Hey, human!   Stand by for the next session!

#GlobalAILisboa #GPPBLisboa #GlobalAI #GPPB2023

Build AI enabled devices in semi-connected scenarios
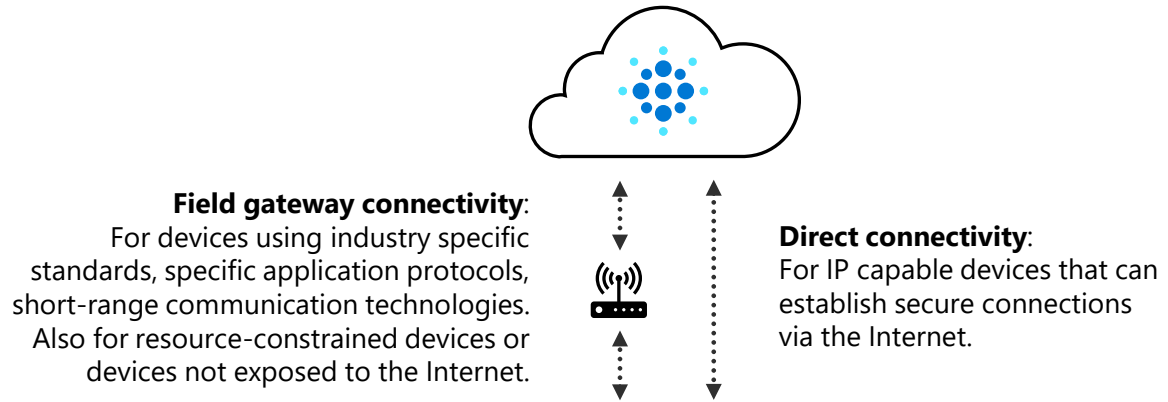
Marco Dal Pino

Technical Consulting

This event is organised by the following non-profit technical communities:

#GlobalAILisboa #GPPBLisboa #GlobalAI #GPPB2023

Intelligent IoT devices need software and connectivity

Field gateway connectivity:
For devices using industry specific standards, specific application protocols, short-range communication technologies. Also for resource-constrained devices or devices not exposed to the Internet.

Direct connectivity:
For IP capable devices that can establish secure connections via the Internet.

Anatomy of an IoT device
(Typically embedded systems or intelligent devices)

Microprocessor (MPU)
The functions of CPUs on single or multiple integrated circuits. More likely to have support chips, with more IO capabilities and the ability to run more complex/ intensive software

Microcontroller (MCU)
A single-chip computer, with CPU, RAM, and ROM. Low BOM costs and limited external IO interfaces

Storage
Required for the OS, apps, data etc. May be RAM, HD, or SSD. Needs vary considerably.

Software
Operating systems, runtimes, containers/modules, applications, communications protocols

## Many variables in choosing edge technologies

Compute power required perform the device tasks

- **Power requirements** (battery or powered, consumption, heat dissipation etc.)

- **Storage** amount required based on promised functionality

- **Serviceability and support** (management and updates, component customization, etc.)

- **User interface** and input requirements (GUI, touch, pen, keypad etc.)

- **Determinism of response** (e.g. predictable or guaranteed latency requirements)

- **Development** environment, tools, expertise

- **Cost** of components and overall device price point

- **Security** requirements

- **Connectivity** (IO, USB, Wi-Fi, HDMI, Ethernet, I2C Modbus etc.)

- **Connection** continuity and dependability, bandwidth, latency

- **Communication protocols**: HTTPS, AMQP, MQTT, UDP, BLE, BACnet, Modbus, OPC-UA etc.

AI on tiny devices (MCU class devices)

AI on CPU class devices (Industrial PC, Raspberry PI etc.)
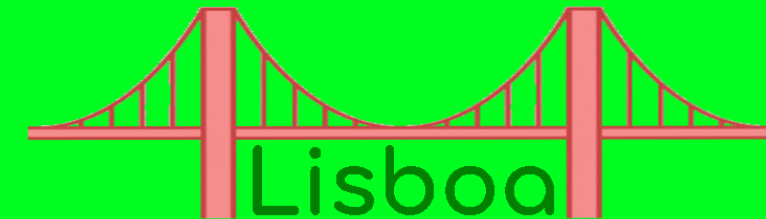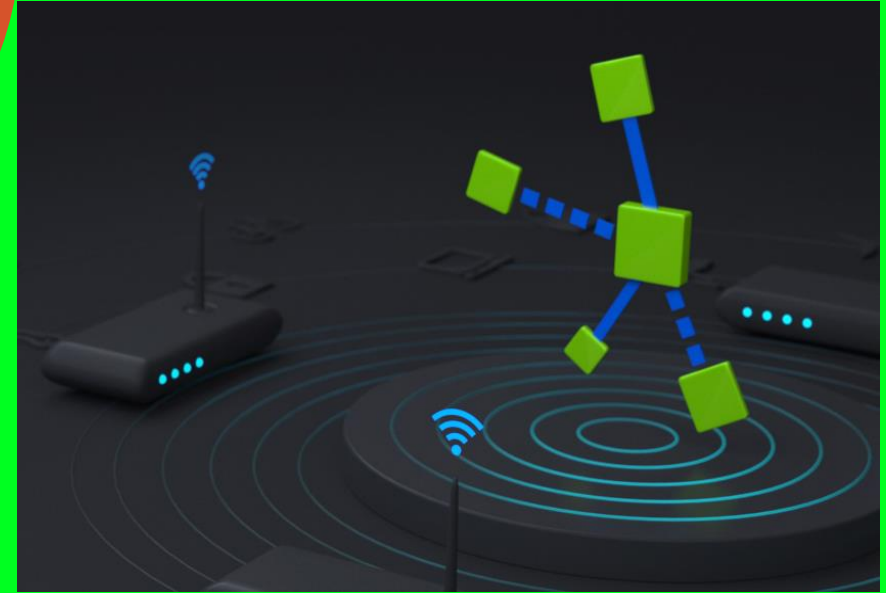
Demo
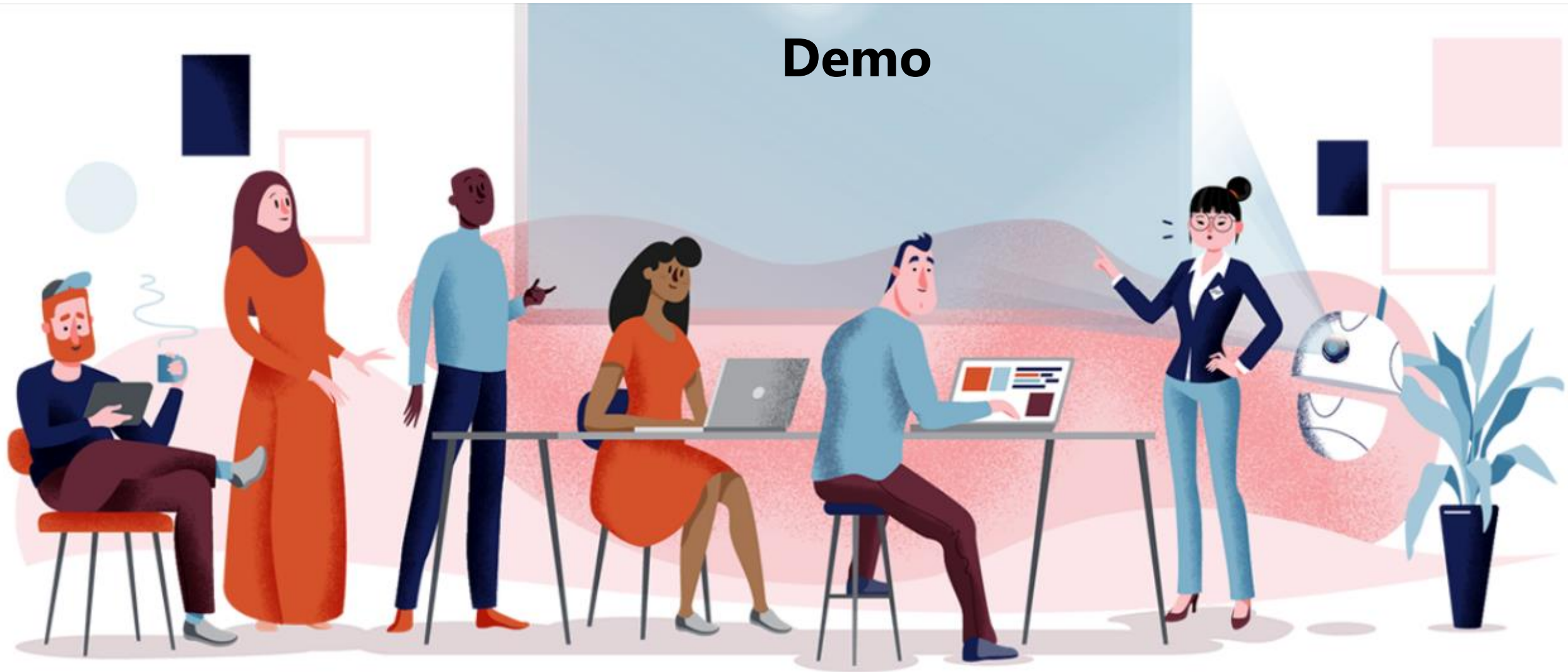
Azure RTOS

Azure Sphere

Azure IoT Edge

Windows for IoT

IoT Gateways

Lisboa

Summary comparison of Microsoft edge offerings

	Azure RTOS	Azure Sphere	Azure IoT Edge	Windows for IOT
Product/ Components	Real-time OS, middleware & Windows tools	Silicon chips, OS, & cloud security service	A fully managed runtime service with cloud interface through Azure IoT Hub	Full-featured OS offerings
Headline	Small memory footprint for resource constrained devices. Hard real time processing (Sub-microsecond interrupt response). Inexpensive. Deployed to billions of devices.	Fairly small memory footprint. Meets the 7 properties of highly secured devices and supports a secured root of trust. Ongoing servicing for updates to keep devices secure.	Deploy your cloud workloads—artificial intelligence, Azure and third-party services, or your own business logic—to run on edge devices via standard containers.	Windows for specific-use (dedicated), embedded devices where a full feature set or GUI is required for complex scenarios. More than 1B Windows 10 devices deployed.
Primary Target Audience	Semiconductor companies of 32-bit parts as well as original equipment manufacturers (OEMs) and SOC suppliers	Greenfield manufacturers (or OEMs) who build new MCU-class connected devices Organizations who want to securely connect existing (brownfield) equipment	Intelligent edge devices needing to run containers locally and eventually coordinate through Azure IoT Hub.	OEMs/ODMs building specific/dedicated use devices with long lifecycles
Typical use case	Low cost, resource-constrained devices requiring reliably fast performance	Highly-secured, Internet-connected microcontroller (MCU) devices	Low latency required to determine alerts/actions on-premises OR enabling intelligence at the edge when devices may be disconnected.	Connected or unconnected devices which may have a rich GUI experience and require a higher level of processing power
Licensing	Production license included with Azure RTOS enabled MCUs; or available separately from MS	NTE $8.61/unit; one-time purchase includes all components (MCU, OS, and Security Service)	Azure IoT Edge Runtime is free IoT Hub and Modules may have cost implications	Windows 10 IoT Core – Royalty Free Windows 10 IoT Core Services – $0.30/mo. / device Windows 10 IoT Enterprise – Based on silicon
Requires Cloud connection?	No	Yes	Yes (not constant)	No
Azure Connectivity*	Azure RTOS ships with an Azure Security Center for IoT security module that covers threats and vulnerabilities on real-time operating system devices.	Azure Sphere only natively connects to AS3 security service (no different to Windows getting an update).	Cloud interface through IoT Hub	Windows 10 IoT includes an IoT Device Agent, etc.
Availability	Made available through pre-licensed partners, availability depends on the partner's device distribution model. Also available through MS licensing GA (May 2020)	GA (Feb 2020)	GA	GA

*Applications may also connect to Azure. For example, an application running on Azure Sphere can make it's own connection to it's own Azure IoT Hub.

Azure RTOS – Product description

Comprehensive suite of multithreading facilities, middleware, and Windows tools for developing embedded IoT applications on small, resource-constrained devices with hard real-time requirements. Features Azure RTOS ThreadX, a small, fast, reliable real-time operating system that is already powering more than 6.2 billion devices worldwide. The Azure RTOS ThreadX kernel and set of libraries are delivered as source code that is compiled and linked with an OEM application and board support package (BSP) from the OEM or silicon partner to create the binary image for a device.

- **Azure RTOS ThreadX** – high performance real-time operating system (RTOS) kernel
- **Azure RTOS NetX Duo** – TCP/IP IPv4/IPv6 embedded network stack that supports TLS/DTLS security protocols
- **Azure RTOS FileX** – embedded FAT file system that offers optional fault tolerance and flash memory wear leveling for always-on devices

Azure RTOS USBX – a USB host and device embedded stack

Azure RTOS GUIX – a small-footprint, low-overhead runtime engine and development tool featuring automatic code generation for embedded systems capable of graphic display

Azure RTOS GUIX Studio – complete design environment to create and maintain Windows-based GUIs

Azure RTOS TraceX – graphical view of real-time system events to help analyze unexpected behaviors and resolve problems

Memory footprint:
2 KB (ThreadX OS Kernel)

Architecture support:
All 32-bit CPU architectures, including various ARM cores, MIPS, PowerPC, and RISC-V. Also supports 64-bit ARM cortex A53, and SMP ARM

Positioning

Small memory footprint for resource constrained devices. Hard real-time processing. Easy to use. Inexpensive. For connecting deeply embedded sensors, devices, and gateways from the edge to the Internet. Enables fast to market and access to the power of Azure.

- Features preemptive, deterministic, and time-bound capabilities and predictable response times
- Supports the most popular embedded development tools

Example use cases

- Smart phones (esp. Wi-Fi chips)
- Consumer Electronics (e.g. cameras, fitness trackers)
- Office/Business Automation
- Retail Automation
- Industrial Automation & Energy/Power
- Low capacity sensors like lightbulbs, temperature gauges, traffic sensors, and more
- Anti-lock brakes, ADAS, Vehicle-to-everything (V2X) and more automotive features
- Safety-critical applications requiring guaranteed maximum response time (in milliseconds)

Other things to know

- Azure RTOS partners provide integrated solutions for prototyping and developing enterprise-ready solutions.

MICROCHIP
Microchip Technology

NXP
NXP Semiconductors

Qualcomm
Qualcomm

ST life.augmented
STMicroelectronics

RENESAS
Rensas Electronics

- Azure RTOS ThreadX was launched in 1997 and was part of the X-Ware IoT platform developed by Express Logic which Microsoft acquired in April 2019. It is deployed to billions of devices.

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Azure RTOS (cont'd)

Microsoft Security

When we rebranded the product to Azure, we changed the code, albeit in minor ways. As a result, the code must be re-reviewed and re-certified by governing authorities. We are working to get off-the-shelf safety re-certifications for core products (ThreadX, FileX, GUIX, NetX Duo, USBX) from TUV and UL).

In addition, NetX Secure TLS and NetX MQTT will be re-certified under EAL4+ and the NetX software crypto library will be re-certified to FIPS 140-2.

Azure RTOS ThreadX is currently MISRA compliant (with MISRA C:2004 and MISRA C:2012). MISRA C is a widely recognized standard for embedded C programming in most safety-related industries.

Licensing

Available to freely to test and explore the source code (available on GitHub)

Production license included at no cost if deployed to any of the supported pre-licensed devices from listed Semiconductor partners (initially STMicroelectronics, Renesas, NXP, Microchip, and Qualcomm). A list of pre-licensed devices will be available on GitHub.

Simple annual licensing for all other devices. $29,000 annual fee (direct from Microsoft) for up to 1M devices. (Contact Microsoft of deploying more than 1M devices.)

Optional add-on industrial certification package (formal reports with test results from TUV, UL and others certifying that the code behind specific Azure RTOS components has met rigorous safety and security standards) available in fall 2020 for $30,000 annual fee.

FAQs

Can Azure RTOS and Azure Sphere be used together?
Yes. Azure Sphere chips include real-time processing cores that are protected by the Azure Sphere OS, however, does not provide the real-time operating system (RTOS). But Azure RTOS can be used with Azure Sphere to allow embedded developers to take advantage of these real-time processing cores enabling a highly secure device with real-time processing capabilities.

Can Azure RTOS broadly available?
Azure RTOS is currently in "public preview" which is really about showing off the integration work done by industry leading partners in their embedded development kits which feature Azure RTOS ThreadX. These partners together represent the vast majority of the market for 32-bit MCUs.

Azure Sphere – Product description

Azure Sphere is a comprehensive IoT device security solution that is purpose-built to allow any developer to create a connected device that is highly secured by default. It is an integrated solution that includes Azure Sphere-certified hardware, the Azure Sphere operating system, and Azure Sphere Security Service with ongoing OS and security updates. Azure Sphere is a certified MCU device that works seamlessly with OS and cloud security components to provide active security by default.

- **Azure Sphere certified chips (from hardware partners)** – physical MCUs and SOCs with built-in Microsoft security technology. Supports a secured hardware root of trust for connected, intelligence edge devices

- **Azure Sphere OS –** OS offers defense in depth, i.e., multiple layers of security combining security innovations pioneered in Windows, threat monitoring, and a custom Linux kernel to create a highly-secured software environment and a trustworthy platform for new IoT experiences

Azure Sphere Security Service – a SaaS cloud service that brokers trust for device-to-cloud communication, detects threats, and continually renews device security

Azure Sphere SDK – provides integrated development tooling for programming and debugging Azure Sphere solutions in Visual Studio and Visual Studio Code

Memory footprint: 4 MB
Azure Sphere certified chips are available today from MediaTek. Development kits and modules are available from ecosystem partners Avnet, AI-Link, Seeed Studio, USI, and qiio. NXP and Qualcomm chips coming soon.

Positioning

An integrated hardware, software, and cloud services solution for securely connecting existing equipment and to create new IoT devices with built-in device to cloud security.

- Provides a complete solution to enable any developer—by default—to build highly-secured connected devices.
- Suitable to secure even devices that connect directly to the internet due to its defense-in-depth approach across hardware, software/OS, and security service
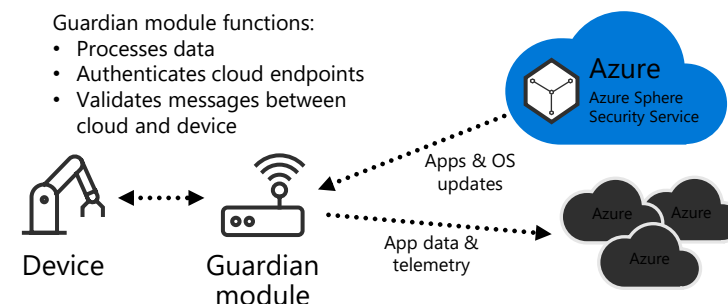
Example use cases

- Food services
- Refrigeration
- Industrial/Manufacturing/Infrastructure
- Logistics/Transportation
- HVAC controls
- Medical devices
- Drones
- Home appliances
- Escalators/elevators
- Badge scanners

Other things to know

Azure Sphere guardian modules.

Azure Sphere guardian modules (developed by partners) are secure data connectors built on Azure Sphere that can help securely connect legacy "brownfield" devices (and existing architectures) to the cloud.

Guardian module functions:
- Processes data
- Authenticates cloud endpoints
- Validates messages between cloud and device

Device   Guardian module

Azure
Azure Sphere Security Service

Apps & OS updates

App data & telemetry

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Azure Sphere (cont'd)

Microsoft Security

OEMs using Azure Sphere are building on top of a platform that, by default, provides all 7 properties of highly secured devices.

Azure Sphere's integrated hardware, software, and cloud services work seamlessly together and deliver active security by default.

Every Azure Sphere device comes with over 10 years of security and OS updates. Microsoft builds, manages and deploys these updates directly to the devices.

Security updates and improvements are delivered automatically to each Azure Sphere device from the Azure Sphere Security Service continuously. OEMs can use the same Azure Sphere Security Service to remotely update their applications.

Licensing/Pricing

The Azure Sphere includes three components, always sold together as one solution: Azure Sphere certified MCU, Azure Sphere OS, Azure Sphere Security Service

Customers purchase the solution (chips) from a distributor. Each chip comes bundled with the Azure Sphere license that covers the Azure Sphere OS—including more than 10 years of ongoing security and OS improvements—and a subscription to the Azure Sphere Security Service for as long as the device is connected. (Separate subscriptions are required for other cloud services.)

Prices will be variable by each partner developed Azure Sphere MCU depending on the capabilities and manufacturer requirements. For the first Azure Sphere MCU, the MediaTek MT3620 AN, the price will be less than $8.65 (including all three components) and varies based on volume.

FAQs

Does a company have to be an Azure customer to use Azure Sphere?
No. The Azure Sphere Security Service is engineered to let device manufacturers integrate with the tools and services they already use. While the Azure Sphere Security Service runs in Azure, customers have the choice to connect to any proprietary or public cloud for app data.

Is a Visual Studio License required?
Customers have a choice of which development tools they use, however leveraging Visual Studio and Azure IoT services, allows organizations to develop applications for Azure Sphere more efficiently. Proper licensing of Visual Studio is required to use the Visual Studio Tools for Azure Sphere.

Market and applications

Azure RTOS

| Smart phones | Fitness trackers | Sensors | Consumer Electronics | Thermostats, Smoke Alarms | Medical diagnostics | POS, Kiosks ATMs, Gas Pumps, Vending, Digital signage | PLC/Indus. Automation Embedded Servers |

Azure Sphere

| Connector Boards Guardian modules | Medical diagnostics | Home appliances | IOT Gateways | Consumer Electronics | Smart phones | Fitness trackers |

Windows IoT

| POS, Kiosks ATMs, Gas Pumps, Vending, Digital signage | HMIs, PLC/Indus. Automation Embedded Servers | MRI, Xray devices | Industrial Robots & gateways | Consumer Electronics | Smart phones | Fitness trackers | Sensors |

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Azure IoT Edge for Linux on Windows

EFLOW

Azure IoT Edge For Linux On Windows brings the best of both worlds

Windows IoT

Robust user experience

Extensive application ecosystem

Trusted Enterprise-grade security

Established IT Admin infrastructure

World-class long-term servicing

Flexible hardware options

Linux

Containerized Microservices

Native Docker packaging

Broad Edge module adoption

Enable AI/ML scenarios

Enable IIoT workloads

Azure EFLOW

Lower Cost

One device can do it all

Simple to deploy, manage, and update with existing tooling

Leverage existing app and infrastructure investments

Minimal impact to IT Administration

New Capabilities

Easily connect to Azure

Broadest of AI/ML modules

Existing IIoT module support

Even more 3rd party modules
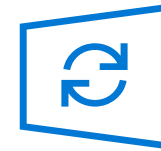
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Enabling Linux-base cloud native workloads on Windows edge device

Microsoft Supported
Linux VM

IoT Edge Linux
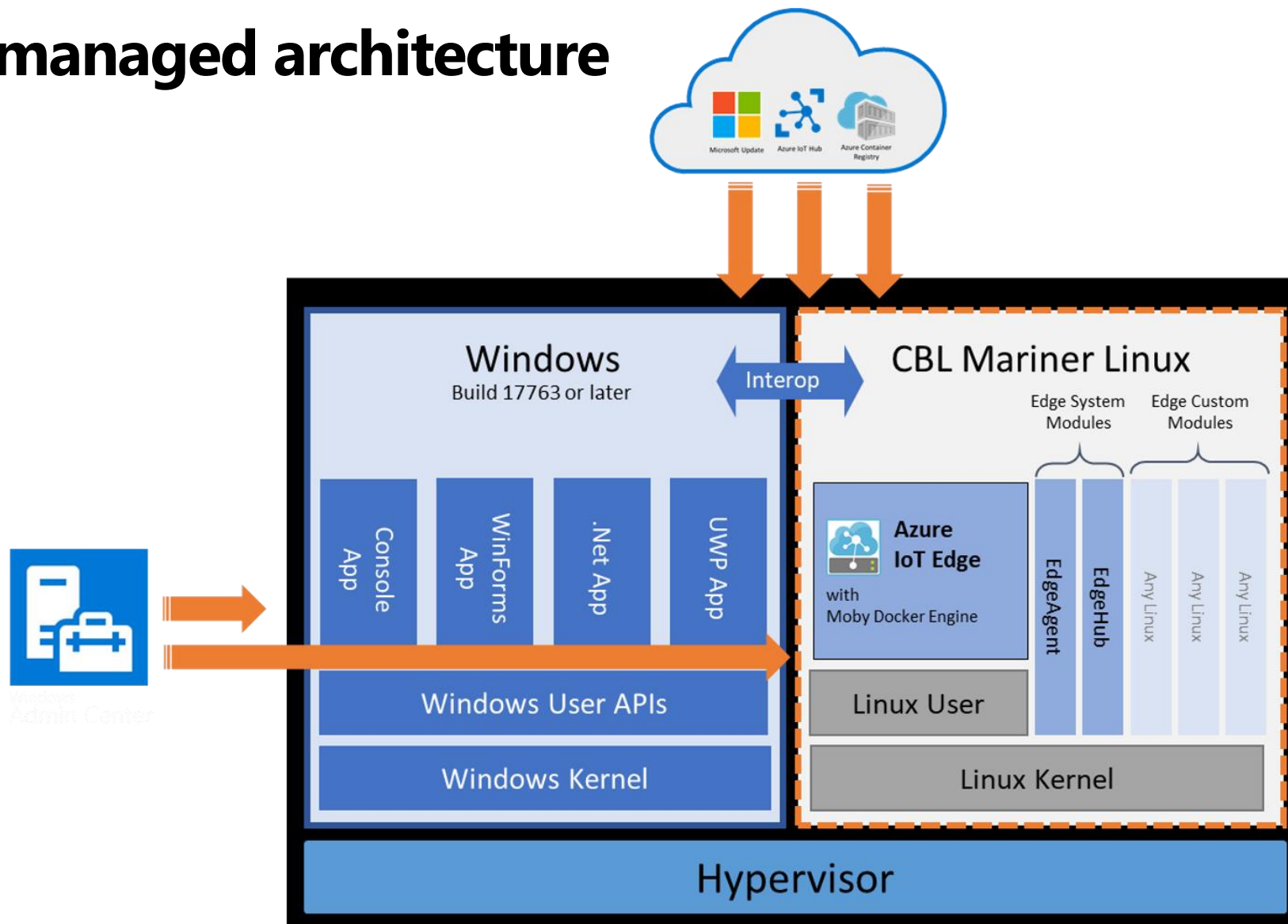Module ready

Always up
to date

Windows
Administration

Flexible
Scripting

App to Module
Interoperability

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Microsoft managed architecture

Multiple reasons to choose EFLOW

If your organization...

| EFLOW provides... |

is a Microsoft shop and does not want to introduce a different OS

does not have Linux knowledge in house or on location

Familiar Windows management tools for deploying Linux workloads

is sometimes deploying solutions in remote, less accessible locations

has network latency, outages and/or delays that prohibits running workload in the cloud

Deployment of cloud-native workloads to the edge

is using Linux today but would prefer Windows to perform the same function

Ability to use existing Linux modules but manage & secure your devices with Windows

wants to keep the cost of hardware assets in check

has both Windows and Linux devices and wants to reduce overhead

Linux IoT Edge modules run on Windows devices

is developing IoT Edge solutions and selling those in the IoT Edge marketplace

Linux + Windows capabilities and interoperability on a single machine

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Run EFLOW on your existing edge devices

Supported OS
Windows Pro / Enterprise 2109 (build 17763) or later
Windows Server 2019 (build 17763) or later

Free Storage
10GB Minimum*

Memory
Physical: 4GB Minimum* - Free: 1GB Minimum*

Virtualization
Physical: 4GB Minimum* - Free: 1GB Minimum*

Licensing
Free with supported OS versions – Azure subscription required

Resource	Link
Documentation	https://aka.ms/AzEFLOW-Docs
Wiki	https://aka.ms/AzEFLOW-Wiki
Release Notes	https://aka.ms/AzEFLOW-Releases
Sample Code	https://aka.ms/AzEFLOW-Samples
GitHub	https://aka.ms/AzEFLOW-Github

* Memory and Storage requirements depend on the size of the VM selected at deployment

Hardware access

TPM 2.0

Trusted Environment for DPS Provisioning

Learn More:
aka.ms./AzEFLOW-TPM
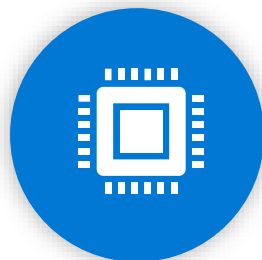
GPU

HW Accelerated Inferencing

Learn More:
aka.ms./AzEFLOW-GPU

Camera

AI / ML with USB attached Camera

Learn More:
aka.ms/AzEFLOW-USBCameraToRTSP
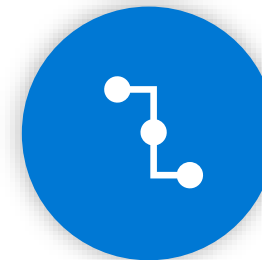
Serial

Data ingestion from serial attached devices

Learn More:
aka.ms/AzEFLOW-SerialPassthrough

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IT Admin Target Audience
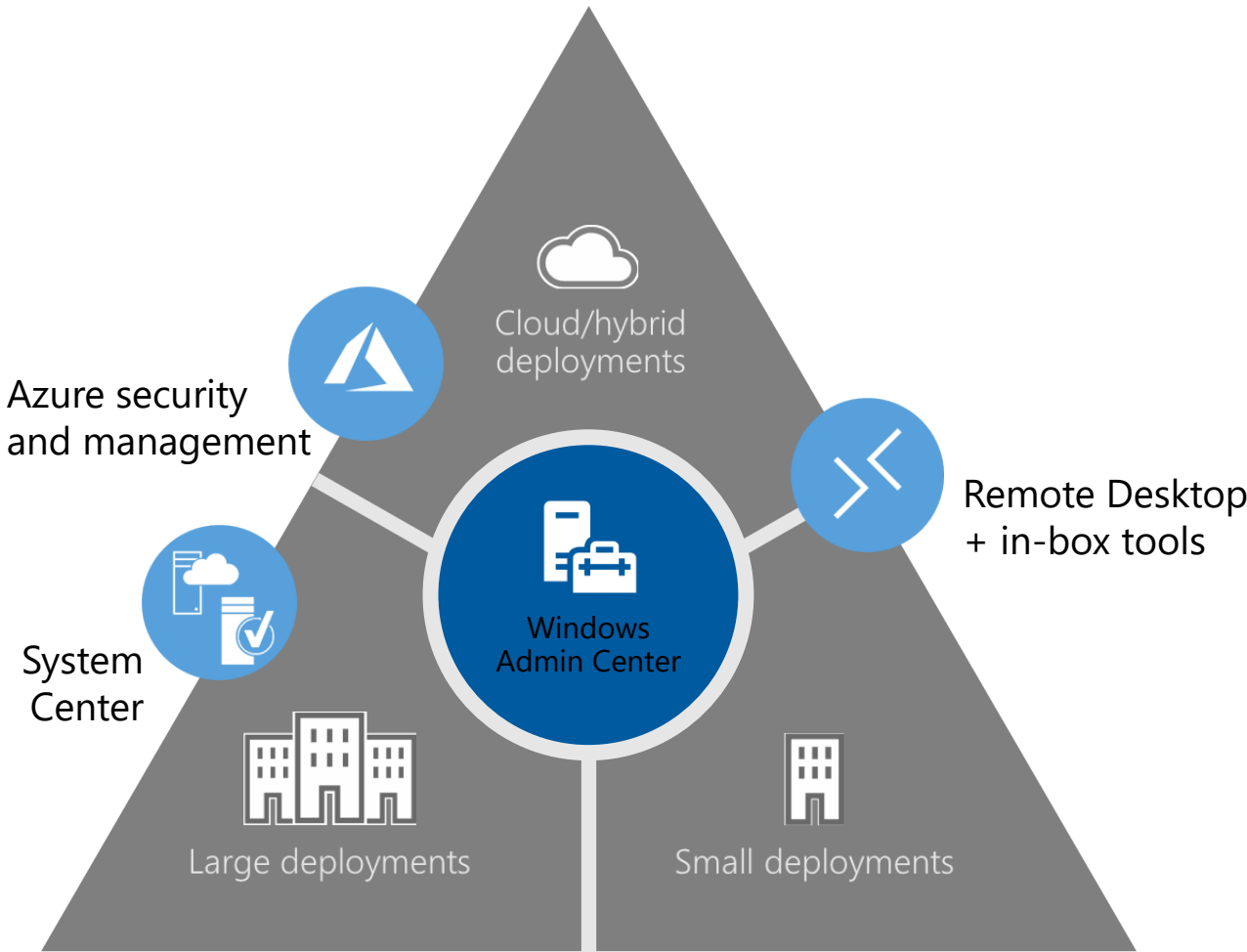
Package installation and configurations using PowerShell
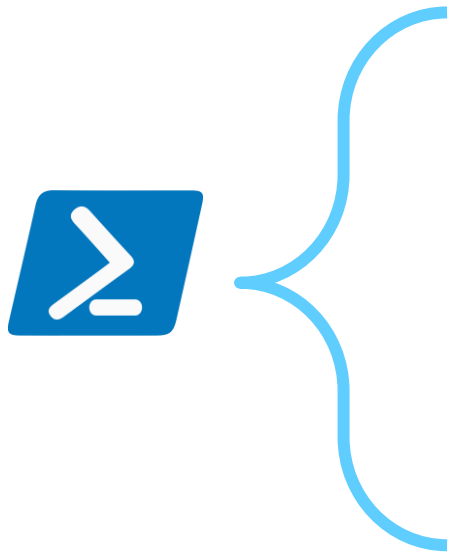
- ➢ PowerShell 5.1
- ➢ PowerShell 6
- ➢ PowerShell 7 (soon)
- ➢ PowerShell SDK (soon)

Function

Deploy-Eflow

Provision-EflowVm

Start-EflowVm / Stop-EflowVm

Connect-EflowVm

Get-EflowVm

Set-EflowVm

Invoke-EflowVmCommand

Copy-EflowVmFile

Learn more: https://aka.ms/AzEFLOW-PowerShell

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Azure Kubernetes Service (AKS)

A Microsoft managed Kubernetes solution spanning Azure to Edge

Azure Defender

Azure IoT

Microsoft Azure

Azure Kubernetes Service

Azure Digital Twins

Azure Arc

CLOUD

Tiny Edge

Light Edge

Heavy Edge

MCU-class Sensors/Actuators

Azure RTOS

MPU-class

Windows
IoT 10/11 Pro & Ent

e.g., Gateways, Industrial HMIs, Medical Devices, Robots, POS, Digital Signs...

e.g., Intel NUC with Edge Secured Core and Intel Core i5 w/ 4GB RAM

Server-class

Windows Server and Server IoT

Hybrid server, Hyper converged infra

Azure Stack

EDGE

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Server-class

Hyper-V Windows Server and Server IoT

Hybrid server, Hyper converged infra

Hyper-V Azure Stack

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EDGE

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MCU-class Sensors/Actuators

Azure RTOS

Akri

MPU-class

Hyper-V

Windows IoT 10/11 Pro & Ent

Server-class

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Hybrid server, Hyper converged infra

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e.g., Intel NUC with Edge Secured Core and Intel Core i5 w/ 4GB RAM

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Interoperability with Windows Apps

AKS lite

Windows native applications

| Edge Browser | Console App | Java App | .NET App | UWP App |

Windows User APIs

AKS Lite Mariner VM
Built from EFLOW Base

K8s/K3s Linux Worker

K8s/K3s Control Plane

Mariner User

Azure containers
- Flux & other Azure agents
- Arc-Connected Cluster

User containers
- Any Linux
- Any Linux
- Any Linux

Mariner kernel

AKS Lite Windows VM (Optional)

K8s/K3s Windows Worker

User containers
- Windows container
- Windows container
- Windows container

Windows

AKS Lite Installer, PowerShell, and agent

Windows

Hardware

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Azure to Edge

Azure Resource Manager

Build and manage cloud deployments directly from the Azure portal
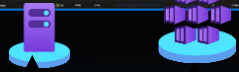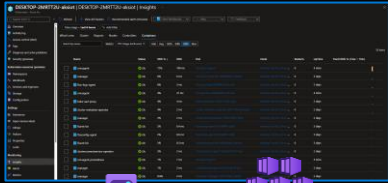
Deploy Cluster extensions

Azure Monitor
Monitor servers in Azure, machines on-premises or at other cloud providers.

Azure Policy
Enforce organizational standards and assess compliance at-scale.

Azure App Service
Quickly build, deploy, and scale web apps and APIs on Kubernetes or Azure.

Deploy your own workloads

PR Pipeline

App repository

GitOps
Manage your desired state Kubernetes cluster configurations with Git

CI Pipeline

CD Pipeline

GitOps repository

Microsoft Artifact Registry
Build, store, and manage container artifacts for your deployments

OS and VM Updates

Windows Update
Get the latest fixes, updates and security improvements

Azure Arc

Pull cluster desired state

Deploy AKS lite on a device like an application

Containerized workloads

Cluster extensions

User workloads

Flux

AKS lite Kubernetes Platform

K8s/K3s

Linux VM

Windows VM (optional)

Connected via Azure Arc-enabled Kubernetes

Connected via Azure Arc-enabled servers

Windows Host OS (with Hyper-V)

Hardware

AKS lite hybrid option (preview)

Deploy your Linux and/or Windows containerized workloads

AKS hybrid options on Windows

Azure Arc control plane to manage your cluster in Azure

Standard kubectl to manage your cluster using PowerShell
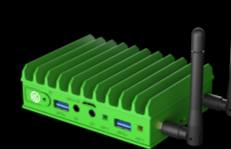
CNCF-conformant Kubernetes platform

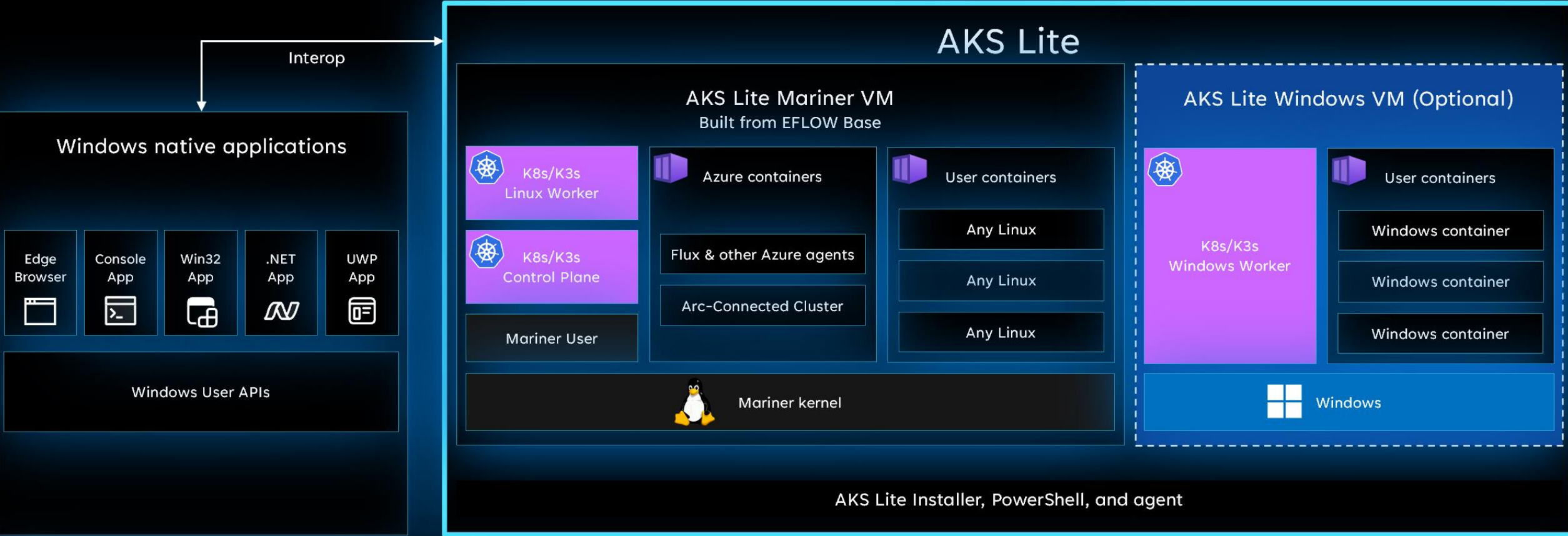PowerShell cmdlets and agents to enable provisioning and control of VMs and infra

Windows 10/11 (IoT Enterprise / Enterprise / Pro /) and Windows Server

Edge computing devices (with 8GB+ RAM)

Azure Kubernetes Service (AKS) Lite architecture

Windows native applications

Interop

Edge Browser

Console App

Win32 App

.NET App

UWP App

Windows User APIs

AKS Lite

AKS Lite Mariner VM
Built from EFLOW Base

K8s/K3s Linux Worker

K8s/K3s Control Plane

Mariner User

Azure containers

Flux & other Azure agents

Arc-Connected Cluster

User containers

Any Linux

Any Linux

Any Linux

Mariner kernel

AKS Lite Windows VM (Optional)

K8s/K3s Windows Worker

User containers

Windows container

Windows container

Windows container

Windows

AKS Lite Installer, PowerShell, and agent

Windows

Hardware

Enabling solutions with Edge Modules from Microsoft

Azure Video Analyzer

Generate real-time business insights from video streams, processing data near the source and applying AI of your choice.

Learn more: https://aka.ms/LVA

Cognitive Services

Embed the ability to see, hear, speak, search, understand, and accelerate decision-making

Learn more: https://aka.ms/Cognitive

Anomaly Detector

Monitor and detect abnormalities in your time series data without having to know machine learning.

Learn More: https://aka.ms/AnomalyDetector

Blob Storage

Enables Edge modules that use Azure Storage SDK to alternatively store the data locally on a local blob store.

Learn more: https://aka.ms/SQLEdge

SQL Edge

Manage data at the edge with data streaming, time series data analysis, and machine learning-based data inferencing.

Learn more: https://aka.ms/SQLEdge

Industrial IoT

OPC Publisher connects to existing OPC UA servers and publishes data from these servers in OPC UA "Pub/Sub" format
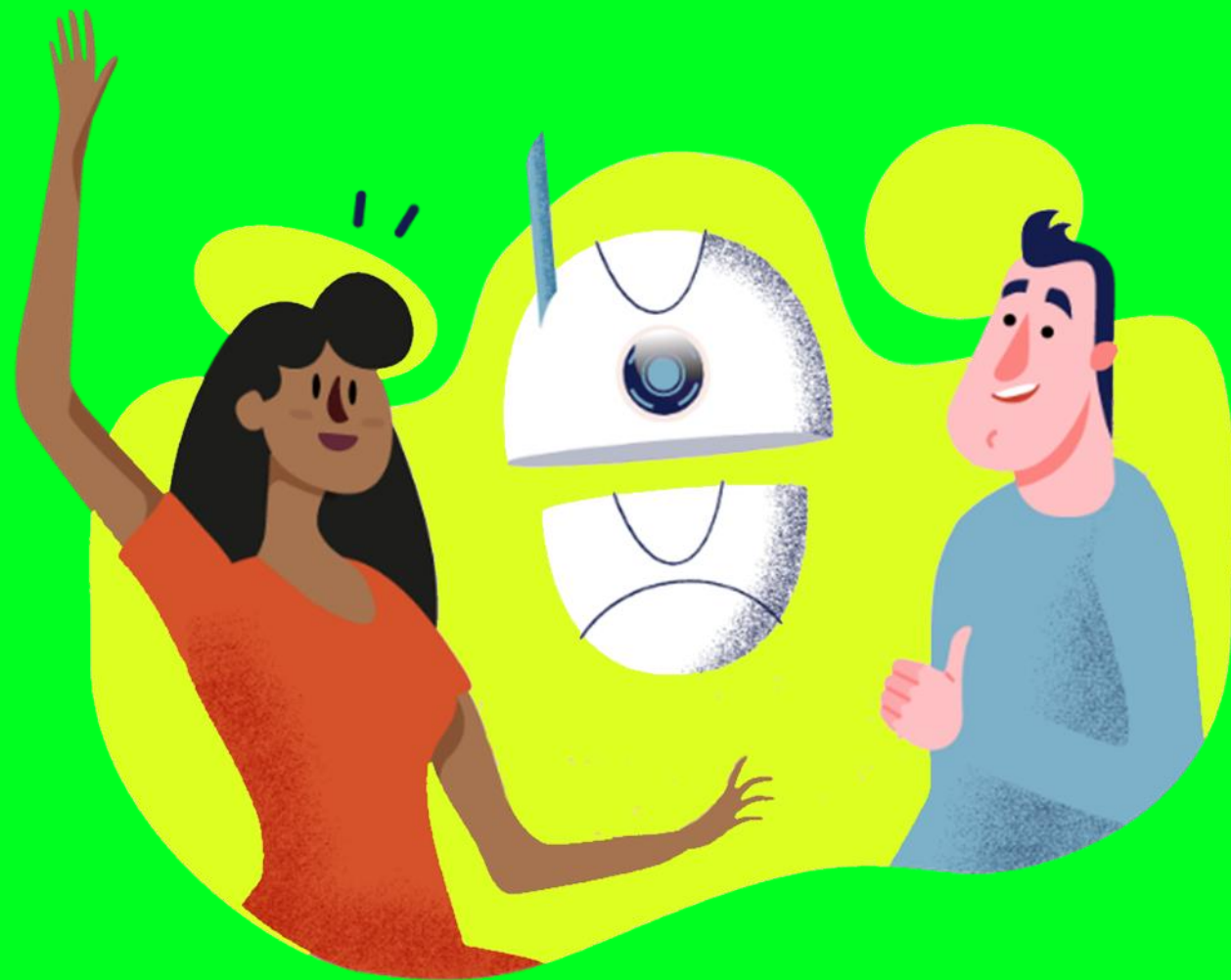
Learn more: https://aka.ms/OPCPublisher

Modbus enables acquisition of data through Modbus TCP or RTU protocols

Learn more: https://aka.ms/Modbus

Resources

Blogs & Videos

General Availability

Blog: aka.ms/AzEFLOW-blog

IoT Show: aka.ms/AzEFLOW-show

EFLOW and WSL in Edge Dev

Blog: aka.ms/AzEFLOW-wslblog

IoT Show: aka.ms/AzEFLOW-wslshow

Product

Overview: aka.ms/AzEFLOW-docs

QuickStart: aka.ms/AzEFLOW-quickstart

Install: aka.ms/AzEFLOW-install

PowerShell: aka.ms/AzEFLOW-powershell

Modules: aka.ms/AzEFLOW-modules

GitHub

Home: aka.ms/AzEFLOW-github

Wiki: aka.ms/AzEFLOW-wiki

Issues: aka.ms/AzEFLOW-issues

Samples: aka.ms/AzEFLOW-samples

Releases: aka.ms/AzEFLOW-releases

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Lisboa

POWER PLATFORM BOOTCAMP

Marco Dal Pino

- 30+ years in IT (Developer, Architect, Consultant, PM, Trainer)
- Speaker, Community addicted
- IoT Influencer

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