



사물인터넷 디바이스 오픈소스 플랫폼(Mbed OS) 프로그래밍

1. Mbed Ecosystem

이동명
2020.07

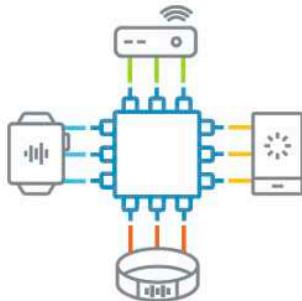


Agenda

1. Mbed Ecosystem
2. Setup develop environment
3. Peripheral IPs control practice
4. Cloud / Web application with Mbed

<https://bit.ly/2Cs6YLu>

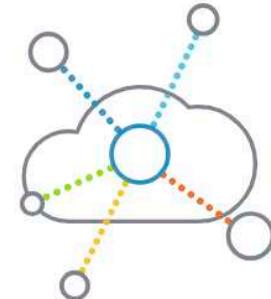
arm



Processor IP

Technology for the Widest Range of Devices—from Sensors to Servers

Arm is the world's leading technology provider of silicon IP and custom SoCs at the heart of billions of devices. Our portfolio of products enable partners to get-to-market faster.

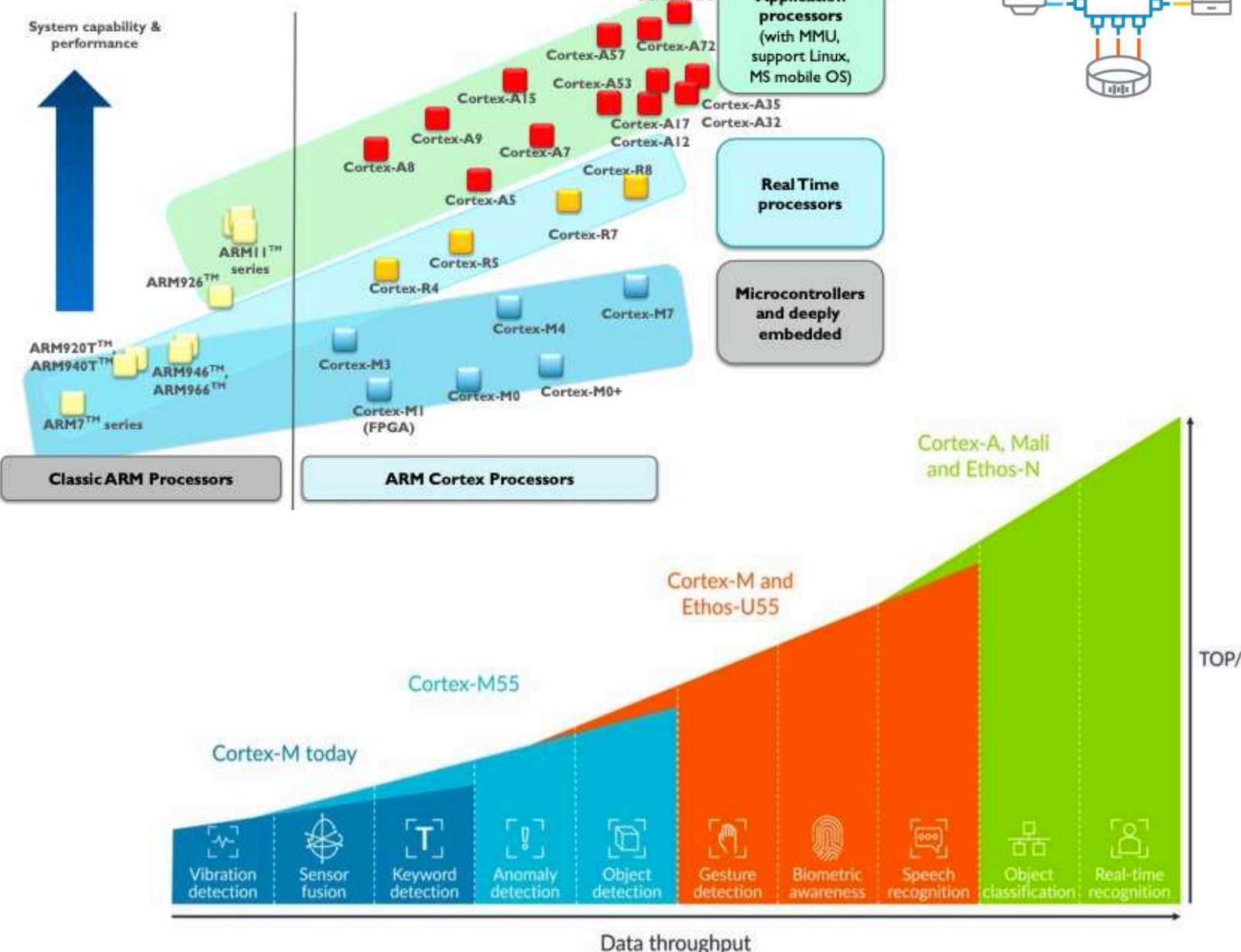
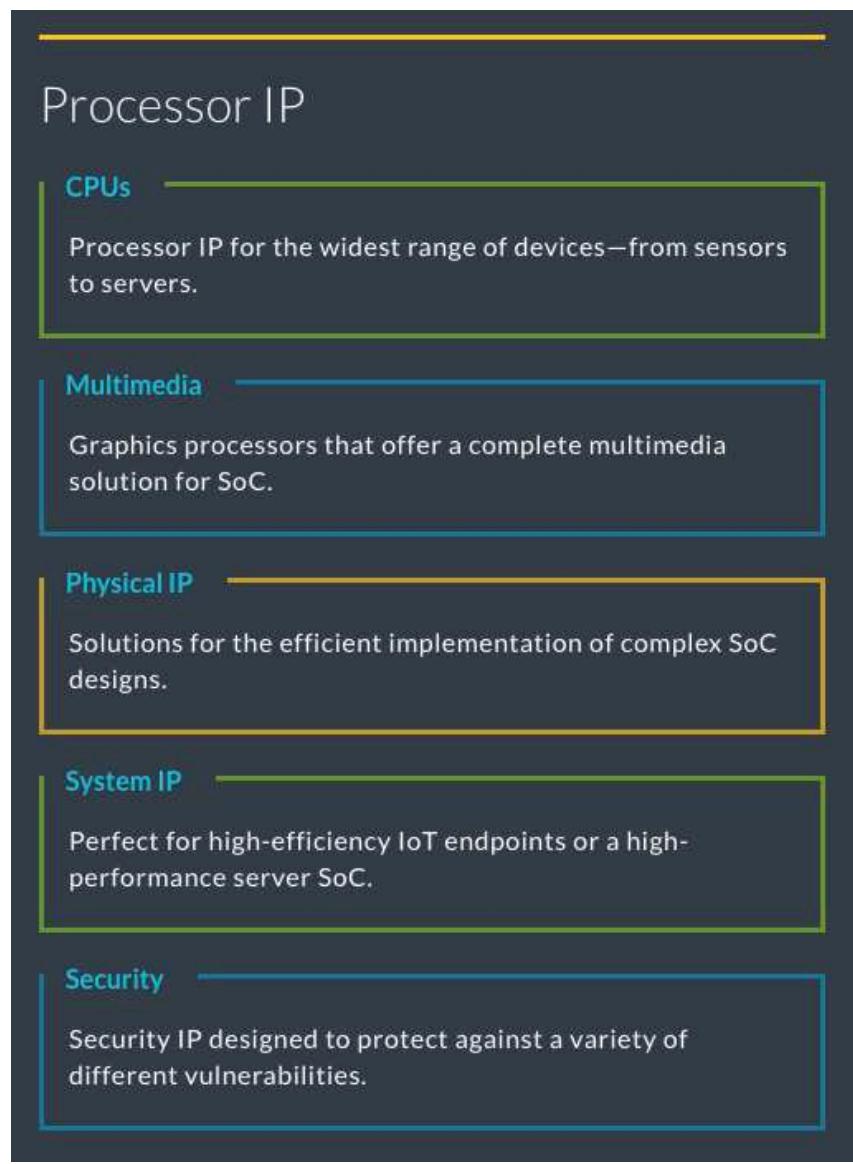


IoT Products

Technology that Removes the Complexities of IoT

Arm removes the complexities of IoT with a complete IoT products and pre-integrated subsystems that enable customers and partners to rapidly design and deploy flexible IoT solutions.

Arm - Processor



Arm - IoT

IoT

Pelion IoT Platform

The Pelion IoT Platform is a flexible, secure, and efficient foundation spanning connectivity, device, and data management.

Platform Includes:

- Connectivity Management
- Device Management
- Data Management

Mbed OS

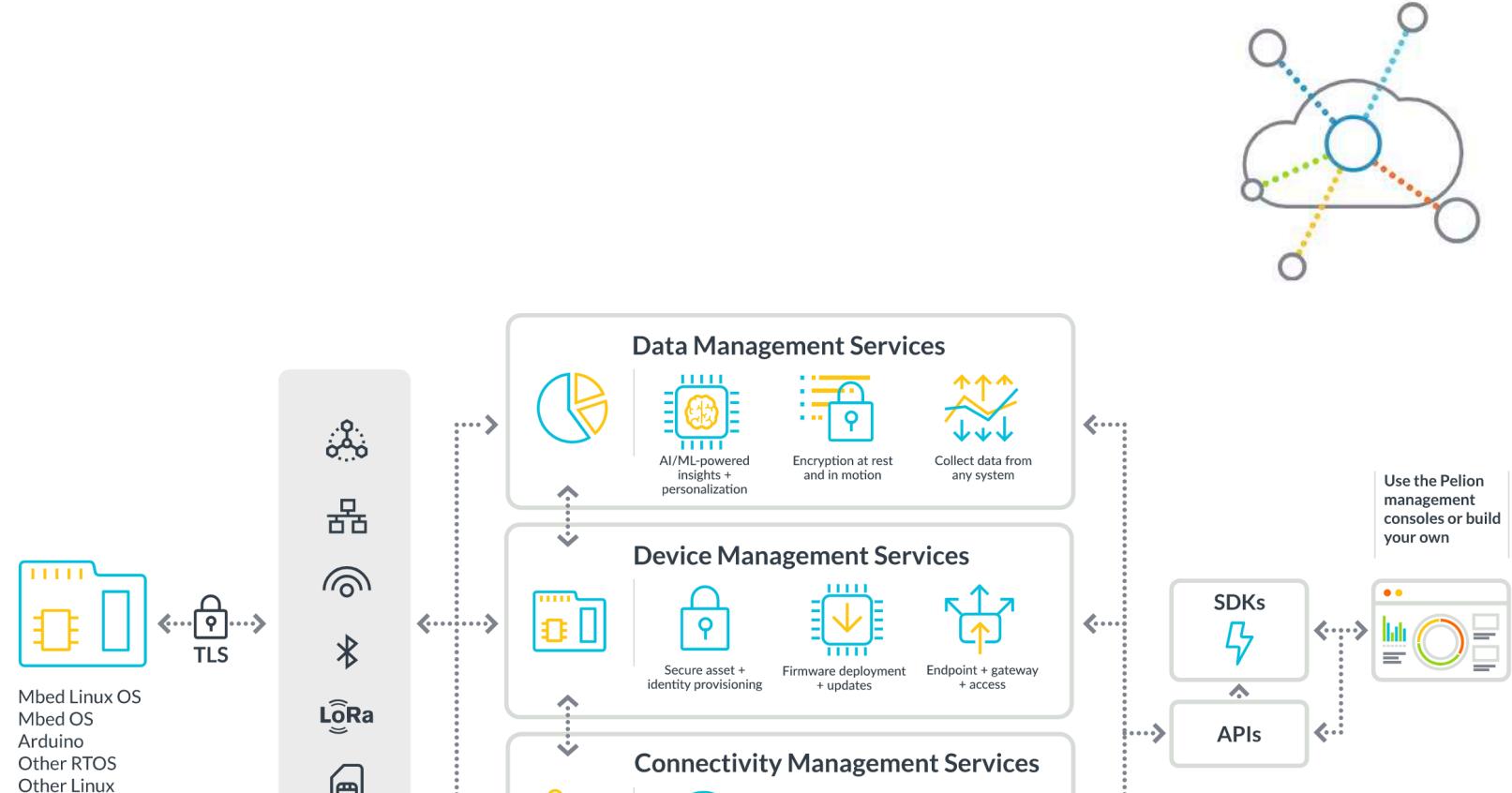
Open-source embedded operating system ideal for IoT connected products.

IoT SoC Solutions

Tools to accelerate time to security for SoC designers, device makers, and developers.

Kigen SIM Solutions

Build and remotely provision SIM, eSIM and iSIM.



Arm - IoT

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Mbed OS

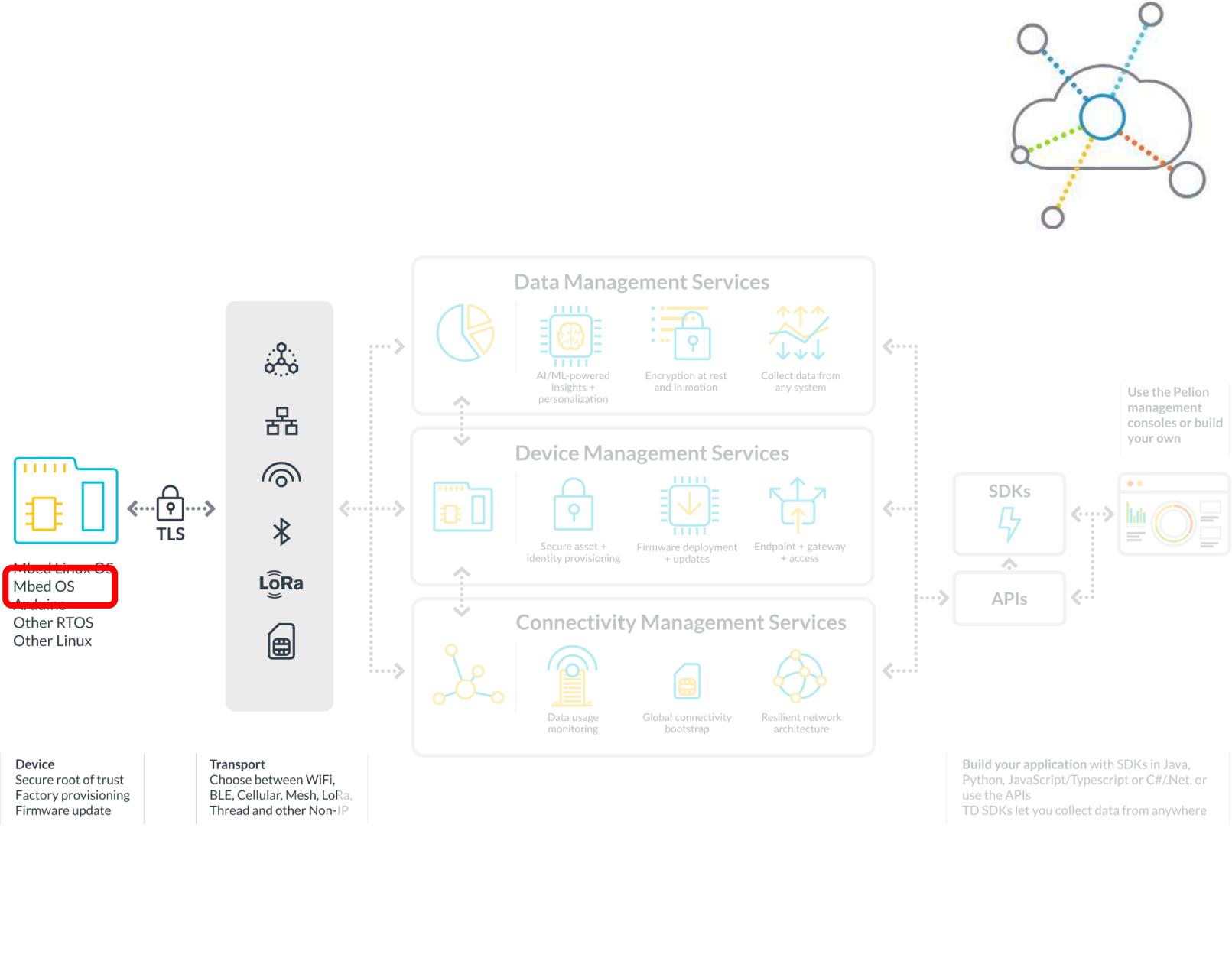
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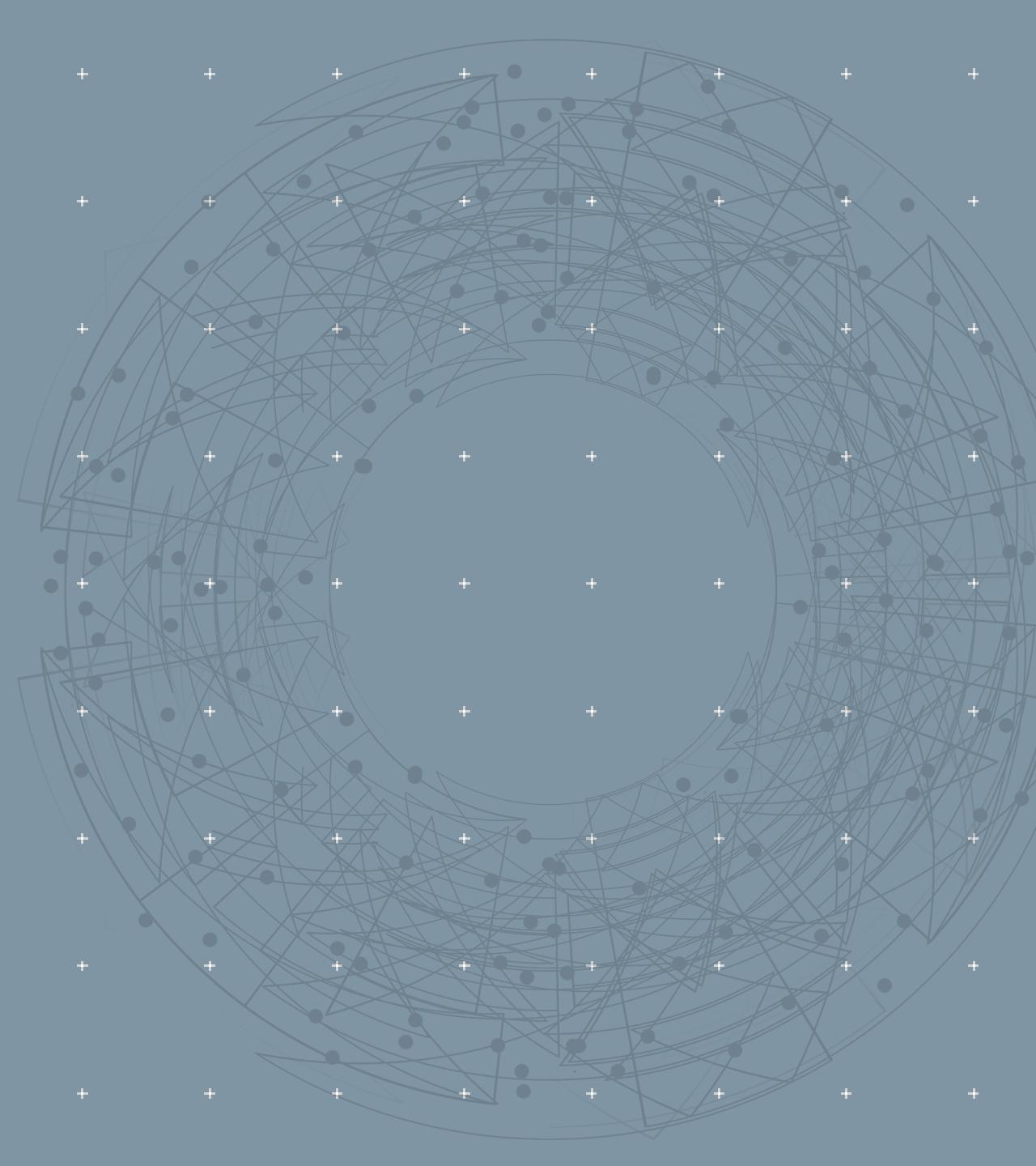
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Mbed OS Ecosystem

The Mbed OS ecosystem is a collection of open-source components and tools that enable the development of real-time operating systems for embedded systems.

The ecosystem includes a variety of drivers, libraries, and tools for hardware components such as sensors, actuators, and communication modules.

The Mbed OS ecosystem is designed to be easy to learn and use, making it accessible to developers of all levels.

The ecosystem is also highly modular, allowing developers to easily integrate new components and features into their projects.

The Mbed OS ecosystem is a valuable resource for anyone looking to develop embedded systems for a variety of applications.

The ecosystem is constantly evolving, with new components and tools being added regularly.

If you're interested in learning more about the Mbed OS ecosystem, be sure to check out the official documentation and developer forums.

With its extensive resources and modular design, the Mbed OS ecosystem is a powerful tool for developing embedded systems.

Whether you're a beginner or an experienced developer, the Mbed OS ecosystem has something to offer.

So why wait? Start exploring the Mbed OS ecosystem today!

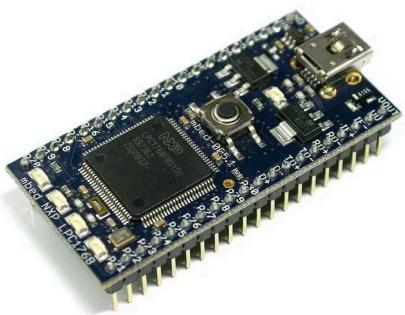
Open Source Platform



8bit - AVR



32bit – Cortex M3



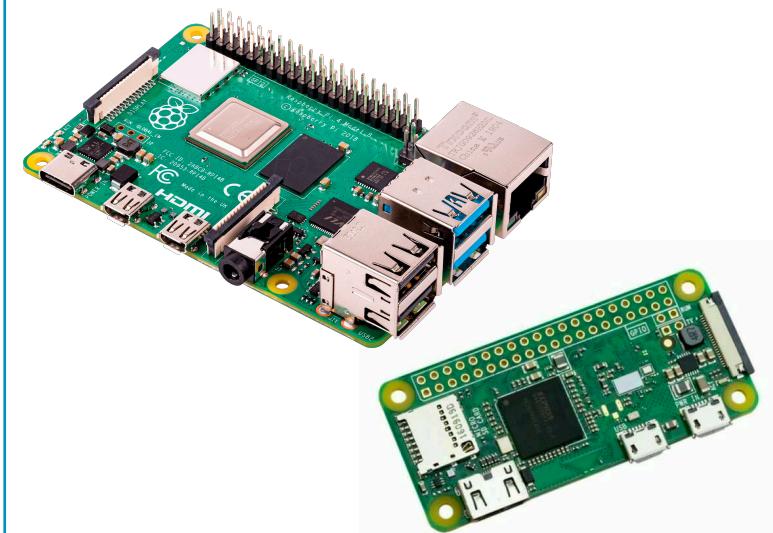
32bit – Cortex M3



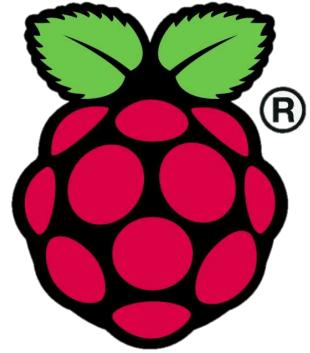
32bit – Cortex A9



Quad core Cortex-A72 (ARM v8) 64-bit Soc

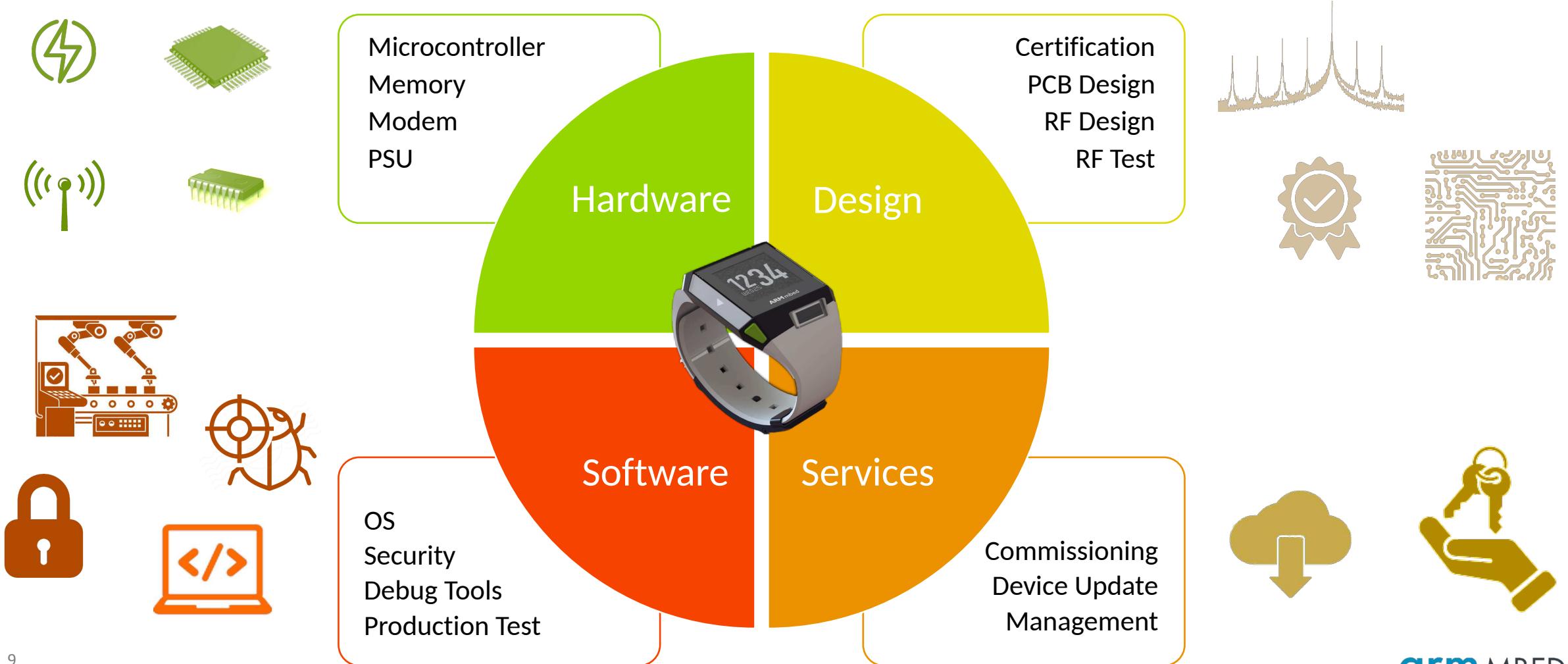


arm MBED

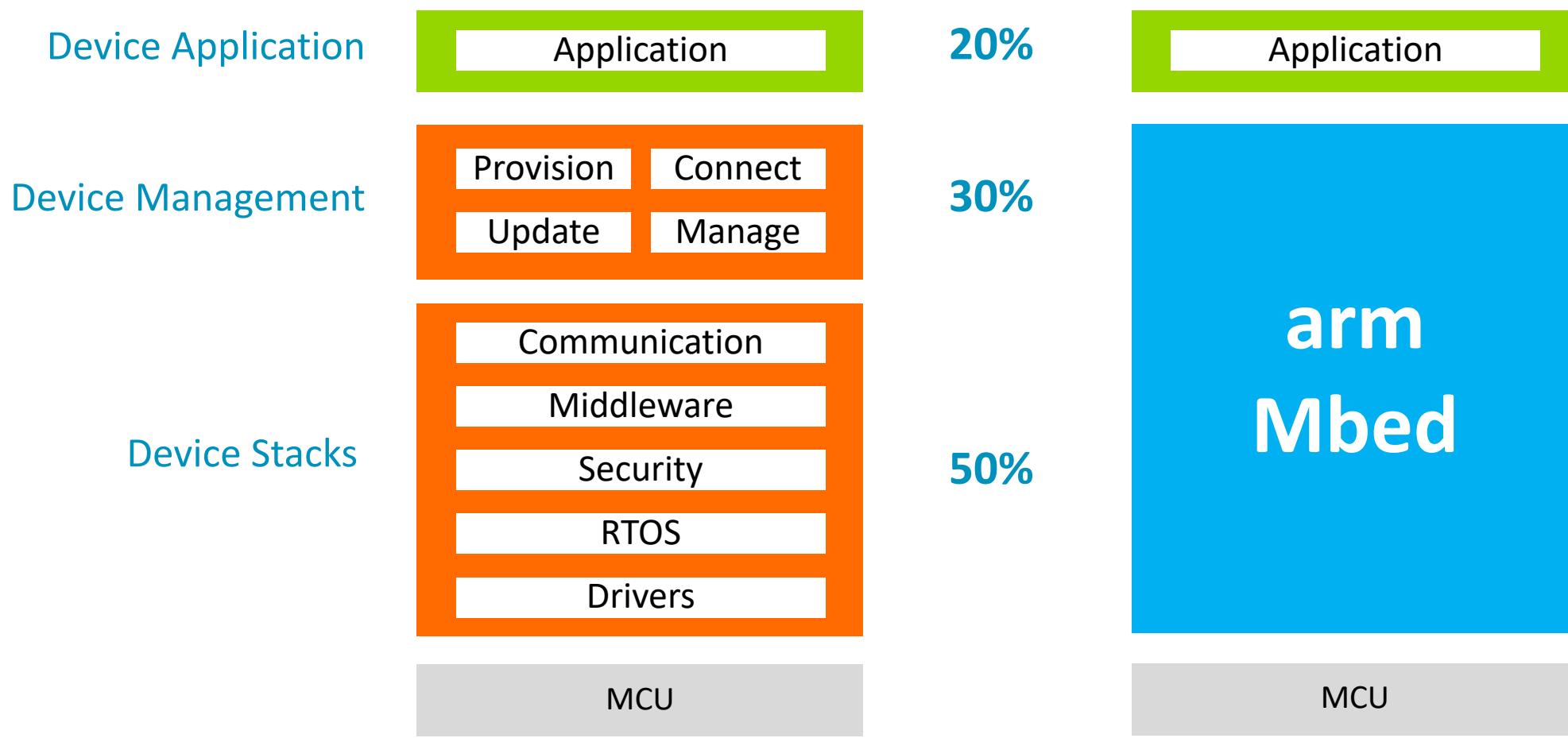


Raspberry Pi

IoT 사업을 시작할 때 고려해야 할 사항은?

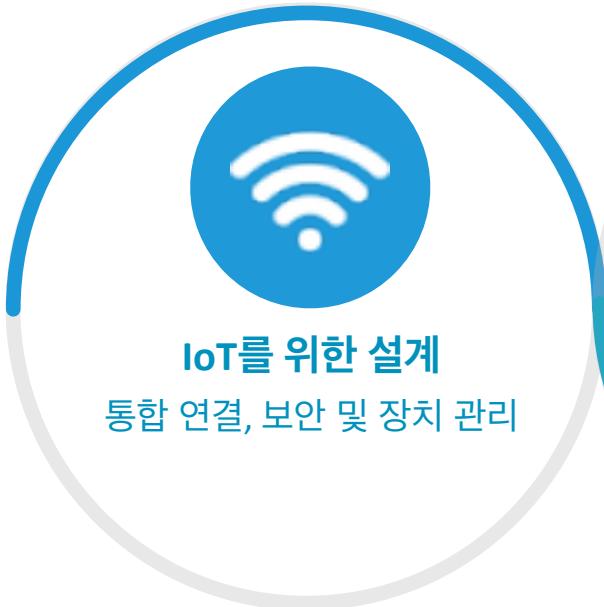


개발 복잡도



Mbed 란?

IoT 장치의 복잡한 요구 사항을 충족시키는 운영 체제 솔루션



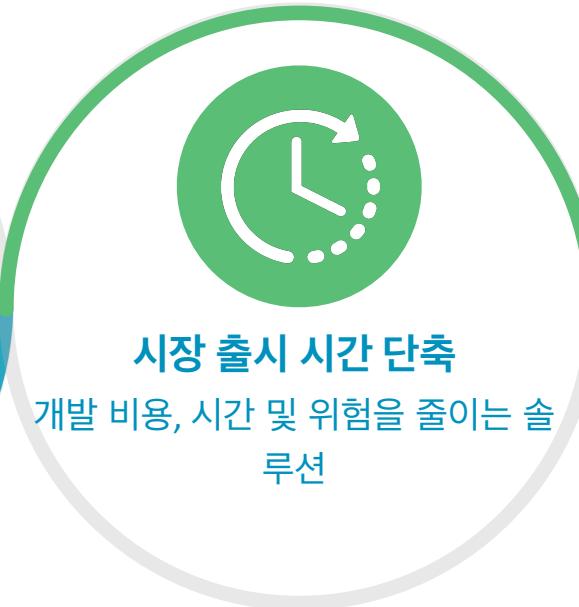
IoT를 위한 설계

통합 연결, 보안 및 장치 관리



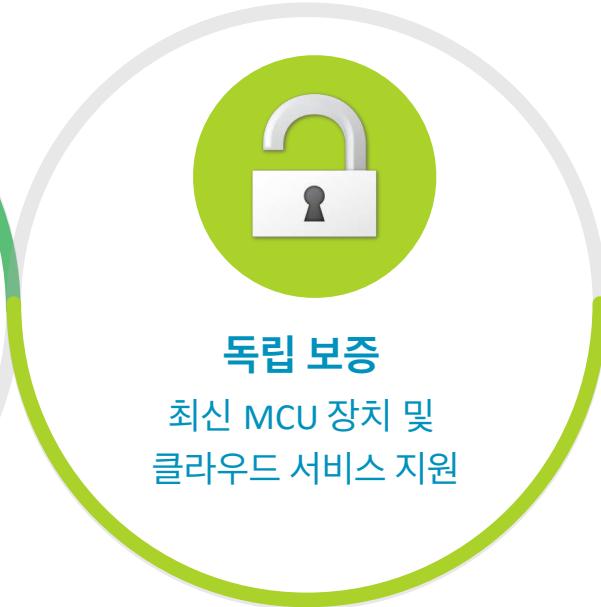
번성하는 생태계

실리콘, 모듈, 클라우드 공급업체 및 OEM 개발자 포함



시장 출시 시간 단축

개발 비용, 시간 및 위험을 줄이는 솔루션

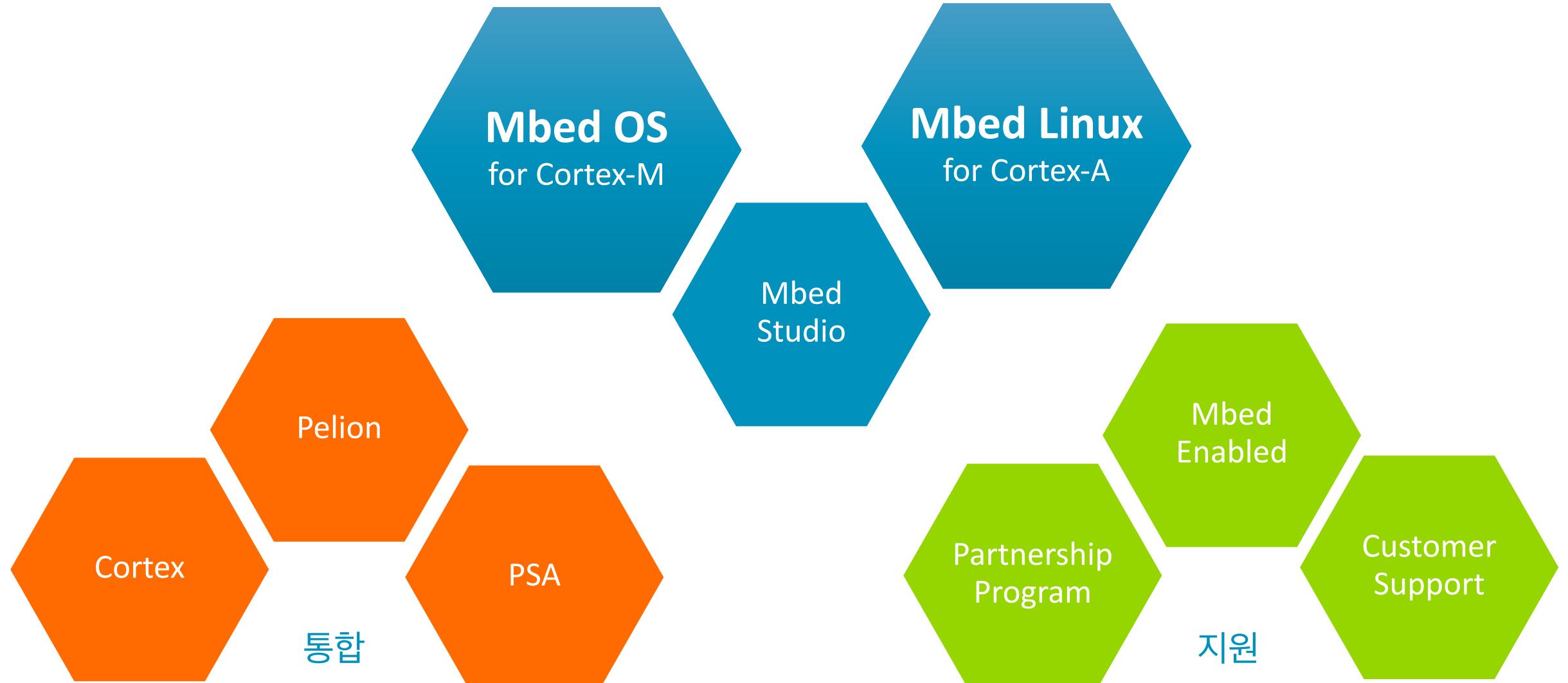


독립 보증

최신 MCU 장치 및 클라우드 서비스 지원

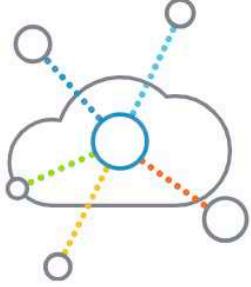
실리콘 파트너와 협력하여 개발되었으며 IoT 디바이스의 생성을 가속화하기 위해 칩 사용자들에게 **무료로 제공됨**.

Mbed ecosystem



arm MBED

IoT 장치를 대상으로하는 무료 오픈 소스 플랫폼 OS



170여개 이상의 개발보드



Arm Mbed 솔루션의 장점



시장 출시 시간 단축

- 완벽하게 통합되고 테스트된 기반
- 장치 소프트웨어는 장치 및 연결 관리를 위해 Pelion, AWS, Azure, GCP 등 Cloud Service 를 사용할 수 있다.

향상된 코드 재 사용성

- 변화하는 통신 요구 사항에 대한 유연성
- 핵심 기술이 아닌 부가 가치에 중점
- 모듈 형 객체 지향 코드

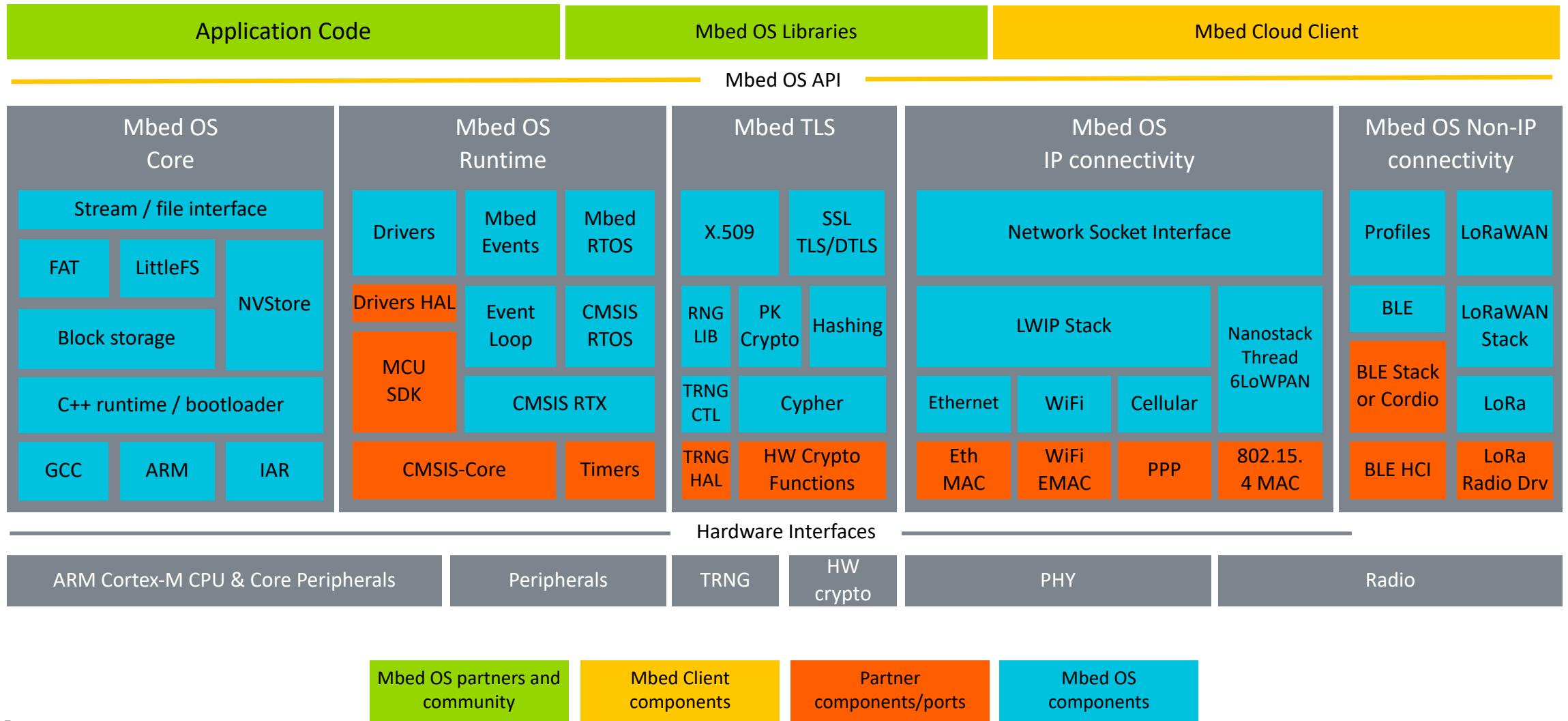
설계 위험 감소

- 엄격한 테스트를 거친 구성 요소
- 입증 된 개방형 표준
- 오픈 소스 소프트웨어

최첨단 기술에 대한 접근성

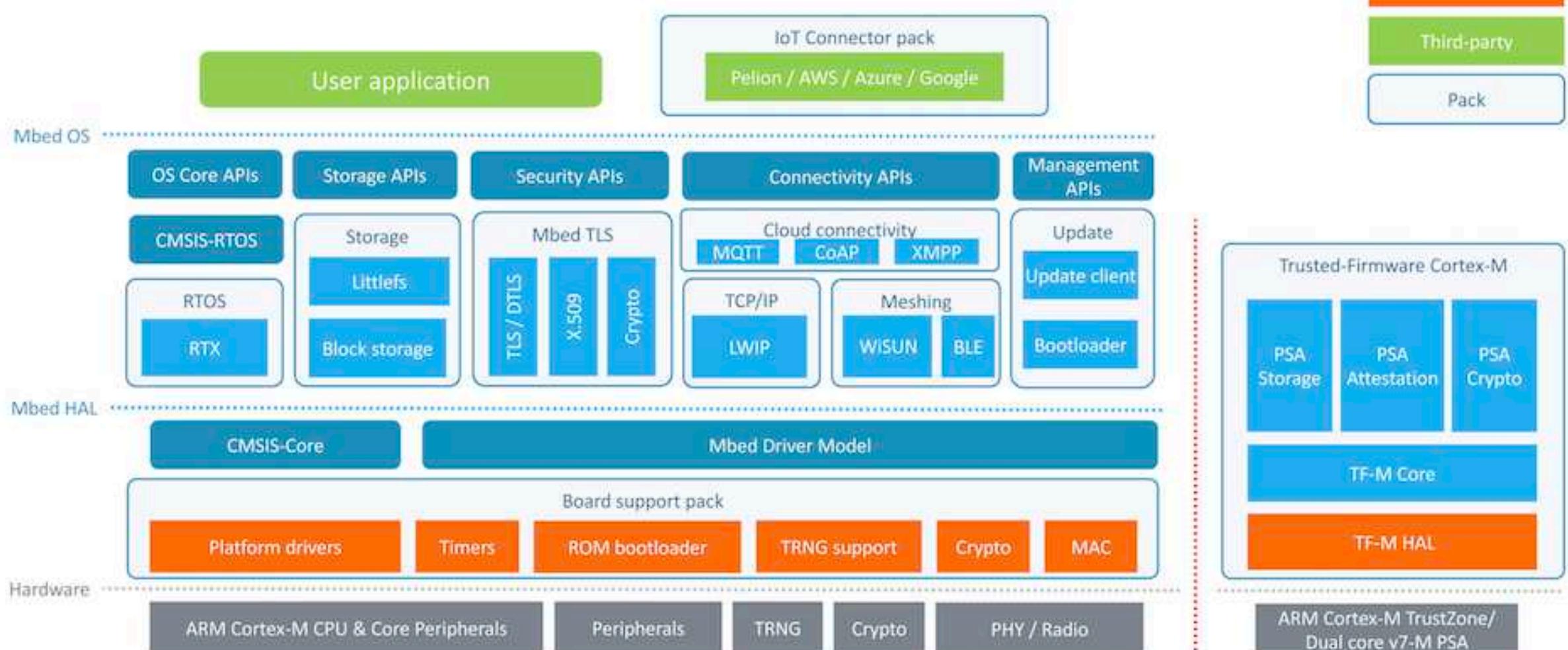
- 최첨단 MCU 기술
 - E.g. Cortex M23/M33
- 기존 및 새로운 통신 프로토콜의 가용성
 - LoRA, NB IoT, LTE CAT M1, Thread/WiSun, BLE Mesh

Mbed OS 5 - Architecture



Mbed OS 6 - Conceptual Architectural

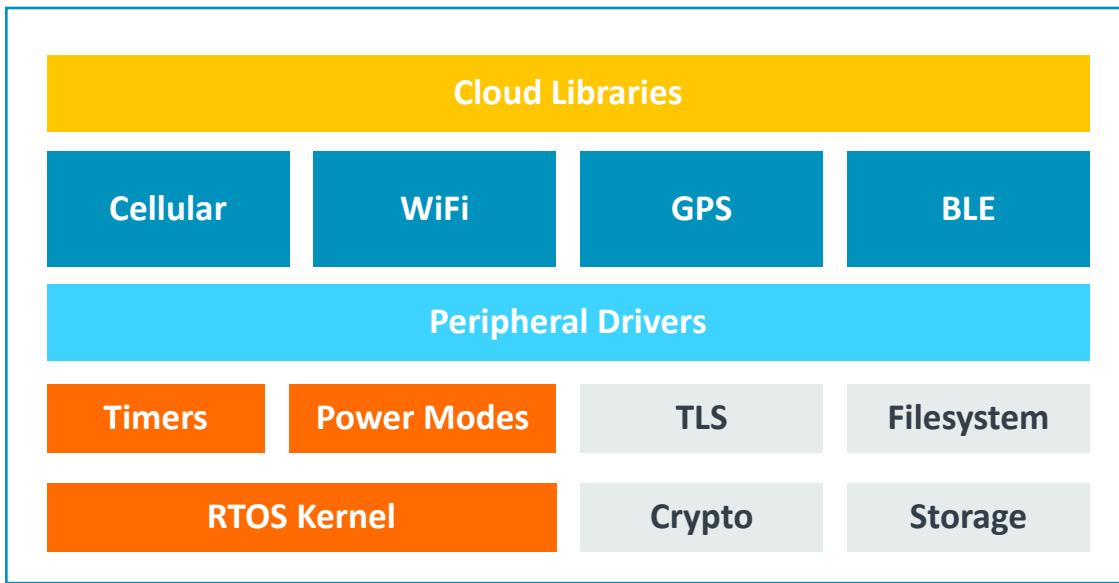
Componentized, Layered Architecture



Comparison

- Ex, 자산 추적장치

전통적인 RTOS



Available with Traditional RTOS

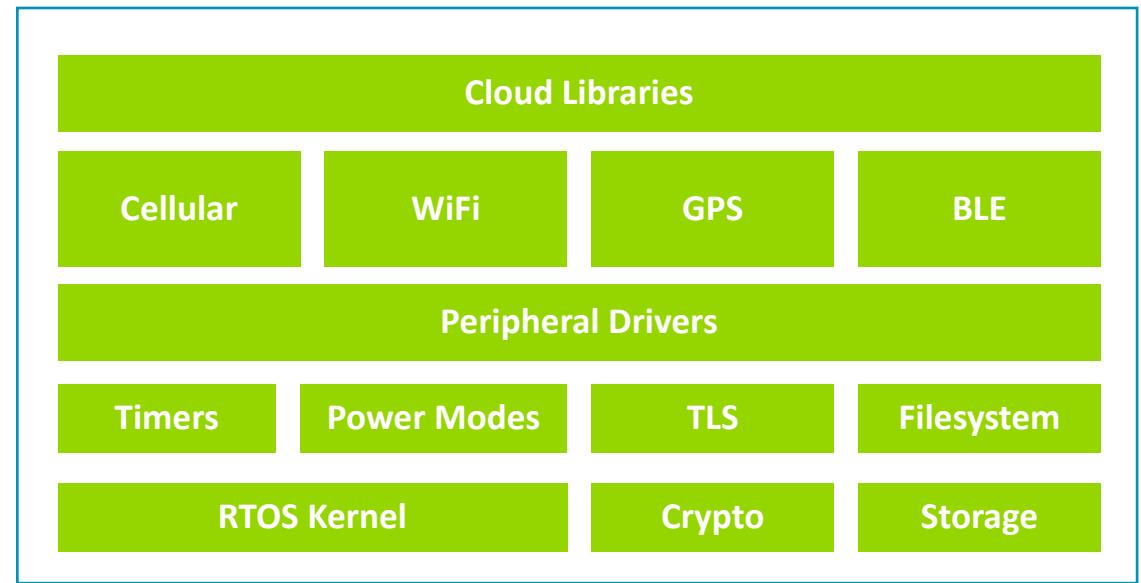
Provided by Silicon Vendors

Available with Ecosystem/Third party

Not available

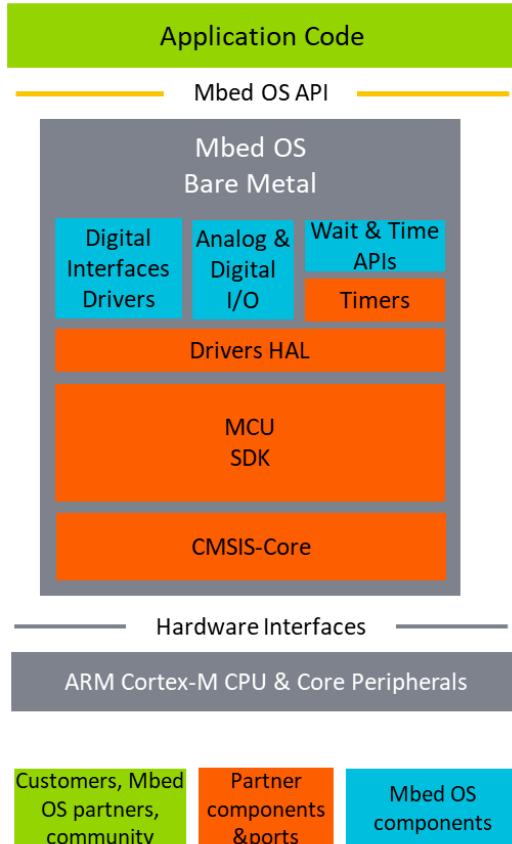
One vendor supported/
not available

Mbed OS



Available with Mbed OS

Mbed OS 5 – Bare metal



Features	Mbed OS 5 bare metal	Mbed OS 5
Analog I/O	Available	Available
Digital I/O	Available	Available
Digital interfaces	Available	Available
Timers	Available	Available
Development tools (For example, Mbed CLI, Mbed Studio, Mbed Online Compiler, GCC, Arm Compiler 6 and so on)	Available	Available
Support for Mbed Enabled development boards	Available	Available
RTOS	Not available	Available
Storage	Ecosystem libraries	Available
Mbed TLS	Not available	Available
Mbed PSA	Not available	Available

Another Major RTOS...



Microsoft



MBED OS

arm
arm MBED

Mbed OS vs FreeRTOS, Zephyr, and ThreadX

1. Information from [Wikipedia](#)



	Thread X	Zephyr	FreeRTOS	Mbed OS
Architecture	Diverse architecture			Only Cortex core of Arm
Compiler	IAR, Keil, GCC. (Depend on each dev board vendor)			IAR, Keil, and GCC supported as a mandatory
IDE	Depend to each dev board vendor.			Dedicated development tools.
Flash build image	Using JTAG/SWD and basically image flash support in each vendor's IDE tool.			Drag & Drop of the firmware via DAPLink onto the board. Further, auto image flash is also supported.
Board Information	Each vendors page is simple .	Each vendors page contains detail descriptions .	Each vendors page is quite simple	Each vendor board has its own dedicated page with code examples and descriptions for all the supported drivers.
Sensor driver(example)	Depends on each dev board vendor. In the case of STM, the example code is included in the source code. The user must find example code and manufacturer's guide.			Providing examples for each sensor driver. Users can find drivers on vendor's dedicated page.
Num. of supported platforms	Around 20 vendor(silicon) boards, over 70 boards	Around 7 architecture, over 200 boards (over 180 boards in case of Arm)	Around 25 vendor(silicon) boards, over 130 boards	Over 32 vendor(silicon) boards, over 170 boards(Mbed enabled board based)
OS version	5.8 (Last released on June 1, 2017) ¹	2.2.0-rc3 (Old version, latest is 2.2.99)	10.0.1(Old version, latest is 10.3.1)	5.15.1(latest version)
Image Size	Depend to each compiler IAR,GCC, and GCC + Vendor IDE, but showing under 14KB			58 KB(Depend to each compiler)
Compile Speed	Around 1 mins on IAR(windows env.)	Around 15 seconds on CLI (GCC)	Around 10 seconds on GCC + STM workbench(Eclipse)	Online compile(arm V6 compiler) : under 1 mins IAR(Windows env) : under 15 mins Mbed CLI(GCC) : under 4 mins.
Time it takes for the LED to Blinky.	Normally, It takes over 1hours			Around 5 mins, with Online compiler and Mbed studio. Around 10 mins with Mbed CLI
Source code (package) size	17 MB	431 MB	141MB	1GB
User registration	Yes	No	FreeRTOS : No, AWS FreeRTOS : Yes	Yes
Guide documents	RTOS description is fairly good but example code guide is poor.	Good (PDF type)	Good (PDF type)	Good (Web page)
Support developer community or forums	No, Couldn't find.	Yes	Yes	Yes
License	Royalty free	Apache 2.0	MIT	Apache 2.0

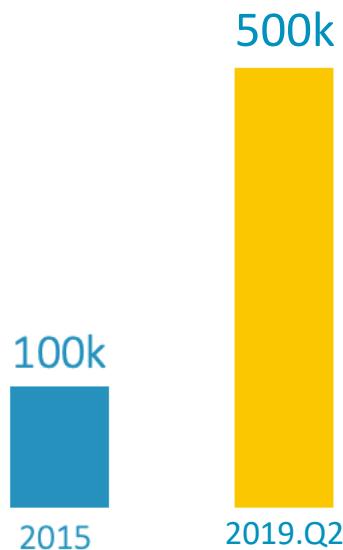
Video clip

(<https://youtu.be/-TUKizoOxC0>)

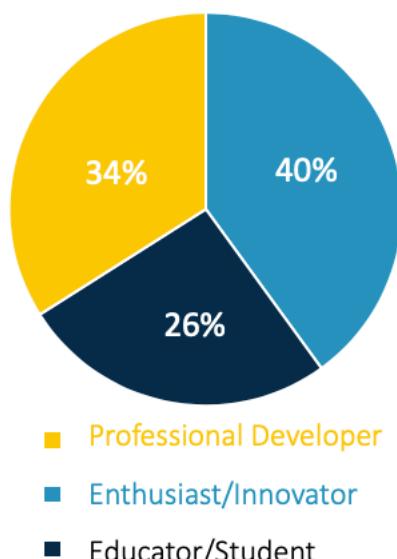
Mbed 개발자 파이프라인

IoT 제품 개발자를 위한 다양한 채널 확대

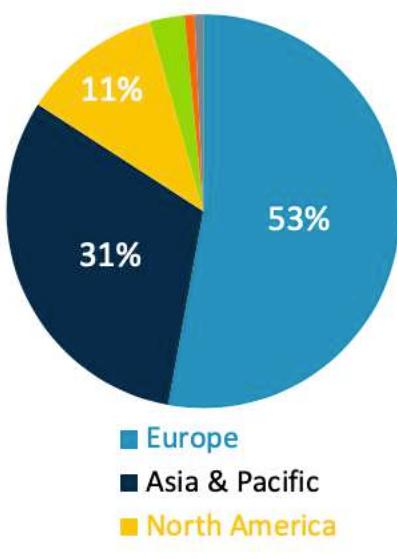
생태계 성장 가속화



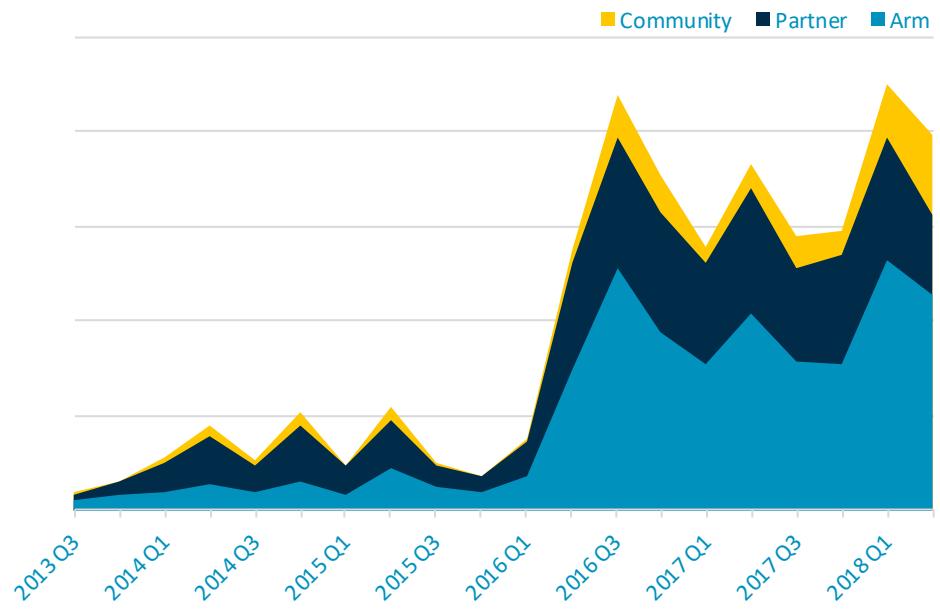
다양한 분포



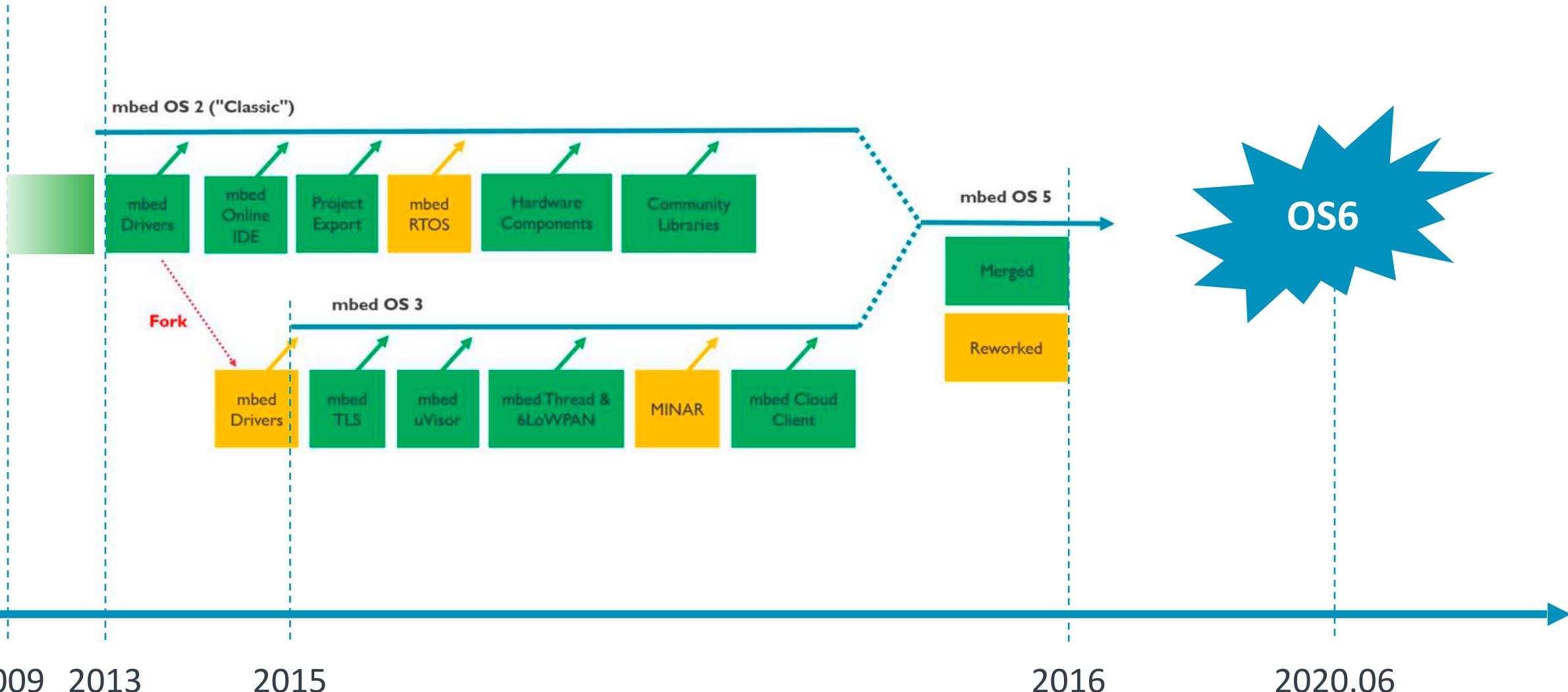
사용지역



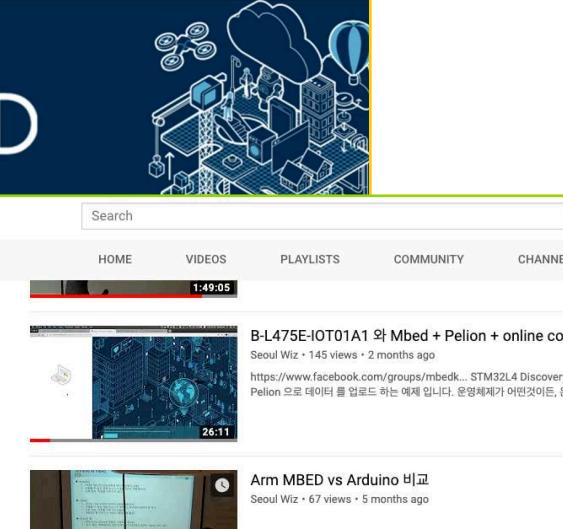
Mbed OS의 활동현황



History



다양한 교육자료 & 커뮤니티



arm MBED
Office Hours
Low Power, Tickle
Bartek Szatkowski

1:49:05

B-L475E-IOT01A1 와 Mbed + Pelion + online compiler 실습 예제
Seoul Wiz · 145 views · 2 months ago
https://www.facebook.com/groups/mbedk... STM32L4 Discovery kit 와 Mbed Online compiler 을 이용해서 Pelion 으로 데이터 를 업로드 하는 예제입니다. 운영체제가 어떤것이든, 온라인으로 컴파일 하고 무로 개정으로 실습해

26:11

Arm MBED vs Arduino 비교
Seoul Wiz · 67 views · 5 months ago

4:53

Connecting your platform to Pelion(arm MBED 클라우드)
Seoul Wiz · 266 views · 7 months ago

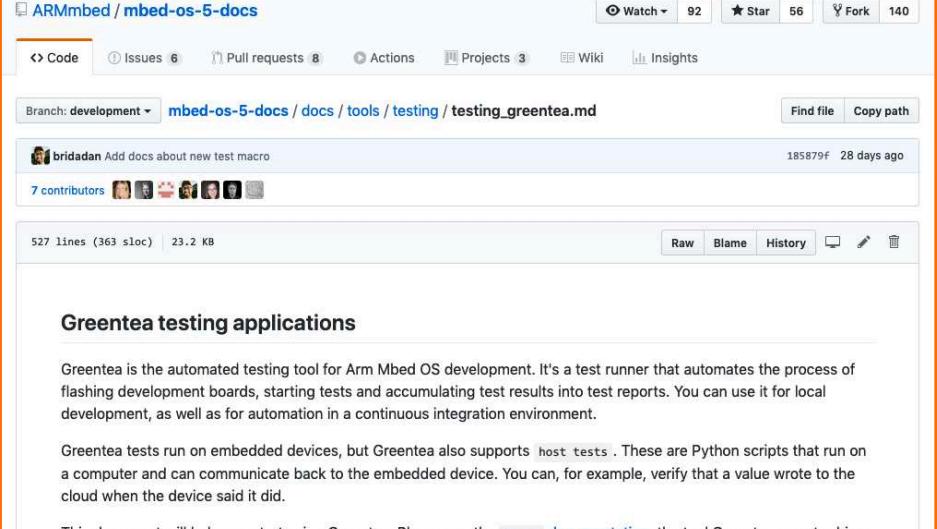
21:14

Greentea testing applications

Greentea is the automated testing tool for Arm Mbed OS development. It's a test runner that automates the process of flashing development boards, starting tests and accumulating test results into test reports. You can use it for local development, as well as for automation in a continuous integration environment.

Greentea tests run on embedded devices, but Greentea also supports host tests. These are Python scripts that run on a computer and can communicate back to the embedded device. You can, for example, verify that a value wrote to the cloud when the device said it did.

This document will help you start using Greentea. Please see the [htrun documentation](#), the tool Greentea uses to drive tests, for the technical details of the interactions between the platform and the host machine.



ARMmbed / mbed-os-5-docs

Code Issues Pull requests Actions Projects Wiki Insights

Branch: development mbed-os-5-docs / docs / tools / testing / testing_greentea.md

bridaan Add docs about new test macro 185879f 28 days ago

7 contributors

527 lines (363 sloc) | 23.2 KB

Raw Blame History

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<https://cafe.naver.com/mbedkoreanforum>



MBED KOREA FORUM

엠베드 한국 사용자 모임

<https://cafe.naver.com/mbedkorean>



<https://www.facebook.com/groups/mbedkorea>



arm MBED
Get started with Mbed



Mbed OS 특징



Feature

- KEIL RTX RTOS 기반 (KEIL RTX)
- 이벤트 스케 줄러 (Mbed Events)
- 파일시스템 (FAT and LittleFS)
- 장치 통계(Device statistics)
- 메모리 사용/분석등 추적 지원 (Memory tracing supported)
- 저전력(Low power)
- 다양한 네트워크 스택(Networking stacks)
- 다양한 OS 기반에서 개발 가능(Windows, Linux and Mac)
- 온/오프라인 Tool 무료 제공(Online compiler, Mbed CLI, Mbed Studio)
 - Mbed Studio 의 경우 전용 arm compiler 6 를 사용
- 다양한 형상 관리 툴지원 (GitHub, Mercurial and so on)
- Simulator / uTensor(Deep-learning on microcontrollers)

CMSIS RTOS - Arm Cortex-M를 위한 검증된 RTOS

- 수백만개 이상의 디바이스에 사용 되는 Keil RTX5 기반 RTOS
- 많이 사용 되는 RTOS 커널
 - 널리 채택 된 RTOS 커널
 - 수백만 대의 장치에 배포
 - 업계에서 10년 이상 사용되어 신뢰할 수 있는 제품
- Arm Cortex-M을 위한 특화된 설계
 - Cortex-M 장치 용으로 최적화되고 최적의 성능을 얻도록 설계
- 오픈 소스
 - Apache 2.0 license 기반
 - Arm, IAR 및 GCC를 포함한 주요 컴파일러 지원



<http://www.keil.com/pack/doc/CMSIS/General/html/index.html>

Security

- Built on secure foundations

파티션 관리

- 제한된 보안 채널을 통해 통신하는 분리된 영역
- 정보 숨기기
- 정보 손상 관리에 유용

암호화 기능

- 모든 암호화 하드웨어가 추상화 됩니다
- 암호화 H/W가 있는 경우 자동으로 사용 되도록 보장
- 모든 암호화 기능(API)은 개발자가 쉽게 액세스 할 수 있음

전송 계층 보안

- 전송 중인 데이터 보호 : 인증, 무결성, 기밀성
- 안전한 통신을 위한 프로토콜 인 TLS 사용
- 라이브러리는 가볍고 모듈식이며 문서화되어 있다

<https://tls.mbed.org/> → <https://www.trustedfirmware.org/>

<https://tls.mbed.org/supported-ssl-ciphersuites>

<https://os.mbed.com/blog/entry/Arm-announces-Mbed-OS-PSA123/>

Security

Supported SSL / TLS ciphersuites

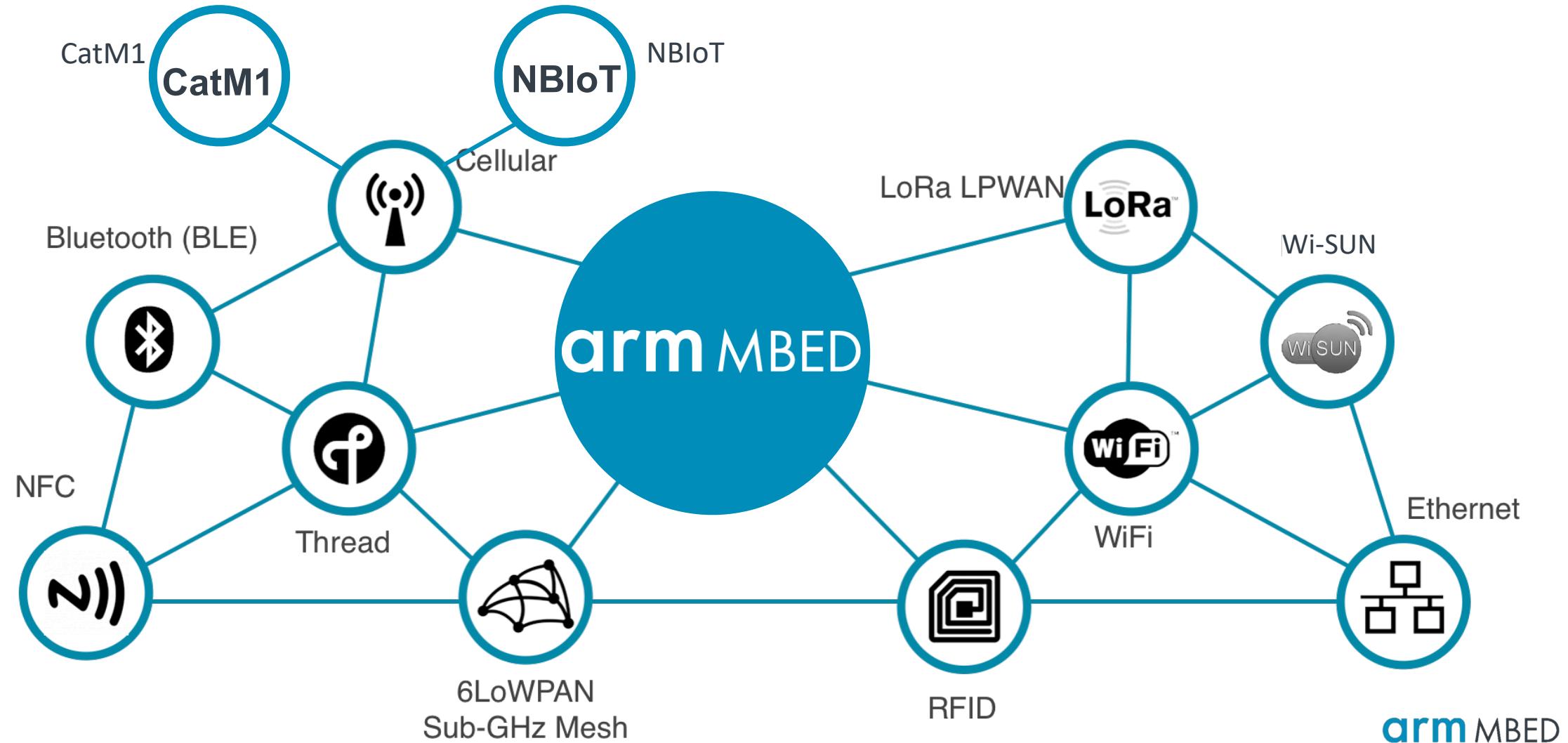
The following key exchanges and ciphersuites are supported in mbed TLS. mbed TLS uses the official NIST names for the ciphersuites. For reference purposes, the OpenSSL equivalent of the used names are provided as well (based on the OpenSSL website from November 1st 2015).

- › RSA (RSA) key exchange
- › RSA with Ephemeral Diffie Hellman
- › RSA with Elliptic Curve Ephemeral
- › RSA with Elliptic Curve Diffie Hellman
- › ECDSA with Elliptic Curve Ephemeral
- › ECDSA with Elliptic Curve Diffie Hellman (ECDH-ECDSA) key exchange
- › Pre Shared Key (PSK) key exchange
- › Pre Shared Key with Diffie Hellman (DHE-PSK) key exchange
- › Pre Shared Key with Elliptic Curve
- › Pre Shared Key with RSA (RSA)

RSA (RSA) key exchange		
mbed TLS Name / NIST Name	OpenSSL equivalent	Value
TLS-RSA-WITH-AES-128-CBC-SHA	AES128-SHA	{0x00,0x2F}
TLS-RSA-WITH-AES-256-CBC-SHA	AES256-SHA	{0x00,0x35}
TLS_RSA_WITH_AES_128_CBC_SHA256	AES128_SHA256	{0x00,0x3C}

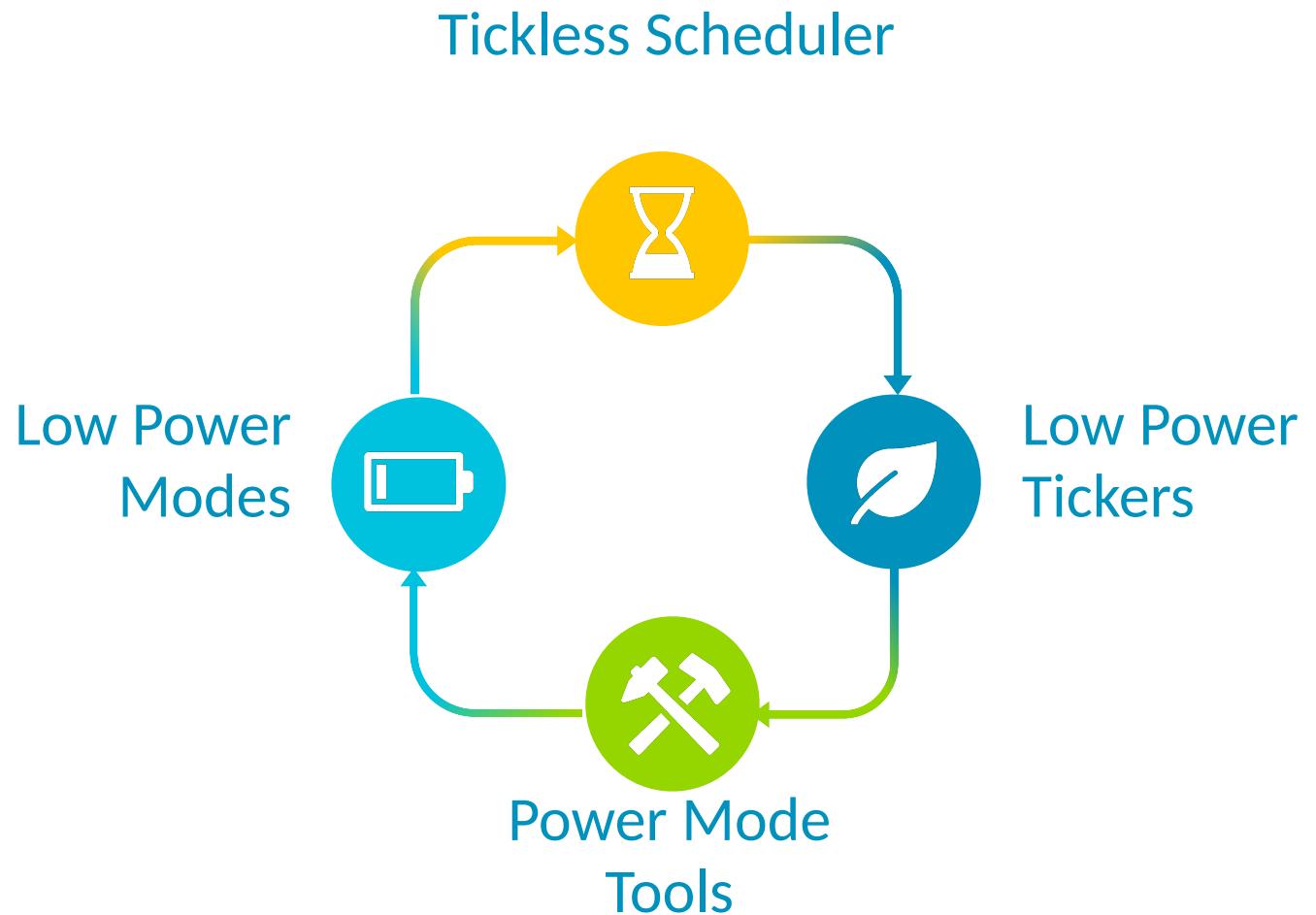
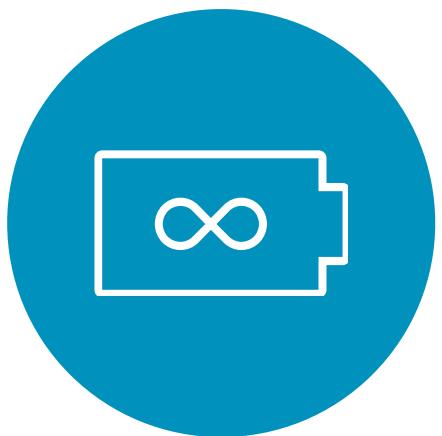
Pre Shared Key with Diffie Hellman (DHE-PSK) key exchange		
mbed TLS Name / NIST Name	OpenSSL equivalent	Value
TLS-DHE-PSK-WITH-RC4-128-SHA	DHE-PSK-RC4-SHA	{0x00,0x8E}
TLS-DHE-PSK-WITH-3DES-EDE-CBC-SHA	DHE-PSK-3DES-EDE-CBC-SHA	{0x00,0x8F}
TLS_DHE_PSK_WITH_AES_128_CBC_SHA	DHE_PSK_AES128_CBC_SHA	{0x00,0x90}

Interface



Low Power

IoT 디바이스가 필요로 하는 저전력 & 전력 최적화 기능을 제공

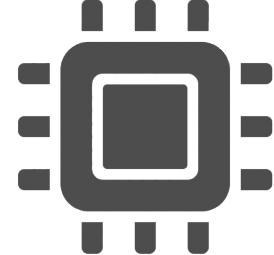


Storage

- 다양한 저장장치 요구 사항을 해결하기 위해 여러가지 저장장치 유형을 지원함.

Mbed OS Storage

MCU Program
FLASH



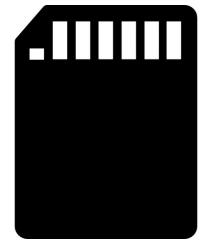
NVStore

Low-Cost SPI
FLASH



LittleFS

Removable Media
(SD, USB)



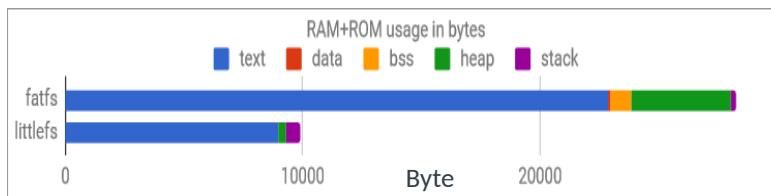
FatFS

Filesystem – Little FS

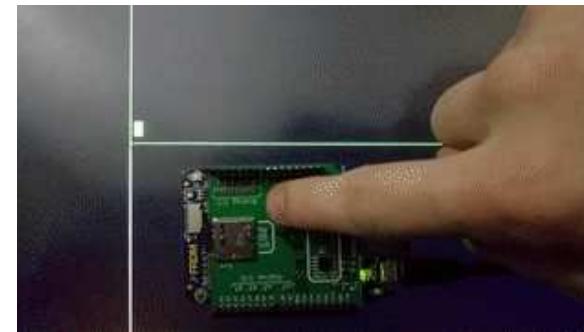
- 디바이스상의 FLASH 메모리를 위한 높은 무 결성의 오버 헤드가 작은 파일시스템
- RAM과 FLASH 사용률을 최소화하기 위한 효율적인 설계



작은 메모리 사용률



데이터 손실 방지



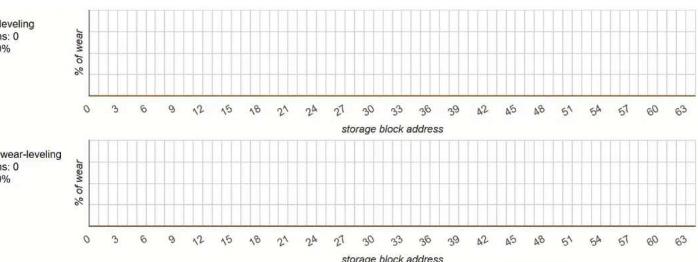
분산 저장(Wear leveling)

Write endurance [edit]

The write endurance of SLC floating-gate NOR flash is typically equal to or greater than the number of擦写operations per block.

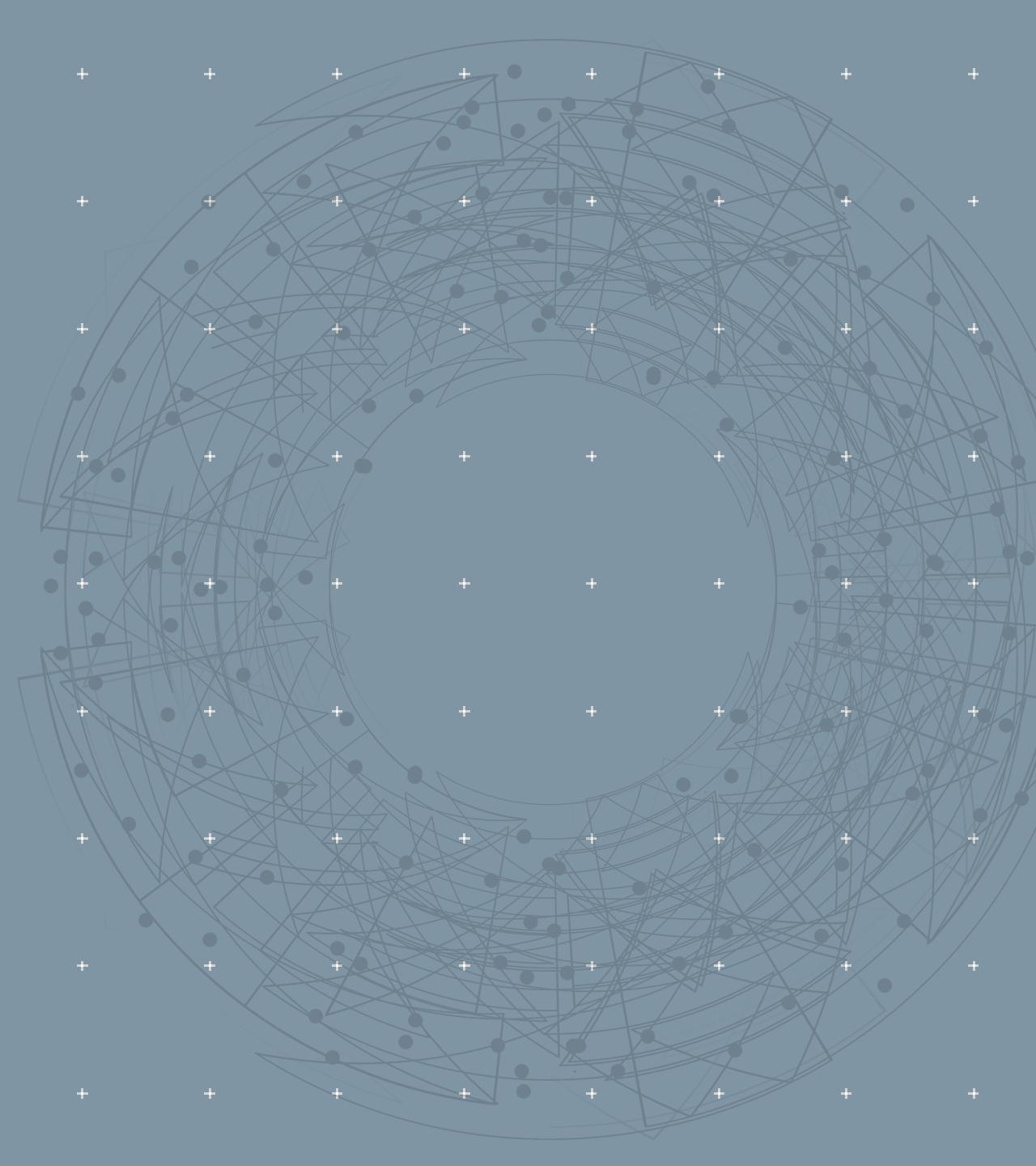
Type of flash memory	Endurance rating (erases per block)
SLC NAND	100,000
MLC NAND	5,000 to 10,000 for medium-capacity applications; 1,000 to 3,000 for high-capacity applications ^[93]
TLC NAND	1,000
3D SLC NAND	100,000
3D MLC NAND	6,000 to 40,000
3D TLC NAND	1,000 to 3,000
3D QLC NAND	100 to 1,000
3D PLC NAND	Unknown
SLC (floating-gate) NOR	100,000 to 1,000,000
MLC (floating-gate) NOR	100,000

https://en.wikipedia.org/wiki/Flash_memory



<https://os.mbed.com/blog/entry/littlefs-high-integrity-embedded-fs/>

arm MBED



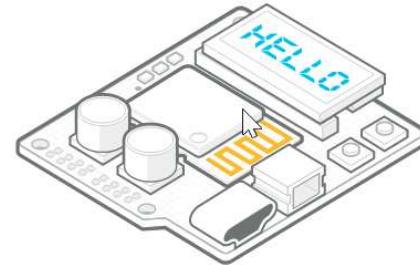
Mbed Enabled



Mbed Enabled 분류

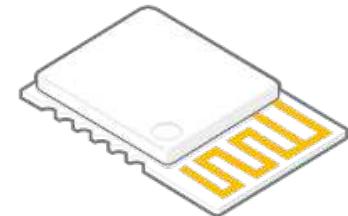
Boards

평가 및 신속한 프로토 타이핑에 중점을 두고 있는 보드는 마이크로 컨트롤러 또는 모듈을 구성 요소와 통합하는 개발 플랫폼.



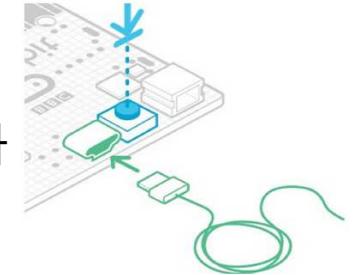
Modules

생산을 목표로 제품의 핵심 부분에 필요한 마이크로 컨트롤러, 연결성, 프론트 엔드, 소프트웨어 및 서비스가 통합 된 사전 통합 인증 하드웨어 플랫폼



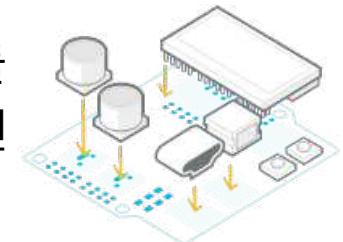
Interface

Arm 기반 마이크로 컨트롤러에서 진행하는 개발, 디버그 및 테스트 소프트웨어에 사용되는 하드웨어 회로 및 펌웨어.



Components

하드웨어 구성 요소는 마이크로 컨트롤러, 모듈 또는 보드의 기능을 확장하고 Mbed OS와 관련된 소프트웨어 라이브러리를 포함.



Products

Mbed 기술을 이용한 최종 제품 (즉, 개발자 제품이 아님).



Hardware 환경

NXP

ST

xi

M2X

EA

TI

PCB

Components

Software

Hardware

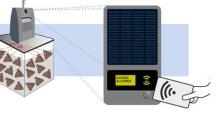
Finder

Capacitive Touch Sensing

Compass

MBED

Built with Mbed

  LightGrid	  Smart Speakers	  Tilt monitor	  Beacons	  Parking sensor	 Gateway	  EV Charger	  Door lock
 Asset tracker	  Office lighting	  Factory humidity	  Electric meter	  Gateway	 Smart City	  Luminaire	  Patient tracker
  Industrial sensor	  Smart city bins	  Parking barrier	  City mapping	  Pedometer	  Street light	  Smart shelf	  Agriculture
  Water sensor	  Submarine	  Air vent	  Food allergy	  Indoor positioning	<p>Please visit https://www.mbed.com/built-with-mbed/</p>		



ADVANTECH

Alcatel-Lucent

ANALOG
DEVICES

ARROW

ATHOS

Atmel

AVNET

Baidu 百度

COMTECH
TELECOMMUNICATIONS CORP.

CYPRESS
PERFORM

DELTA

devicepilot
LOCATE, MONITOR & MANAGE AT SCALE

dialog
SEMICONDUCTOR

EBV Elektronik
I An Avnet Company I

ELAN

element14

QUECTEL
Wireless Module Expert

expresslogic

ERICSSON

FORGEROCK

FUTURE
ELECTRONICS

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Peak

IBM

muRata
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NIPPON SYSTEMWARE CO.,LTD.

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NXP

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ON Semiconductor®

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TECHNOLOGIES

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ROHM
SEMICONDUCTOR

MAKER SPACE
G·CAMP

Schneider
Electric

SEMTECH

AVNET®
Silica

SILICON LABS

Silver Spring
NETWORKS

REALTEK

SmeshLink
EXPERT OF IoT

SoftBank
Technology

SpinDance

ST
life.augmented

SWITCHSCIENCE

TOSHIBA

ThunderSoft®

TEXAS
INSTRUMENTS

teks

ublox

WIREPAS
Things connected – Naturally

myotest

lierda
利尔达科技集团

ZEBRA
TECHNOLOGIES

ZUMTOBEL

RDA

QUALCOMM®

PollenTech

Omnisense

arm MBED



Mbed Lab

Mbed Lab

- <https://labs.mbed.com/>

The image shows a screenshot of the Mbed Lab website. At the top left is the 'Mbed OS Simulator' section, which includes a code editor with C++ code for a LED blink example, a schematic diagram, and a terminal window showing serial output. Below this is a brief description: 'Write, test and debug Mbed OS 5 applications in your browser.' To the right of the simulator is a photograph of a blue microcontroller board with a yellow central chip labeled 'JS'. Below the photo is the text 'JavaScript on Mbed' and a description: 'Build your IoT applications in JavaScript, and run them on any Mbed-enabled microcontroller.' At the bottom of the page are three cards: 'LoRaWAN FUOTA' (multicast firmware updates over the air using LoRaWAN), 'Bluetooth Devicelink' (connect BLE devices to the cloud through Pelion Device Management), and 'uTensor' (deep-learning on microcontrollers by running TensorFlow models on Mbed OS). The 'uTensor' card is highlighted with a red border.

Arm Mbed OS simulator

```
1 #include "mbed.h"
2
3 DigitalOut led(p5);
4
5 int main()
6 {
7     while(1) {
8         led = !led;
9         printf("Blink! LED is now %d\n", led.read());
10        wait_ms(500);
11    }
12 }
```

Mbed OS Simulator

Write, test and debug Mbed OS 5 applications in your browser.

JavaScript on Mbed

Build your IoT applications in JavaScript, and run them on any Mbed-enabled microcontroller.

LoRaWAN FUOTA

Multicast firmware updates over the air using LoRaWAN.

Bluetooth Devicelink

Connect BLE devices to the cloud through Pelion Device Management.

uTensor

Deep-learning on microcontrollers by running TensorFlow models on Mbed OS.

Arm Mbed OS simulator

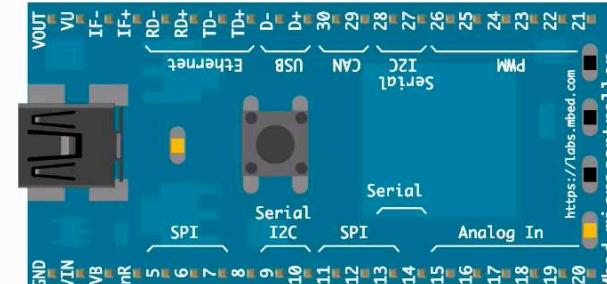
[Download offline version](#) | [GitHub project](#)

Blinky Load demo

Run

+ Add component

```
1 #include "mbed.h"
2
3 DigitalOut led(LED1);
4
5 int main() {
6     while (1) {
7         led = !led;
8         printf("Blink! LED is now %d\n", led.read());
9
10        wait_ms(500);
11    }
12 }
```



Serial output

Blink! LED is now 1

<https://simulator.mbed.com/>

<https://os.mbed.com/blog/entry/introducing-mbed-simulator/>

<https://youtu.be/FhbCAD0sO1c>

Korea Mbed Forum

- Naver Café: <https://cafe.naver.com/mbedkoreanforum>

<https://cafe.naver.com/mbedkoreanforum>



MBED KOREA FORUM
엠베드 한국 사용자 모임

<https://cafe.naver.com/mbedkorean>



- Facebook: <https://www.facebook.com/groups/mbedkorea>

<https://www.facebook.com/groups/mbedkorea>



armMBED
Get started with Mbed



A photograph of a paraglider in flight against a dramatic sunset sky. The sky is filled with various shades of orange, yellow, and grey clouds. The paraglider's canopy is dark, contrasting with the bright sky. The pilot is visible in the seat below the canopy.

Thank You

Danke

Merci

谢谢

ありがとう

Gracias

Kiitos

감사합니다