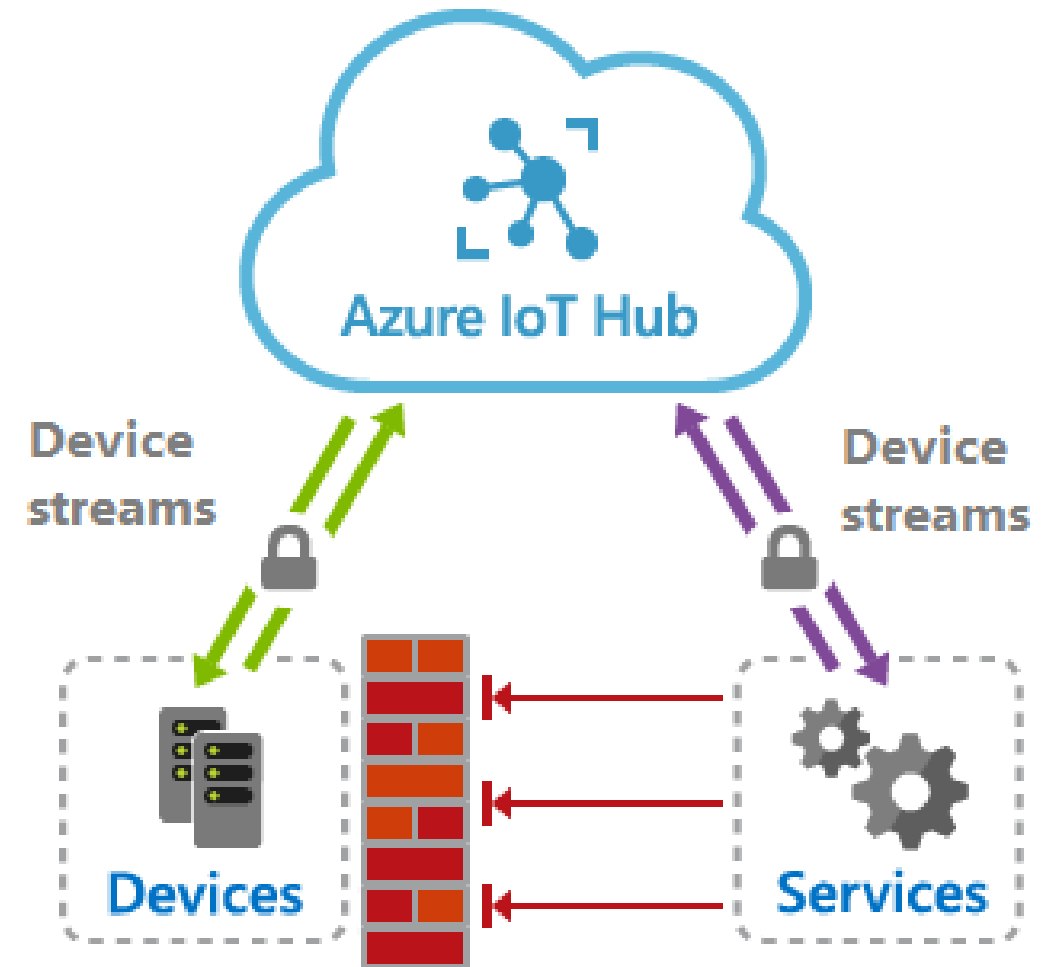
Azure IoT Hub – Device Management

- Used to orchestrate software/firmware/configuration changes
- Enables customers to build custom support for any OS
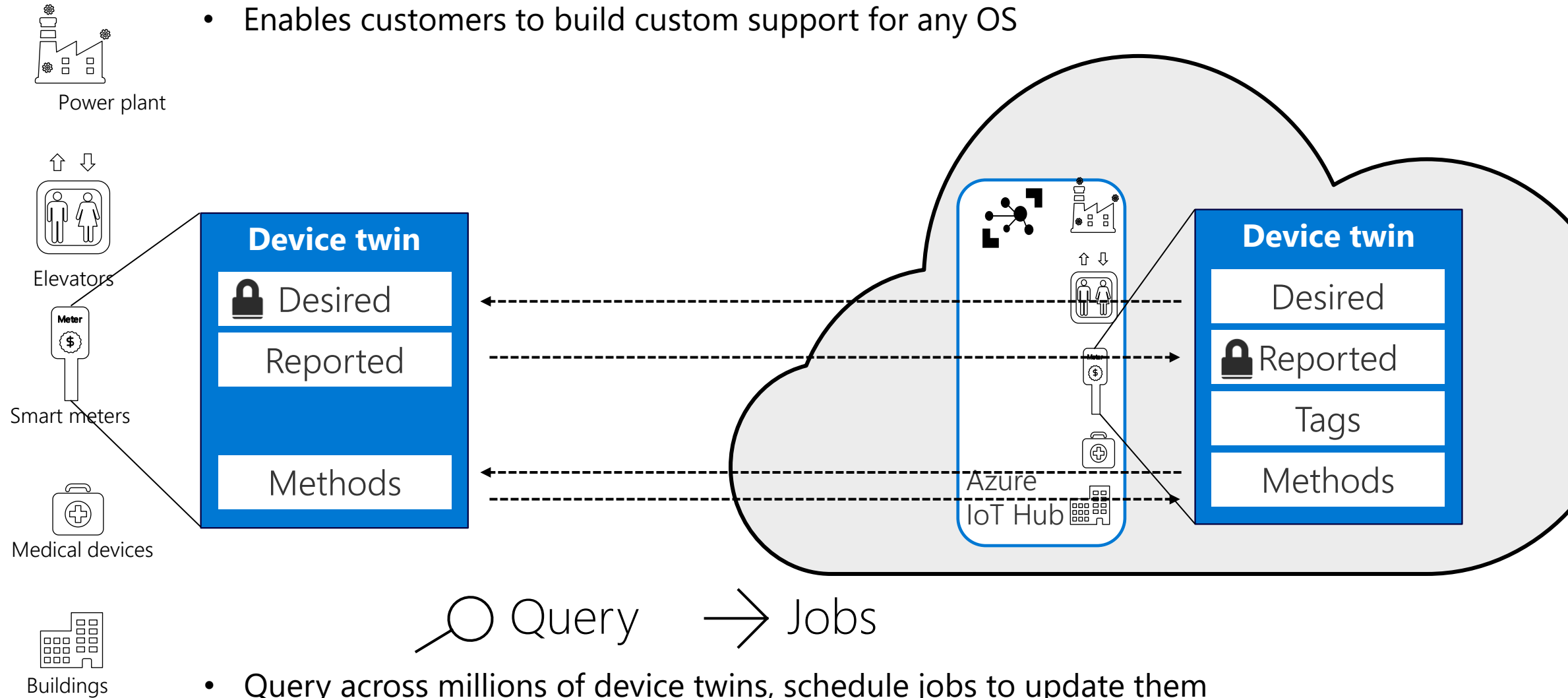
- **Query across millions of device twins, schedule jobs to update them**

Protocols

- IoT Hub is inherently a message-based cloud-hosted service
- Supported protocols are **AMQP**, **MQTT** and **HTTP**
- Devices maintain a persisted connection to IoT Hub
- Connections are all TLS-enabled and devices are authenticated
- Devices have an IoT Hub identity (SAS key or a certificate)
- We allow a special-purpose service-identity with higher privileges, e.g.,

Feature	Device-side protocols	Service-side protocols
D2C telemetry messaging	MQTT/WS + AMQP/WS + HTTP	AMQP/WS + HTTP
C2D messaging	MQTT/WS + AMQP/WS + HTTP	AMQP/WS
Direct methods	MQTT/WS + AMQP/WS	HTTP
Twin operations	MQTT/WS + AMQP/WS	HTTP
Device streams	MQTT/WS + AMQP/WS (C/C# only)	AMQP/WS (NodeJS/C# only)

IoT Hub Connectivity Models

All setups use IoT Hub's core features
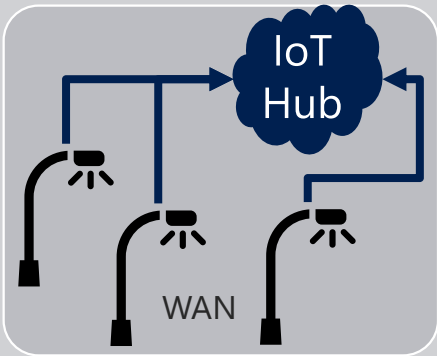
Direct over WAN

- Devices have public IPv4 & connect to IoT hub directly
- Device talks our supported protocols
- e.g., city street lights

IoT Hub Message Enrichments
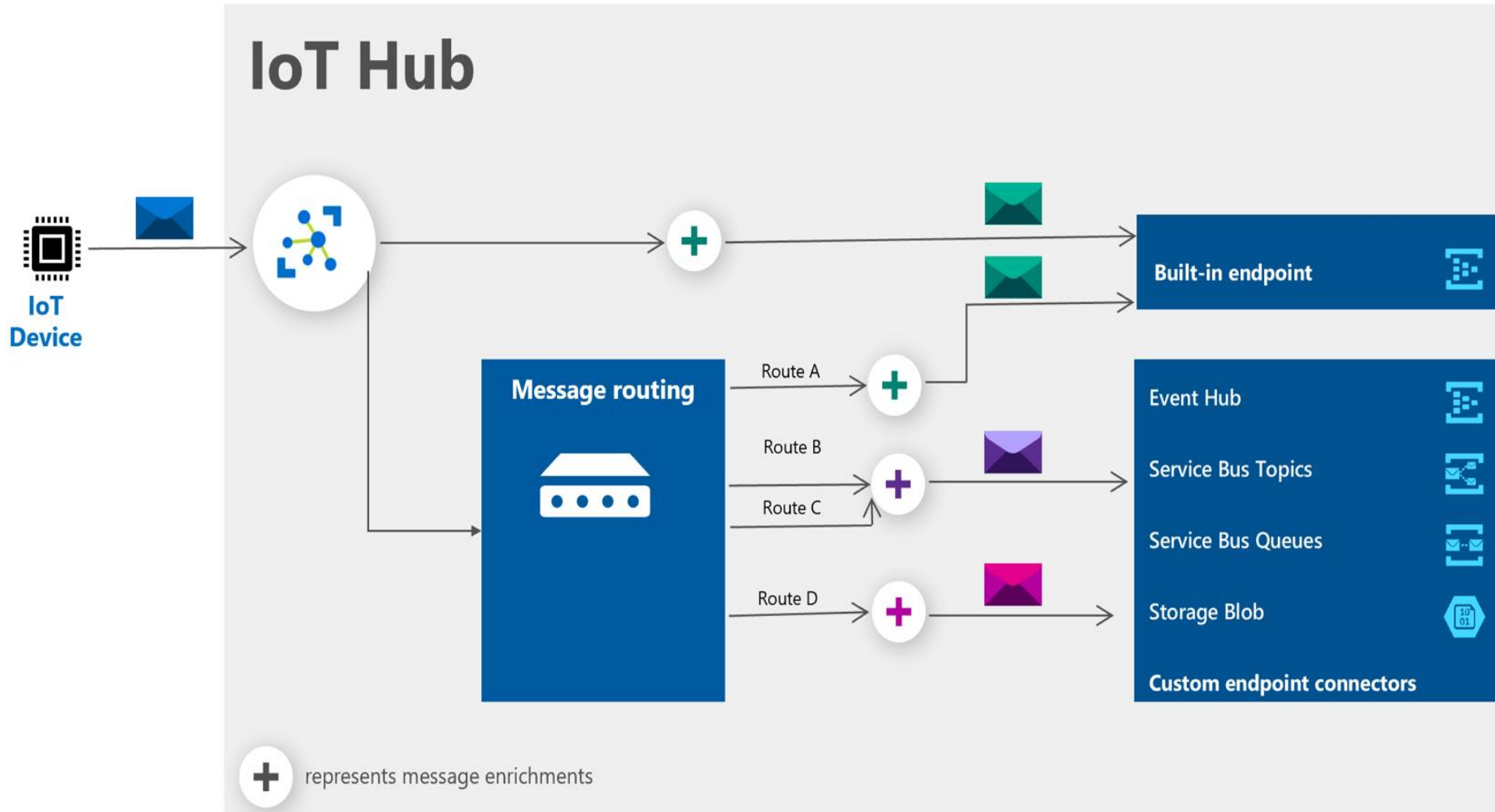
Enrichment Values supported
- Device Twin tags, properties
- IoT Hub name
- Static string

Serverless Integration

Topics   Event Subscriptions

Event Sources
- Blob Storage
- Media Services
- Azure Subscriptions
- Resource Groups
- Event Hubs
- IoT Hub
- Service Bus
- Custom Topics

Event Handlers
- Azure Functions
- Logic Apps
- Azure Automation
- WebHooks
- Queue Storage
- Hybrid Connections
- Event Hubs
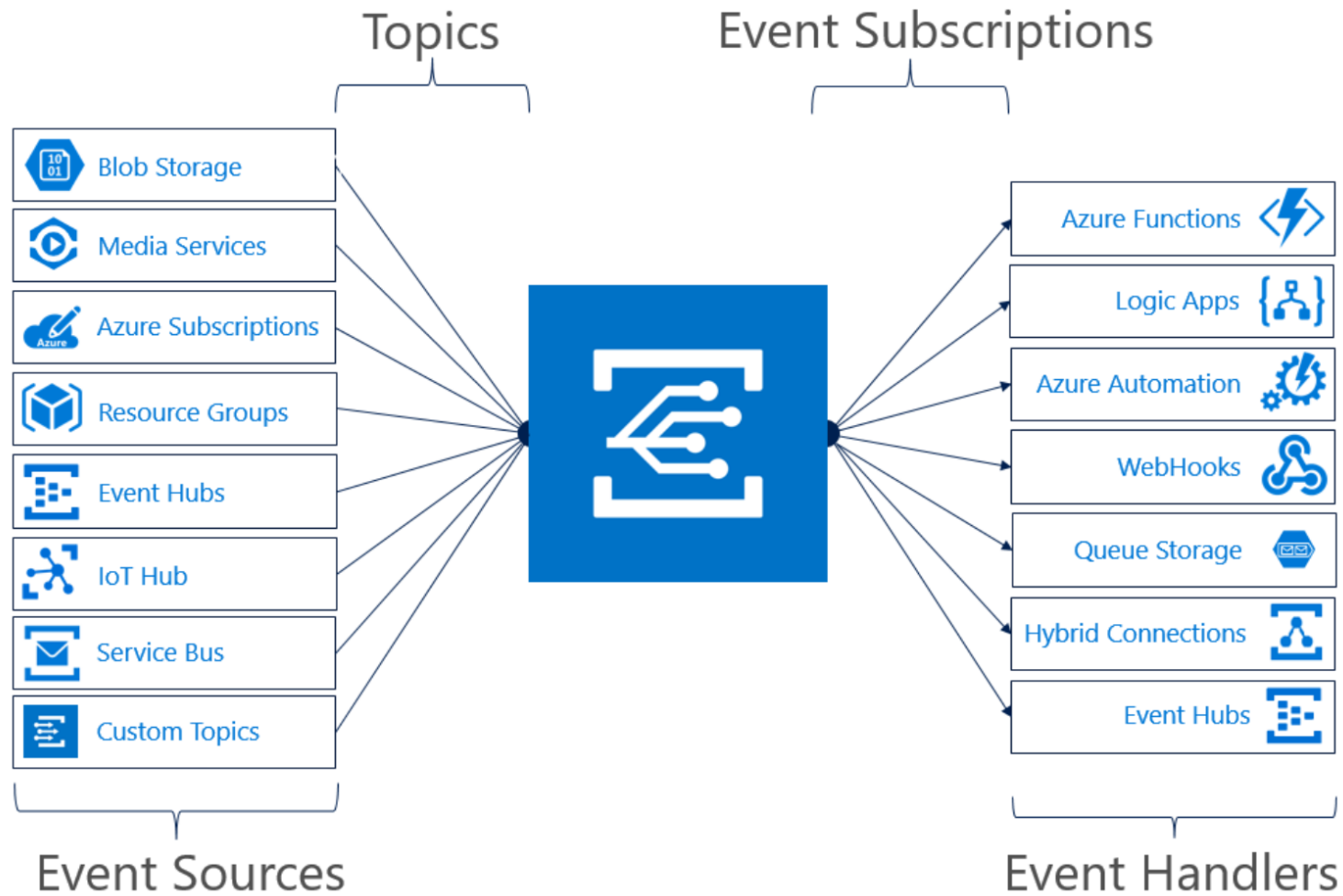
Events supported:
- Device Telemetry
- Device Created/Deleted Events
- Device Connected/Disconnected Events

Learn more about Event Grid

Device Twin

Twin

- Bi-directional device<->hub communication channel
- Based on per-device (per module) json documents
- Used to store configuration and control-plane state
- Supports queries

Twin sections

- **Tags:** set by service and not viewable by device
- **Desired properties:** set by service and delivered to device
- **Reported properties:** set by devices and delivered to service
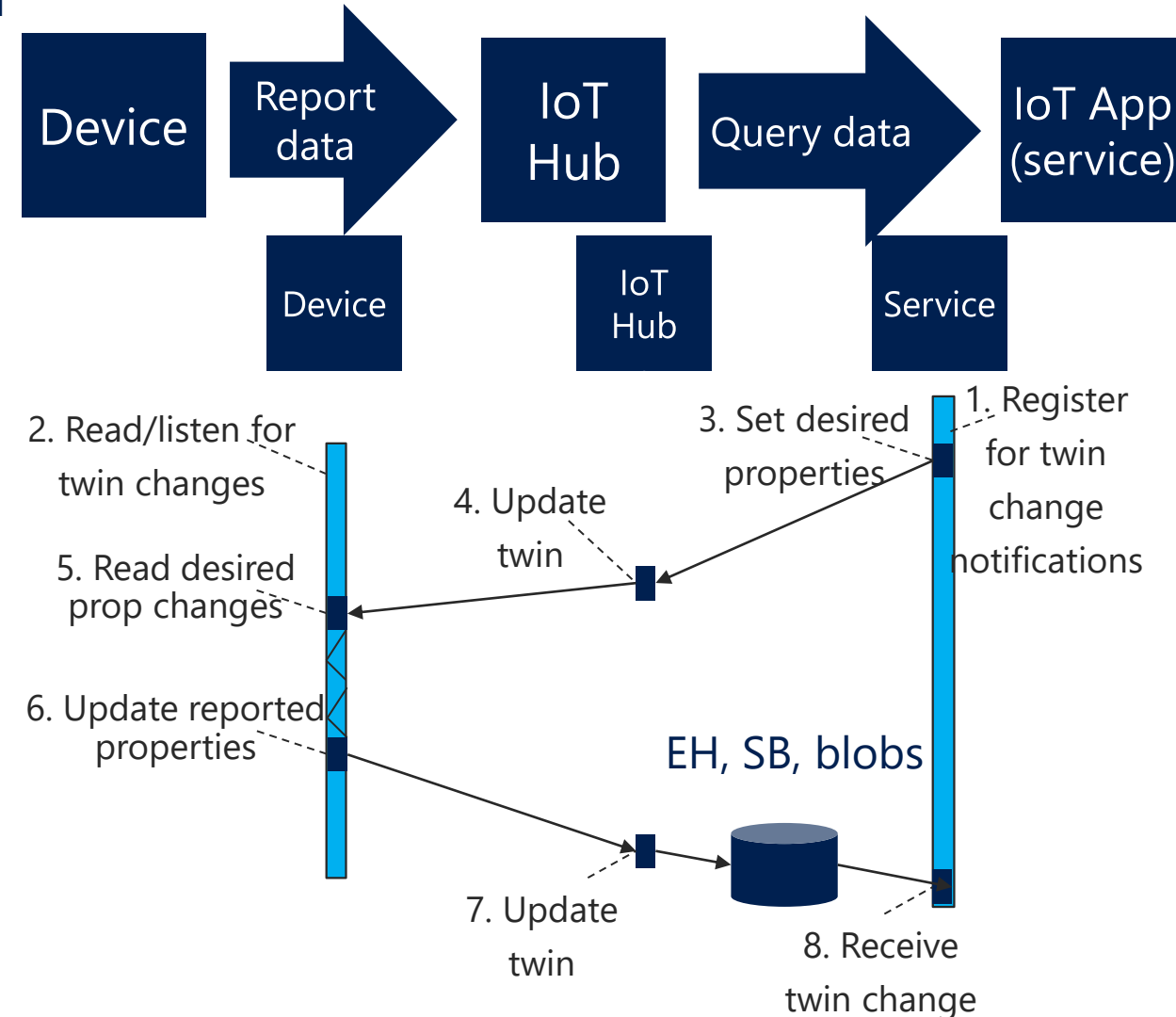
Device → Report data → IoT Hub → Query data → IoT App (service)

Device | IoT Hub | Service

1. Register for twin change notifications
2. Read/listen for twin changes
3. Set desired properties
4. Update twin
5. Read desired prop changes
6. Update reported properties
7. Update twin
8. Receive twin change

EH, SB, blobs

Devices and Device Communication

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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
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 **Preview**
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

Azure IoT Hub tools

Cloud Explorer for VS 2017/2019
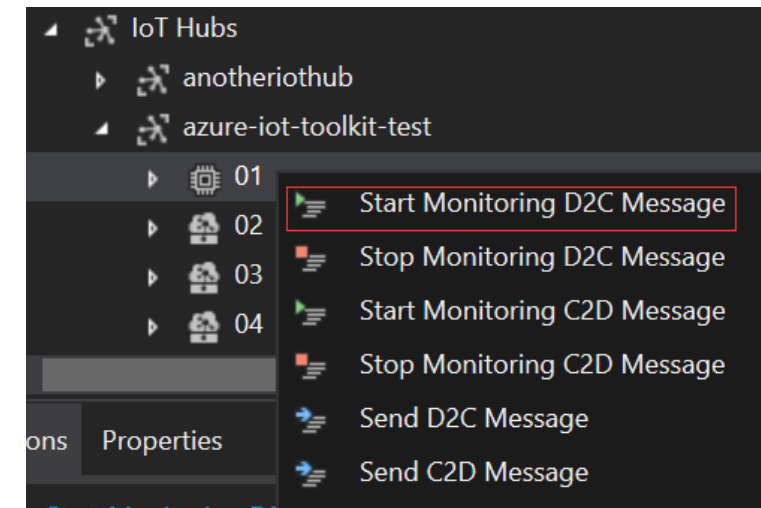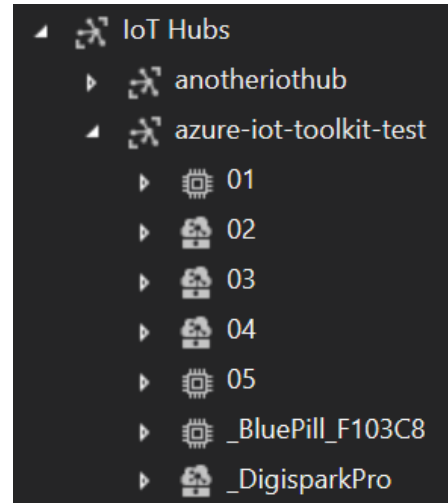
VS Code IoT Hub Toolkit

Azure IoT CLI Extension
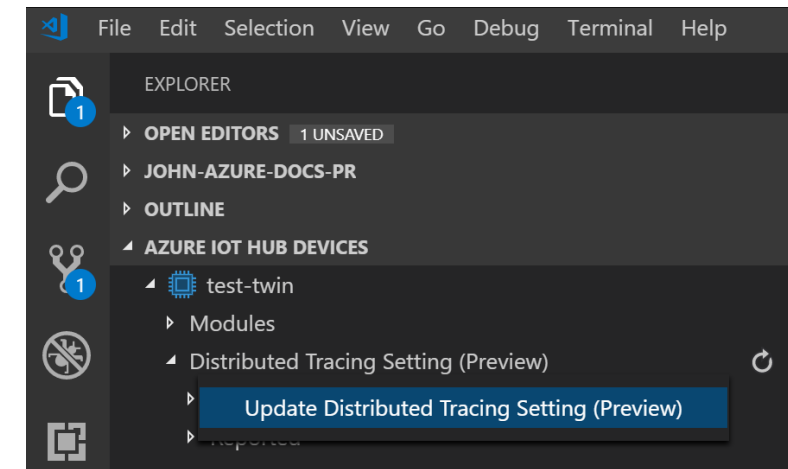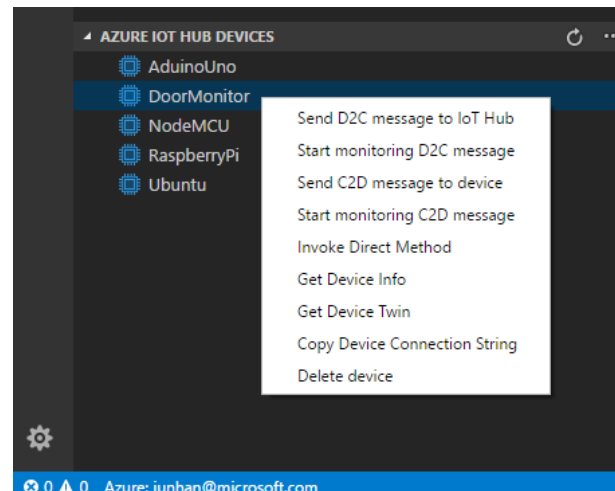
https://github.com/Azure/azure-iot-cli-extension.

Azure IoT Device Workbench for VS Code

- Support Certified Azure IoT Devices
- Start from Solution Gallery or custom IoT project
- Code, build, deploy and debug
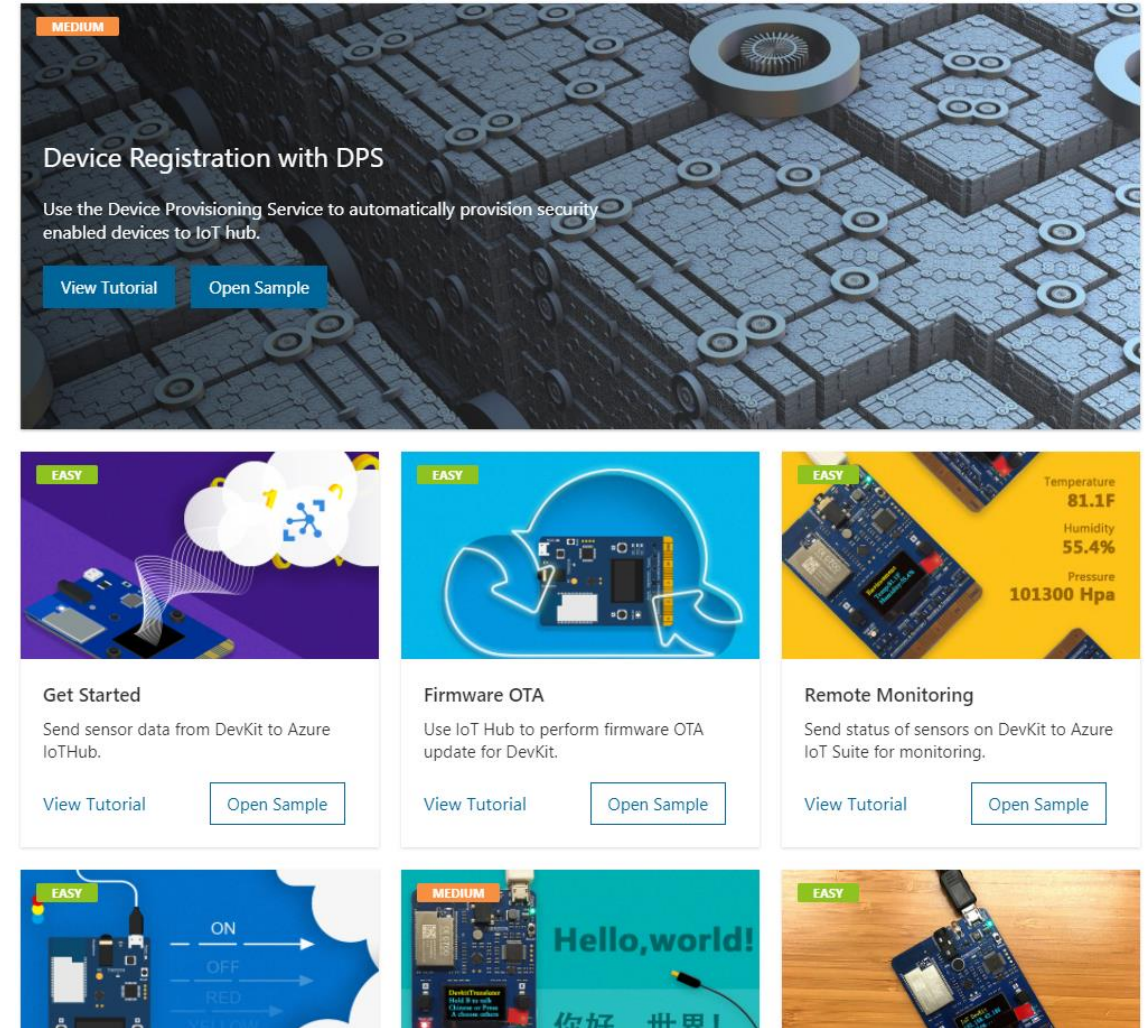
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Developer Resources & Getting started

Get Started Now!

 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
1100 XP

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.

Overview ∨

Automate IoT devices management with Azure IoT Hub
1200 XP

53 min • Module • 9 Units

★★★★★ 4.8 (20)

Automate IoT devices management with Azure IoT Hub

Overview ∨

Manage your Azure IoT Hub with alerts and metrics
900 XP

53 min • Module • 7 Units

★★★★★ 4.8 (21)

Learn about metrics, alerts, diagnostics, and logs. Create an Azure IoT Hub, an app to send vibration telemetry, and then create and test some metrics and alerts.

Overview ∨

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
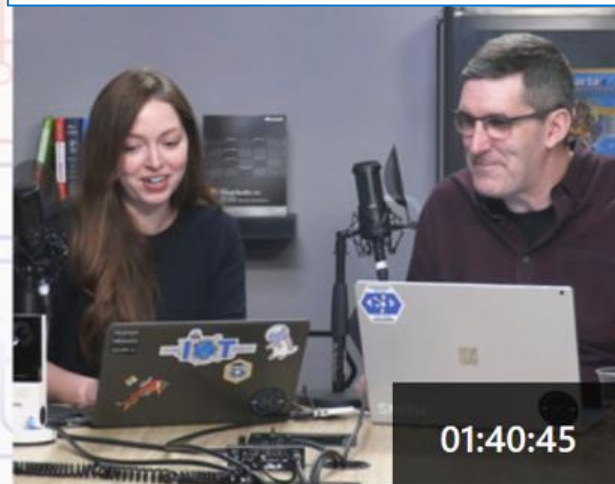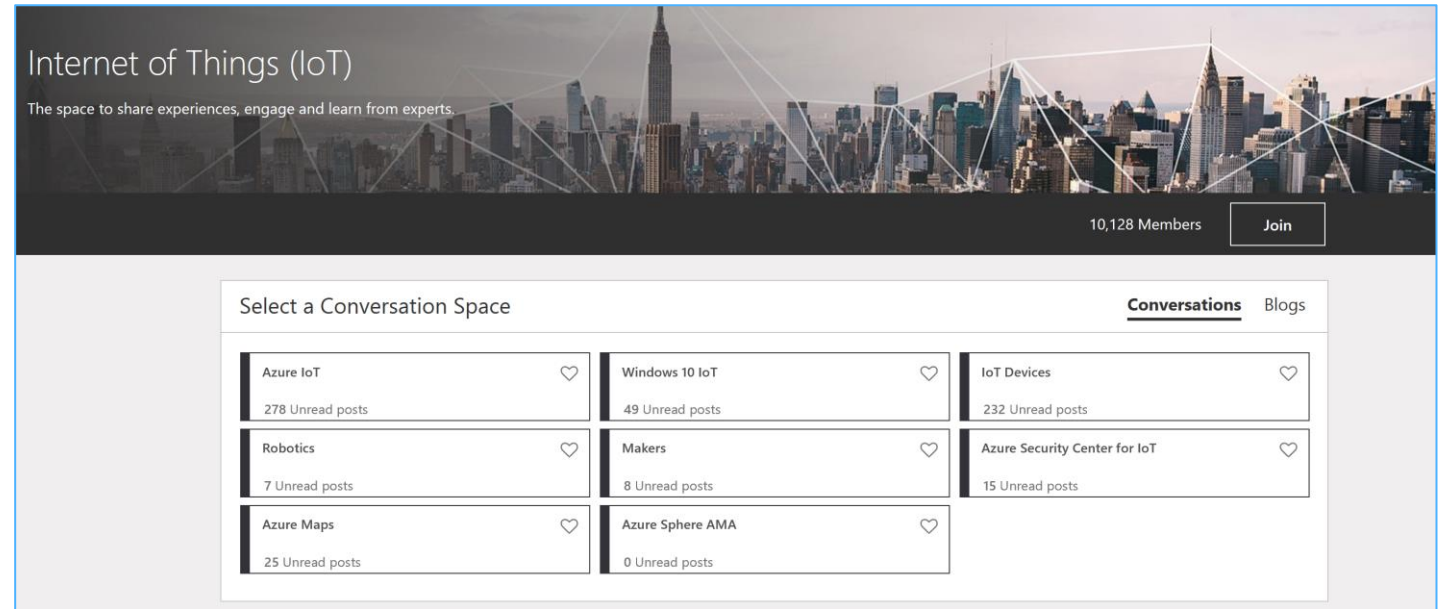
IoT Tech Community

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

Azure IoT DevKit

All-in-One kit built for Cloud