WHITE PAPER

**An Introduction to the ARM® mbed™ IoT Device Platform**

October 6th, 2014

The Internet of Things (IoT) is the collection of billions of end devices, from the low-power constrained end nodes to gateways, intelligently connected to cloud applications and services. Interoperability between devices and cloud services across market segments is needed to unleash the full potential of the IoT.

The ARM Cortex®-M processors family, the world's leading 32-bit MCU which ships in the billions annually, provides a common hardware foundation for the IoT devices. However, the software development for these IoT devices today is highly fragmented, expensive and slow, often using custom or proprietary tools and communication protocols.

ARM and its Partners share a vision where creation and deployment of commercial, standards-based IoT devices is possible at scale. The mbed IoT Device Platform is a result of this vision. This platform has been built around open standards and will bring Internet protocols, security and standards-based manageability into one integrated solution optimized for energy and cost-constrained devices. It is supported by an established and expanding hardware and software ecosystem that will provide common building blocks for IoT devices and services.


Big Data Starts with Little Data
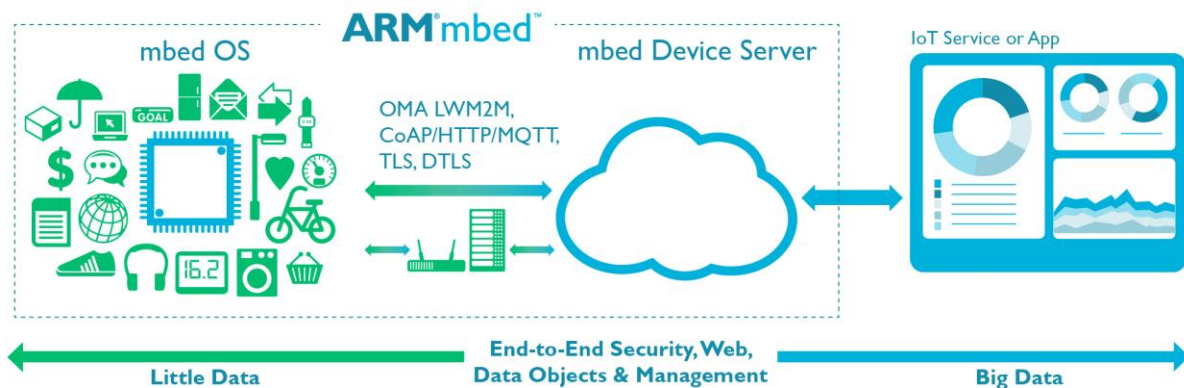
The three key components of ARM mbed are mbed OS, mbed Device Server, and mbed Tools and Services.

mbed OS

mbed OS is a new free operating system for ARM Cortex-M based devices that consolidates the fundamental building blocks of IoT in one integrated set of software components. It contains security, communication and device management features to enable the development of production-grade, energy-efficient IoT devices. It will be available to mbed Partners in Q4 2014 for early development and to the development community in Q1 2015, with the first production devices coming in 2015.
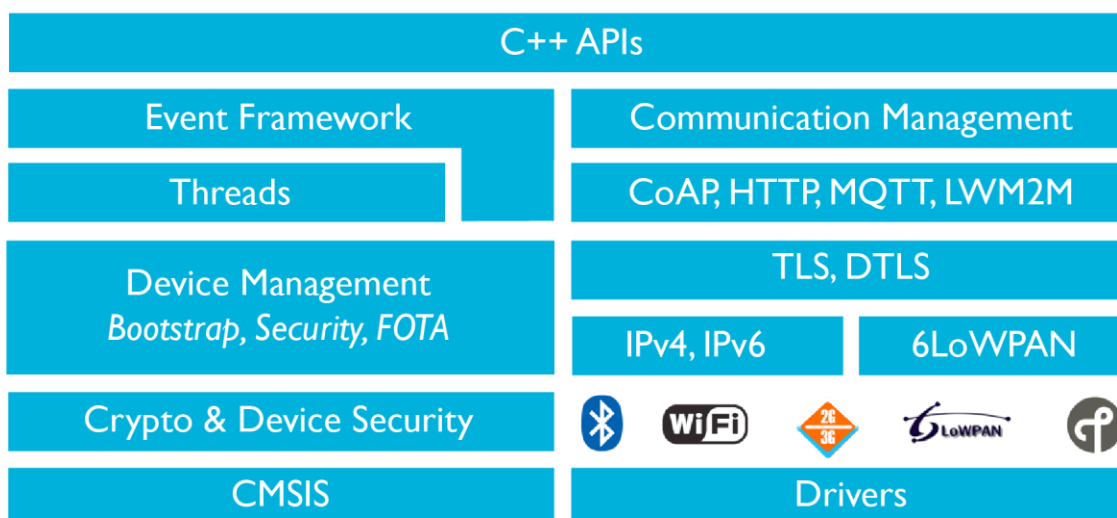
mbed OS is an evolution of the mbed SDK with additional innovative technology from ARM and Sensinode. The mbed OS provides an API-driven approach to coding that eliminates much of the low-level work normally associated with MCU code development. Developers write code using meaningful peripheral abstractions and API calls that are intuitive and already tested. That frees them up to focus on adding value, without worrying about the implementation of the MCU core, its peripherals, the underlying OS or Internet service integration.

Power consumption is one of the key constraints for IoT devices. Many such devices use battery or energy harvesting source for power which further constraints hardware, software and the communication protocol usage. Developers have to know all the complex power management modes in the underlying hardware components and carefully design the algorithms that minimize the switching activity and memory accesses. It is also important to keep the device in sleep or deep sleep mode when not sensing or communicating the data. mbed OS addresses these challenges by supporting an event-framework and automated power management providing a memory and power-efficient way to write software for the constrained IoT devices.

The cost of IoT devices is also very important because of large-scale deployment. Just a few cents of cost savings per device can multiply into a significant amount of money saved when deployed in millions. The direct implication of cost saving is constrained hardware resources. mbed OS is specifically targeted to run on these hardware constrained devices. It requires very small memory footprint while supporting security and key communication and management protocols.

Security is paramount to scale the IoT market and expand user adoption of IoT applications. An IoT system consists of IoT devices, a communication channel and the web application. To make the system secure, devices need to trust the communication channel, the communication channel needs to trust the web application and vice versa. mbed OS enables all the components that are needed to develop a secure and efficient end-to-end IoT application (from device to service). It includes security components for software asset protection, secure firmware updates, encryption and secure communication.

Standards allow acceptance or compatibility of technologies as all the parties involved in the IoT value chain are not locked into one vendor. Open standards also allow interoperability and lowers the barrier to entry for new players in the market. mbed OS supports all the key open standards for connecting and managing IoT devices.

Diverse communication technologies are needed in IoT applications. Depending upon the environment in which the system is deployed, IoT device can use different types of communication protocols. Key communication protocols such as Bluetooth® Smart, Cellular, Thread, WiFi®, and 802.15.4/6LoWPAN along with TLS/DTLS, CoAP, HTTP and MQTT will be supported in mbed OS.

mbed Device Server

mbed Device Server is a licensable software product. It provides the required server-side technologies to connect and manage devices in a secure way. It acts as a bridge between the protocols designed for use on IoT devices and the APIs that are used by web developers. Analogous to a Web Server that accepts connections from mobile phones or web browsers, a Device Server handles the connections from IoT devices. mbed Device Server is a key enabler for cloud service providers, operators and enterprises to access the IoT growth market with production deployments.
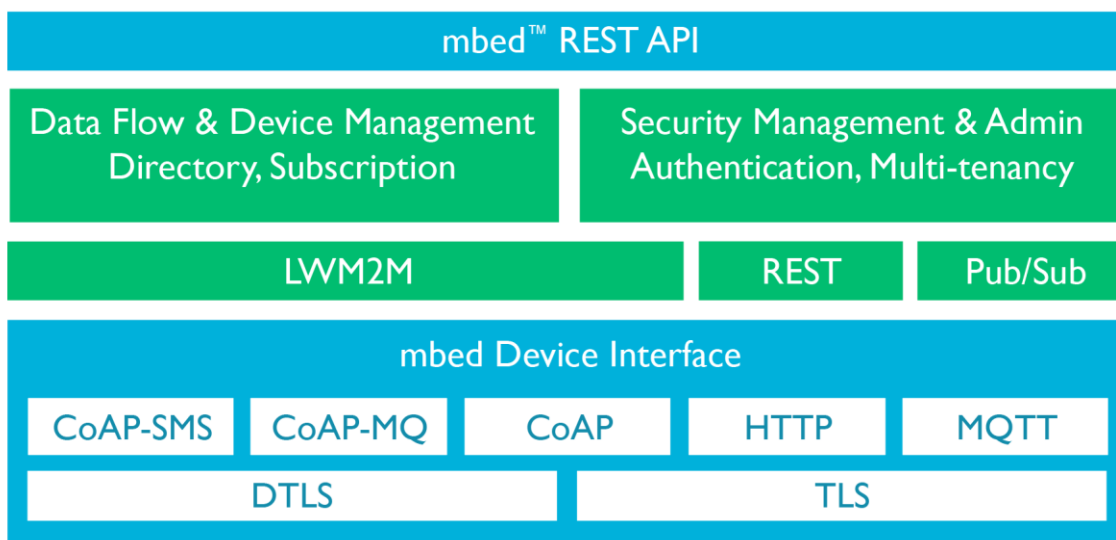
Future proof and Interoperable applications are needed for scale and IoT market growth. Communication in the mbed Device Server solution is based on open standards. mbed Device Server utilizes open standard protocols like CoAP, HTTP, MQTT, TLS and DTLS for IoT device side communication and a RESTful interface for web applications. This guarantees an IoT solution that is both future proof, Interoperable and benefits from a large ecosystem of hardware vendors, application developers and service providers.

Bandwidth and energy efficiency are a must for reducing cost and power consumption. The resource directory along with resource cache features of mbed Device Server allows the bandwidth and power savings by reducing the number of requests from web applications to IoT devices. Once all the resources are registered with the resource directory, all lookup, resolution and discovery can be handled between Web Applications and the mbed Device Server. In addition, the data requested by web application can be acquired from the resource cache instead of web application communicating all the way to the IoT device. This saves

bandwidth and power. Further, for constrained devices, CoAP typically reduces the bandwidth by 10x compared to HTTP.

Simplified application development is needed for rapid product deployment and time to market. The development of back-end applications using legacy M2M technologies has always been a black art and required specialized and arcane skills. mbed Device Server provides a simple REST interface enabling fast web application development. mbed Device Server also includes a Java SDK and reference applications for home automation and smart lighting. No special knowledge beyond standard web page development is needed.

Scalability features are important as millions of devices could be connected to an IoT application. mbed Device Server supports load balancing and clustering to allow scalability. Grouping of end devices is also supported for batch operations. These features make it easier to implement the Web Applications and improves the efficiency of the system.

Security is a must for IoT market growth and adoption of IoT applications. mbed Device Server uses public key cryptography with innovative Transport Layer Security (TLS) technology for data security. Security between IoT devices and mbed Device Server is provided using the DTLS protocol for mutual authentication, integrity protection and confidentiality for all CoAP traffic between a device and the platform. IoT device interface security can also be fully load balanced between clusters of end nodes for system scalability. Security between Web applications and mbed Device Platform is performed on the Web interface using TLS for all HTTP traffic (HTTPS).

mbed Tools and Services

mbed also provides tools and services to further accelerate development. The tightly coupled combination of hardware and software makes it easy to explore designs quickly, so you can be more adventurous, more inventive, and more productive. mbed provides a powerful web IDE that is free for use with supported hardware platforms, and is tightly integrated with the mbed OS. mbed OS will also be available directly as a downloadable SDK with build and component management tools including Keil, IAR and GCC support.

The online IDE allows you to start right away, with nothing to install. You can log in from anywhere using any major web browser. The IDE includes a full code editor and your personal workspace, with multiple files, folders, programs, including a drag and drop folder interface.

The editor also includes features like find and searching across multiple files and filetypes. Integrated version control allows you to version, branch and merge code, with a representation of the state of your project history. Each program has its own local repository, so you can

commit and perform actions on it within your own workspace (such as updating, branching and showing changes).

Importing Libraries or Example Programs through import wizard allows you to import programs and libraries published by other mbed users. This is useful for importing code that has been packaged as a reusable library component (e.g. a class for a peripheral), so you can quickly pull in the building blocks for your project.

The online IDE uses the industry standard ARM RVDS 4.1 compiler engine, optimised for each MCU target to give excellent code size and performance. There are no limitations on code size (apart from the limits of the device itself!), and the generated code can be used freely for commercial and non-commercial use.

Partner Ecosystem

The ARM mbed Partner Ecosystem brings together leading embedded and cloud technology companies along with component manufacturers, system integrators and OEMs who want to enable the technology, tools and services needed to accelerate innovation in the creation and deployment of IoT systems.
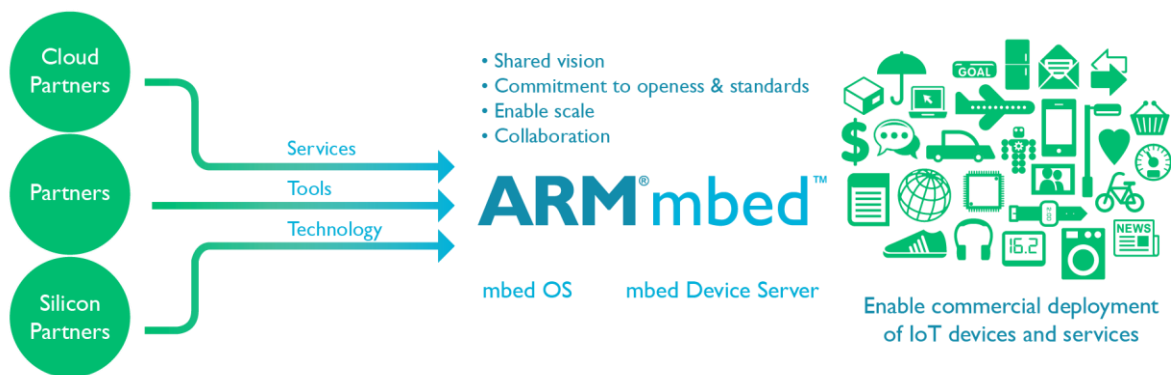
The ARM mbed Partner Ecosystem members share a vision for the future where development and deployment of commercial IoT devices is possible at scale, a commitment to openness and standards, and a desire to collaborate on concrete plans and projects to make the vision a reality. Through our technical and promotional efforts, we are enabling commercial deployment of IoT devices and services using mbed to the benefit of all members.

Partners include:
1. Cloud Partners: Operators, Backend IoT services and Cloud service providers

2. Device Partners: OEMs, ODMs, Systems Integrators and component providers (sensor, actuator, modules etc.)
3. Silicon Partners: MCU providers

Partner benefits include:
- Get time to market advantage and accelerate your development through the mbed Partner early access channel.
- Differentiate your products by adding extra features through source code access.
- Get fast access and exposure to our large pool of developer community, and enable products for mass market customers.
- Get access to interoperability, security, scalability and future proof the mbed Device Server solution.
- Speed up your development and deployment with expert ARM support staff.
- Enhance, innovate and create new products by collaborating with other ARM mbed ecosystem partners to increase you reach and influence.
- Increase your relevance with customers and the developer community through Ecosystem marketing.

ARM technology has the breadth and diversity from processors to hardware platforms to software products, combined with its partnership approach and the ecosystem to meet the needs of the rapidly evolving secured interconnectivity of IoT. In addition, it provides the quickest path to market with connected devices and applications. ARM drives and simplifies current and future IoT applications and services to become truly ubiquitous and intelligent.

Find out more and get started at http://mbed.com or contact Pratul.Sharma@arm.com.