ARM mbed Technical Overview

ARM

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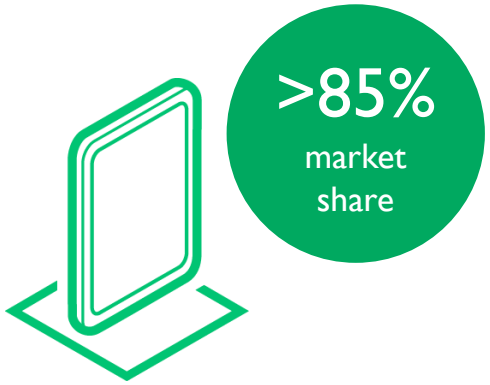
ARM knows the world of connected devices

smartphone

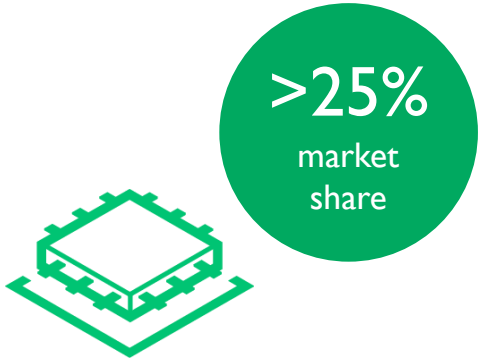


tablet

wearables

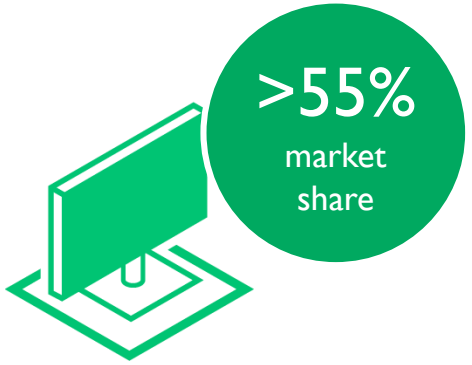
storage

Automotive infotainment



microcontrollers

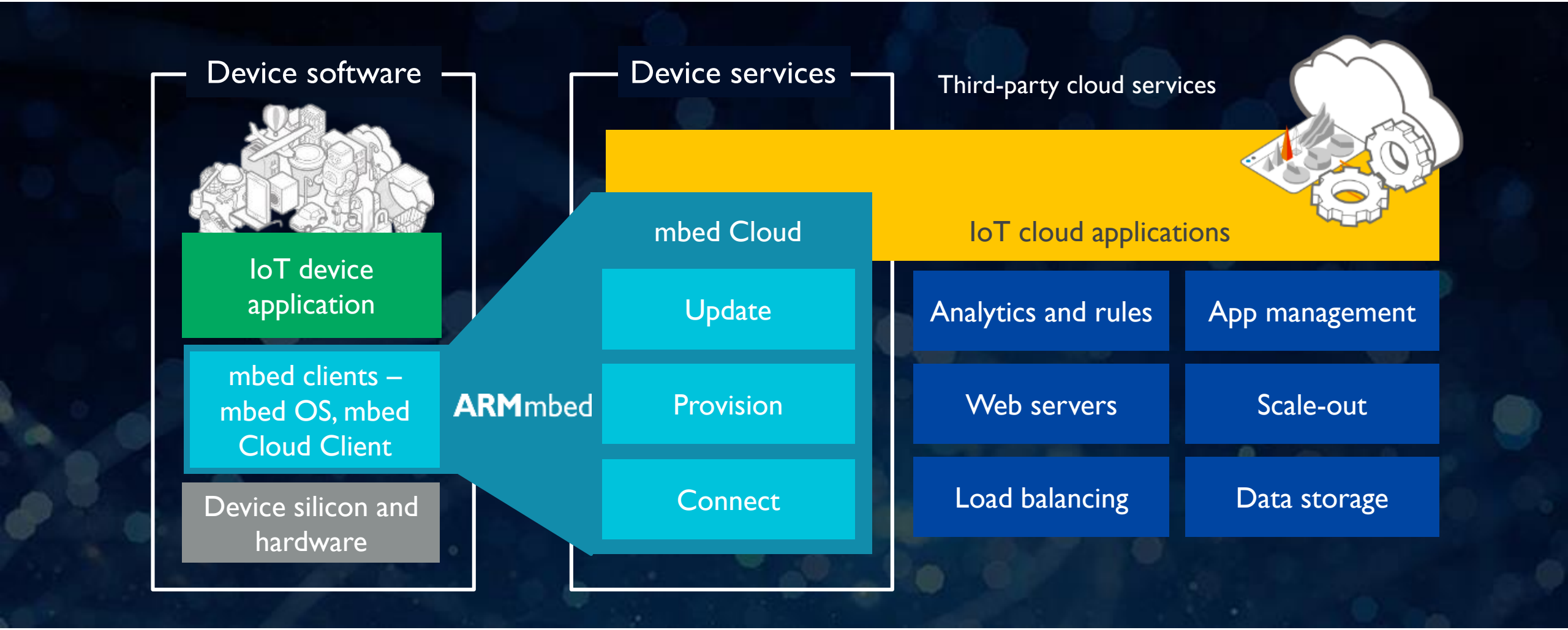
Wireless connectivity



Consumer electronics

ARM

ARM mbed: Connecting chip to cloud



ARM

Air quality monitoring system

mbed Enabled air quality monitor with integrated multi sensor technologies

Demonstrating mbed technologies

- mbed OS
- mbed Cloud Client
- mbed Cloud Connect
- mbed Cloud Update

mbed Cloud

mbed Cloud

ARMmbed
IoT device platform

mbed Cloud simplifies management of IoT devices

- Connectivity, Provisioning and Firmware Update
- Standards-based approach
- Optimized for energy efficiency
- Unique offering for a chain of trust for IoT
- Simplifies firmware update across complex networks

OMA Lightweight M2M

- LWM2M is a Device Management protocols optimized for IoT devices
  - Manage IoT devices remotely and update over-the-air
- LWM2M enables interworking between compatible clients and servers
- Usage of Standard protocols is the key in preventing vendor lock-in
  - Vendor lock-in - a customer dependent on a vendor for products and services, unable to use another vendor without substantial switching costs
- ARM is an active member in the OMA standard body activities
- ARM client and server implementation are standard compliant
  - ARM participate in the on-going TestFests compatibility activities

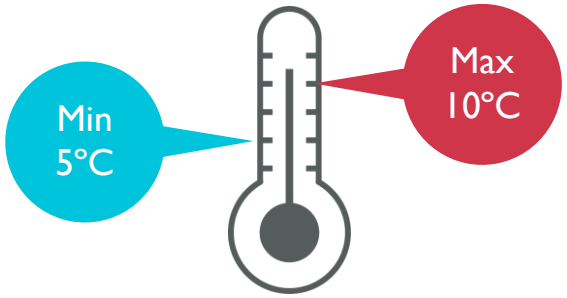
Example of weather station

- Device registers
- Registration lifetime: 24h
- Discover objects & resources:
  - Power switch
  - Temperature
  - Humidity
  - Pressure

Simple observation

- Observe temperature
  - GET /sensors/temperature Observe
- Device notifies everytime a change of temperature happens
  - Notify 14.5C
  - Notify 13C

Observation with attributes



- Write attributes
  - Minimum value 5C and Maximum value 10C
  - Write Attributes PUT /sensors/temperature?tmin=5&tmax=10
- Observe using attributes
  - Notifications are not sent unless temperature goes below 5C or above 10C

ARM

Addressing remote device updates

ARMmbed
IoT device platform

New in mbed Cloud v1.2 – Enhanced update capability

Only device management solution offering secure firmware updates for remote devices

Secure: Authenticity, integrity and confidentiality protection

Fail-safe: Update campaigns protected during power failures and no roll-back

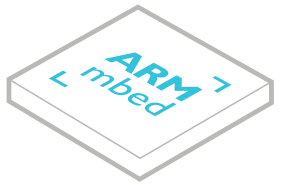
Campaign tracking: Accurate campaign tracking reducing maintenance costs

Conditional control: Rules to avoid interrupting critical device operations

Update Workflow Overview

ARMmbed
IoT device platform

Software Developer



Developer

Publish Firmware

Update Service

Device

Apply Updates

Code Development

Prepare Update Package

Publish Package

Setup Campaign

Distribute Package

Verify Package

Apply

Recover

Device Admin

Manage Campaigns

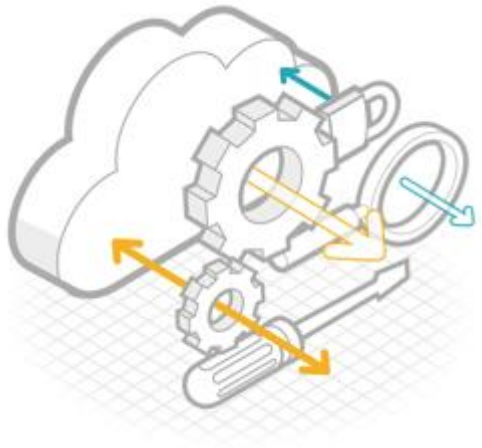
Device Admin/
Service Manager

ARM

Platform OS requirements

- Accelerate the **development** of IoT devices
  - Integrate all the necessary software components needed for constrained IoT devices (MCUs)
  - Bring modern development methodologies and choice to MCUs to improve productivity
  - Provide OS functionality and APIs across many vendor solutions to enable choice

- Accelerating the **deployment** of IoT devices
  - Provide standardised connectivity to the cloud across different transports
  - Provide manageability from the cloud to open opportunities and reduce cost/risk



- Develop and leverage an **ecosystem**
  - Freely available and open source to remove barriers to entry and enable adoption
  - In collaboration with partners to provide maximum gearing of investment for everyone
  - The tools and web infrastructure to support an ecosystem and create network effects

mbed OS

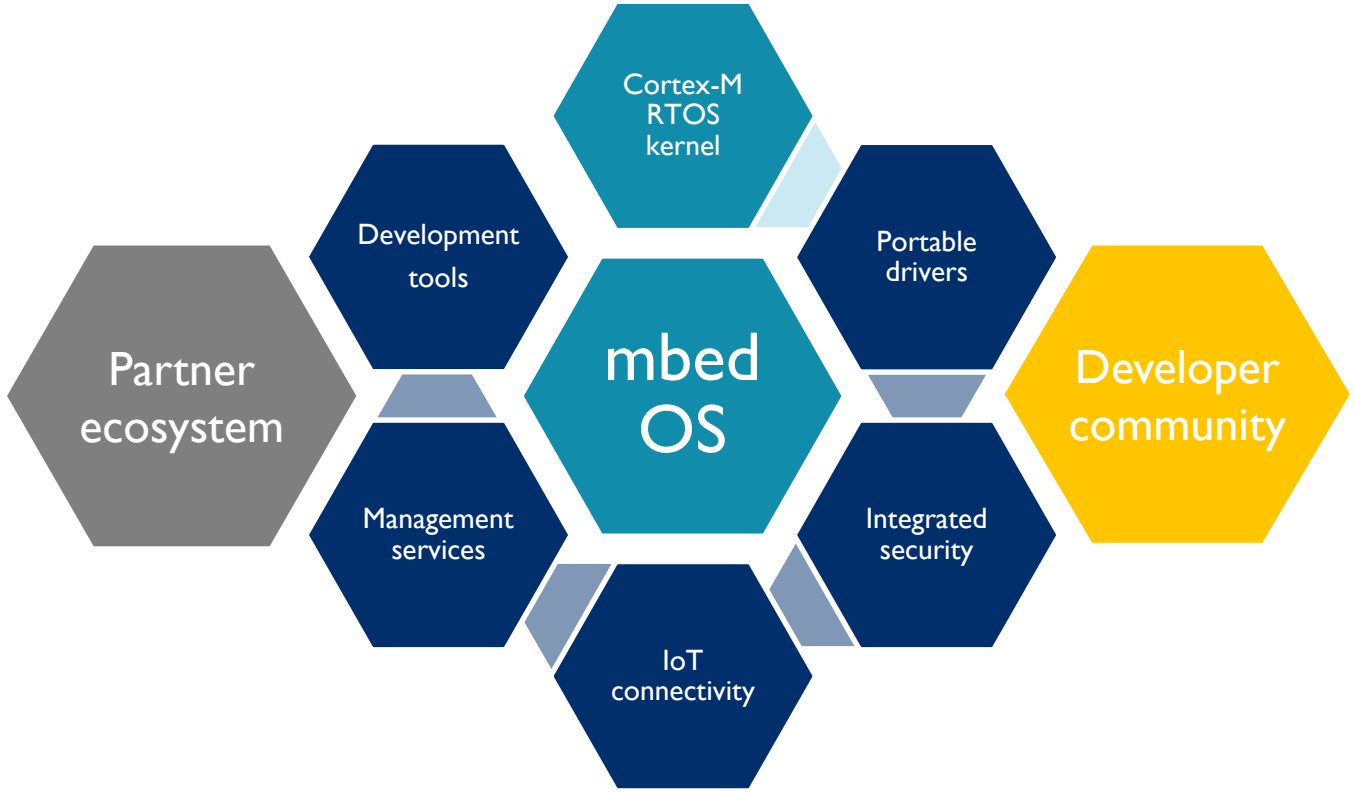
mbed OS 5

mbed OS is built to address the disruptive jump in complexity for embedded software

Addresses built-in security, multi-protocol connectivity and device updatability

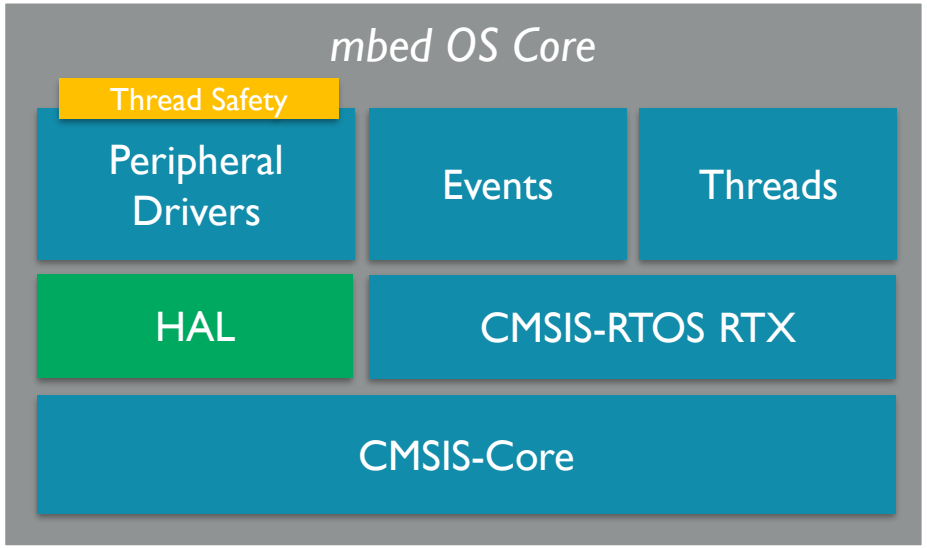
Over 85 silicon platforms supported for developers today

Open collaboration across the ecosystem accelerates IoT system development

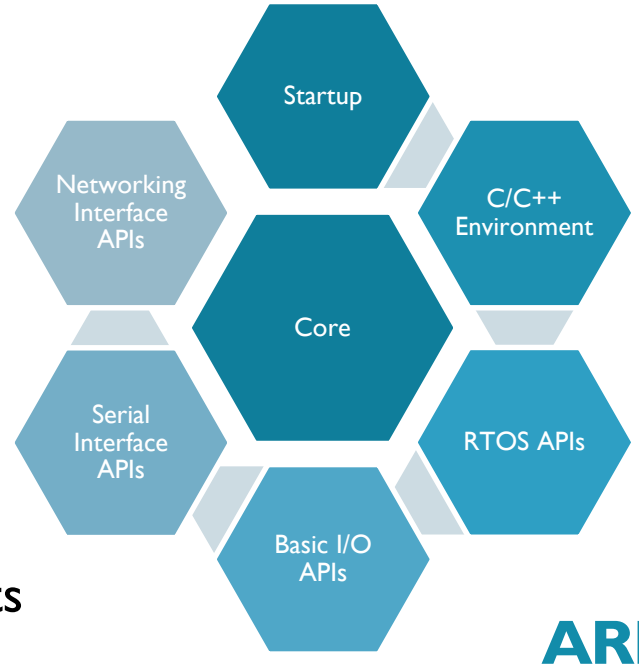


ARM

mbed OS Core

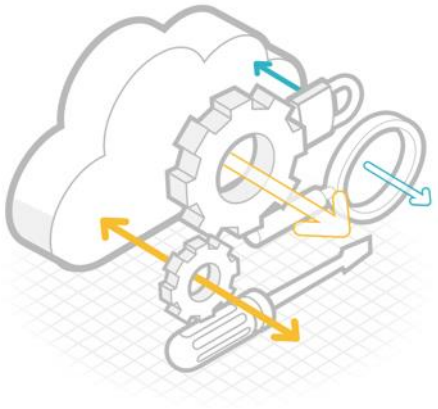


- Includes an RTOS Kernel
  - Built on the open source CMSIS-RTOS RTX
  - Established, widely used RTOS kernel
  - Very small kernel optimised for constrained memory devices
- Includes peripheral driver APIs, consistent across devices
  - Start-up and environment initialisation
  - Memory maps and cross-toolchain support and integration
  - Driver APIs for all common peripherals, supported across all MCUs
- Application and component libraries can be built unchanged
  - Provides portability for developers and helps to deliver network effects



mbed OS 5.5 headline features

CMSIS5 and CMSIS-RTOS2



Entropy/Acceleration Partner HW support

Bootloader and firmware update framework

IoT landscape and networks are constantly evolving

Secure smarter city applications

Cellular and NB-IoT support for faster, more efficient operations

Precision farming and connected sites

Native LoRaWAN API support to allow for rapid software development

Commercial lighting control

Certified Thread1.1 stack by ARM mbed is being adopted by major manufacturers

ARM

mbed OS - Networking

mbed OS Connectivity

LAN

Ethernet

BLE

WiFi

Thread

WAN

Cellular

LoRaWAN

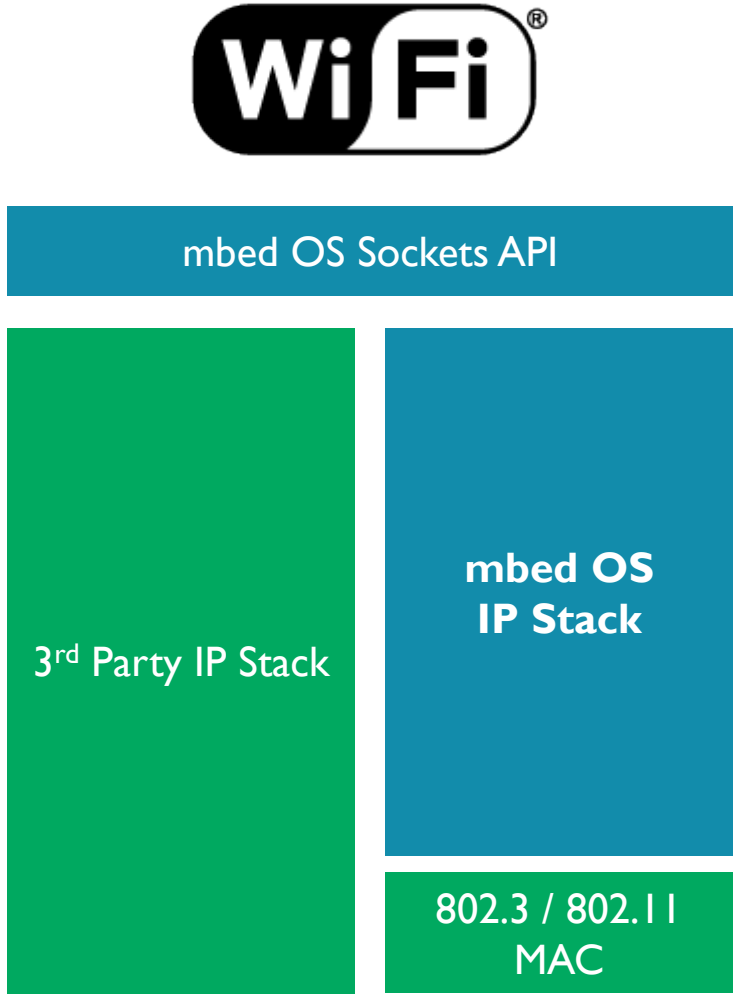
Sub-GHz 6LoWPAN

NB-IoT

Ethernet / Wi-Fi integration in mbed OS

- **Native dual mode IP stack**
  - Integrated stack with MAC porting interface
  - Focused on STA mode
  - IPv4 and IPv6 support

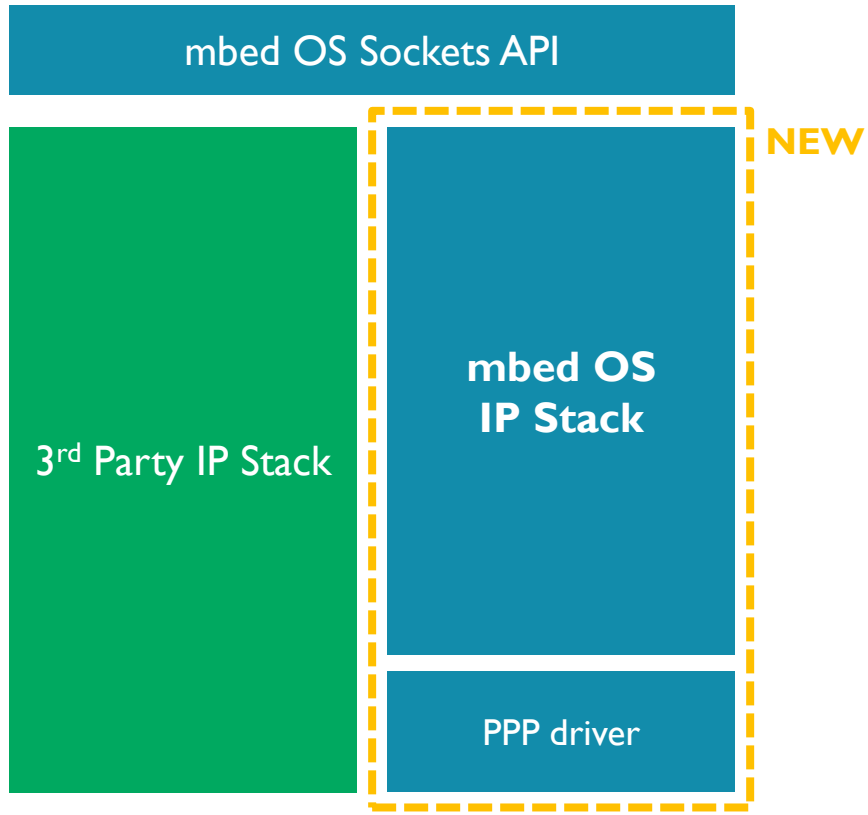
- Unified MAC integrations
  - Simplified integration for partners
  - Consistent behaviour across silicon platforms
  - Testing can focus on MAC port



Cellular integration in mbed OS

- **Native 3GPP 27.007 driver included in mbed OS 5.5**
  - Integrated with mbed OS IP stack
  - IPv4 network capability

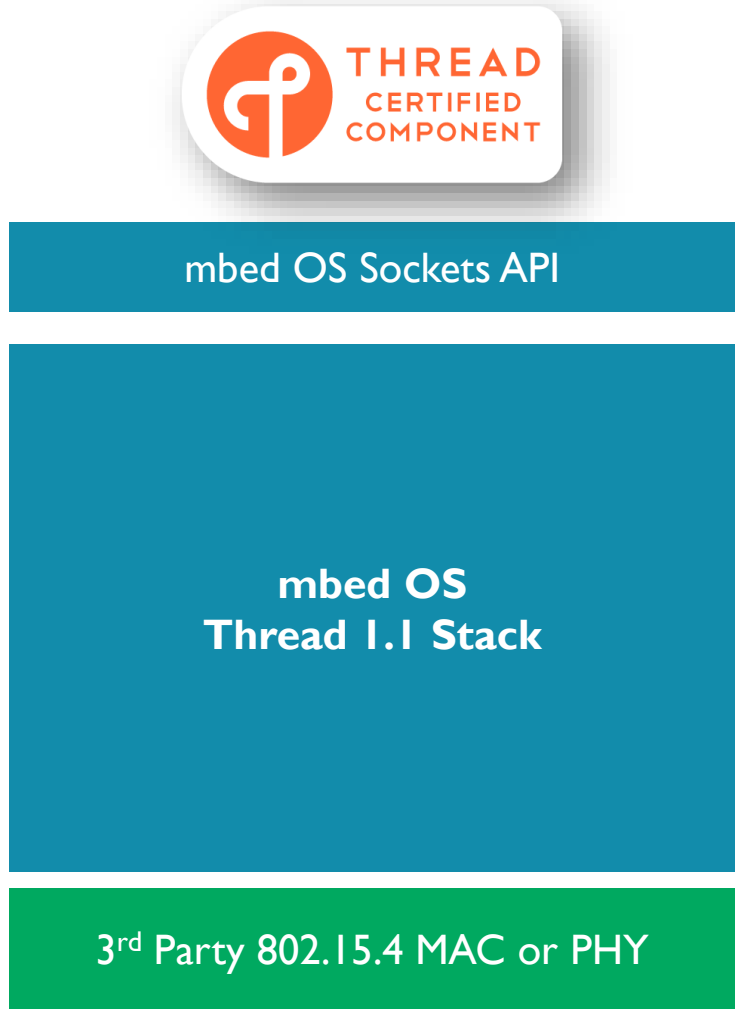
- Extendable architecture
  - UART based AT modem driver
  - Easily extensible to support other digital interfaces such as SPI, USB, etc.
  - Testing can focus on PPP driver



Thread integration in mbed OS

- **Certified Thread 1.1 stack included in mbed OS 5.4**
  - Any silicon or module partner can now enable developers with Thread 1.1 by using existing or porting a new 802.15.4 transceiver

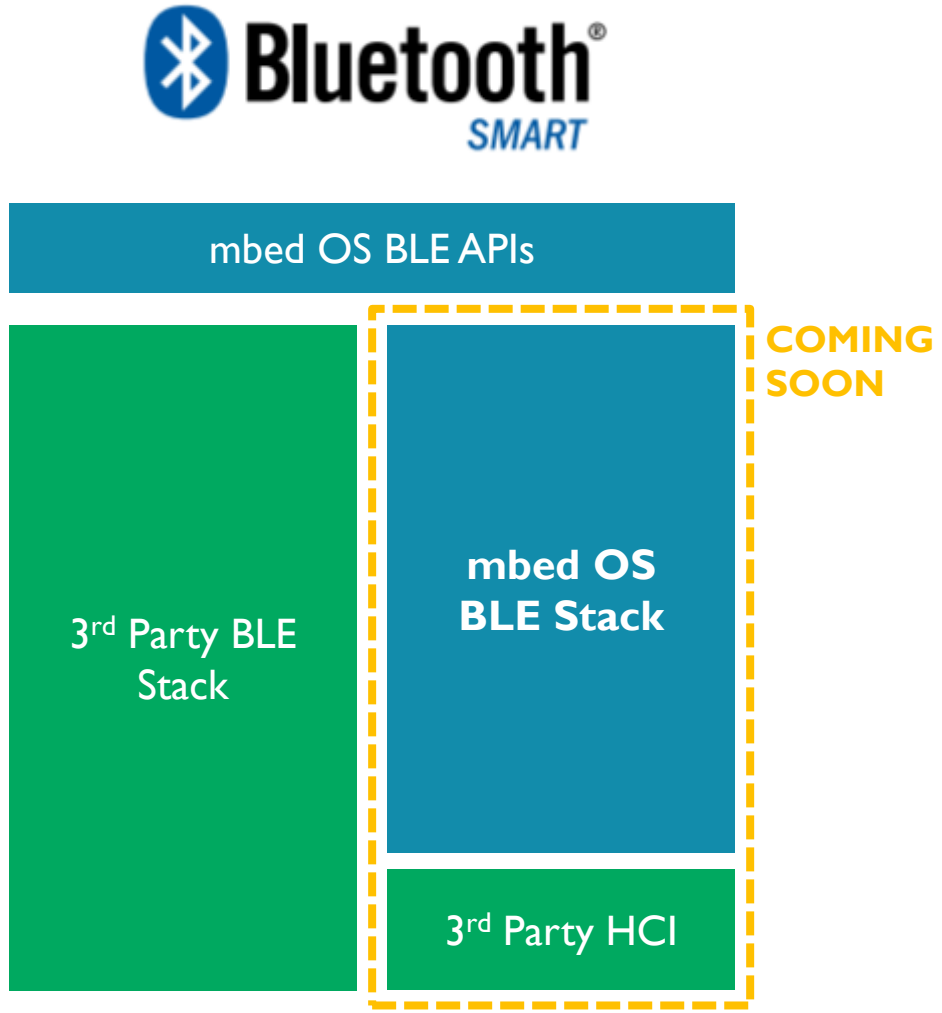
- Release includes developer access to:
  - Thread node support in mbed OS
  - Border router application
  - Linux-based access point reference design



BLE integration in mbed OS

- **Native BLE stack coming to mbed OS**
  - Integrated stack with HCI porting interface
  - Qualification tested and compliant with the latest version of the Bluetooth Core Specification

- Showing ~5x reduction in LoC for integration
  - Simplified integration for partners
  - Consistent behaviour across silicon platforms
  - Testing can focus on HCI port



LoRa integration in mbed OS

- LoRa and LoRaWAN networks
  - Begining to be trialed world wide by operators and cities
  - Bring-your-own infrastructure
- mbed OS already supports LoRa
  - Building in native LoRaWAN support
  - First LoRaWAN APIs available for partner review in mbed OS 5.3

Partner Cooperation case I – FOTA over LoRa

"The mantra of any good security engineer is: "Security is not a product, but a process" It's more than designing strong cryptography into a system; it's designing the entire system such that all security measures, including cryptography, work together."

– Bruce Schneier

mbed OS - Security

mbed security architecture

Lifecycle security

Communication security

Device security

Cloud application platforms

Data Flow Management

Deployment Management

mbed TLS

Connectivity Service

Provisioning Service

Update Service

mbed TLS

Connectivity Client

Provisioning Client

Update Client

mbed uVisor

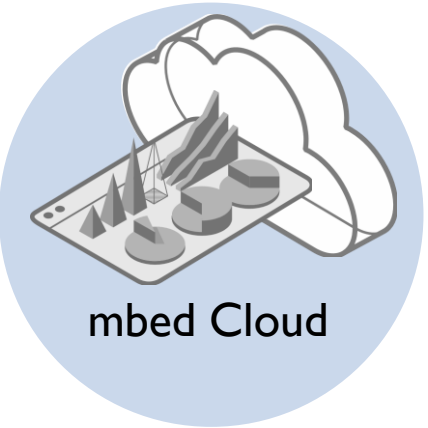
Crypto TL

Conn TL

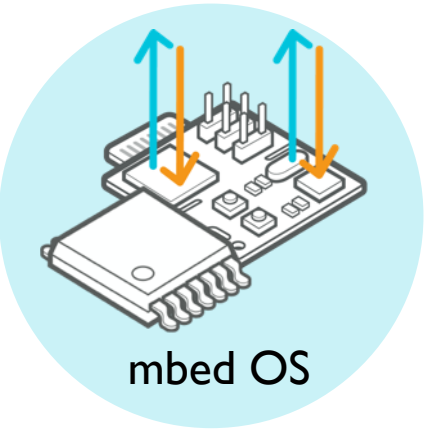
Prov TL

Update TL

Device Hardware



mbed Cloud

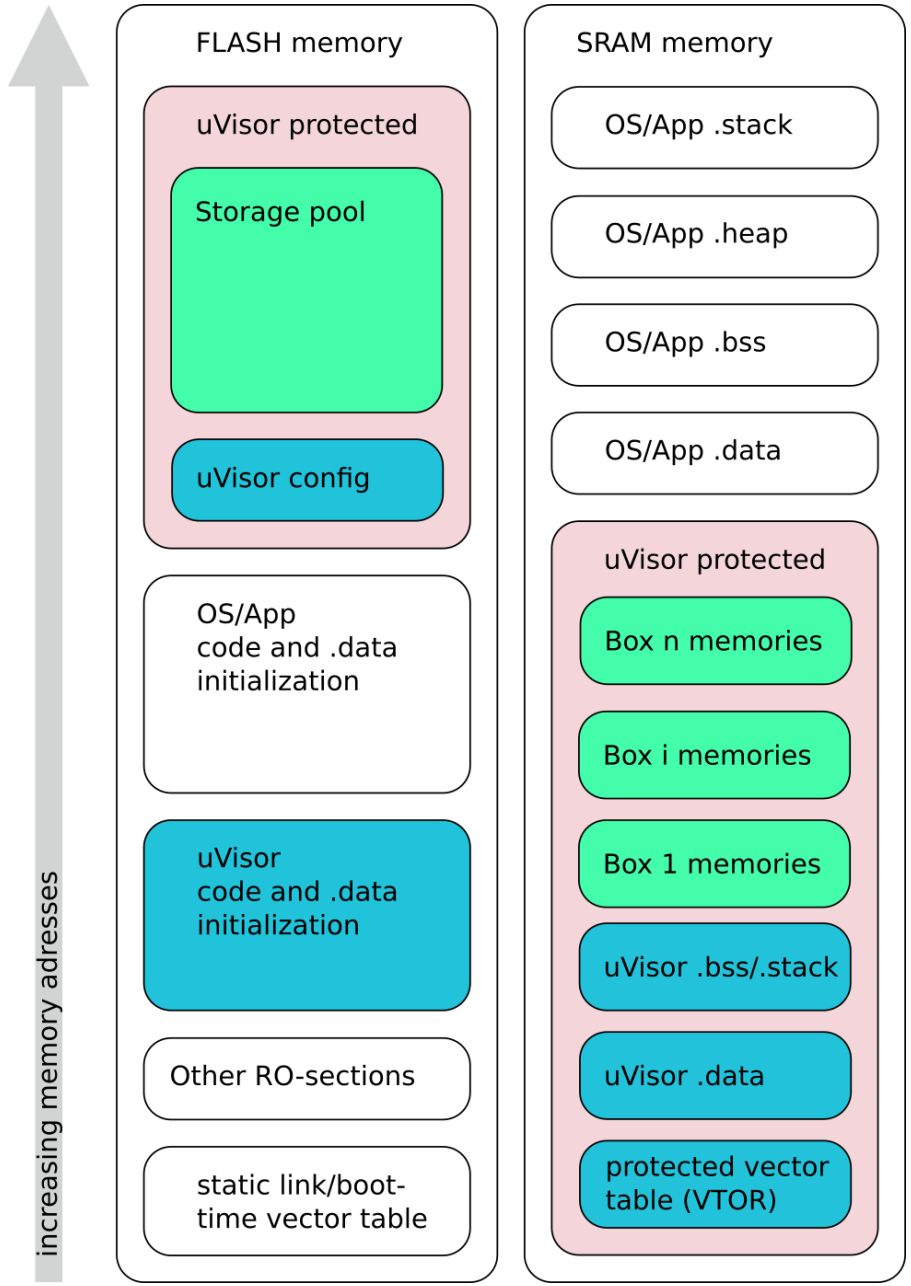


mbed OS

ARM

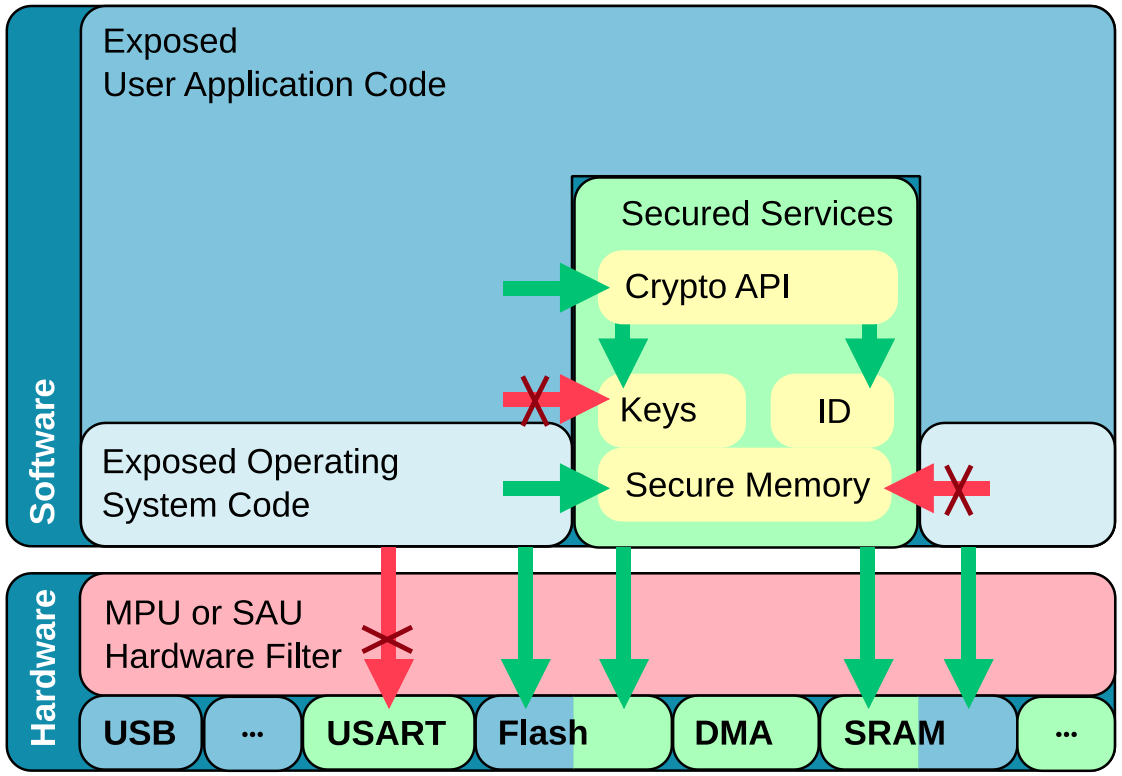
mbed uVisor security

- Enables compartmentalization of threads and processes for microcontrollers.
- mbed uVisor initialized first in boot process
- mbed uVisor allocates protected per-box stacks and detects under-/overflows during operation.
- Per-Box data sections are protected by default:
  - Secure per-box context memory, stack and heap.
  - Shared data/peripherals with other boxes on demand.
- De-privileges execution, continues boot unprivileged to initialize OS and libraries.



mbed uVisor hypervisor: Hardware security for microcontrollers

- Initialization of memory protection unit (MPU) based on box permissions:
  - Whitelist approach – Access Control List(ACL) only required peripherals are accessible to each box.
  - Each box has private .bss data and stack sections.
- Write access to flash is only allowed through APIs of a dedicated flash-access box process



ARM

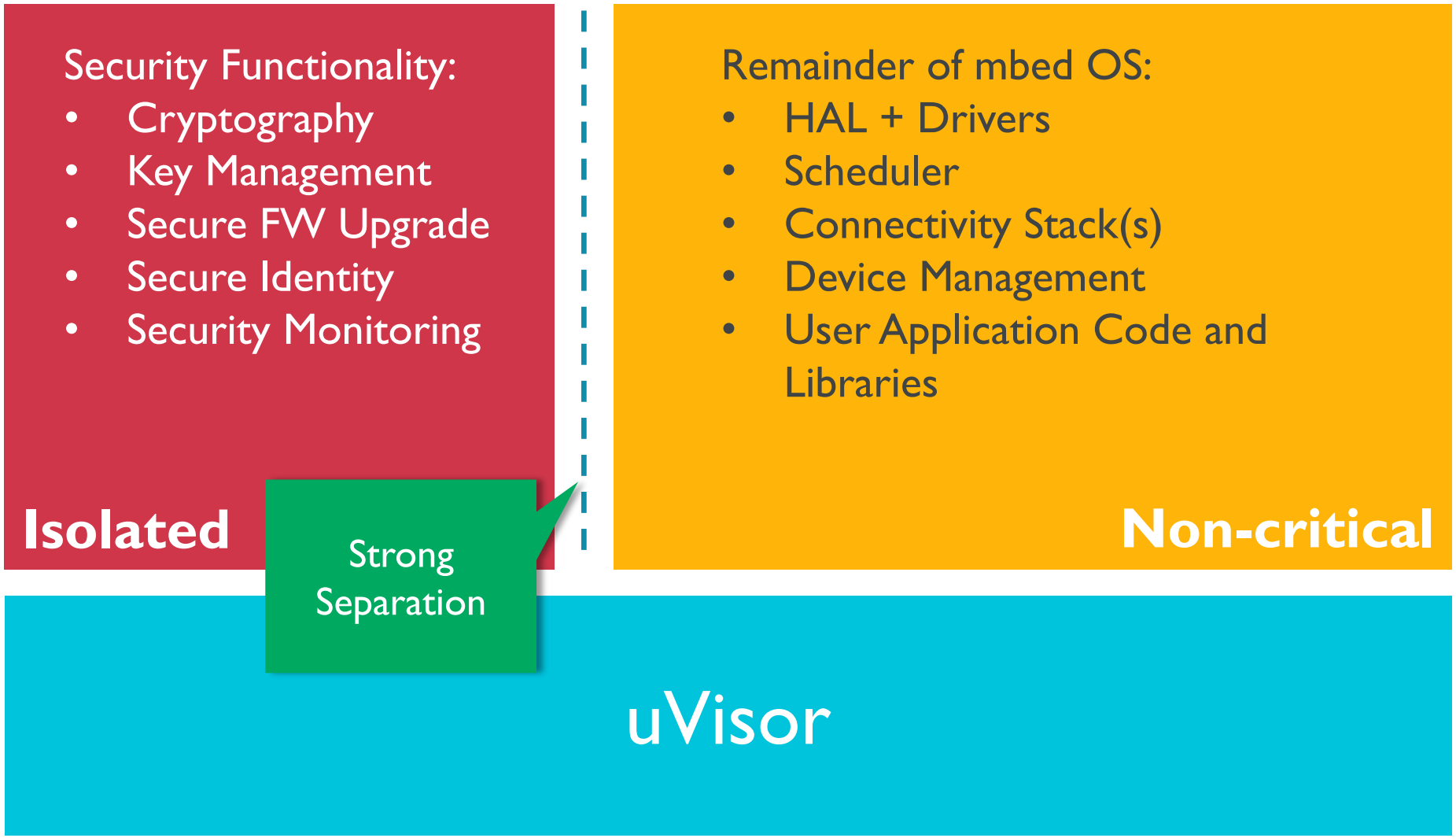
mbed uVisor on TrustZone-M

- ARM mbed uVisor application security model of TrustZone for ARMv8-M is **source-compatible** with the ARMv7-M security model.

- Additionally TrustZone for ARMv8-M enables bus level protection in hardware:
  - ARMv7-M requires software API filters for DMA access and other security critical operations.
  - ARMv8-M can filter for DMA access for requests initiated by unprivileged code on bus level.

- TrustZone for ARMv8-M MPU banking reduces complexity of secure target OS:
  - Secure OS partition owns a private MPU with full control.
  - OS keeps the privileged mode for fast IRQs.
  - Fast interrupt routing and register clearing in hardware.
  - Fast cross-box calls on TrustZone for ARMv8M – optimized call gateways.

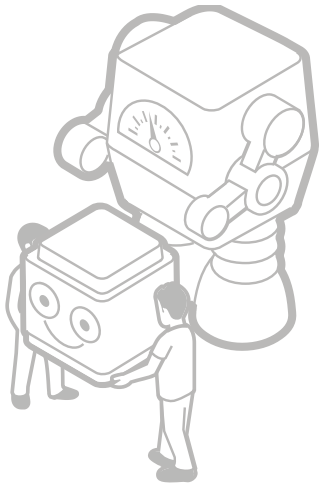
uVisor on TrustZone for ARMv8-M



mbed OS
Contribution and Licensing

mbed OS Licensing and Contribution

- mbed OS is primarily open source, under Apache 2.0 or compatible licenses
  - Proprietary partner components (like radio drivers) can be under free binary license
- Partners pay a membership fee to support and contribute to project
  - Our partners share a vision for the future where development and deployment of commercial Internet of Things (IoT) devices is possible at scale, and a desire to collaborate on concrete plans and projects to make that vision a reality.
- Developers can use it for free

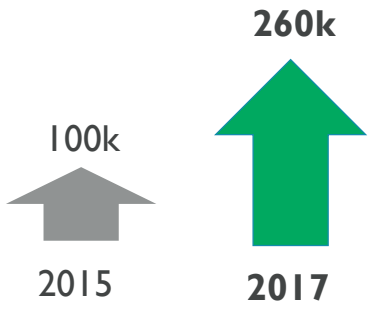


partnership@mbed.com

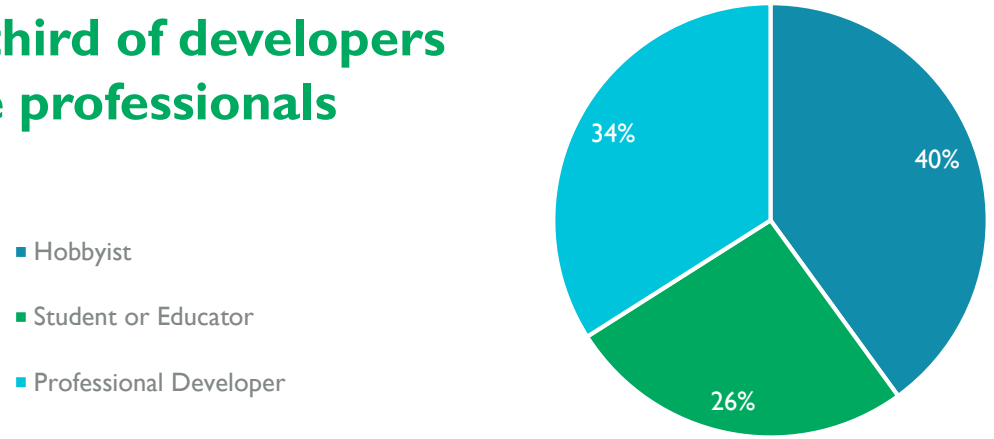
mbed OS
Developers and Partners

mbed Developers

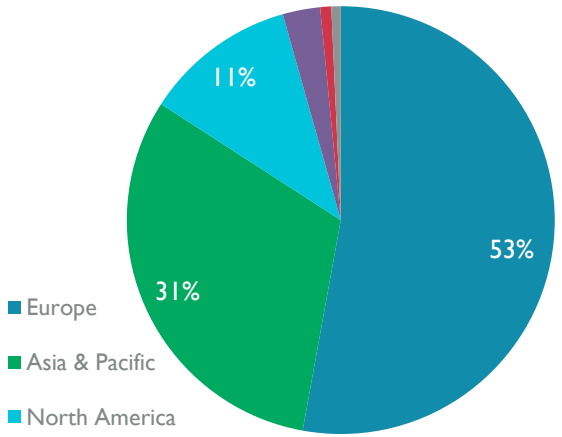
Over 250k registered developers



A third of developers are professionals



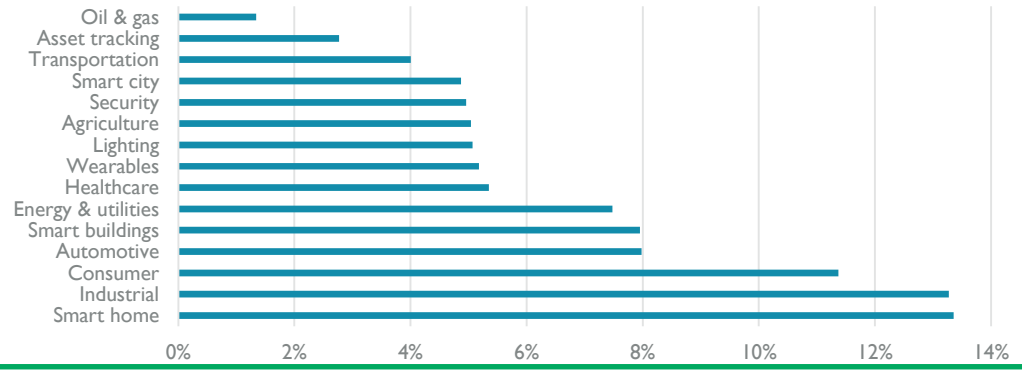
A global footprint



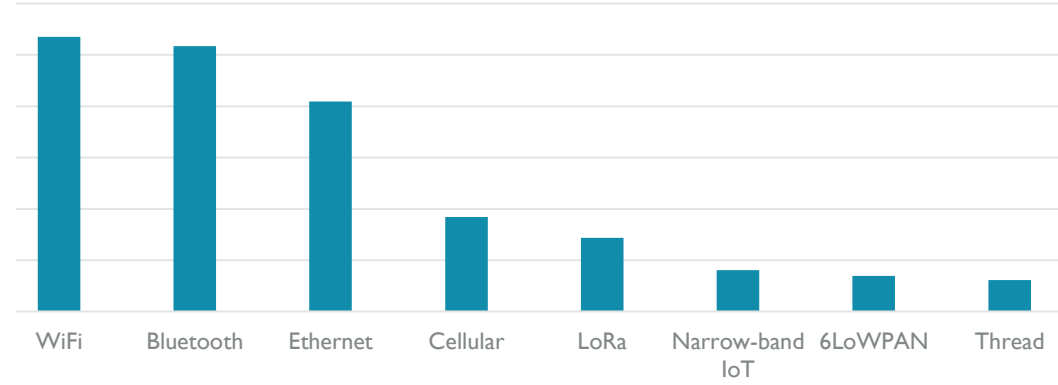
Source: mbed.com, mbed developer survey 2017

mbed Product Development

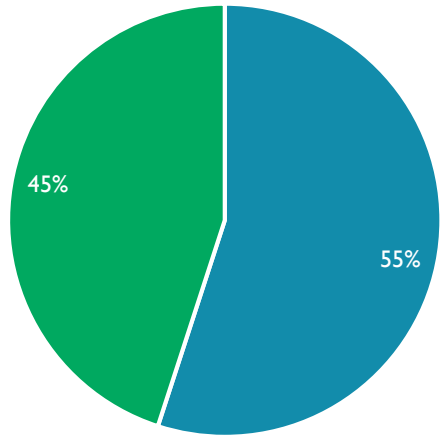
Products target a diversity of IoT markets



Products use a diversity of connectivity



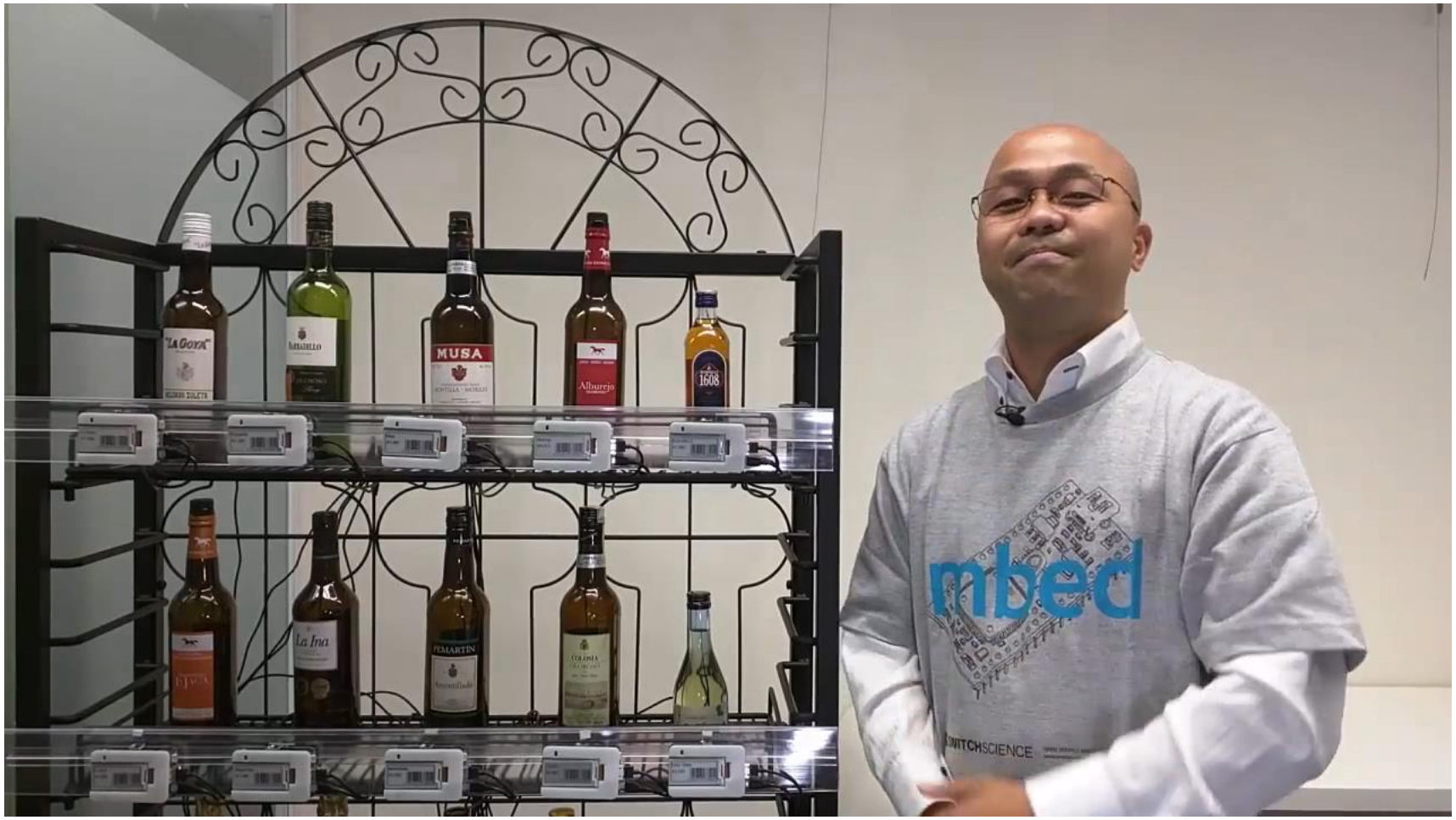
45% of projects expect to achieve deployment



- Don't expect mbed project to be deployed into the market
- Do expect mbed project to be deployed into the market

Source: mbed.com, mbed developer survey 2017

Partner Cooperation case 11 - Digital Tag



mbed Tools Overview

mbed Tools

- Free core tools provide build, debug, test and collaboration workflows
- Third party partner industry tools support

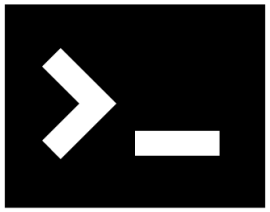
mbed OS DVCS support

git mercurial

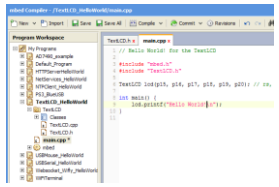
GitHub Atlassian Bitbucket

GitLab developer.mbed.org

mbed OS core tools

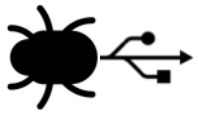


mbed CLI
Command Line Interface



mbed Compiler
Online IDE

mbed Greentea
Porting Testsuite and CI



mbed pyOCD
CMSIS-DAP Debug Library

mbed DAPLink
CMSIS-DAP Debug Firmware

mbed OS IDEs and toolchains

ARMKEIL Microcontroller tools
ARM Compiler 5

IAR SYSTEMS

GCC