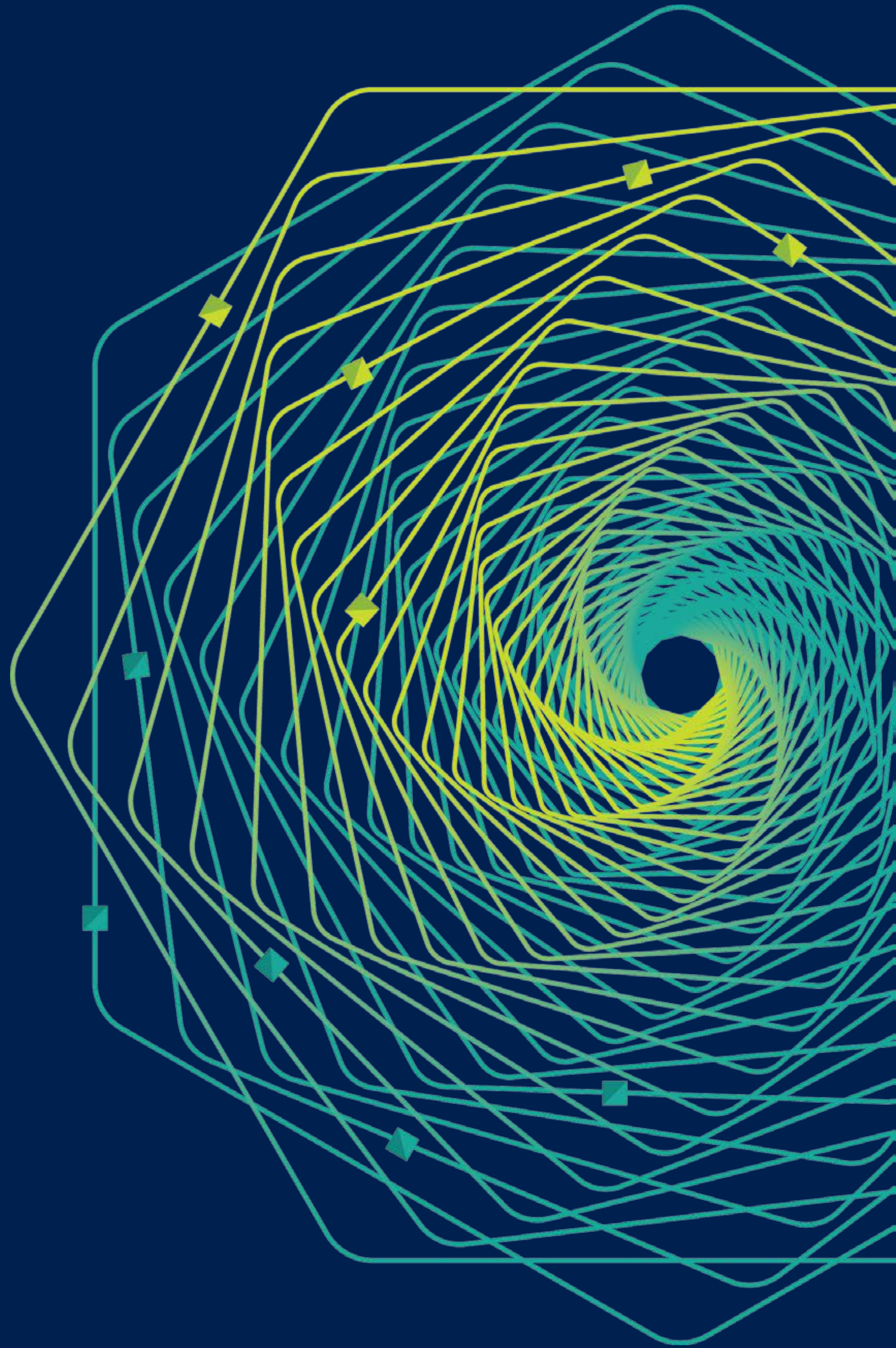
Microsoft

Research Faculty Summit 2018

Systems | Fueling future disruptions



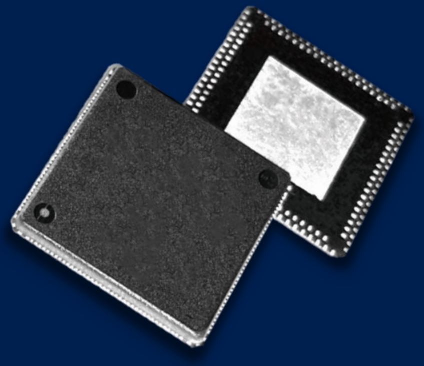
Microsoft

Azure

Azure Sphere

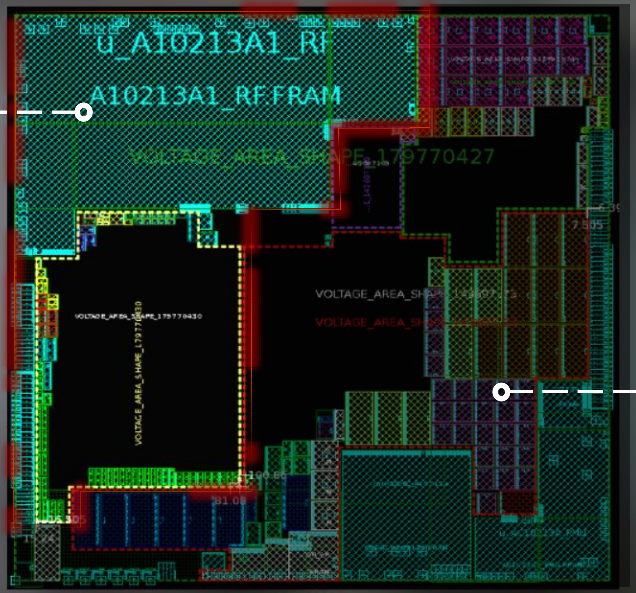
Ed Nightingale
Partner Architect
Microsoft

Microcontrollers (MCUs)
low-cost, single chip computers



9 BILLION new MCU devices built and deployed every year

Radio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A10213A1_RF.FRAM
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VOLTAGE_AREA_SH

MCU

Opportunity | Risk

Connected devices create profoundly better customer experiences.

How does a consumer know the compressor in their fridge needs to be replaced?

Option 1

Melted ice cream

Option 2

Predictive maintenance

What happens when you connect a device to the internet?

“Ransomware attacks will target more IoT devices in 2018”

“Huge IoT botnet may be used for Ukraine attack”

“Industrial IoT to equip new era of corporate intruders coming in through devices”

“When smart gadgets spy on you: Your home life is less private than you think”

“Hacking these IoT baby monitors is child’s play, researchers reveal”

“Security experts warn of dangers of connected home devices”

“Hackers infect 500,000 consumer routers all over the world with malware”

“Your smart fridge may kill you: The dark side of IoT”

“The Lurking Danger of Medical Device Hackers”

“Why the KRACK Wi-Fi mess will take decades to clean up

“Hacking critical infrastructure via a vending machine? The IOT reality”

“Protecting Your Family: The Internet of Things Gives Hackers Creepy New Options”

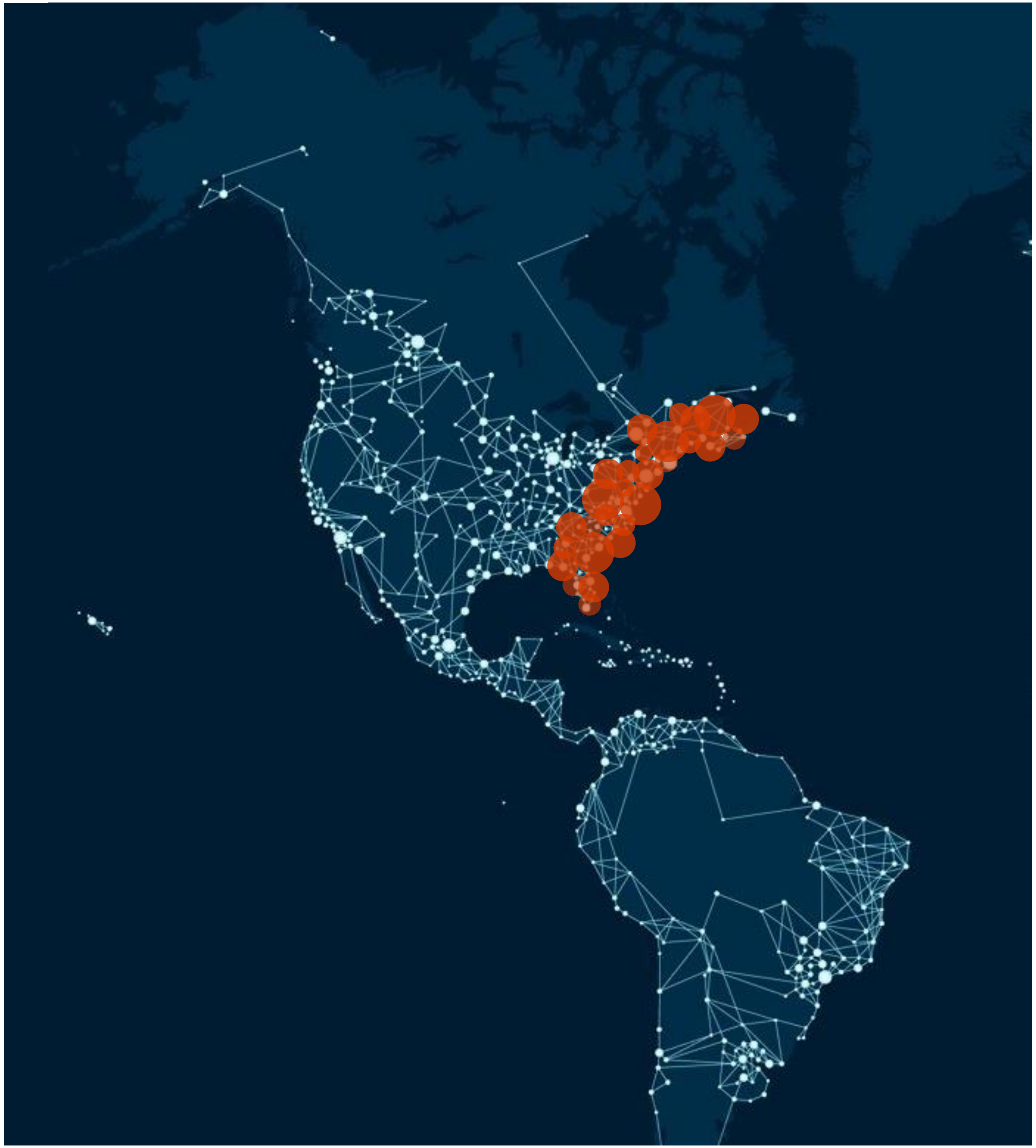
Mirai Botnet attack

Everyday devices are used to launch an attack that takes down the internet for a day

100k devices

Exploited a well known weakness

No early detection, no remote update



Hackers attack casino

Attackers gain access to casino database through fish tank

Entry point was a connected thermometer

Once in, other vulnerabilities were exploited

Gained access to high-roller database

No manufacturer wants to make insecure devices

From: Hackers
To: Consumer
Subject: Your Fridge

We control your fridge.
Send us $5 in bitcoin or else…

Terrorists Ignite Thousands of
House Fires with Hacked Stoves

SECURITY IS FOUNDATIONAL

It must be built in from the beginning.

The 7 properties of highly secured devices

Hardware
Root of Trust

Defense
in Depth

Small Trusted
Computing Base

Dynamic
Compartments

Certificate-Based
Authentication

Failure
Reporting

Renewable
Security

https://aka.ms/7properties

Some properties depend only on hardware support

Hardware
Root of Trust

Hardware Root of Trust

Unforgeable cryptographic keys generated and protected by hardware

- Hardware to protect **Device Identity**
- Hardware to **Secure Boot**
- Hardware to attest **System Integrity**

Some properties depend on hardware and software

Defense in Depth

Dynamic Compartments

Small Trusted Computing Base

Dynamic Compartments

Internal barriers limit the reach of any single failure

- Hardware to **Create Barriers**
- Software to **Create Compartments**

Some properties depend on hardware, software and cloud

Certificate-Based Authentication

Failure Reporting

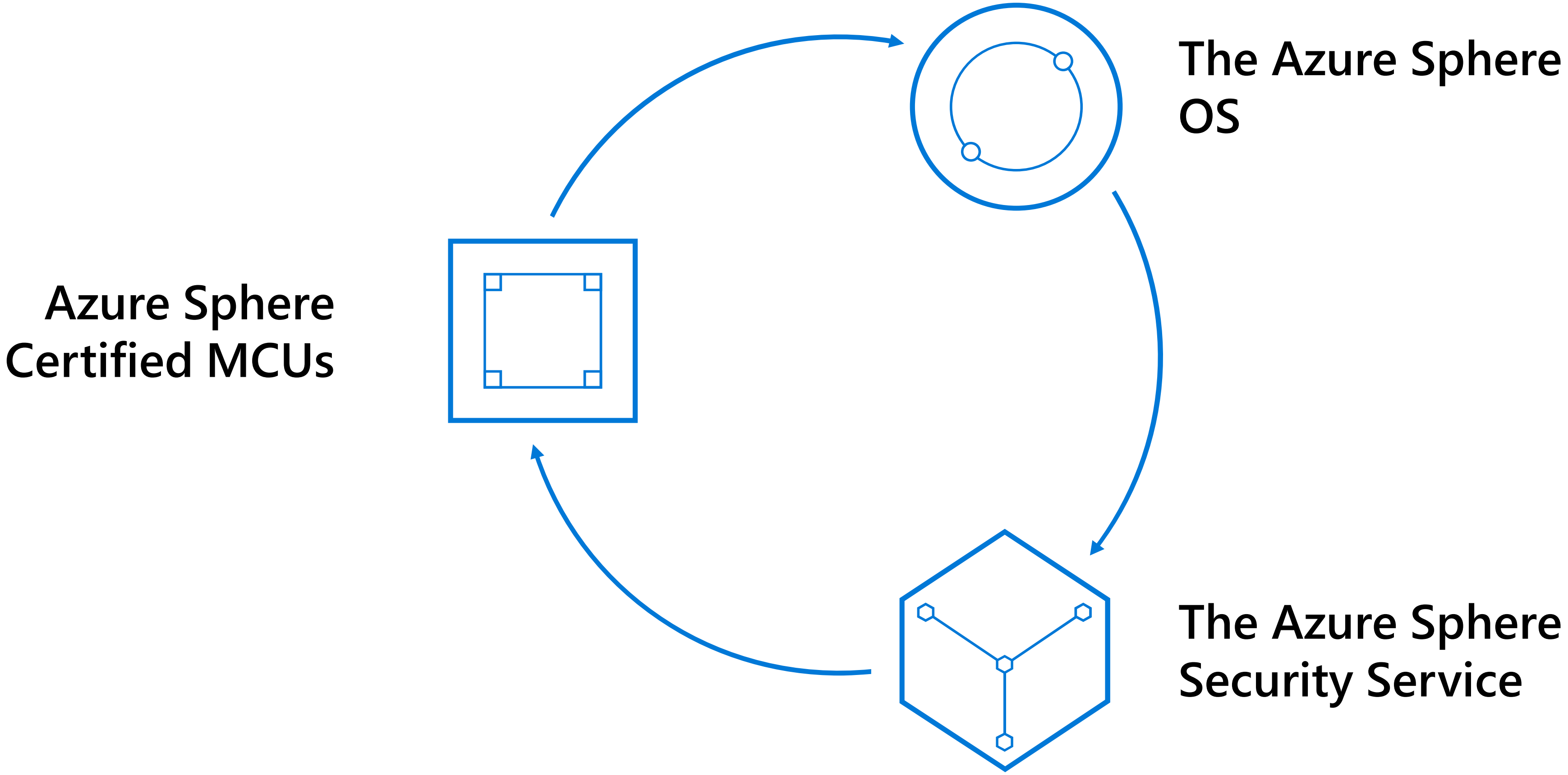
Renewable Security

Renewable Security

Device security renewed to overcome evolving threats

- Cloud to **Provide Updates**
- Software to **Apply Updates**
- Hardware to **Prevent Rollbacks**

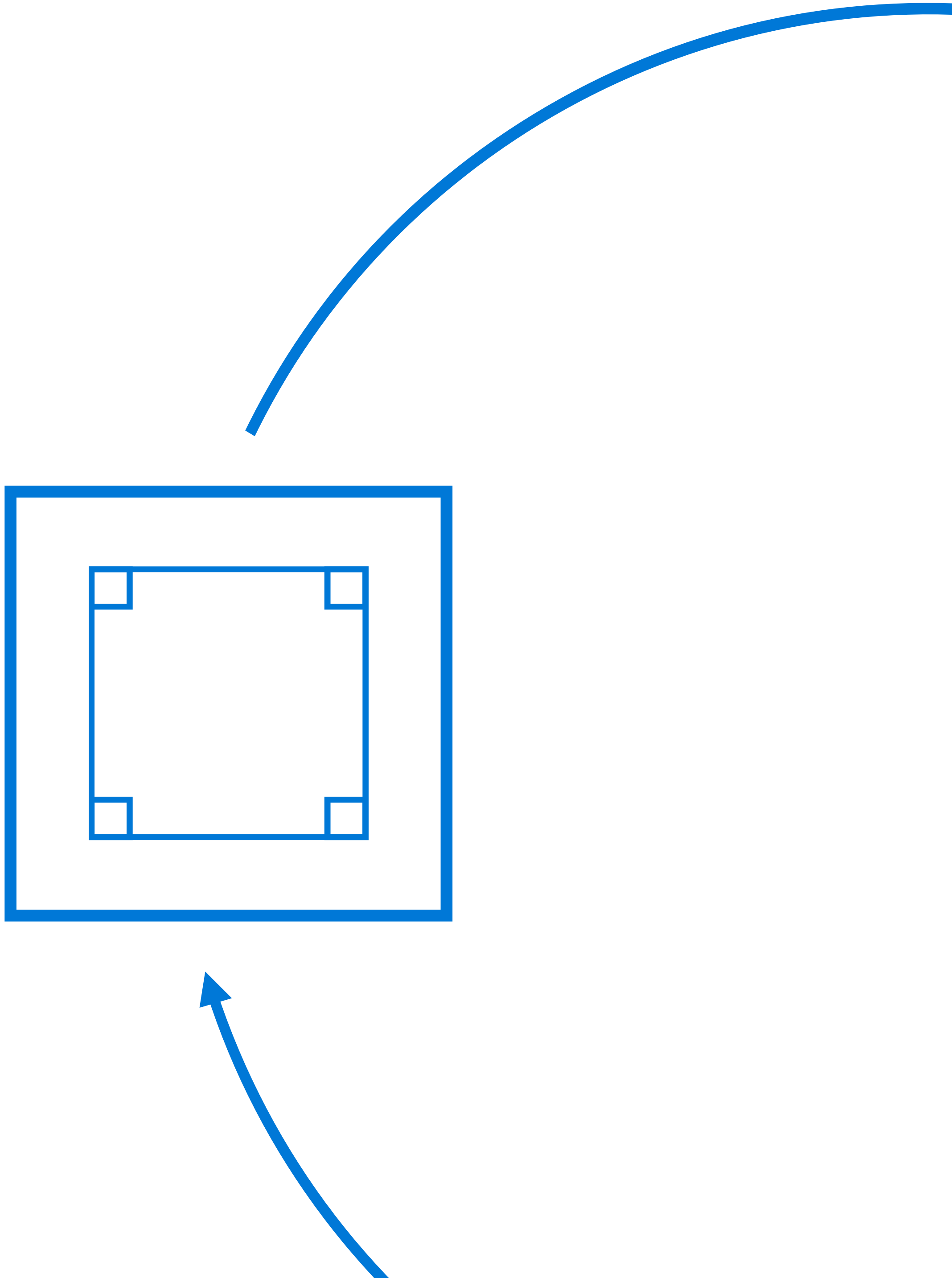
Azure Sphere is an end-to-end solution for securing MCU powered devices

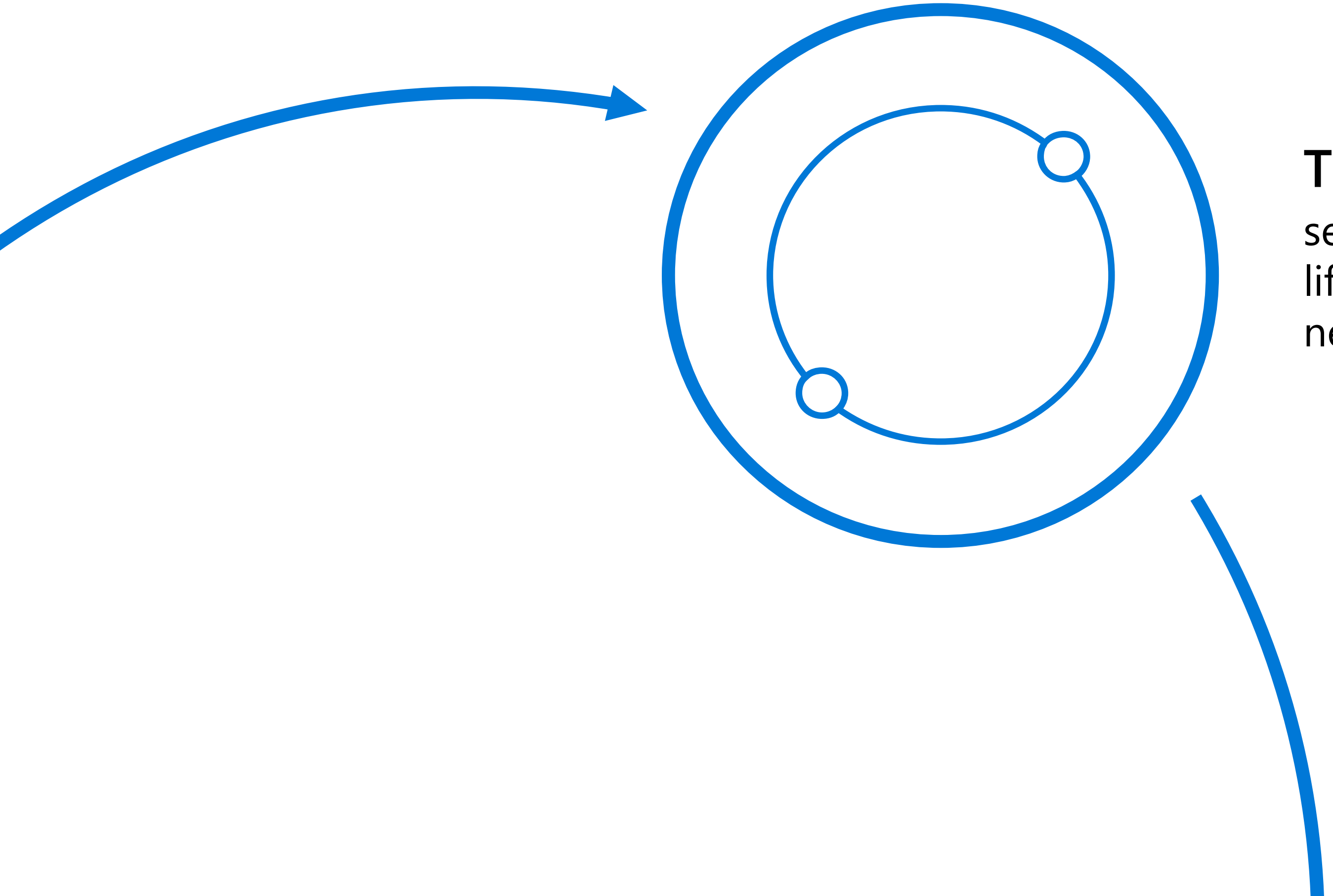


The Azure Sphere OS
Azure Sphere Certified MCUs
The Azure Sphere Security Service

Azure Sphere Certified MCUs

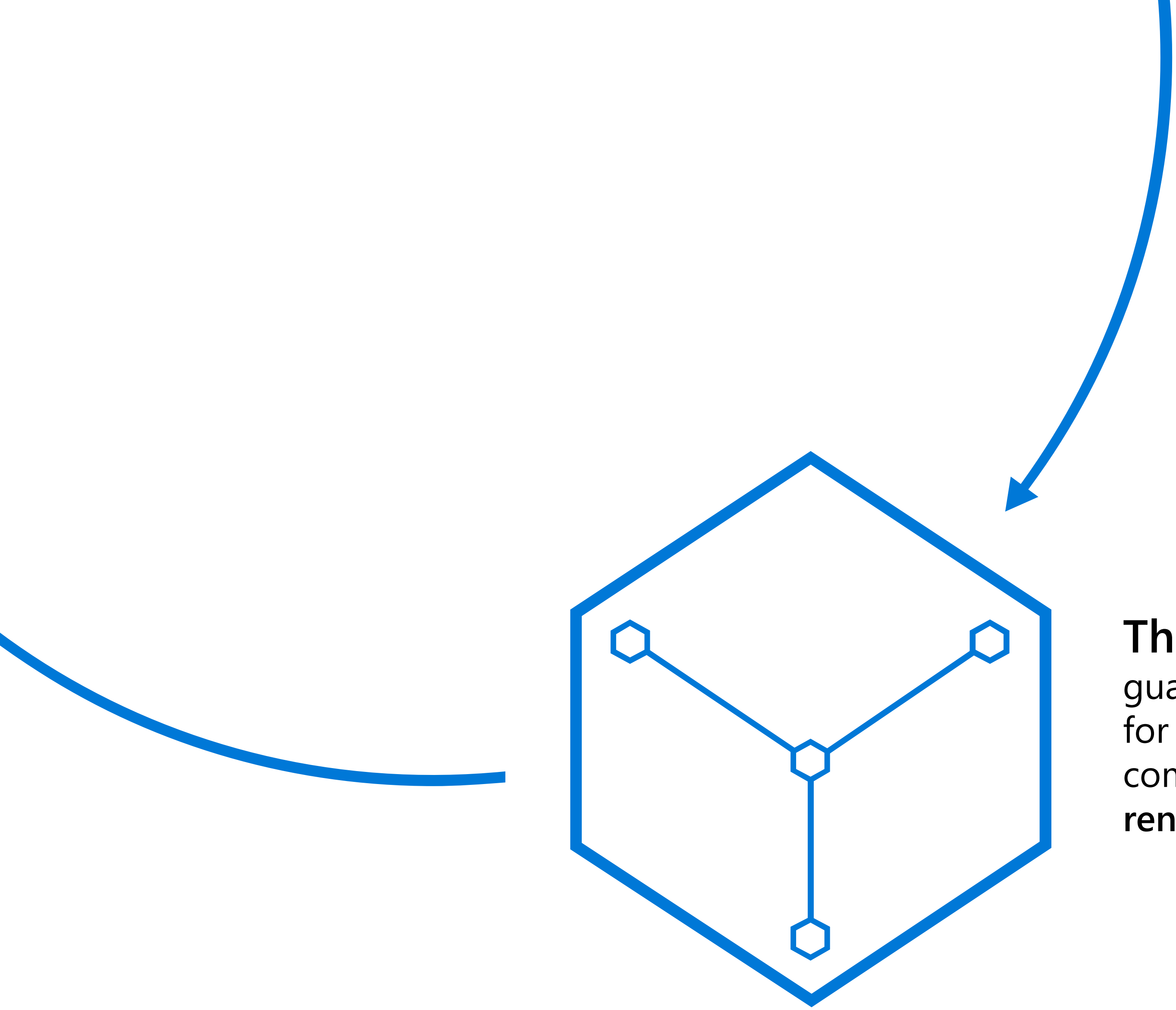
from silicon partners, with built-in Microsoft security technology provide connectivity and a dependable **hardware root of trust.**





The Azure Sphere OS

secured by Microsoft for the devices 10-year lifetime to create **a trustworthy platform** for new IoT experiences



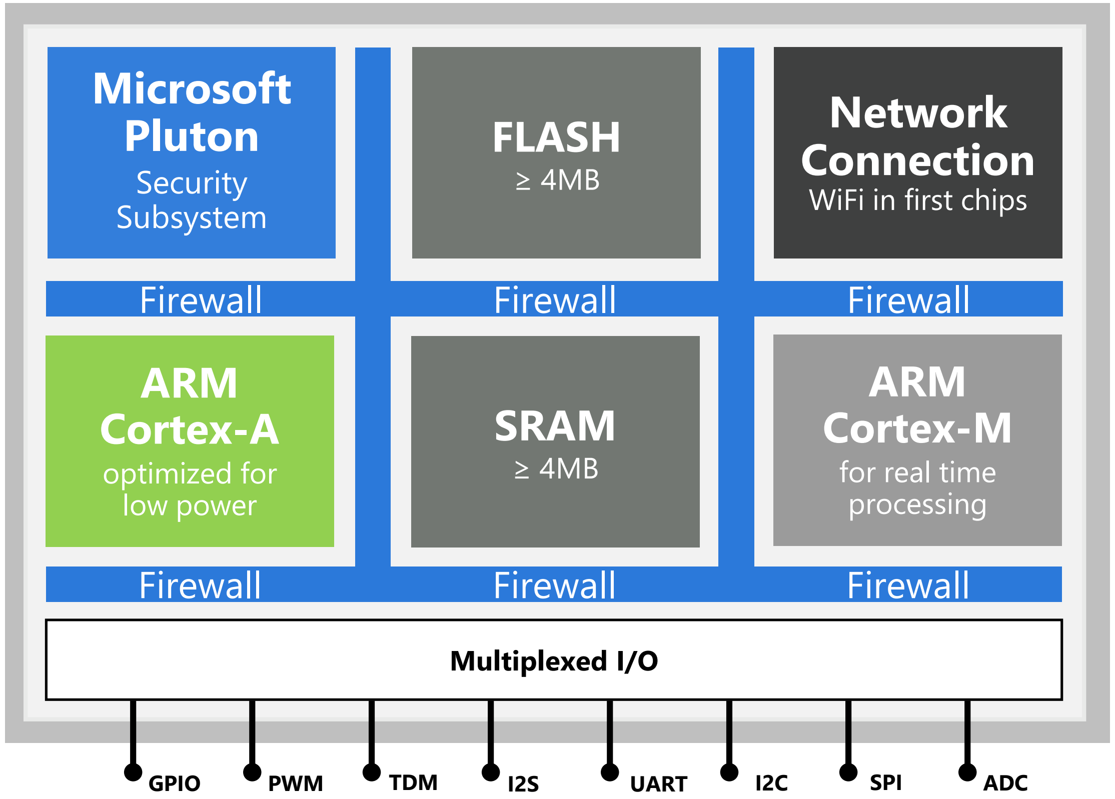
The Azure Sphere Security Service
guards every Azure Sphere device; it **brokers trust** for device-to-device and device-to-cloud communication, **detects emerging threats**, and **renews device security.**

Azure Sphere certified MCUs create a secured root of trust for connected, intelligence edge devices

CONNECTED with built-in networking

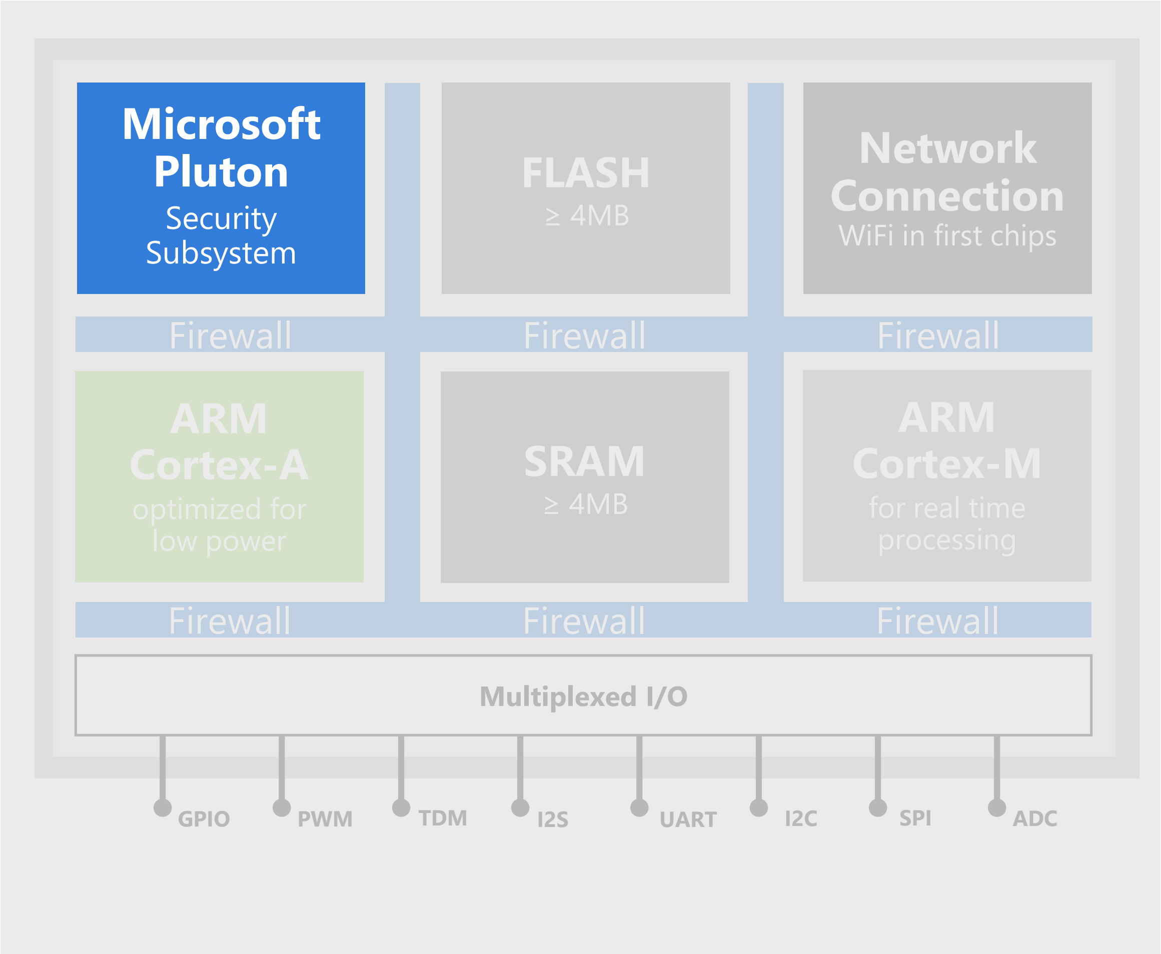
SECURED with built-in Microsoft silicon security technology including the Pluton Security Subsystem

CROSSOVER Cortex-A processing power brought to MCUs for the first time



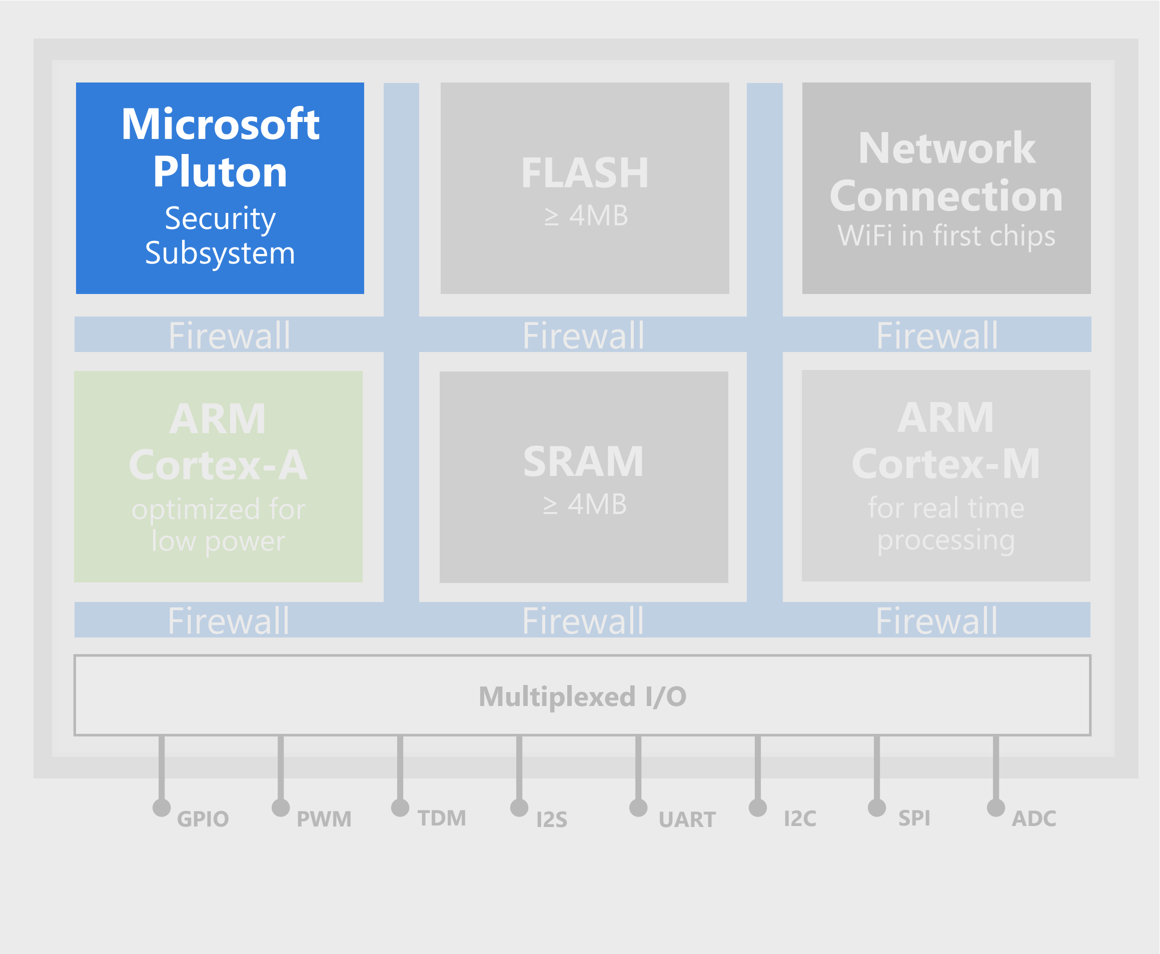
Pluton: A bodyguard for your device

Pluton is the hardware root of trust in an Azure Sphere device.



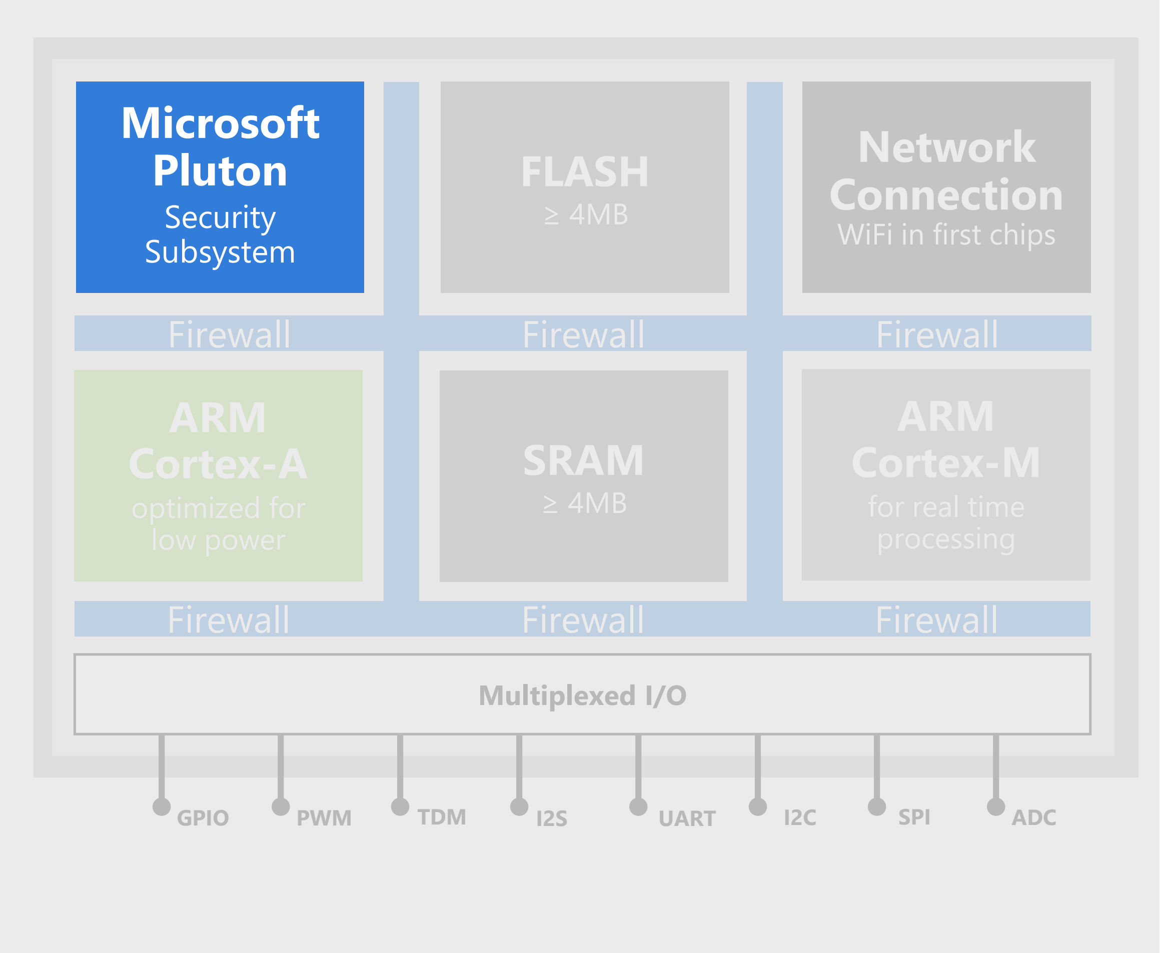
Pluton: A bodyguard for your device

Pluton guarantees the authenticity of your software.



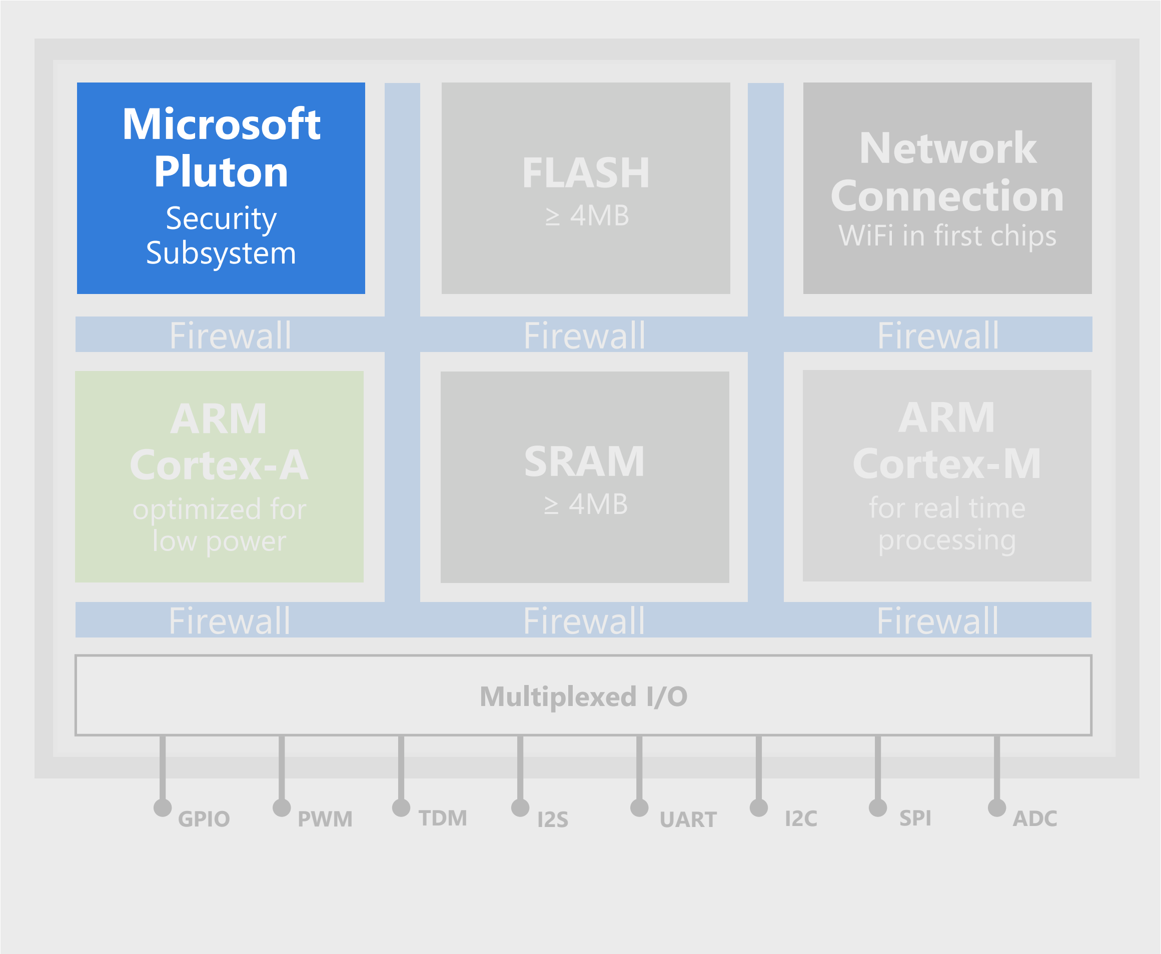
Pluton: A bodyguard for your device

Pluton protects against downgrade attacks.



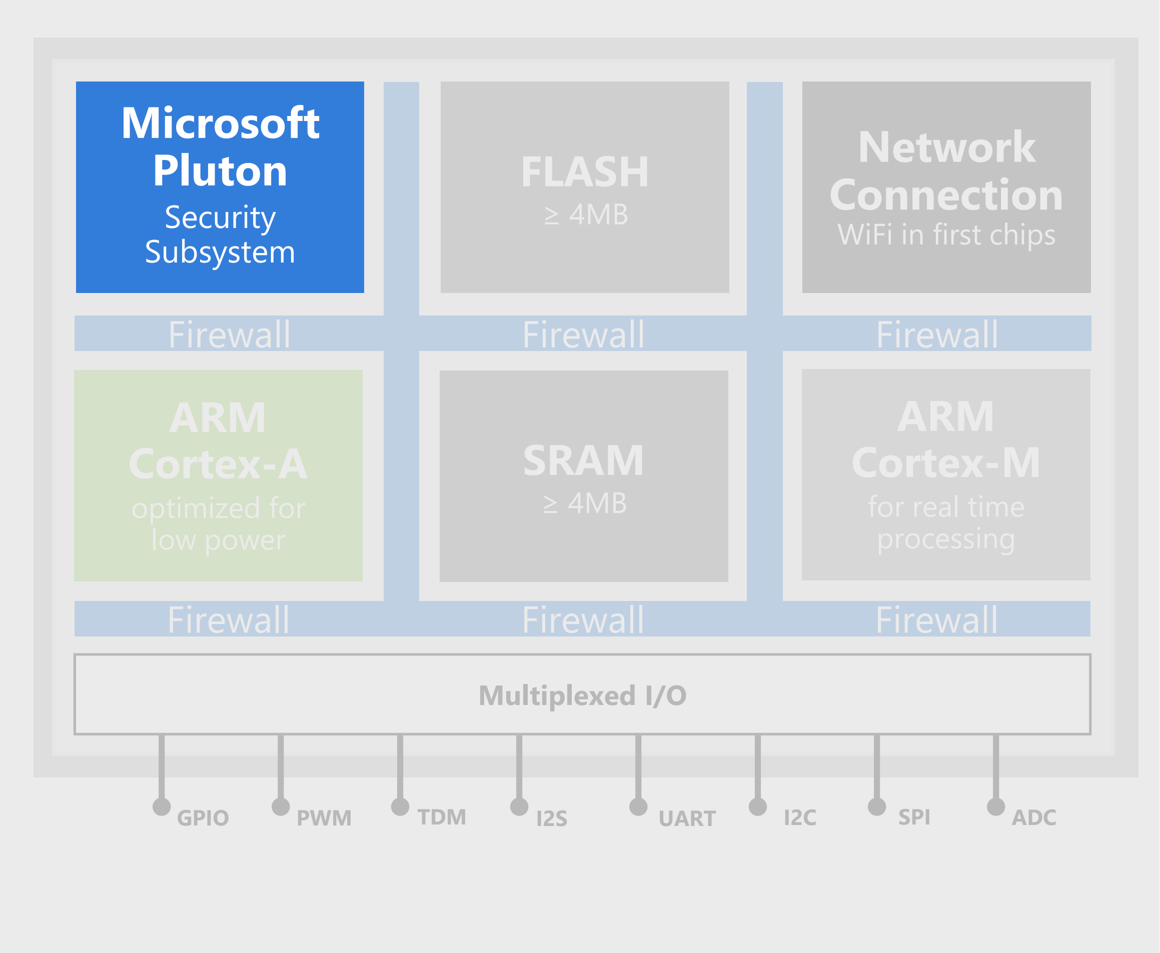
Pluton: A bodyguard for your device

Pluton guarantees the authenticity of your device.



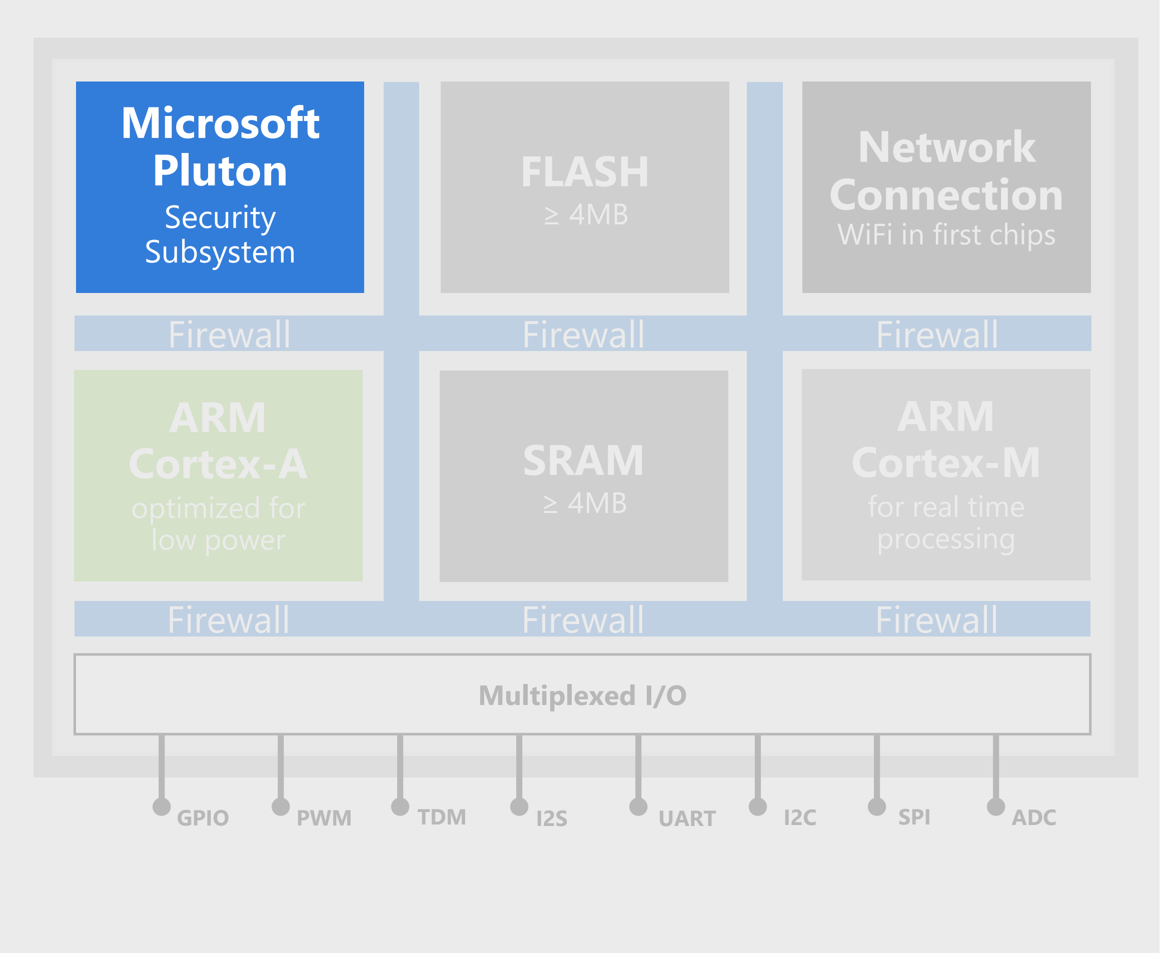
Pluton: A bodyguard for your device

Pluton reduces supply chain risk.



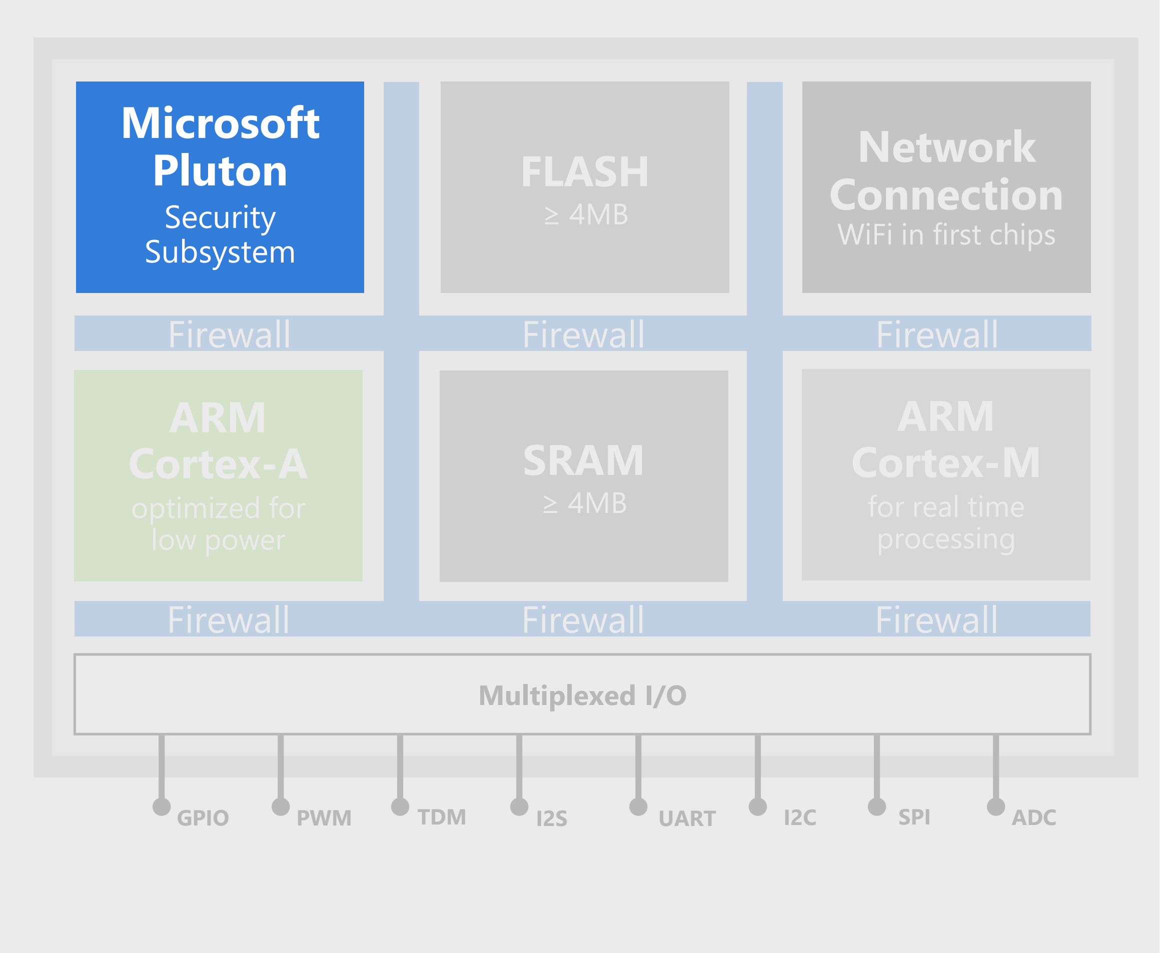
Pluton: A bodyguard for your device

Pluton accelerates cryptographic tasks.



Pluton: A bodyguard for your device

Pluton protects against low entropy attacks.



Azure Sphere MCU's create a secured foundation for intelligent edge devices

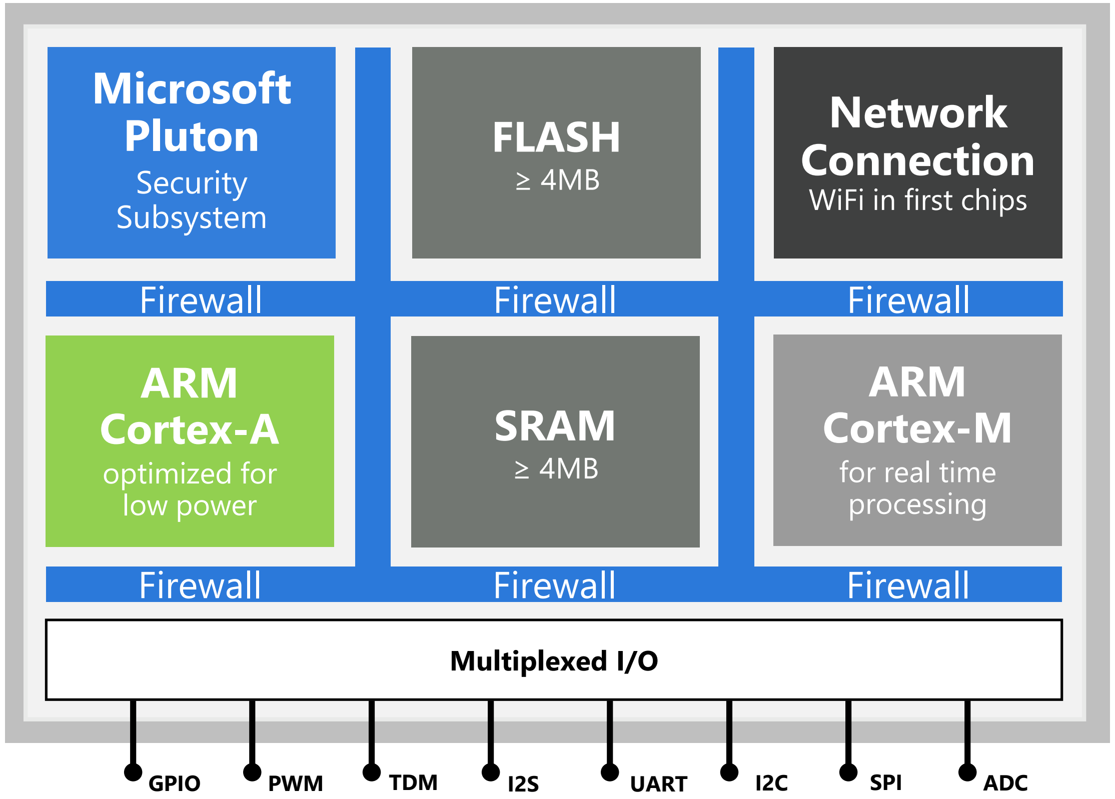
Pluton features implemented **in silicon** include

A hardware root of trust that
-accelerates common cryptographic operations (ECC and AES)
-generates public/private keypairs
-implements secure boot (via ECDSA)

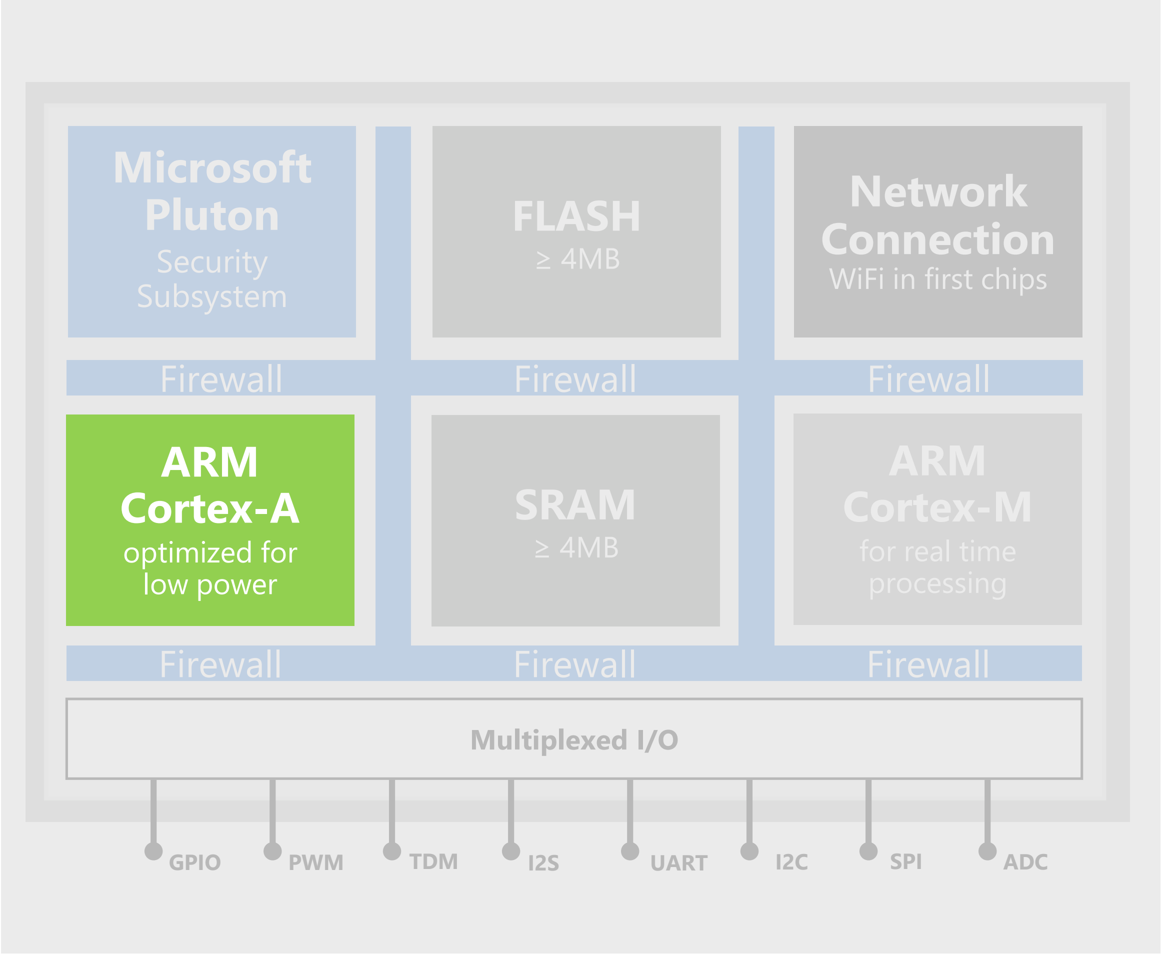
A dedicated core and memory (TCM) that
-resists side-channel attacks that focus on a single core

A true random number generator that
-defends against low-entropy attacks

Measured boot and remote attestation that
-uses a digest accumulator register and nonce register



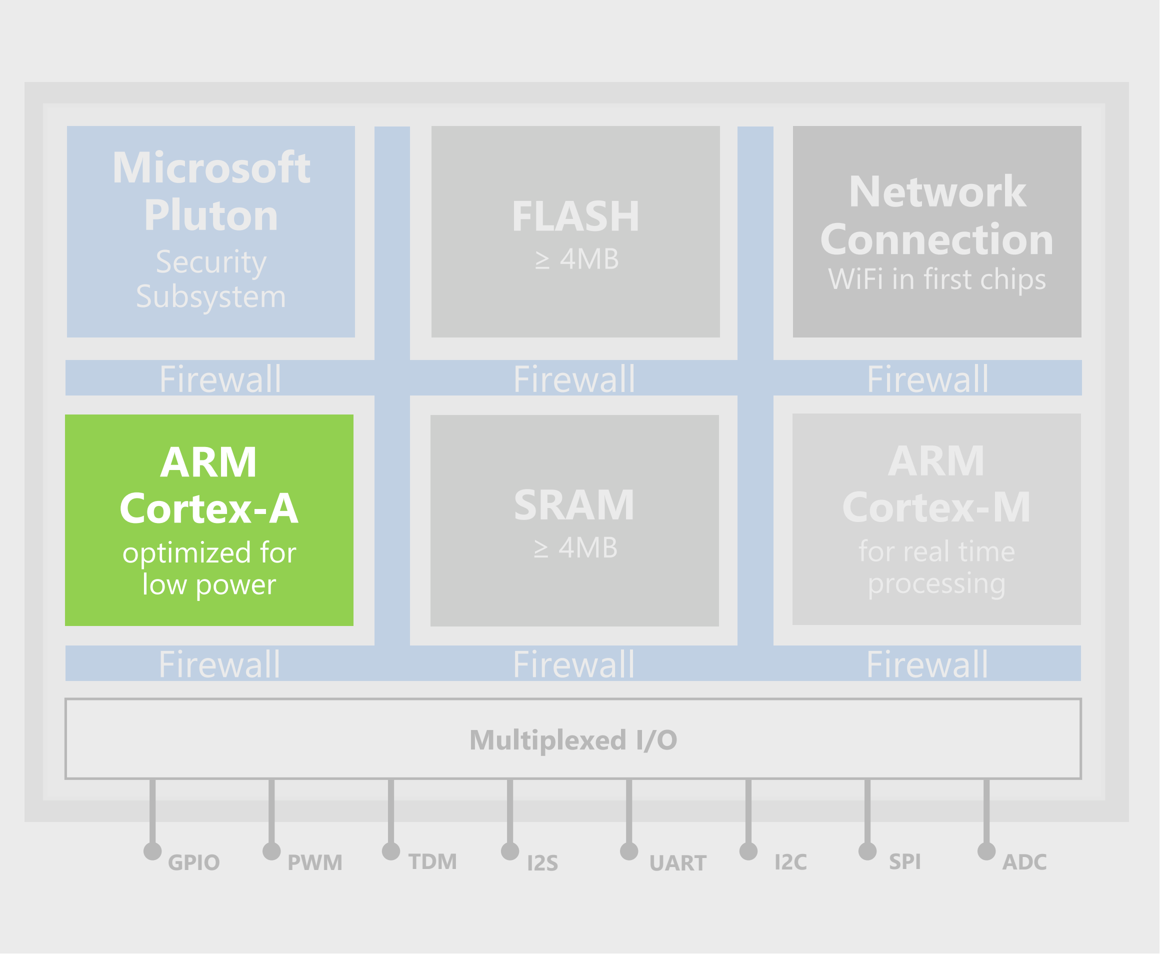
Cortex-A:



Microsoft Pluton
Security Subsystem
FLASH
≥ 4MB
Network Connection
WiFi in first chips
Firewall
Firewall
Firewall
ARM Cortex-A
optimized for low power
SRAM
≥ 4MB
ARM Cortex-M
for real time processing
Firewall
Firewall
Firewall
Multiplexed I/O
GPIO
PWM
TDM
I2S
UART
I2C
SPI
ADC

Cortex-A:

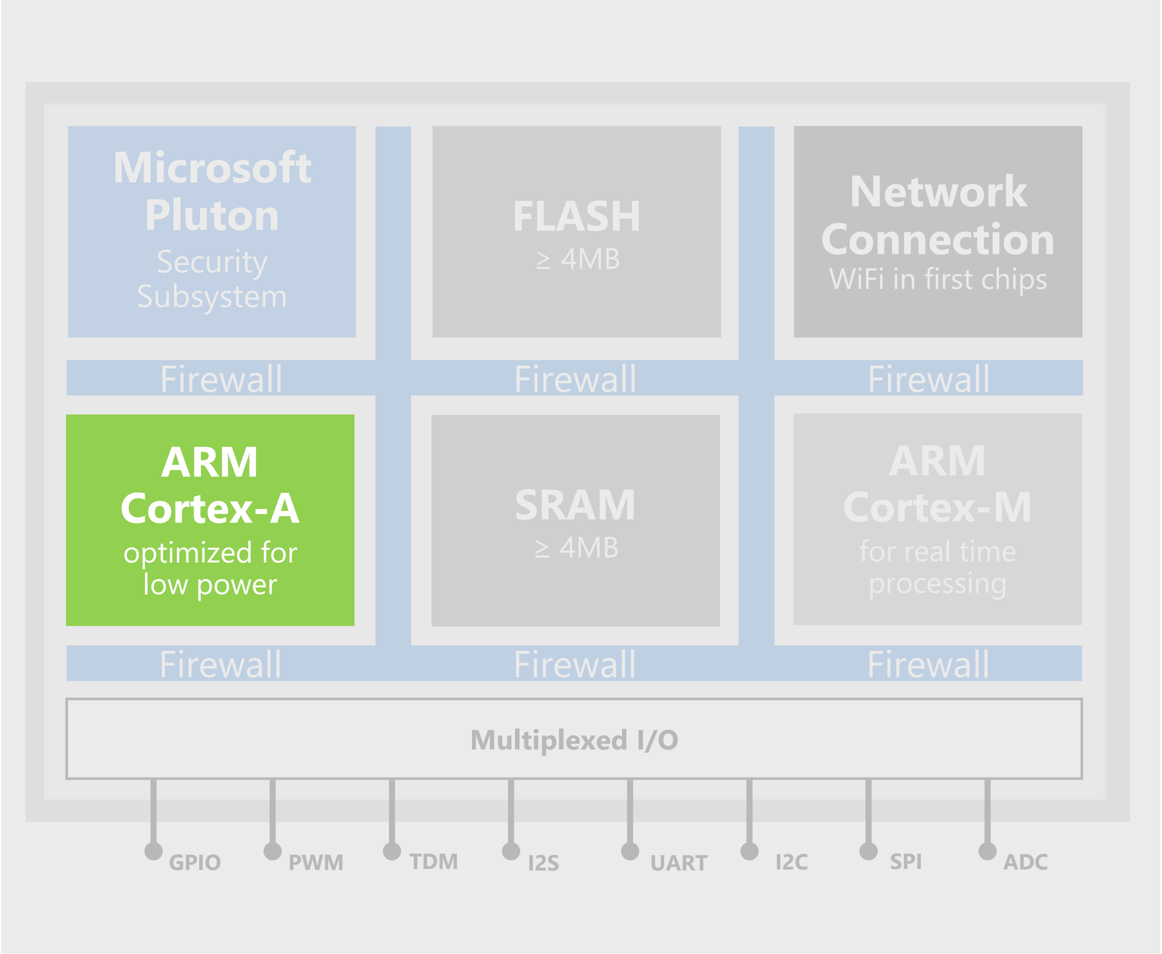
SECURITY



Cortex-A:

SECURITY

PORTABILITY

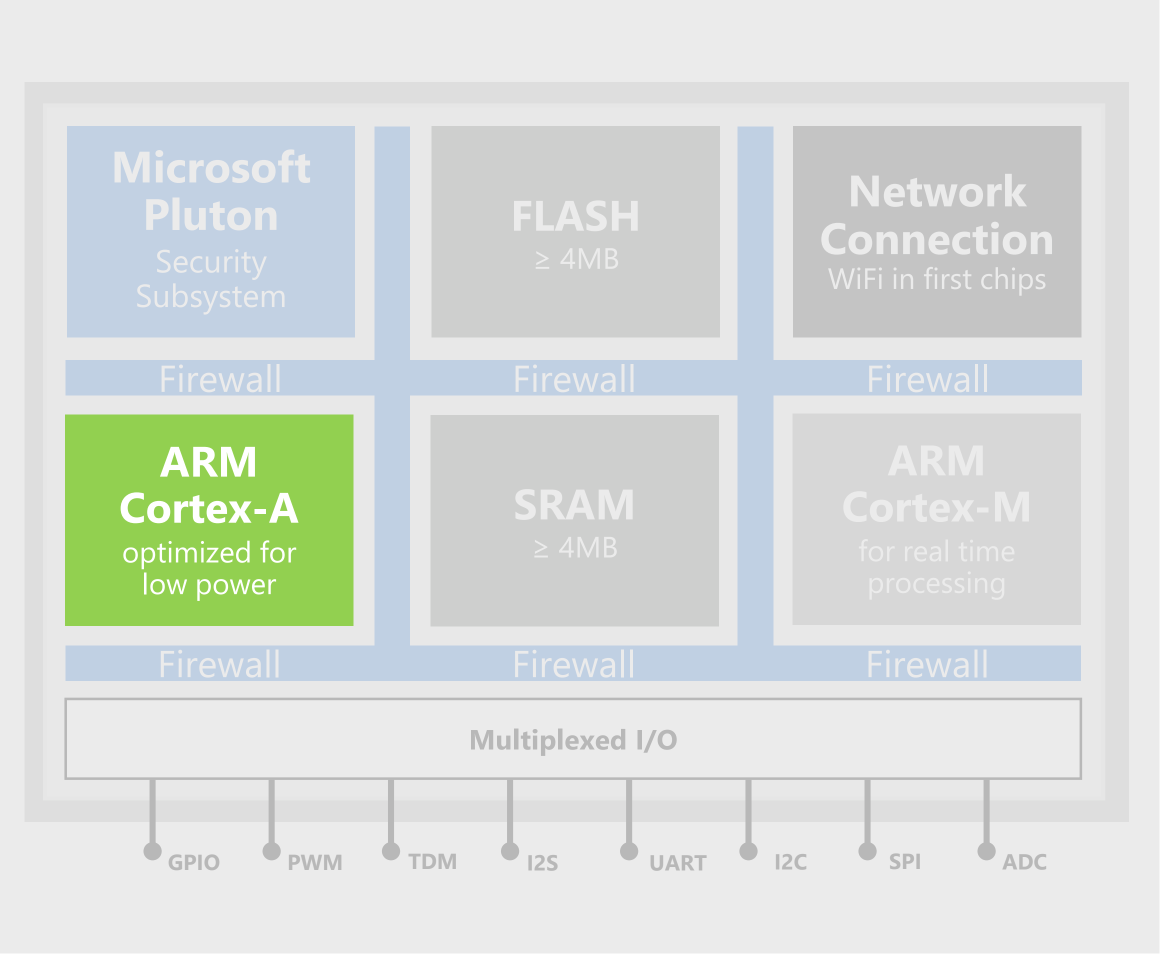


Cortex-A:

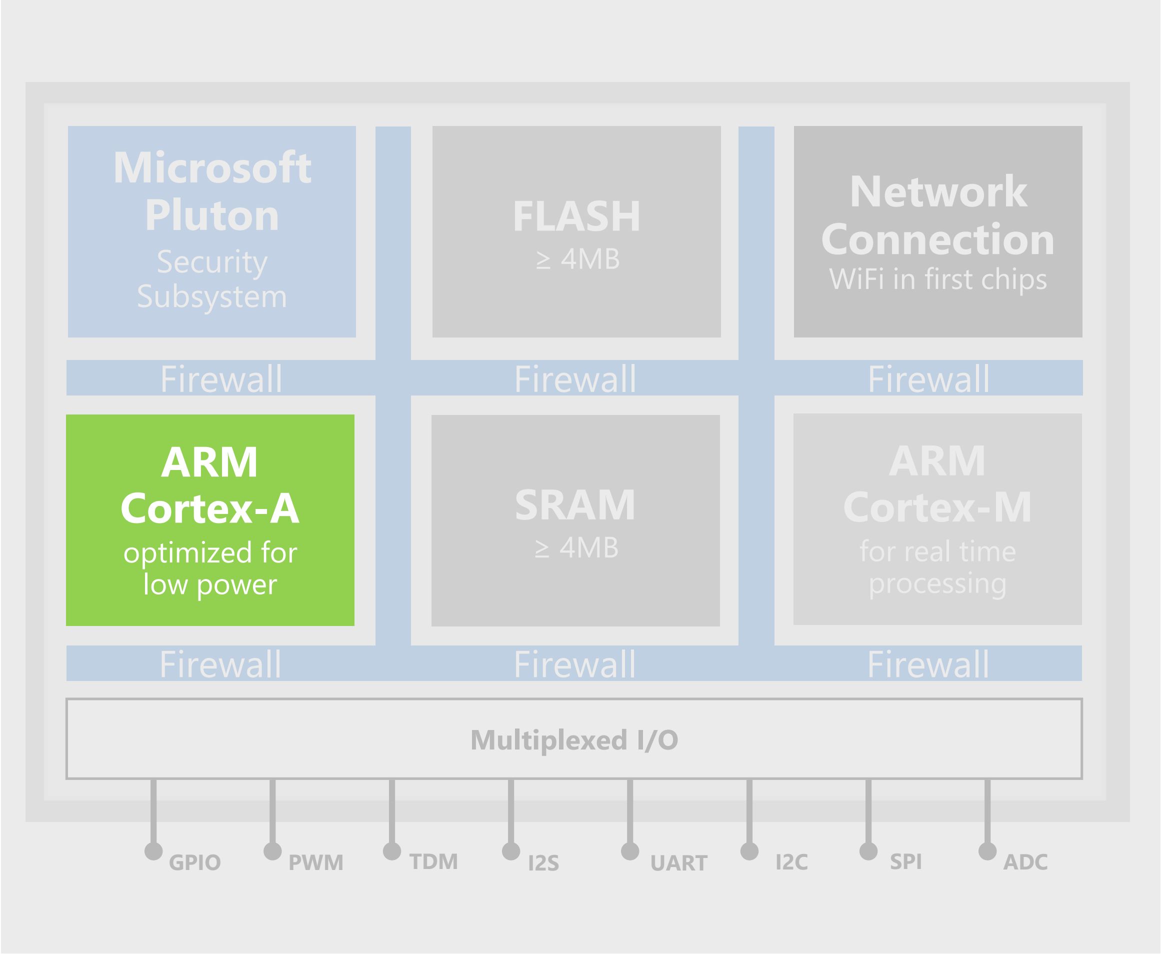
SECURITY

PORTABILITY

EXTENSIBILITY



Cortex-A: Security



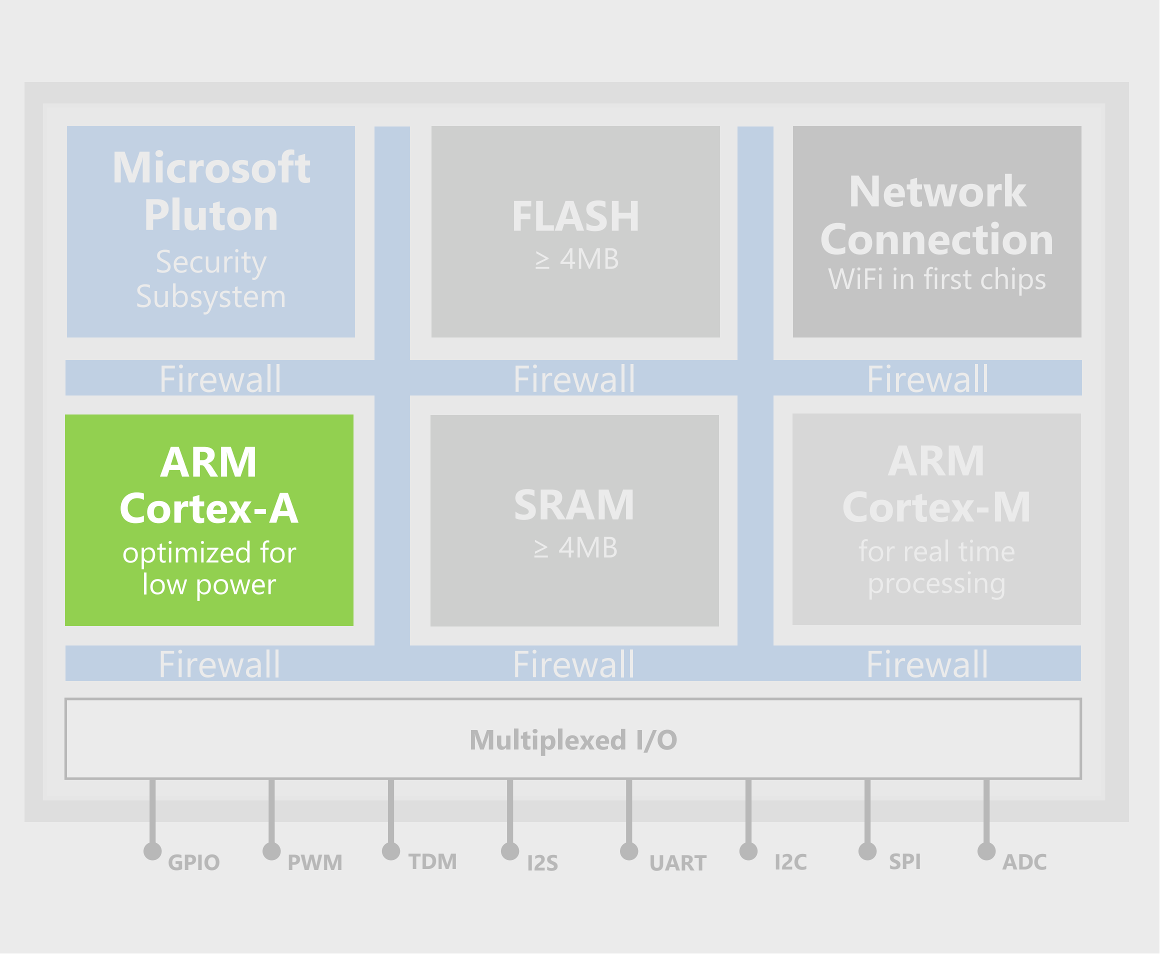
Isolation

The Cortex-A provides process-level isolation via its Memory Management Unit (MMU). The Azure Sphere IoT OS leverages the MMU as part of the application container to protect other applications and services.

Cortex-A: Security

Specialized operating system

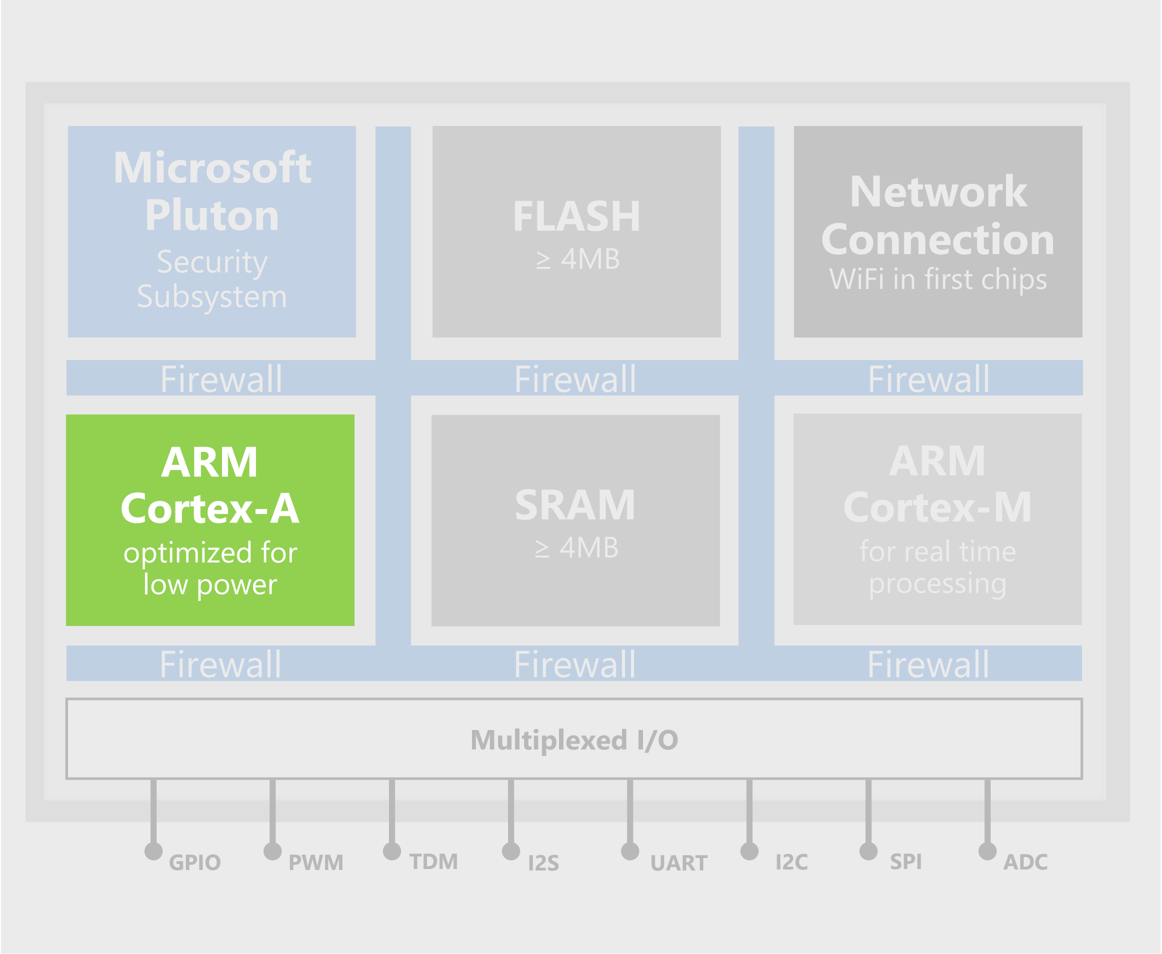
The Azure Sphere OS includes the Azure Sphere runtime and a custom Linux kernel with special IoT functionality. Example: Azure Sphere OS reduces its attack surface by not using passwords, a shell or login. All benefits of a Linux kernel without wasted overhead.



Cortex-A: Security

Authentication

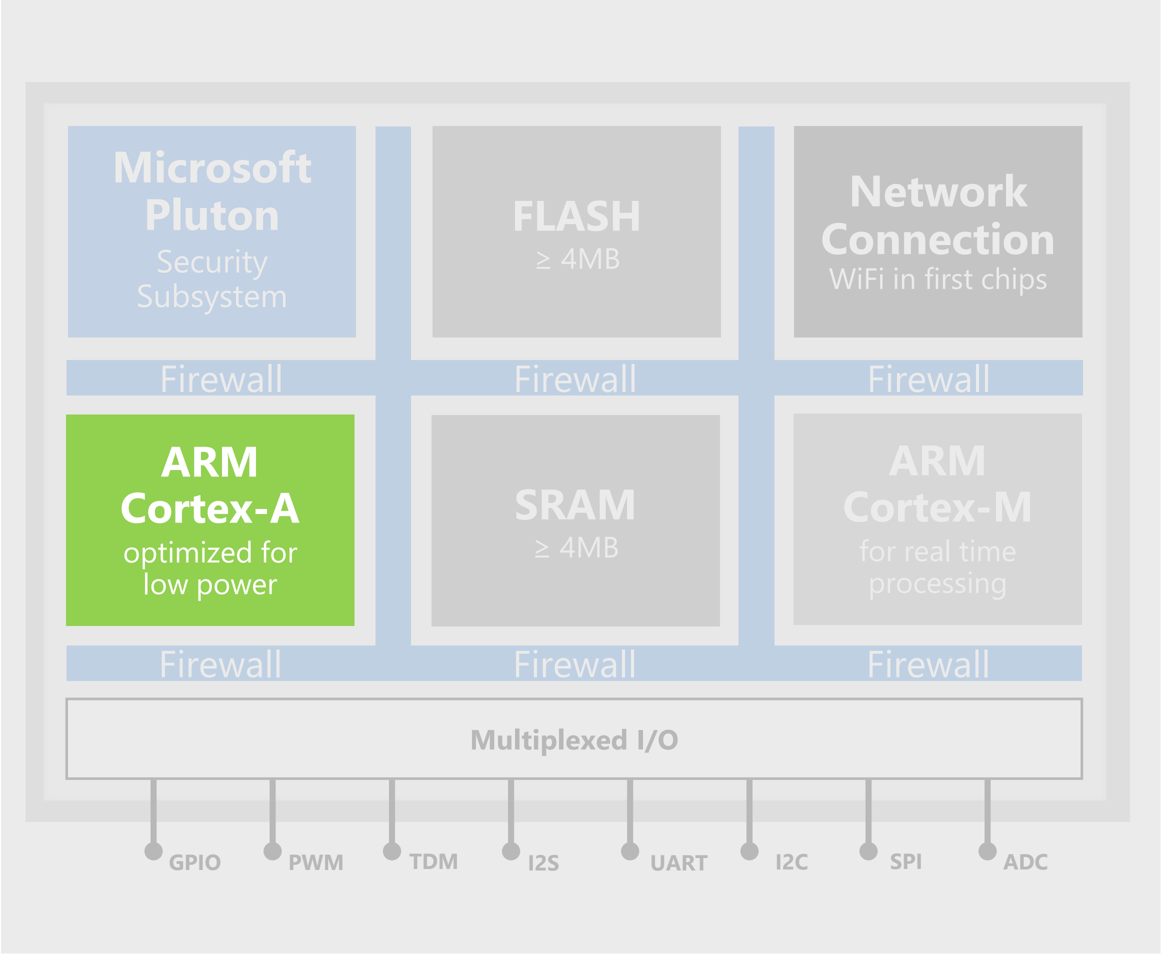
Azure Sphere OS uses client and server certificate authentication for cloud communication.



Cortex-A: Security

Authorization

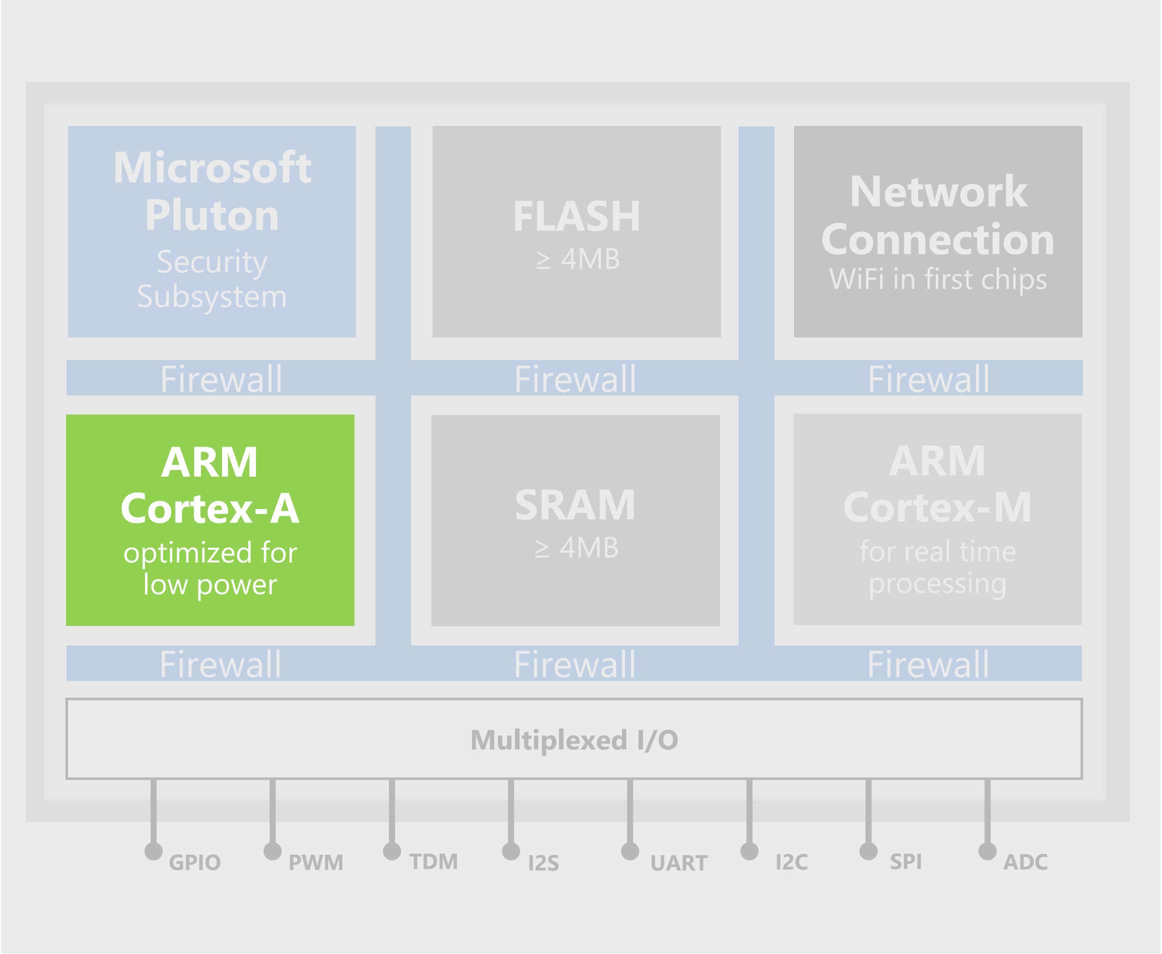
Azure Sphere OS authorizes access to resources via a custom capability system secured by Pluton.



Cortex-A: Portability

Accelerated time to market

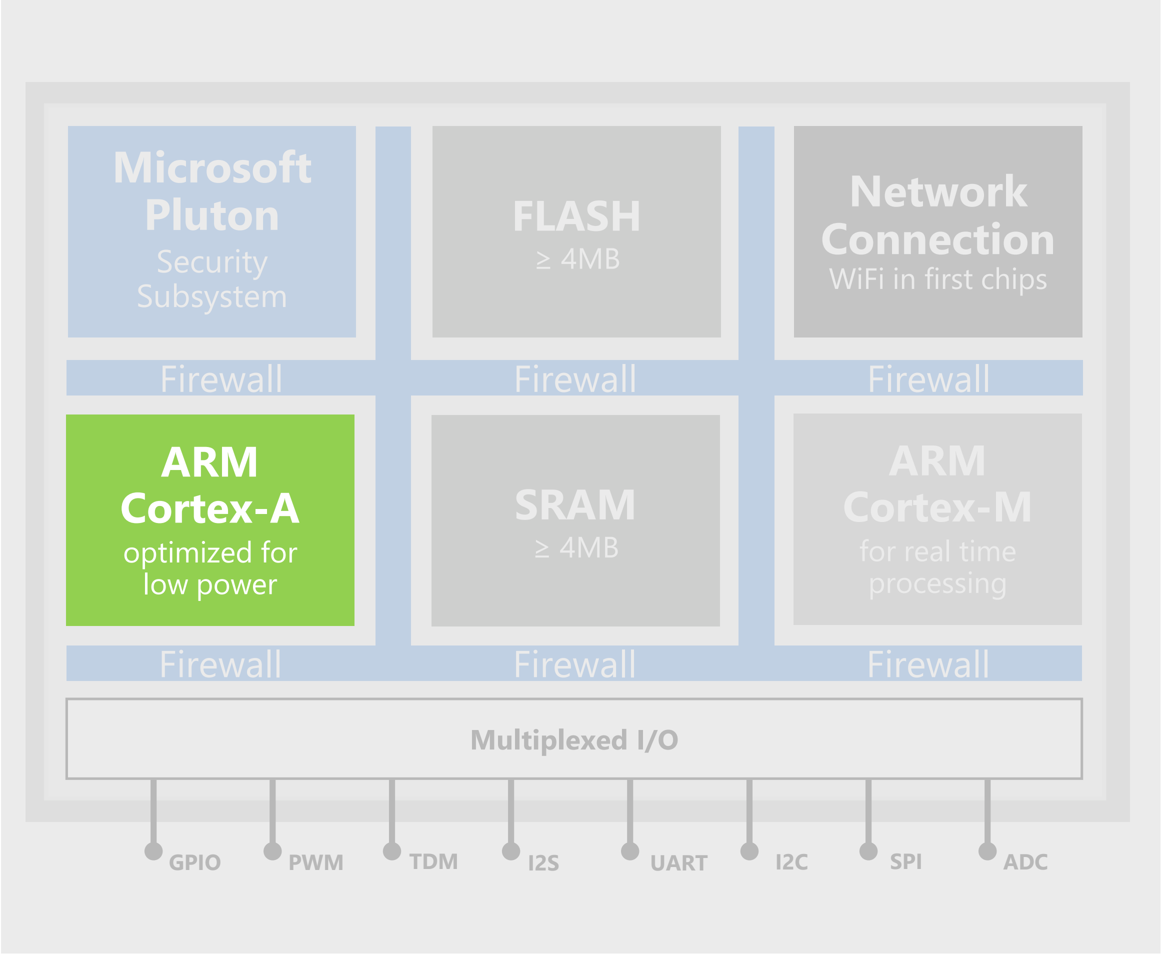
MMU provides address-space virtualization. Azure Sphere OS provides hardware abstraction. Application code is written once and portable across Azure Sphere chips.



Cortex-A: Portability

Source portability

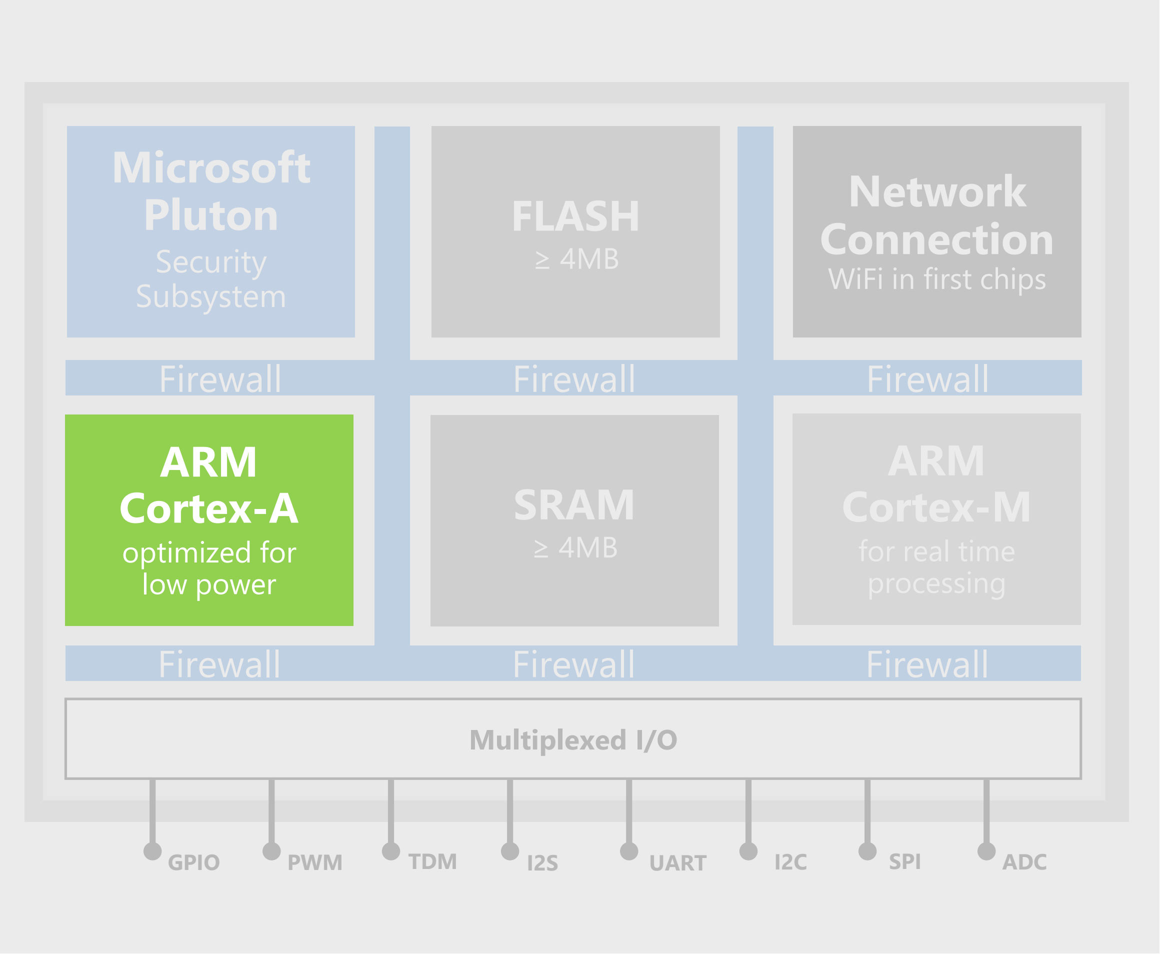
Open source software (OSS) libraries are often written against the POSIX standard. Azure Sphere OS includes a large subset of the POSIX standard, allowing rapid porting of OSS software to your application platform.



Cortex-A: Extensibility

A7 headroom for the future

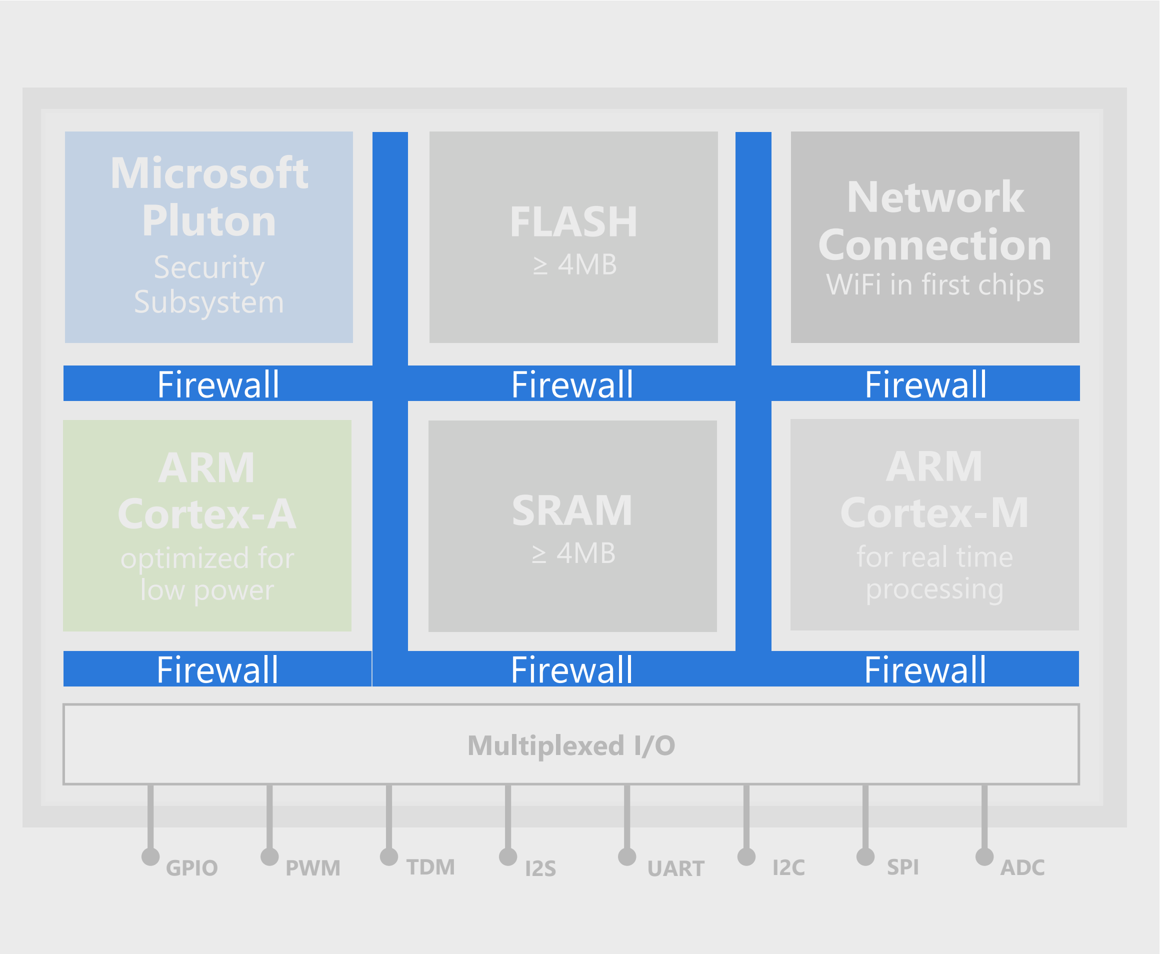
Machine learning, machine translation, vision and AI will be the future of many products. The Cortex-A has headroom for new product features and customer experiences that will set your products apart.



Silicon counter-measures

A secure foundation in silicon

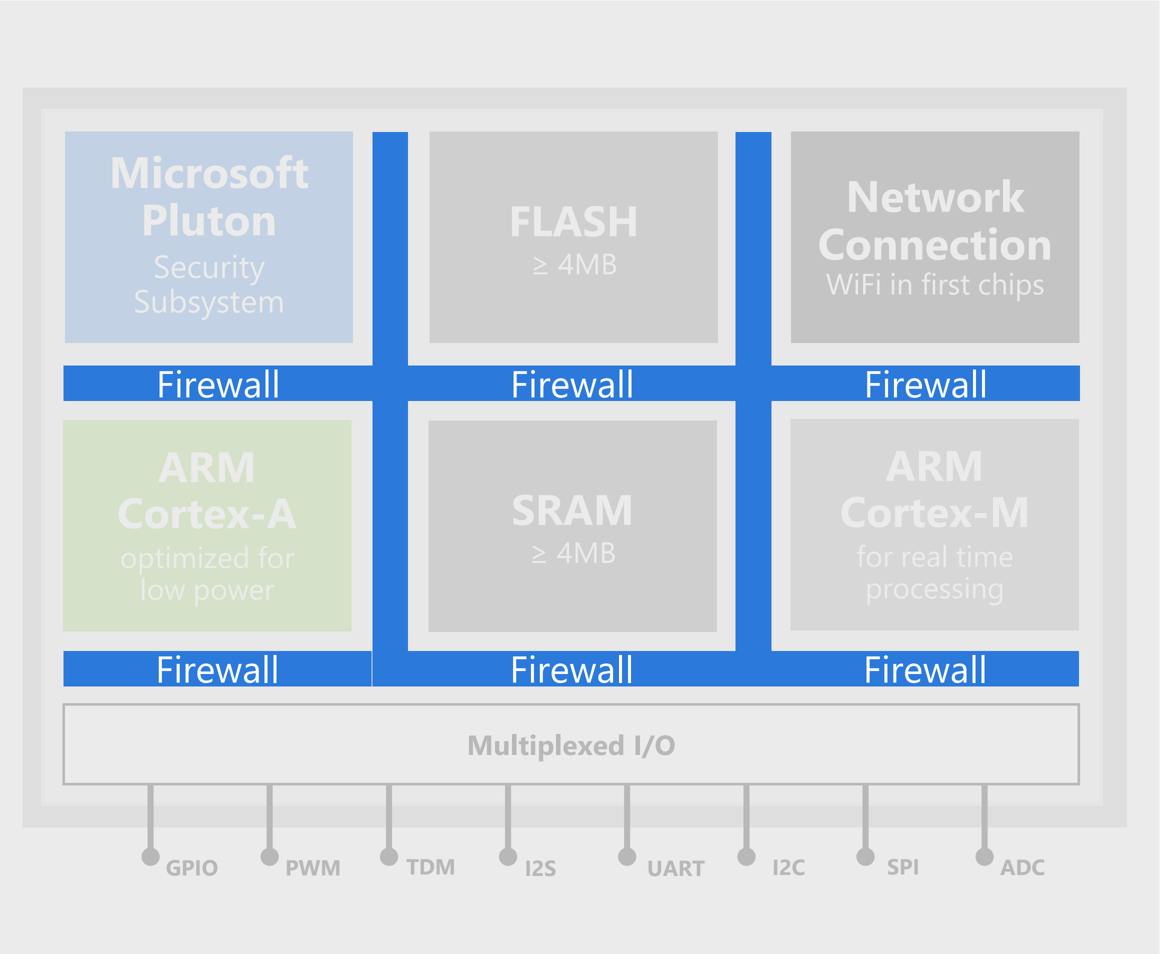
Microsoft firewalls Implement the principle of least-privilege. Software behind the firewall is given access to only those resources that it is given explicit permission.



Silicon counter-measures

Comprehensive protection

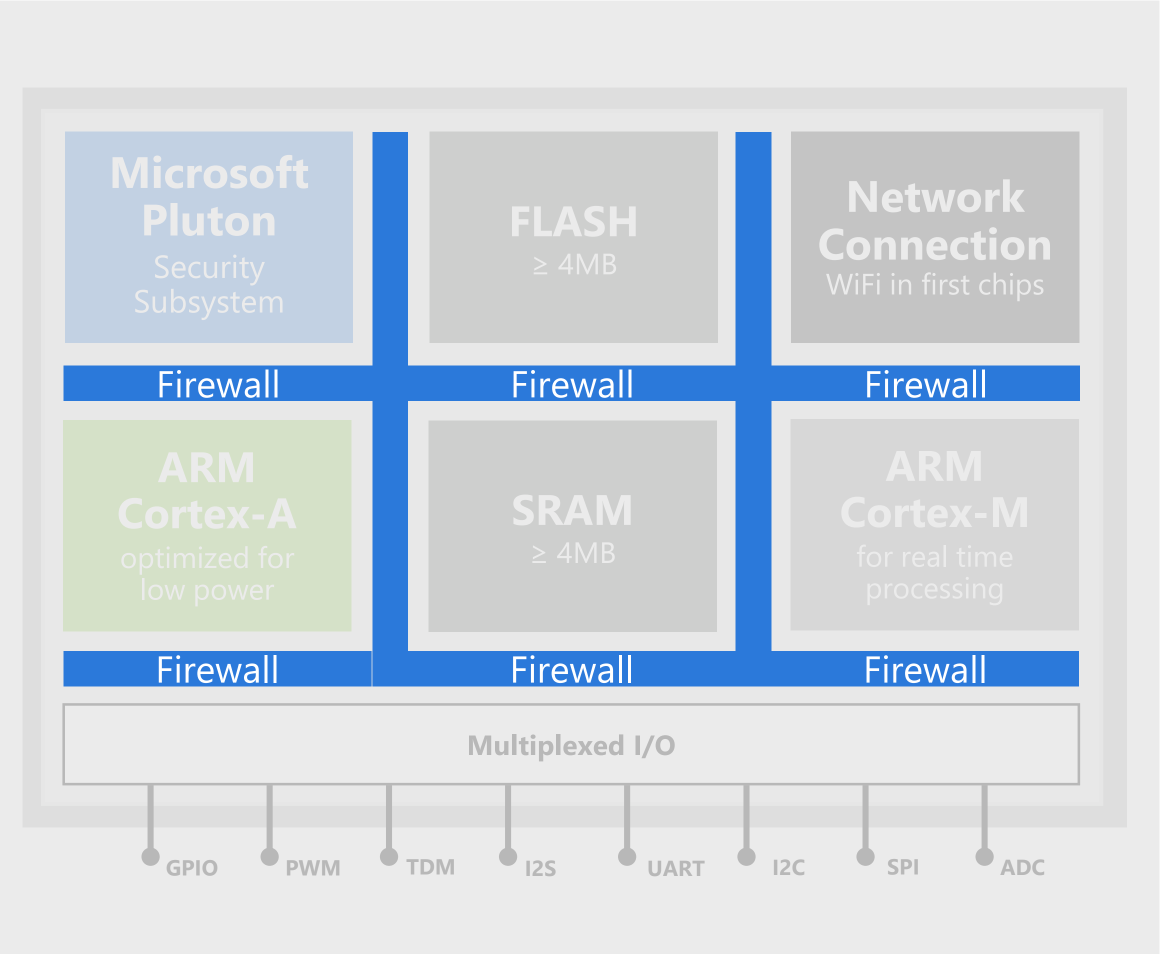
This principle applies to every resource in the system: RAM, network, flash and peripherals.



Silicon counter-measures

Hackers have no way out

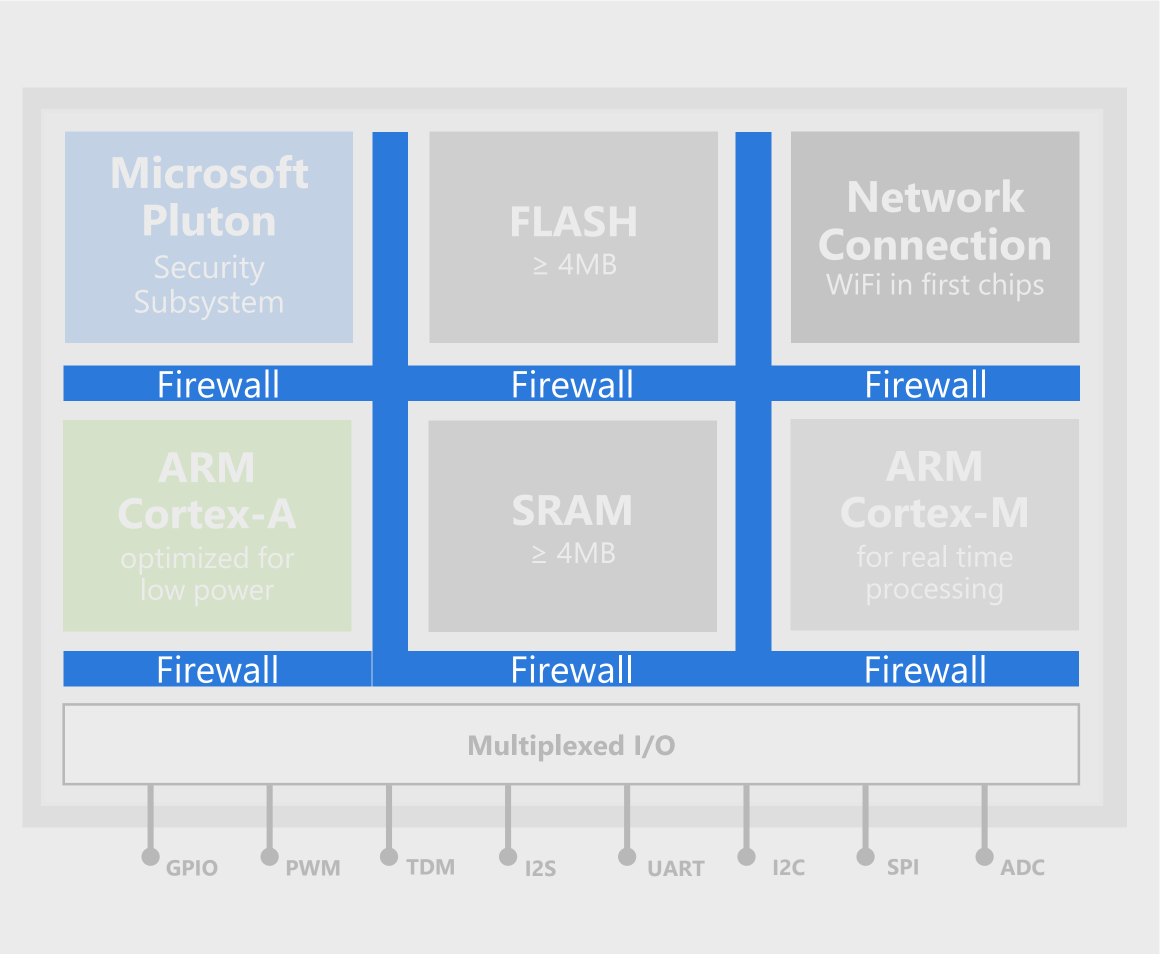
Compromised software cannot access new resources.



Silicon counter-measures

Sticky from the start

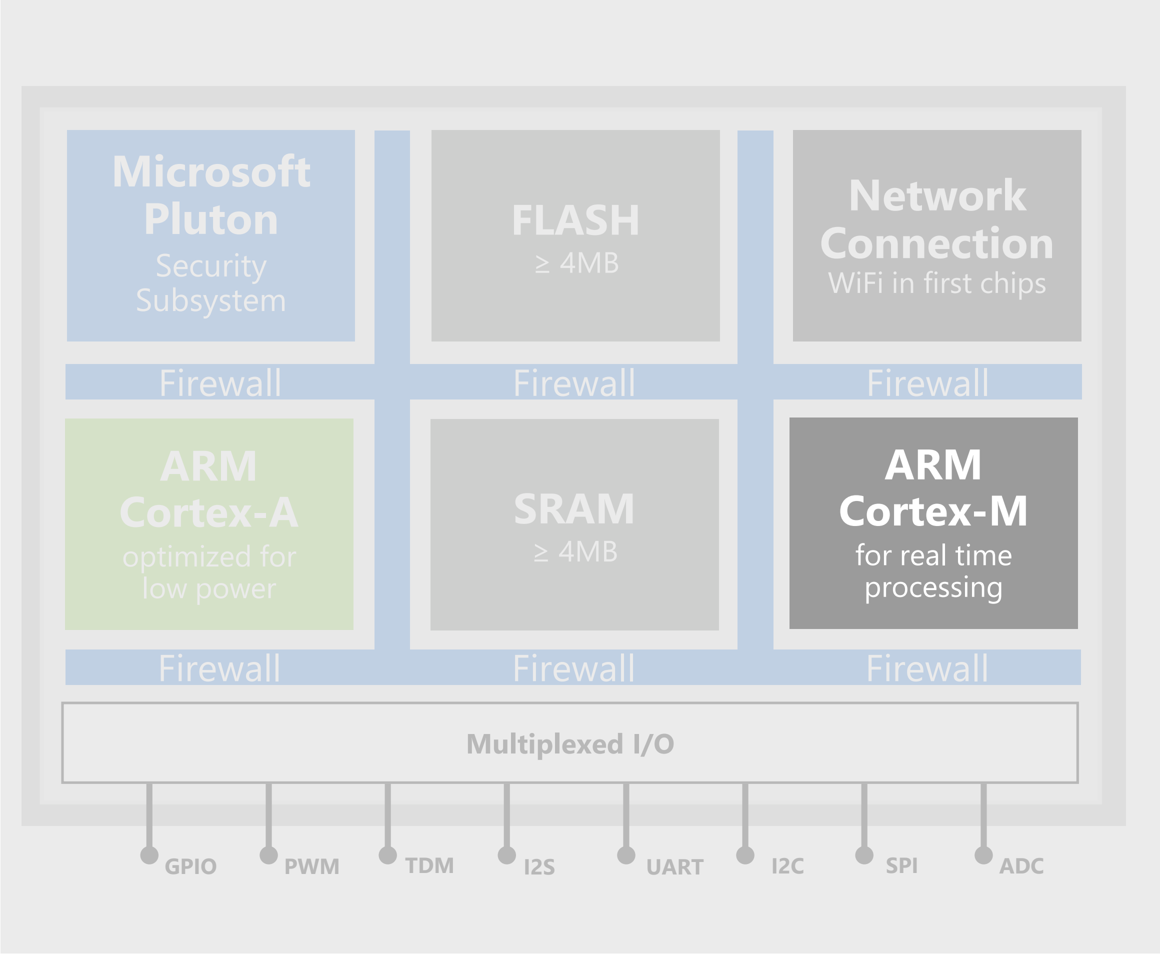
Further, firewalls are sticky. Even if the layer that controls the firewall is compromised, it is not possible to reconfigure until the chip is reset.



I/O Cortex-M

Real-time computation

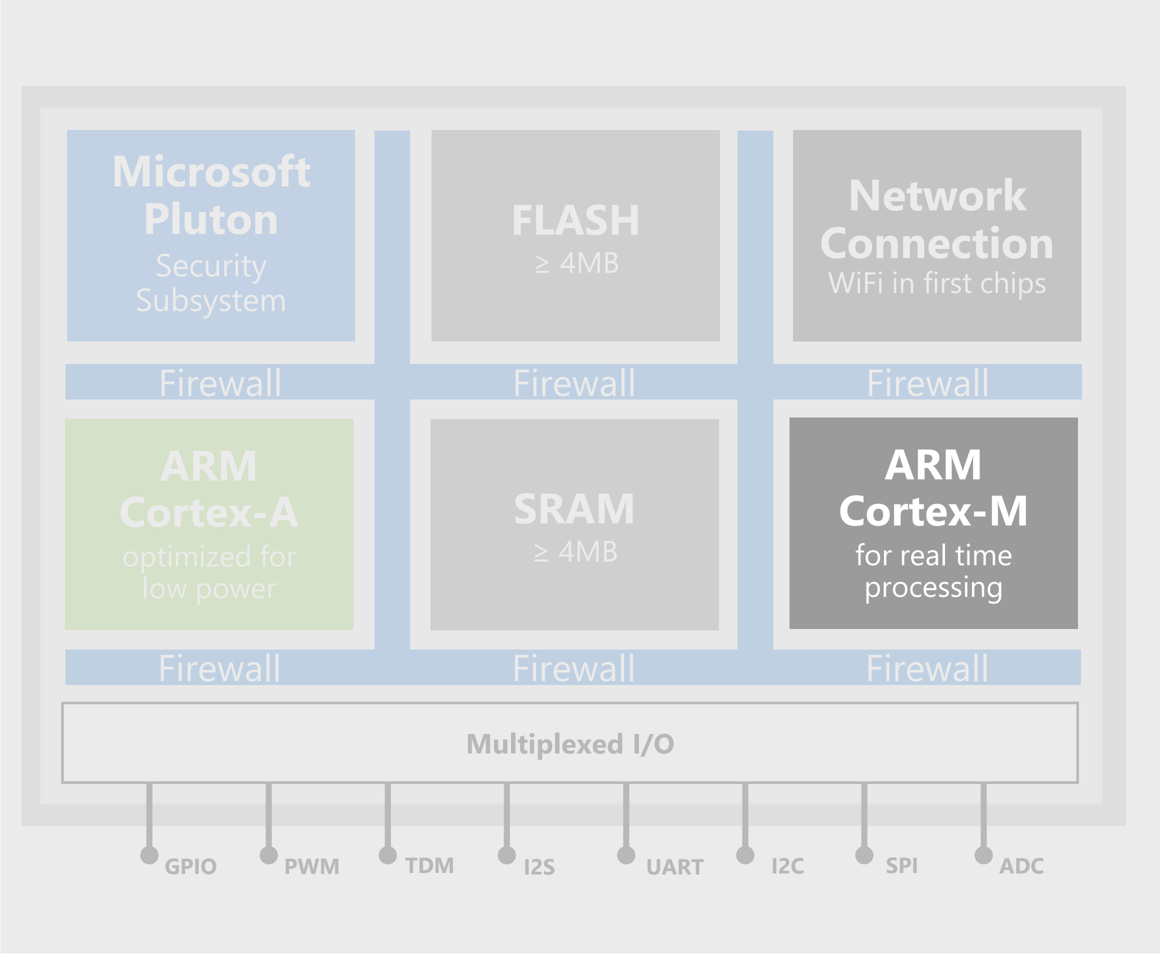
MCUs targeted at real-time computation and real-time interaction with peripherals.



I/O Cortex-M

Low-friction migration

Azure Sphere MCUs provide Cortex-M series MCUs to run your existing MCU collateral secured by Pluton.

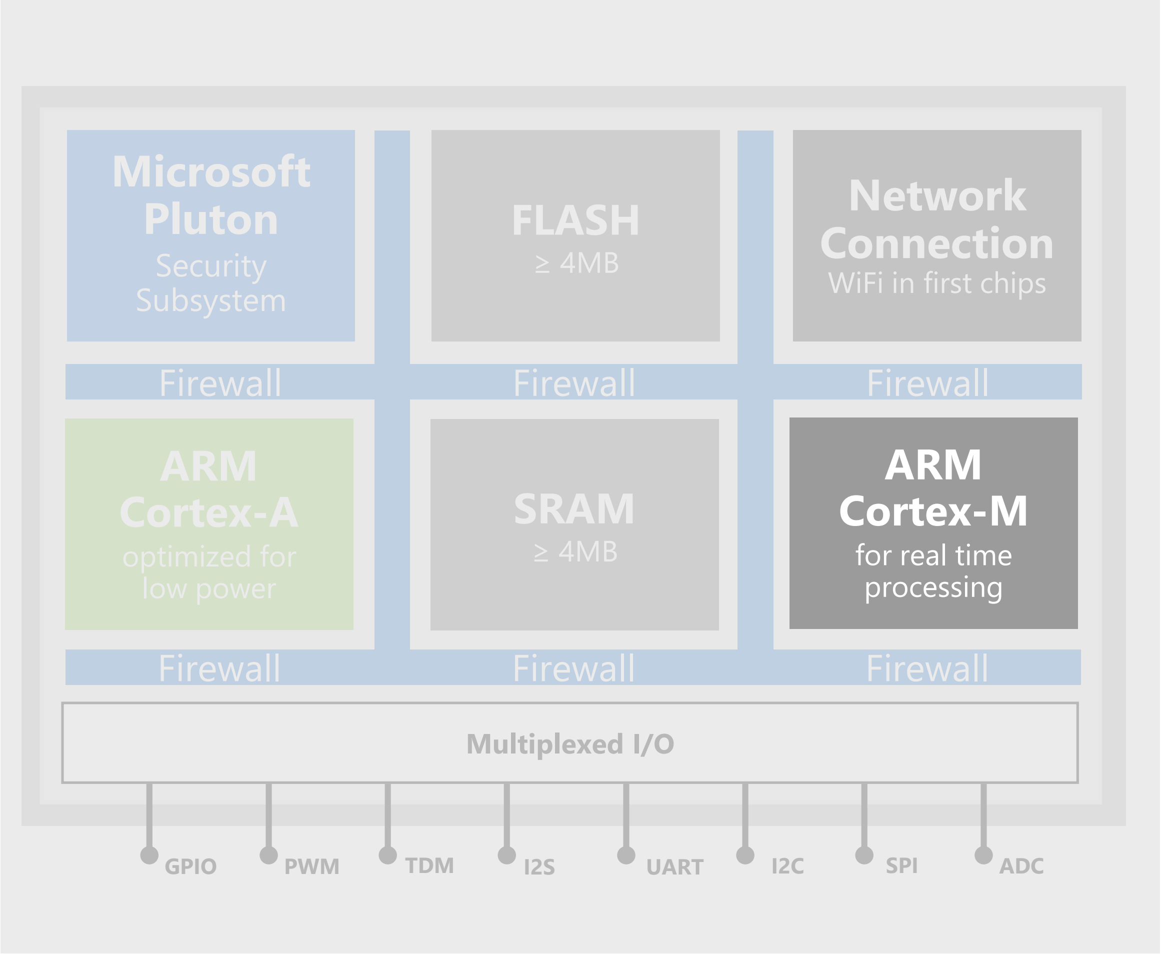


I/O Cortex-M

Maximum flexibility

Manufacturers are free to run any Cortex-M runtime.

Microsoft will provide a reference M4 runtime.



Our Silicon Partners

MediaTek

ARM

STMicroelectronics

NXP

Silicon Labs

Nordic

Nuvoton

Hilscher

Toshiba

VeriSilicon

Qualcomm

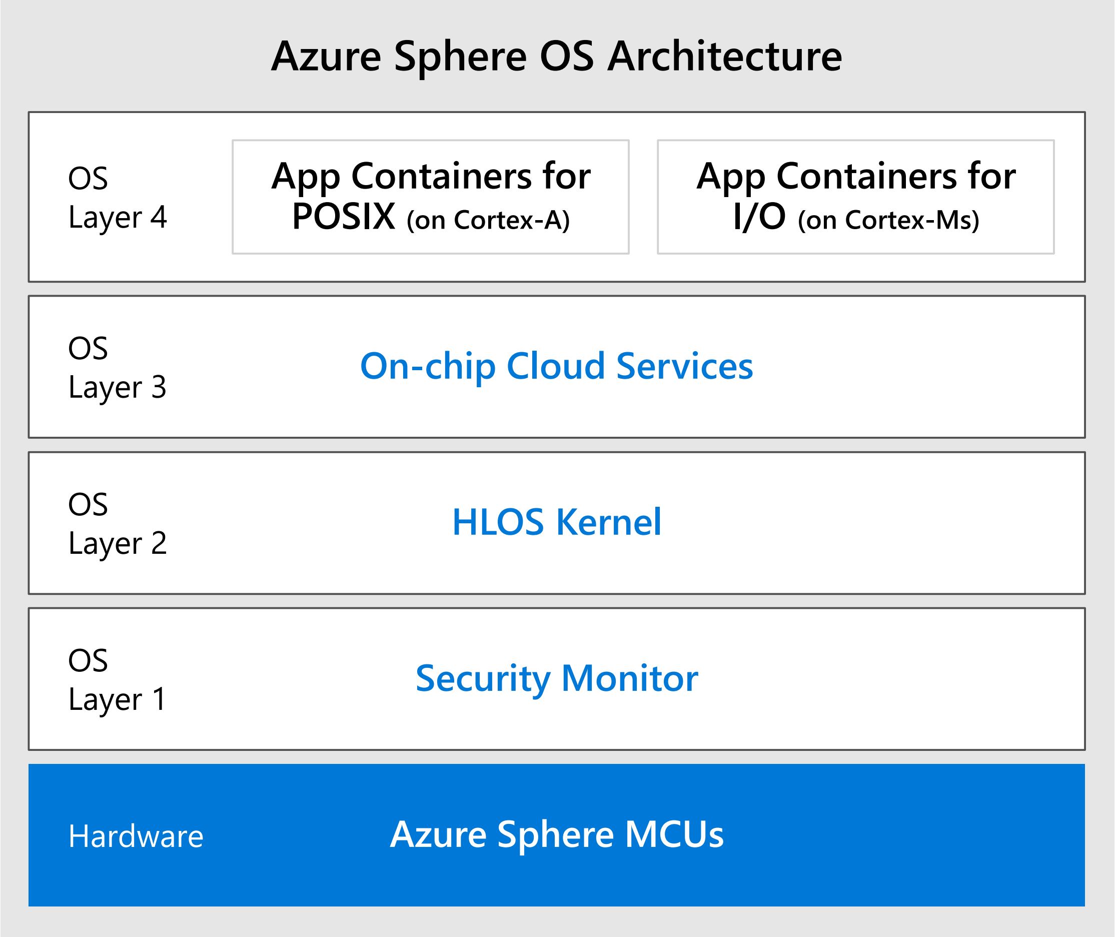
The Azure Sphere OS is optimized for IoT, security, and agility

Secure Application Containers
Compartmentalize code for agility, robustness & security

On-chip Cloud Services
Provide update, authentication, and connectivity

Custom Linux kernel
Empowers agile silicon evolution and reuse of code

Security Monitor
Guards integrity and access to critical resources



Azure Sphere OS Architecture

OS Layer 4 — App Containers for POSIX (on Cortex-A) | App Containers for I/O (on Cortex-Ms)

OS Layer 3 — On-chip Cloud Services

OS Layer 2 — HLOS Kernel

OS Layer 1 — Security Monitor

Hardware — Azure Sphere MCUs

Azure Sphere OS: Defense in depth on a mature OS core

Curated user-mode environment

e.g., no passwords, no shell, no user accounts
Azure Sphere application runtime provides long-term compatibility with OS

OS Services manage connectivity & chip resources

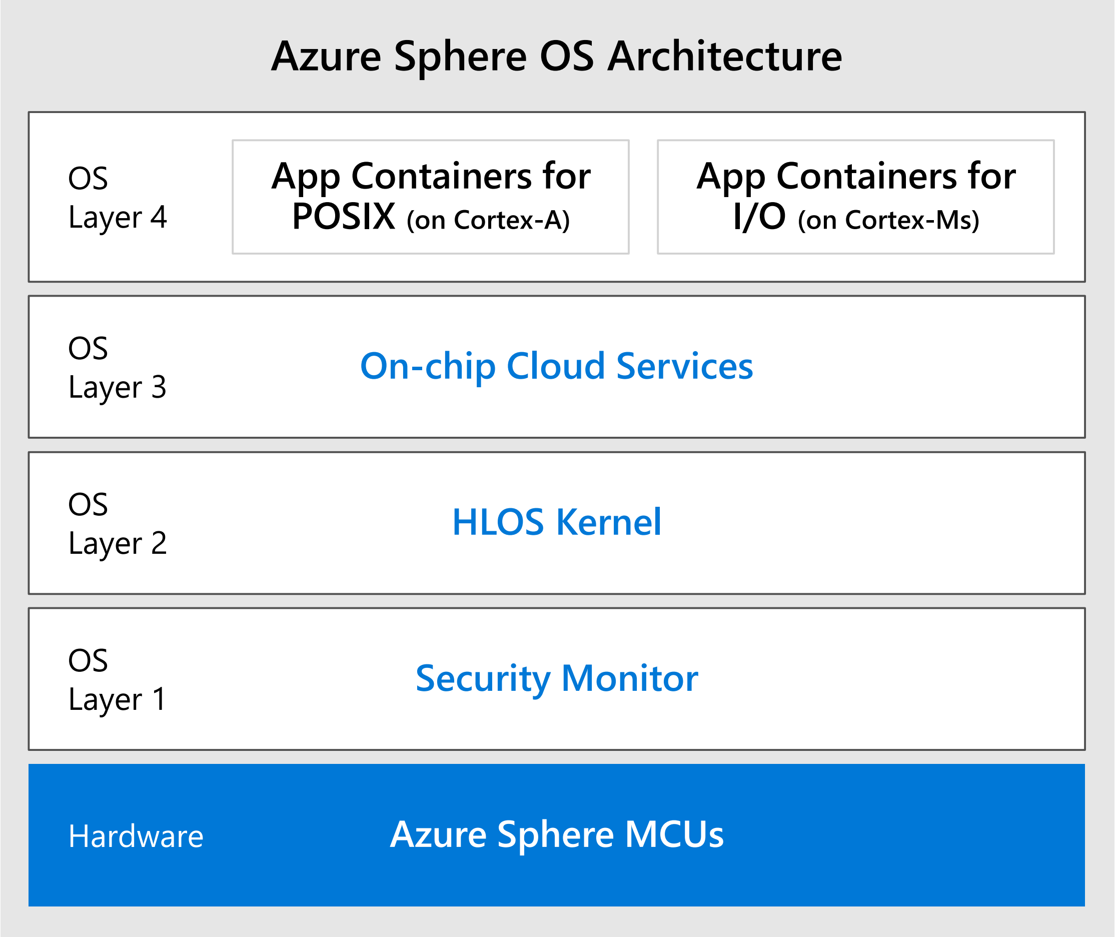
e.g., TLS connection, mutual authentication, peripheral access

Custom Linux Kernel

Linux Security Module protects resource acquisition
Kernel integrates with Pluton services (e.g., RNG)

Security monitor protects critical resources

Guards against corruption using a technique called “erasure coding”
Boot health-check detects and self-heals corrupted data



Azure Sphere OS Architecture

OS Layer 4 — App Containers for POSIX (on Cortex-A) — App Containers for I/O (on Cortex-Ms)

OS Layer 3 — On-chip Cloud Services

OS Layer 2 — HLOS Kernel

OS Layer 1 — Security Monitor

Hardware — Azure Sphere MCUs

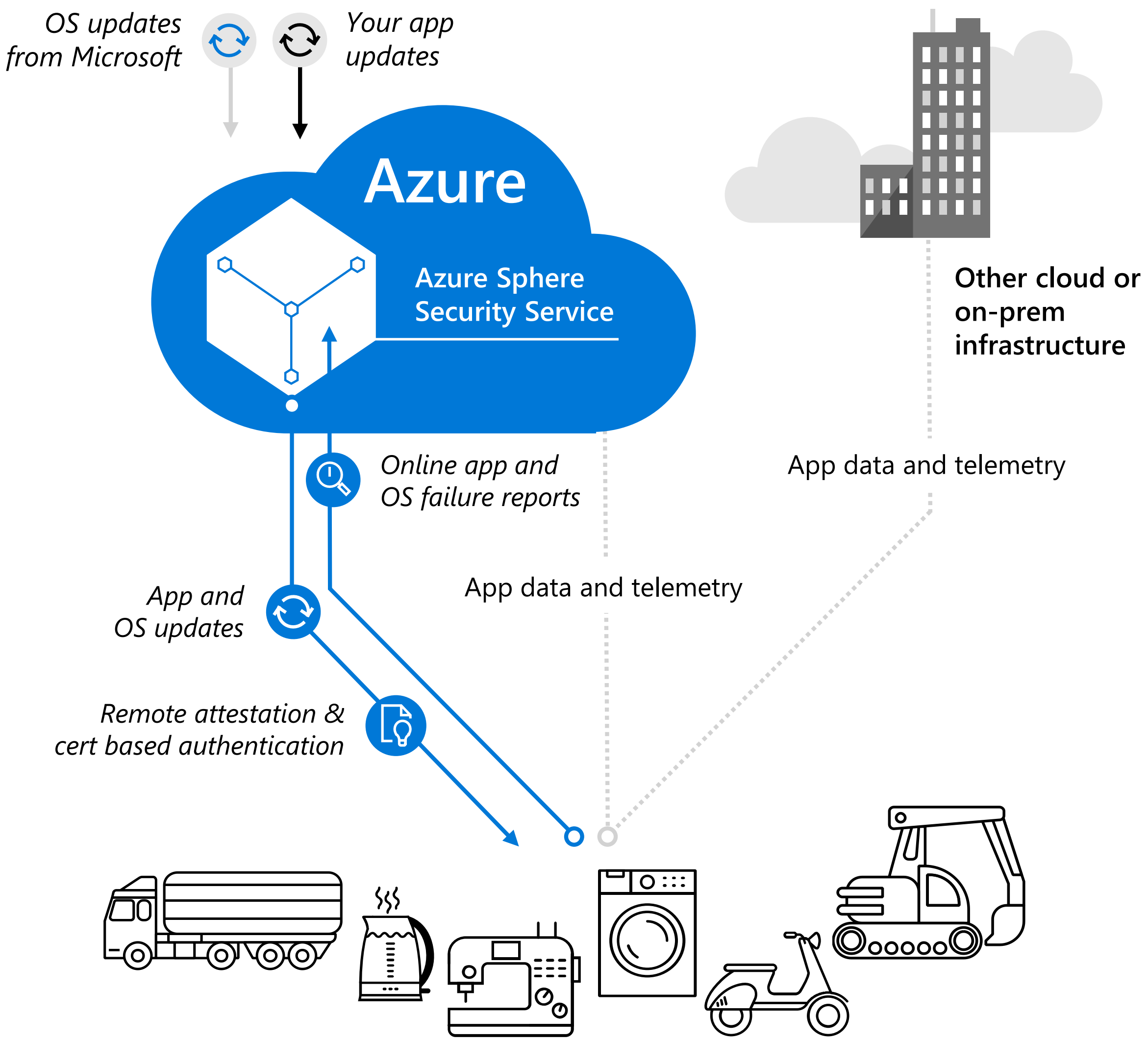
Azure Sphere online services in action

Protects your devices and your customers with certificate-based authentication of all communication

Detects emerging security threats through automated processing of on-device failures

Responds to threats with fully automated on-device updates of OS

Allows for easy deployment of software updates to Azure Sphere powered devices


OS updates from Microsoft
Your app updates
Azure
Azure Sphere Security Service
Other cloud or on-prem infrastructure
Online app and OS failure reports
App data and telemetry
App data and telemetry
App and OS updates
Remote attestation & cert based authentication

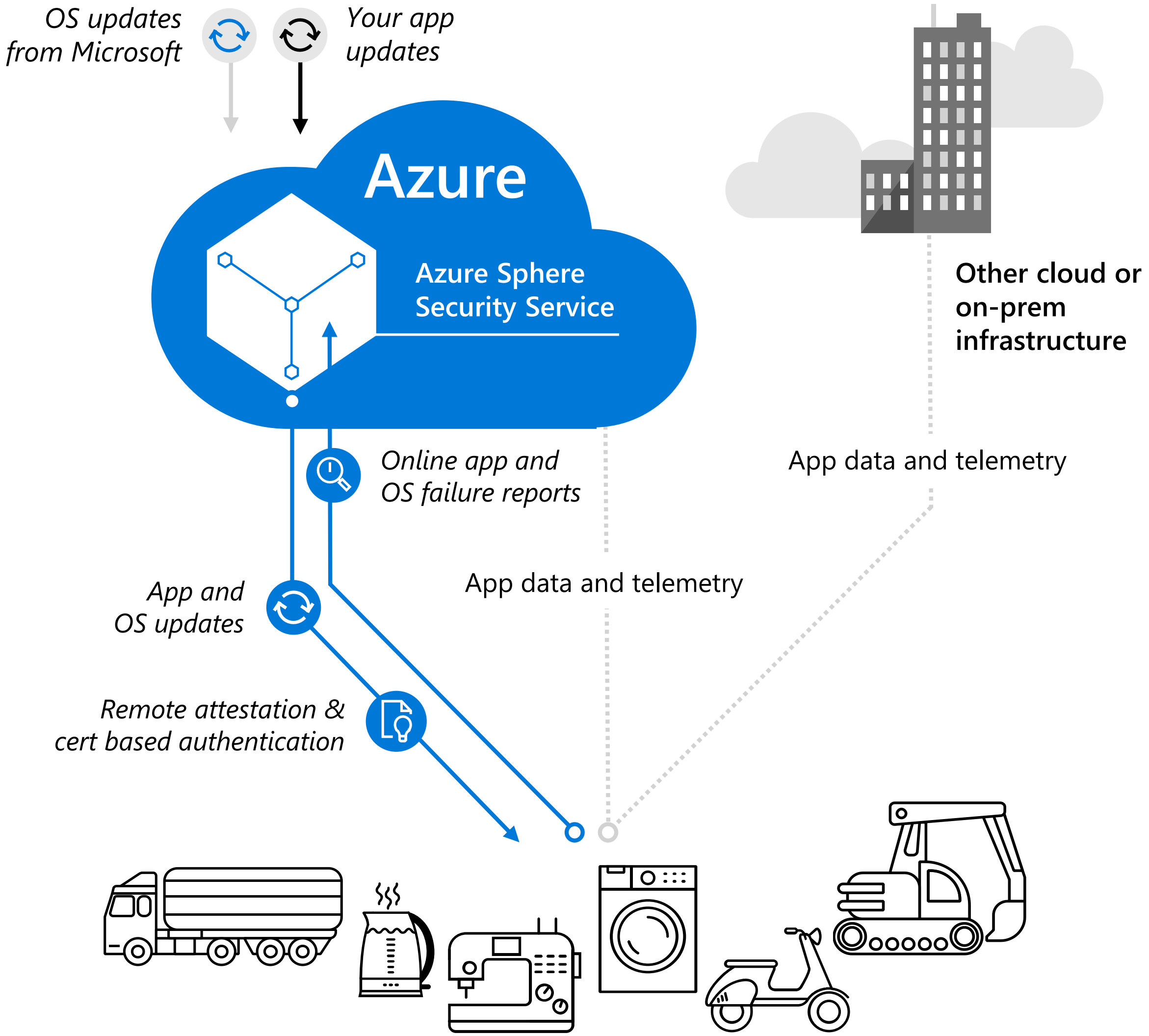
Azure Sphere online services in action

Using attestation to control access to online services

Up-to-date devices are issued a short-lived certificate

Any service that can validate the cert chain can verify attestation completed successfully

Out-of-date devices may be forced to update



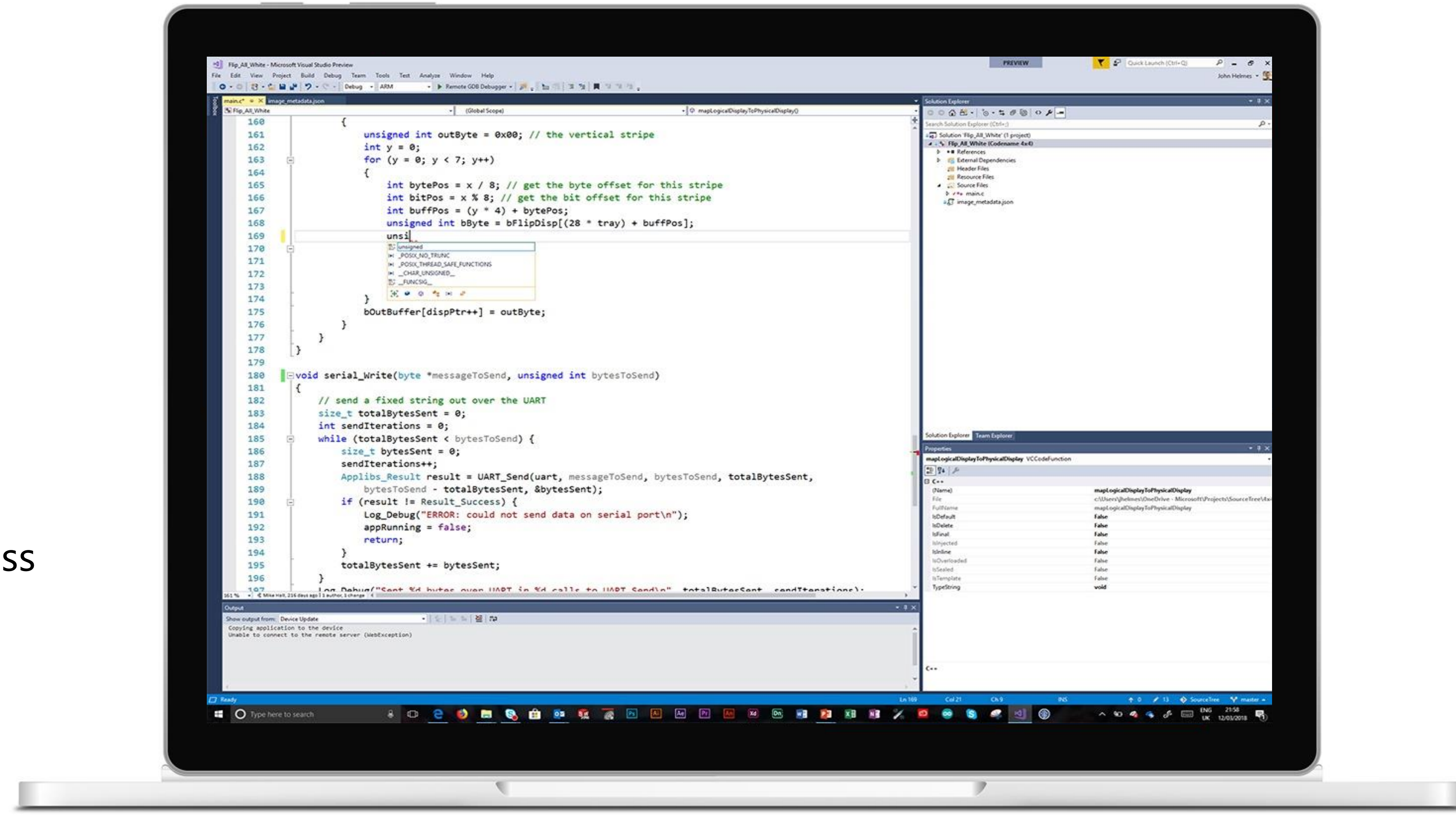
OS updates from Microsoft
Your app updates
Azure
Azure Sphere Security Service
Other cloud or on-prem infrastructure
Online app and OS failure reports
App data and telemetry
App data and telemetry
App and OS updates
Remote attestation & cert based authentication

Modernize MCU development with Azure Sphere and Visual Studio

Simplify development
Focus your device development effort on the value you want to create

Streamline debugging
Experience interactive, context-aware debugging across device and cloud

Collaborate across your team
Apply tool-assisted collaboration across your entire development organization



```
        {
            unsigned int outByte = 0x00; // the vertical stripe
            int y = 0;
            for (y = 0; y < 7; y++)
            {
                int bytePos = x / 8; // get the byte offset for this stripe
                int bitPos = x % 8; // get the bit offset for this stripe
                int buffPos = (y * 4) + bytePos;
                unsigned int bByte = bFlipDisp[(28 * tray) + buffPos];
                unsi






            }
            bOutBuffer[dispPtr++] = outByte;
        }
    }
}

void serial_Write(byte *messageToSend, unsigned int bytesToSend)
{
    // send a fixed string out over the UART
    size_t totalBytesSent = 0;
    int sendIterations = 0;
    while (totalBytesSent < bytesToSend) {
        size_t bytesSent = 0;
        sendIterations++;
        Applibs_Result result = UART_Send(uart, messageToSend, bytesToSend, totalBytesSent,
            bytesToSend - totalBytesSent, &bytesSent);
        if (result != Result_Success) {
            Log_Debug("ERROR: could not send data on serial port\n");
            appRunning = false;
            return;
        }
        totalBytesSent += bytesSent;
    }
    Log_Debug("Sent %d bytes over UART in %d calls to UART_Send\n", totalBytesSent, sendIterations);
```

Output

Show output from: Device Update

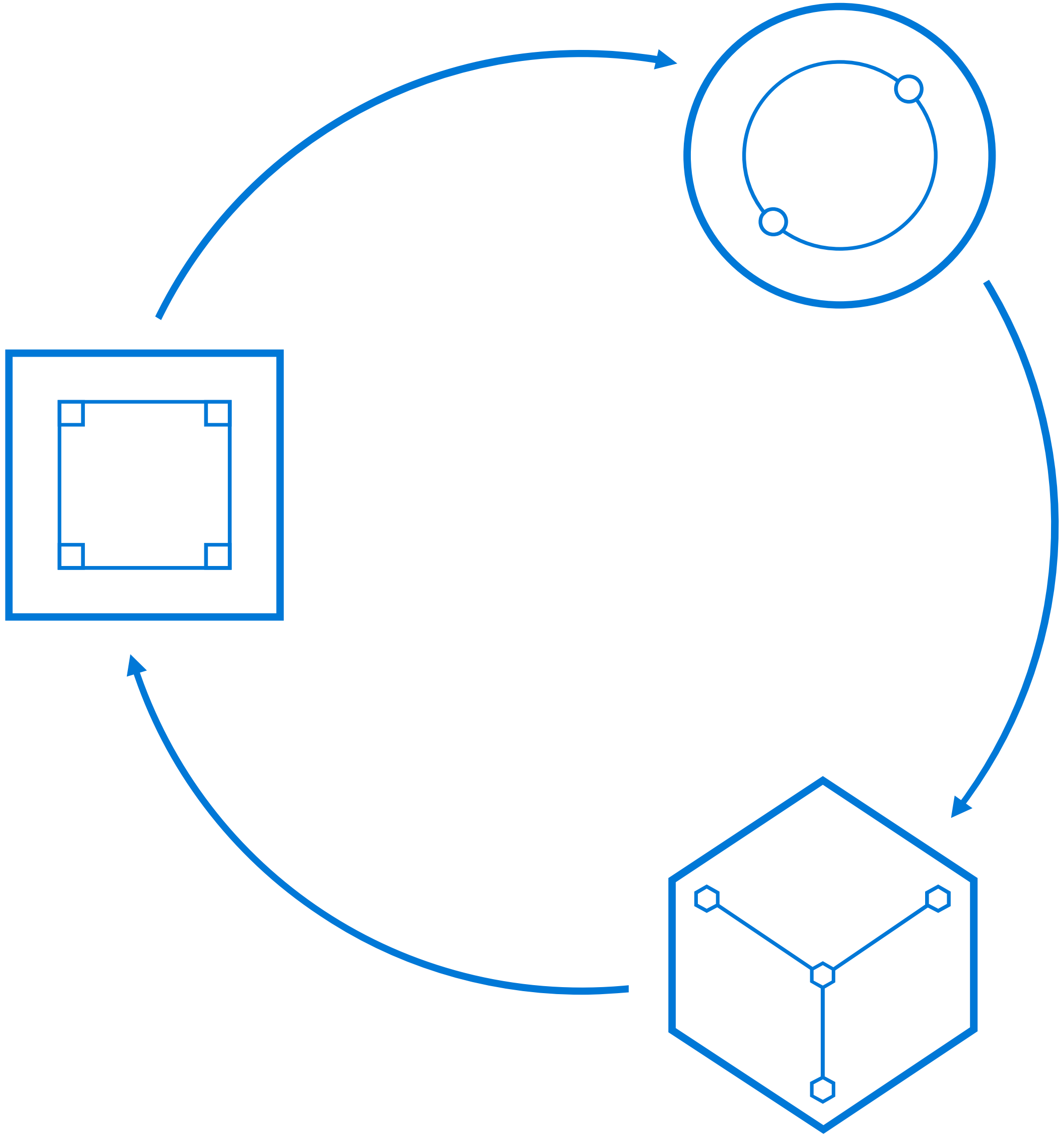
```
Copying application to the device
Unable to connect to the remote server (WebException)
```

Three components.
One low price.
No subscription required.

An Azure Sphere certified MCU

The Azure Sphere OS
with 10 years of on-device security updates

The Azure Sphere Security Service
for the lifetime of your device



Azure Sphere is Open.

Open to any MCU manufacturer
We are licensing our Pluton security subsystem royalty **free for use** in any chip*

Open to any innovation
MCU manufacturers are free to innovate with our GPL'd OSS Linux kernel code base

Open to any cloud
Azure Sphere devices are free to connect to Azure or any other cloud, proprietary or public for application data

Let’s secure the future.

SECURED FROM THE SILICON UP

Thank you!

Microsoft