ARM® Cortex®-M and Java™ in the Internet of Things

Asim Chaudhry
Field Applications Engineer, ARM

ARM's Mission

Deploy energy-efficient ARM-based technology, wherever computing happens…

What does ARM do?

ARM designs and licenses processor technology that lies
at the heart of advanced consumer and embedded products

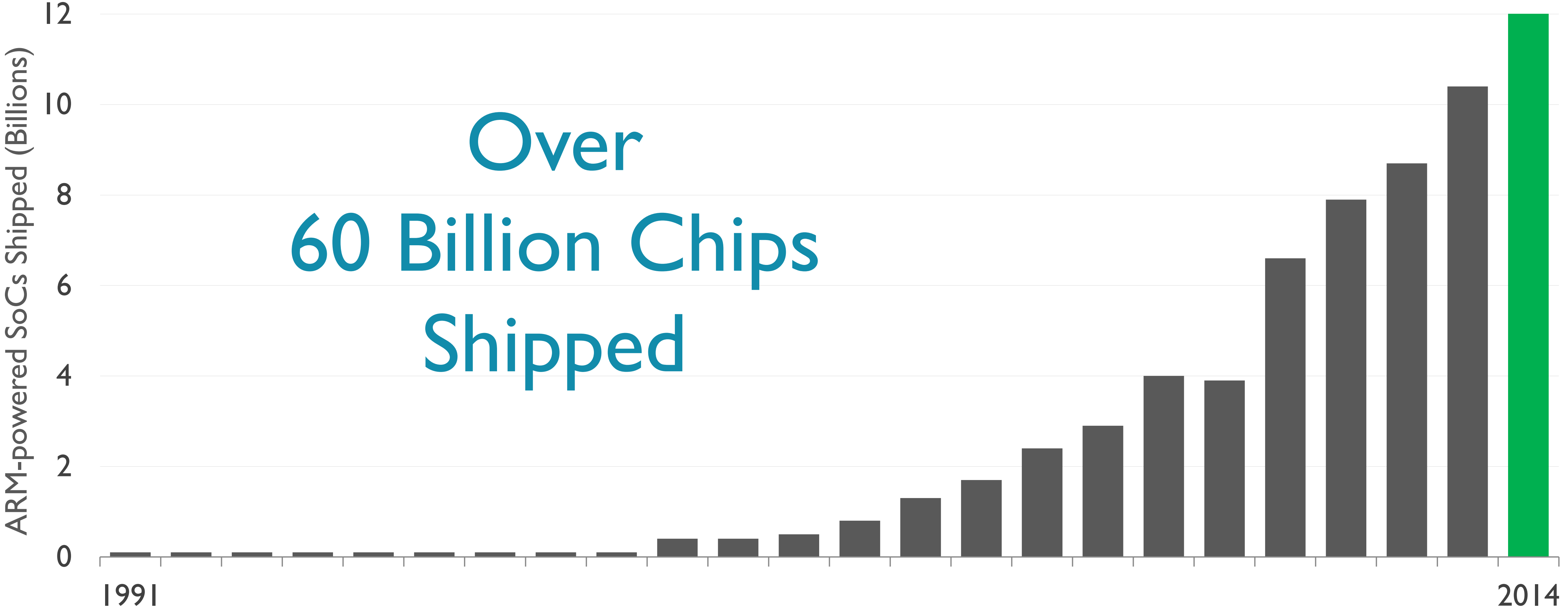
From Sensors to Servers

Embedded Microcontrollers

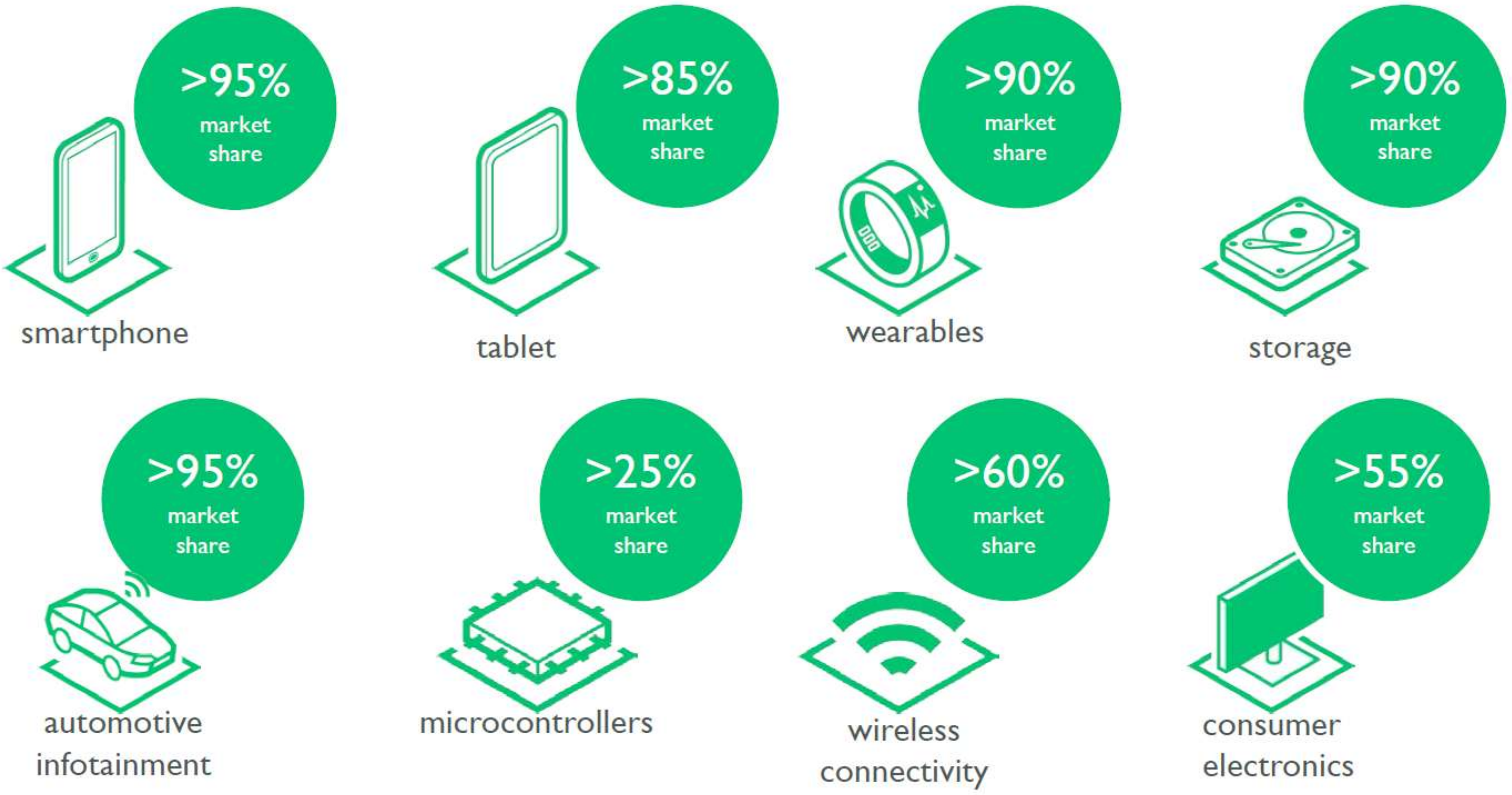
Consumer Devices

Computing

ARM Partnership: Building for the Long Term

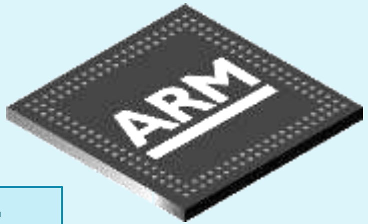


ARM Broad market penetration



ARM® Cortex® Processors across the Embedded Market

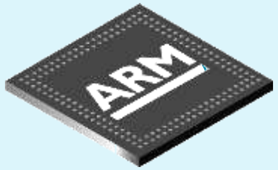
Cortex-A Processors



Rich OS

Highest performance

Cortex-R Processors

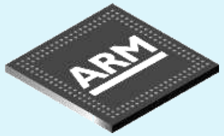


RTOS

Fast response / real-time control

Cortex-M Processors

DSP + MCU



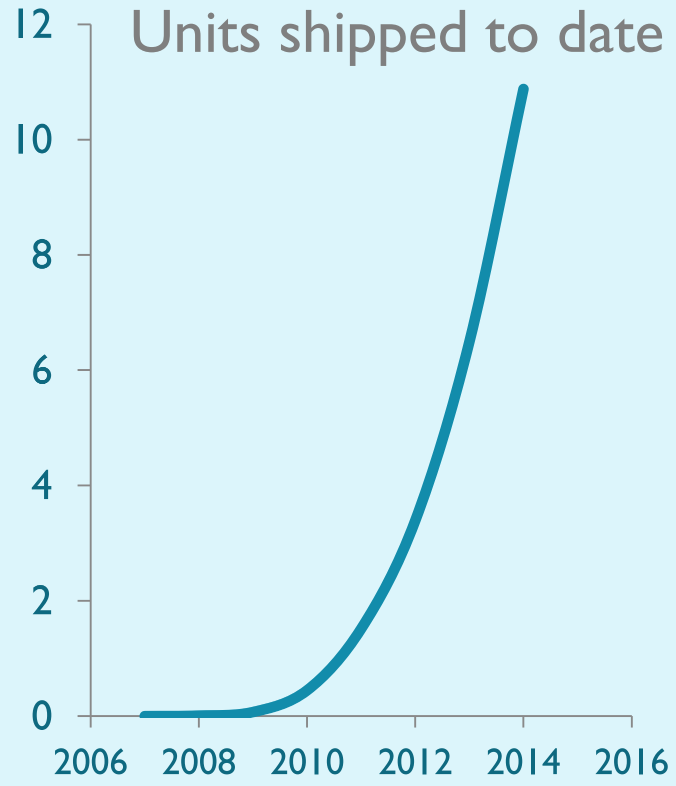
Smallest footprint / lowest power

ARM

ARM Cortex-M: Trusted Choice for Embedded Intelligence

13.1 Bn

Units shipped to date



4.4 Bn

Units shipped in 2014

300+

Licenses

3500+

Catalog parts

† ARM's Embedded Intelligence Market Share by Volume, 2014. Source: ARM

Cortex-M processors serving all applications

Energy grid

Automotive

Environmental

Home automation

Healthcare

Enterprise

Retail

Smart city

Wearables

Farming

Identity & tracking

VR / AR

Building automation

Connected clothing

Robotics

Sensor

Industrial

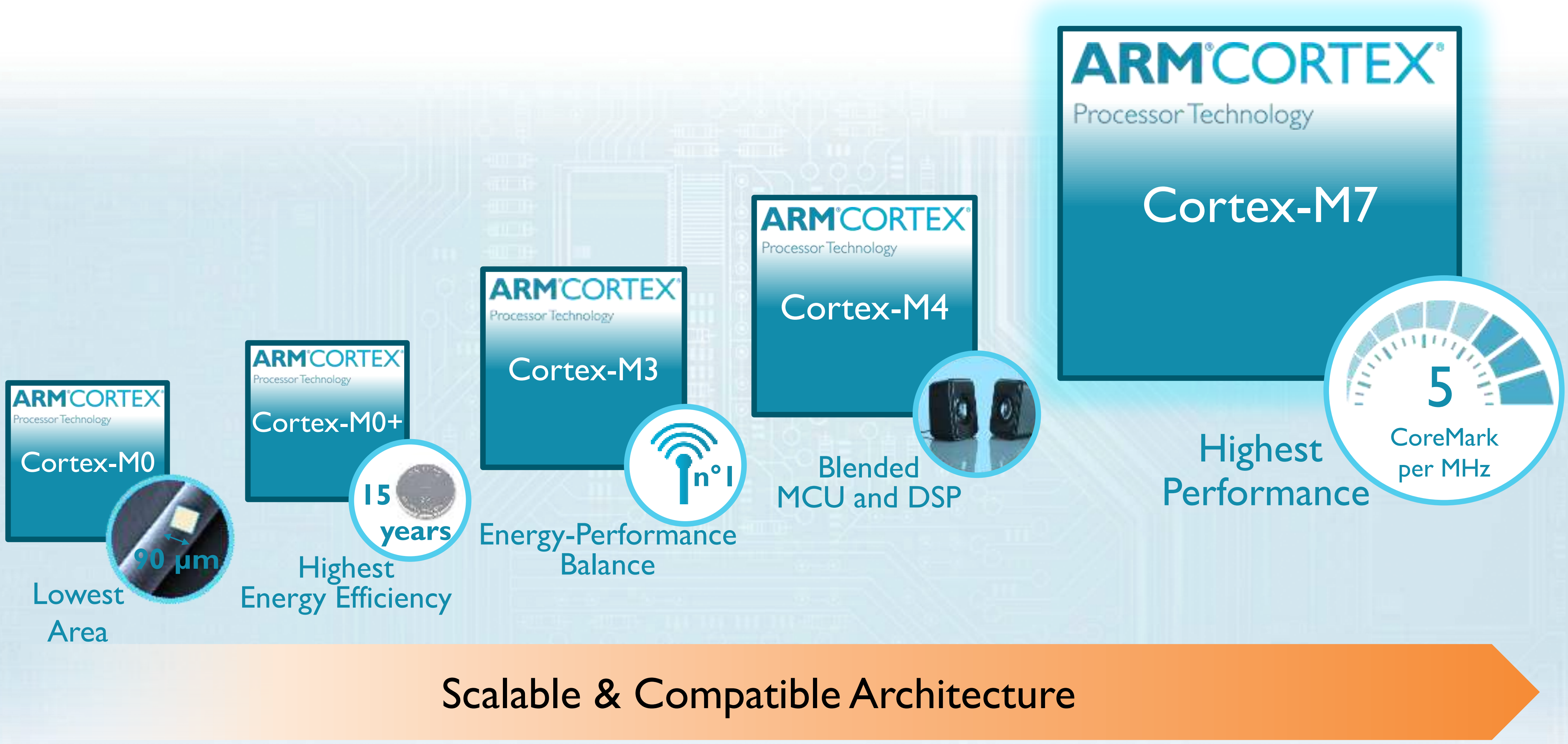
IoT

Smart lighting

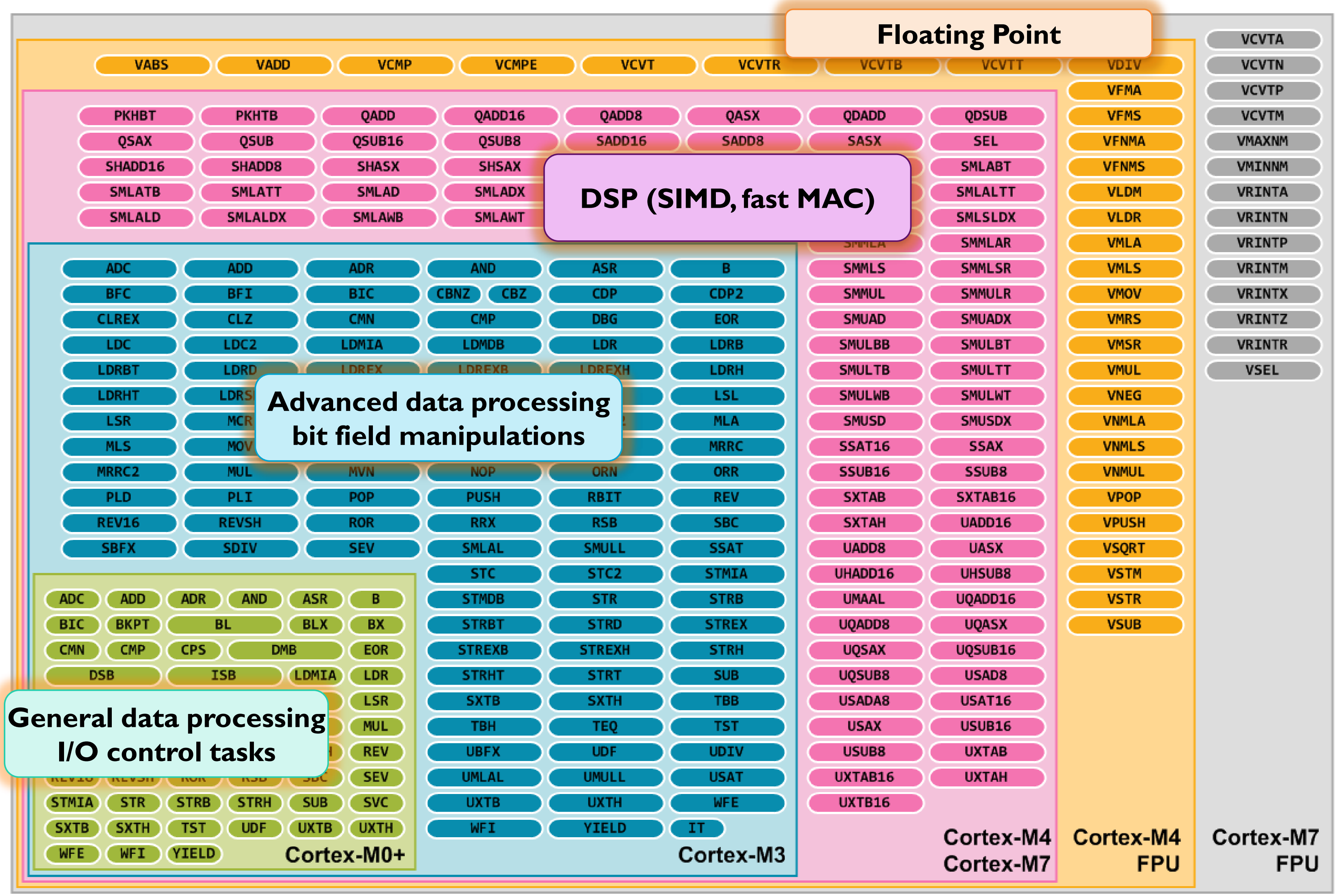
Smart watch

Space

Introduction to the Cortex-M Family

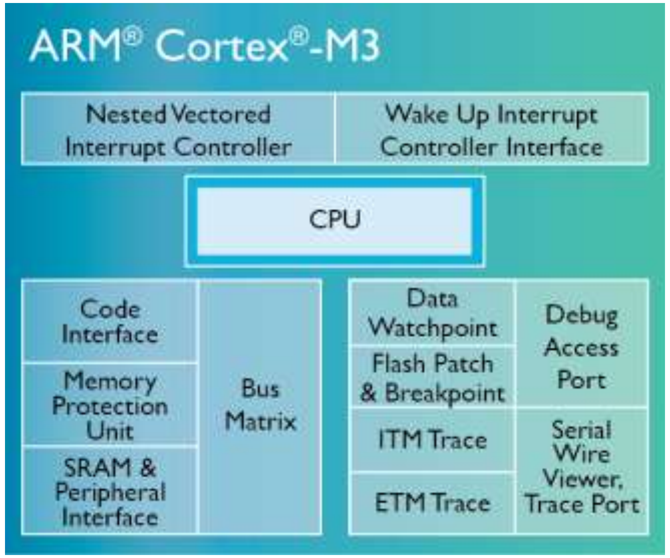


Powerful and scalable instruction set

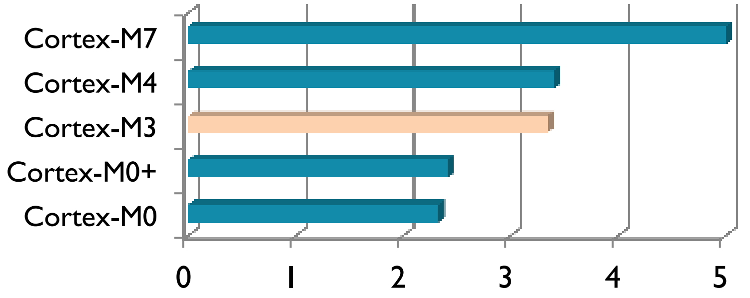


Cortex-M3 – Industry Standard 32-bit CPU for microcontrollers

- ARM's flagship 32-bit energy efficient processor
  - Largest ecosystem for software and tools
- Rich, unified Thumb-2 high performance instruction set
  - Smallest code size and reduced memory requirements
- Advanced instructions for data manipulation
  - Single Cycle Multiply, Hardware Division, Bit Field Manipulation
- 3.34 CoreMark / MHz
- Currently supported in Java ME Embedded 8.X

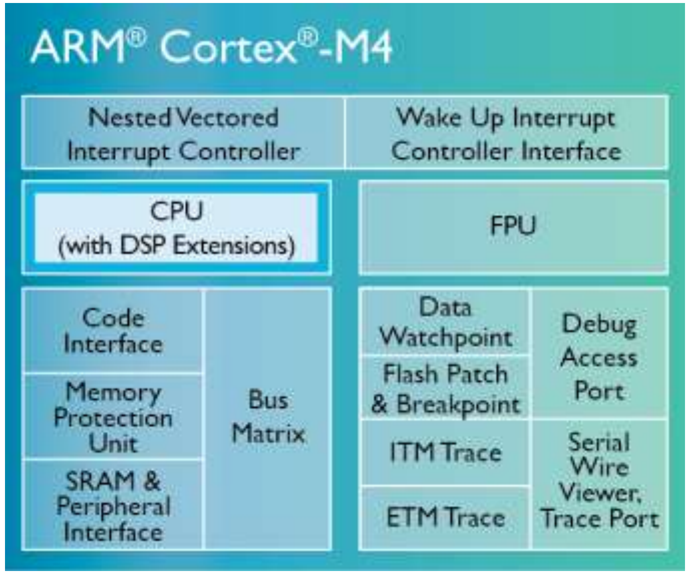


CoreMark®/MHz

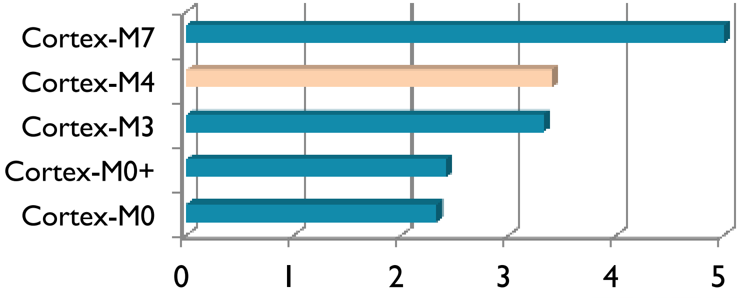


Cortex-M4 – ARM's Powerful Digital Signal Controller

- ARM's 32-bit MCU with powerful DSP capabilities
  - SIMD, single-cycle MAC, saturating arithmetic (DSP extensions)
  - Optional floating point unit
- Rich DSP Library available free-of-charge from ARM website
  - Highly optimised commonly used DSP functions
- 3.40 CoreMark / MHz
- Also currently supported in Java ME Embedded 8.X



CoreMark®/MHz



Cortex-M3/M4 Development Boards for Java ME 8.X

Freescale K70F120M

- Kinetis K70 running at 120Mhz
- 128K SRAM
- Up to 1MB Flash

Freescale FRDM-K64F

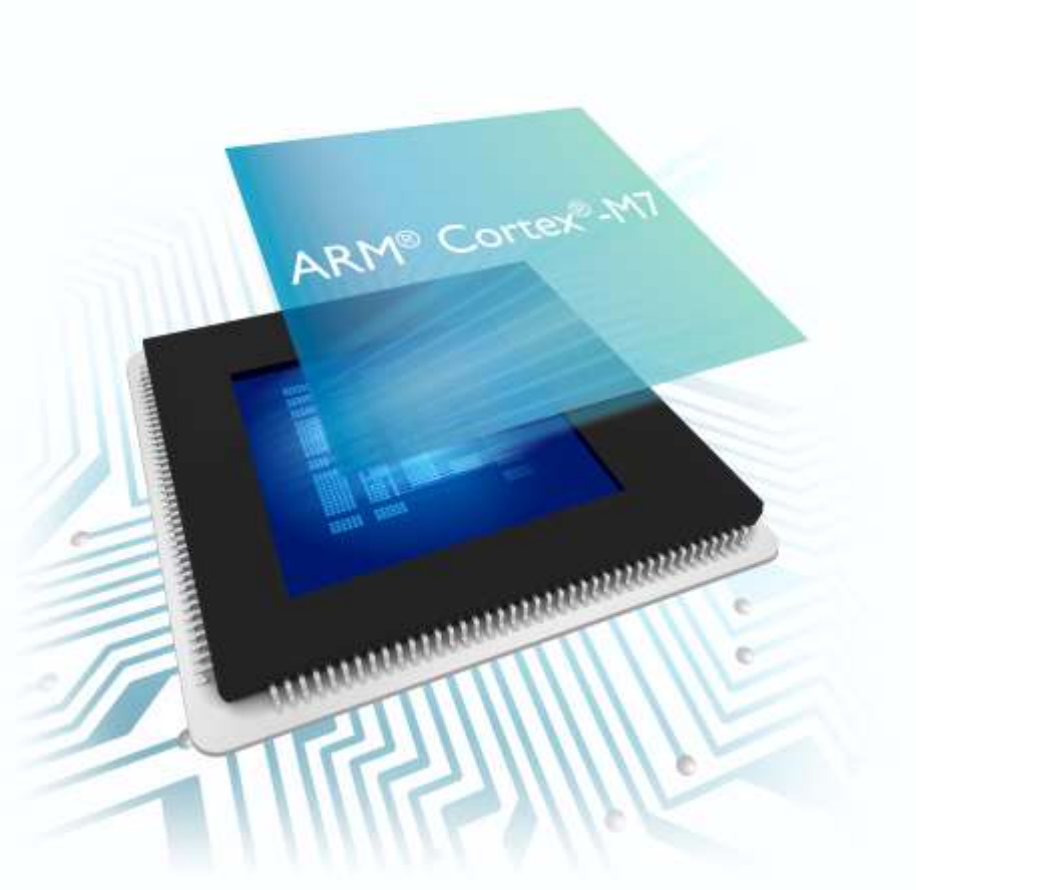
- Kinetis K64F running at 120Mhz
- 256K SRAM
- 1MB Flash

STM STM32429I-EVAL

- STM32F4 running at 180Mhz
- 256K SRAM
- 2MB Flash

Cortex-M7: Built for Performance

- Performance
  - Achieving 5 CoreMark/MHz – 2000 CoreMark* in 40LP
  - Typical 2x DSP performance of Cortex-M4
- Versatility
  - Highly flexible system and memory interfaces
  - Designed for functional safety implementations
- Scalability and compatibility
  - Enables simple migration from any Cortex-M processor
  - Widest third-party tools, RTOS, middleware support



* CoreMark 1.0 : IAR Embedded Workbench v7.30.1 --endian=little --cpu=Cortex-M7 -e -Ohs --use_c++_inline --no_size_constraints / Code in TCM - Data in TCM

High performance embedded compute now shipping

- Delivering highest performance in a Cortex-M processor
  - 2.14 DMIPS/MHz, 5.01 CoreMark/MHz

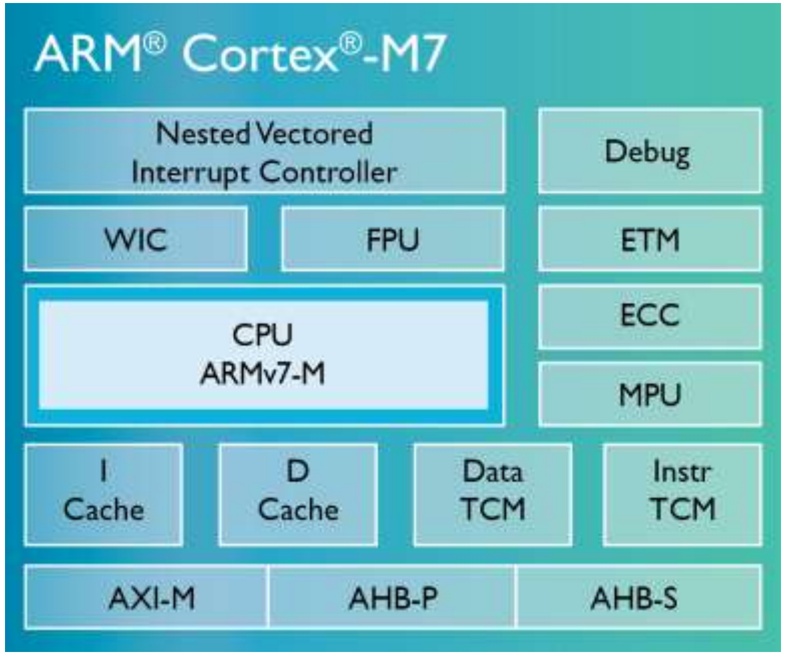
Typical Applications		
Automotive	Factory Automation	Camera Drones
Motor Control	Sensor Hub	Embedded Audio

- Proven and shipping in mass-market silicon
- Supported by ARM's broad ecosystem: software, tools and RTOS
- Now available

Cortex-M7

Cortex-M7 Key Features (1)

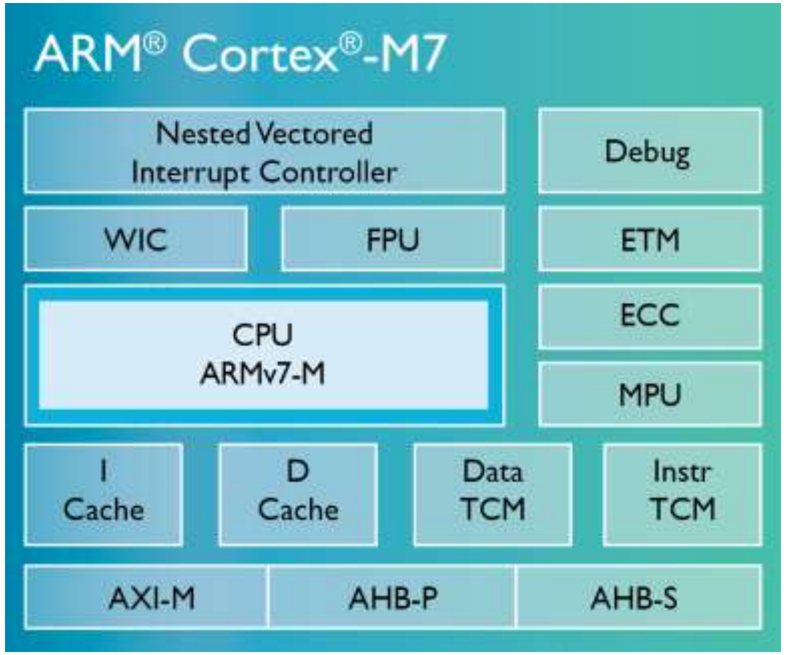
- **High performance core with DSP capabilities**
  - Six-stage dual-issue pipeline
  - Powerful DSP instructions and SP/DP Floating Point
  - **Best-in-class core for high-end MCU, or replace MCU+DSP with Cortex-M7**



- **Flexible, memory system**
  - Tightly-coupled memories for real-time determinism
  - 64-bit AXI AMBA4 memory interface with I-cache and D-cache for efficient access to external resources
  - **Build MCU with access to large external memories and powerful peripherals**

* SP – Single Precision, DP – Double Precision

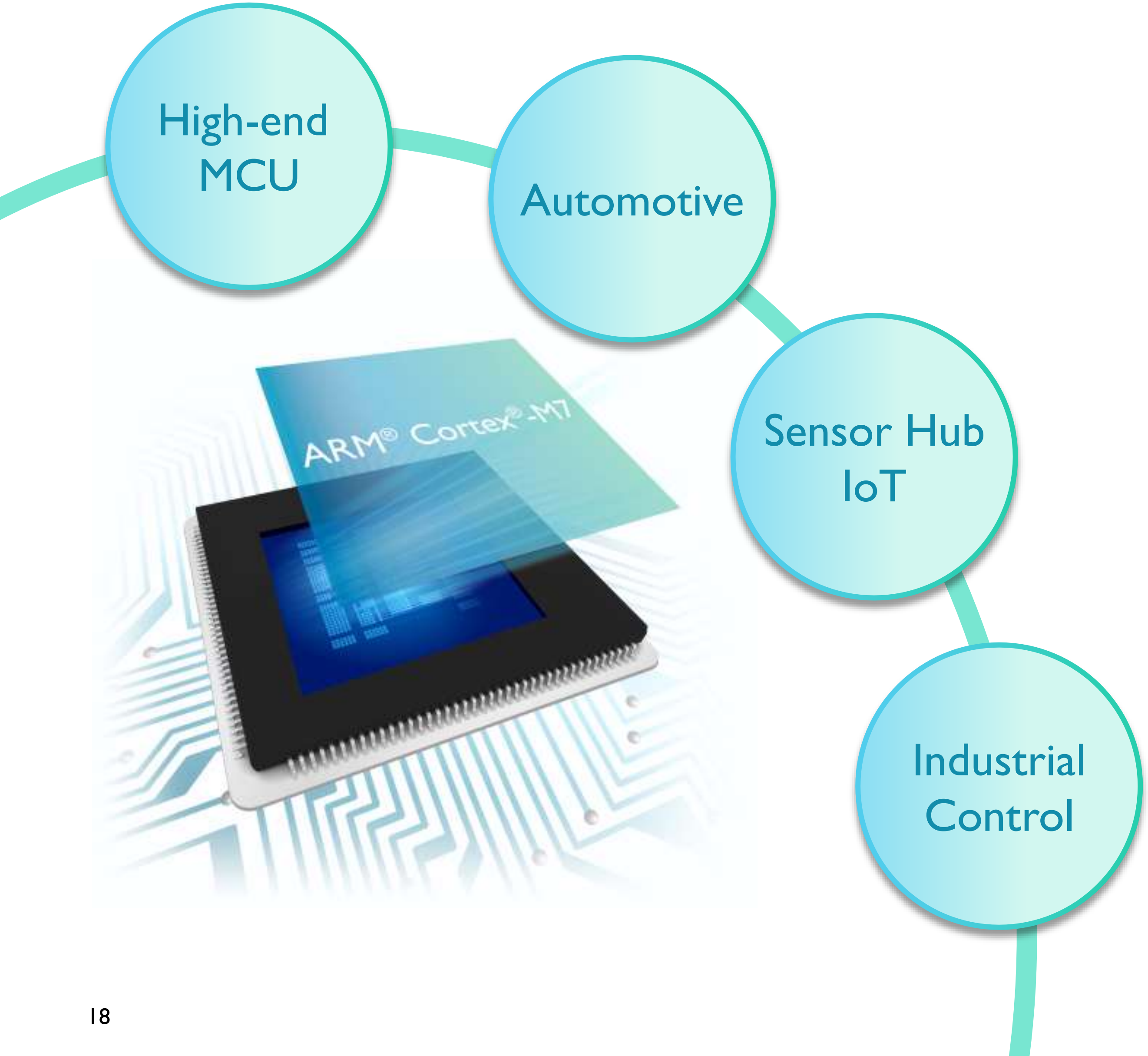
Cortex-M7 Key Features (2)



- **ARMv7-M architecture**
  - 100% binary forwards compatibility from Cortex-M4
  - Key Cortex-M family processor characteristics: Ease of use, excellent interrupt latency
  - **Fast interrupt response for real-time systems, reuse code and system design from existing products to reduce development costs**
- **Safety features**
  - Memory ECC (SEC-DED), MPU, MBIST, lock-step operation, full data trace, safety manual
  - **Enables entry into safety-critical markets.**

ARM

Cortex-M7 Target Applications



- Powerful processor for advanced audio/visual sensor hub processing
- Power-efficient local processor for IoT devices such as an edge router
- Flexible and reliable processor for industrial and motor control

Enabling Smarter Systems Without the Complexity

2x More performance delivering enhanced functionality

- More displays
- More motors
- Advanced touch sensing
- Multiple connectivity options
- Enhanced voice controls

ARM

Helping Drive Richer Audio Experiences

2x More performance delivering advanced sound processing

Cortex-M7

DOLBY AUDIO Dolby Digital Plus (with post processing)

Cortex-M4

DOLBY AUDIO Dolby Digital

- 7.1 Multi-channel audio support
- More speaker EQ processing
- Capacity for decoders
- More connectivity options

ARM

Cortex-M7 in Automotive

- **Trends and challenges:**
  - Safety certification mandated in more regions
  - Convergence of functionality into fewer MCUs/ASSPs
  - Increasing user requirements and expectations
- **Typical Applications**
  - Dashboard in medium-range cars
  - Voice recognition
    (for Multimedia control functions)
  - Character recognition (eg Kanji)
  - "Convenience" features
  - Chassis, electric power steering, "steer-by-wire"
  - Automotive audio

Cortex-M7 Advantages:

- High performance core with fast DSP
- Safety features built in and safety manual
- Determinism with high performance
- Full trace via ETM

Cortex-M7 in Industrial Control

- **Trends and challenges**
  - High performance control functions
  - Safety, reliability and conformance will become mandatory
  - 80-90% of cost is software, Cortex-M offers scalability and protects software investment

- **Typical applications:**
  - Factory Automation
    - Inverters, Servos
    - Programmable Logic Controllers
    - High-speed comms
  - Intelligent motor control

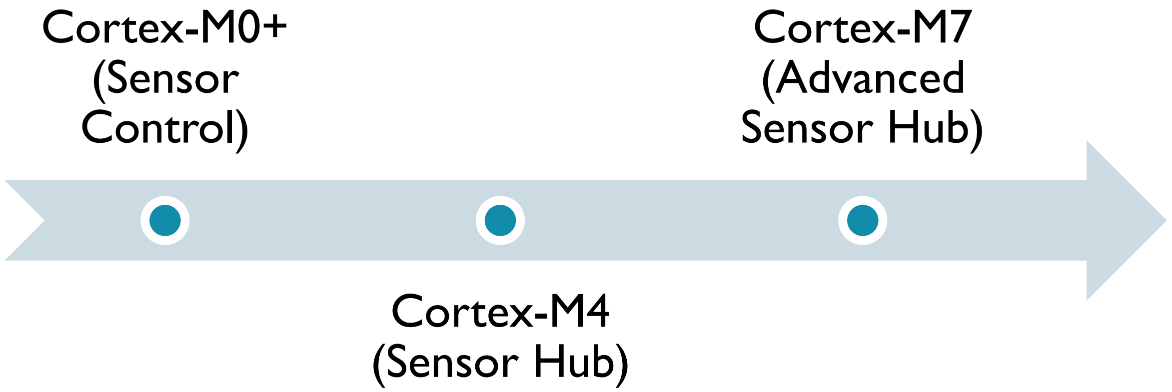
Cortex-M7 Advantages:

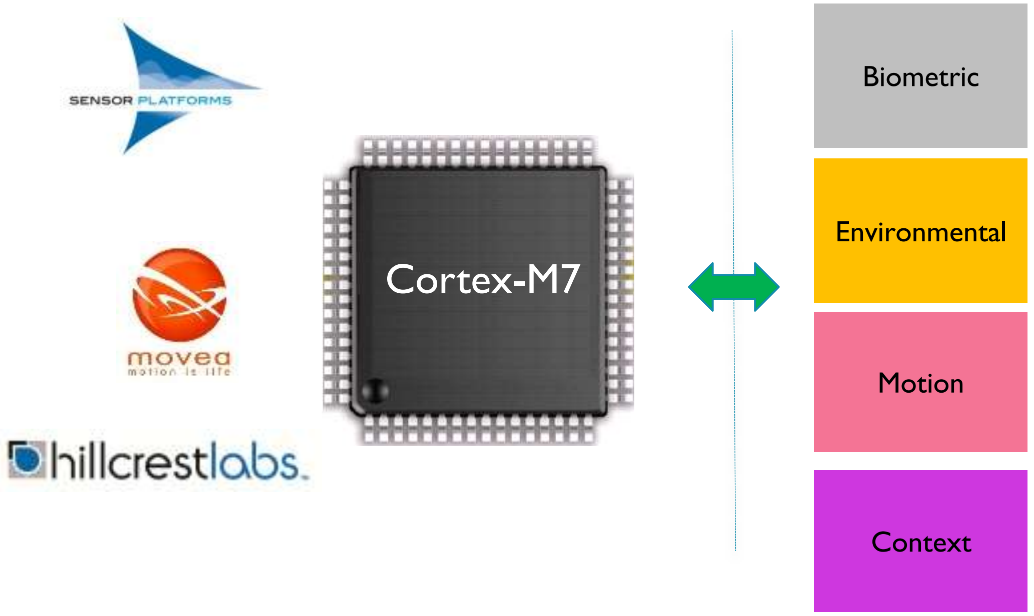
- Increased DSP performance for control functions
- Safety features built-in
- In-order pipeline gives performance with predictability
- TCMs and low interrupt latency: Interrupt response within 100ns required
- Scalability from Cortex-M3 through Cortex-M7 up to Cortex-A53

ARM

Cortex-M7 in Sensor Fusion

- **Trends and challenges**
  - Increased sophistication of fusion algorithm
  - Increase in number and variety of sensors
  - Image sensors / processing
- **Typical applications:**
  - Sensor fusion hubs
  - Sensor control and sensor signal fusion



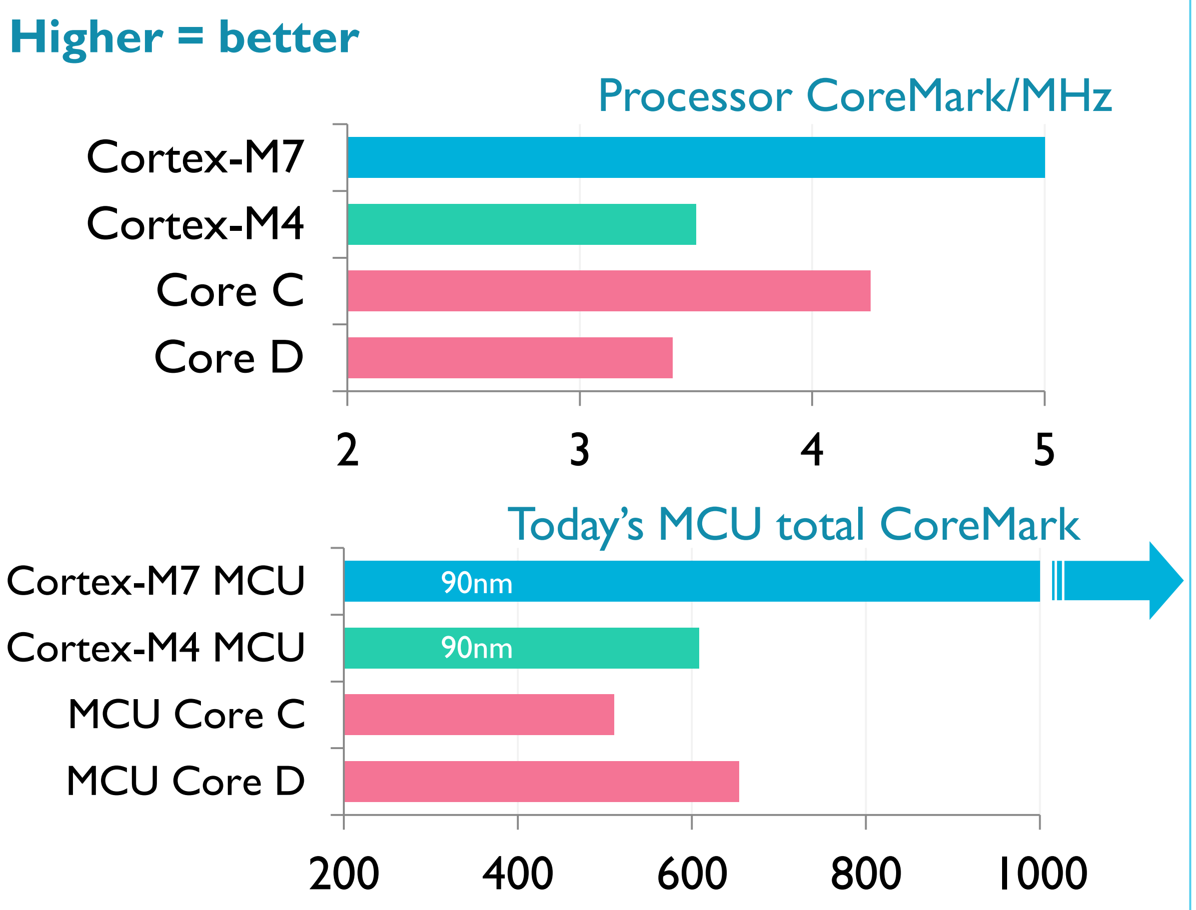


Cortex-M7 Advantages:
- Increased DSP performance for fusion and control operations
- Software support by the top three fusion algorithm developers

ARM Cortex-M7: Built for Performance

- Fast compute for demanding embedded applications
  - Six-stage superscalar pipeline with branch prediction
  - Single and double precision floating point unit
- Flexible memory system
  - 64-bit AXI AMBA4 interconnect
  - I-cache and D-cache for efficient memory operation
- Ultra-fast responsiveness for control
  - 12 cycles interrupt latency
  - Tightly coupled memories for real-time determinism

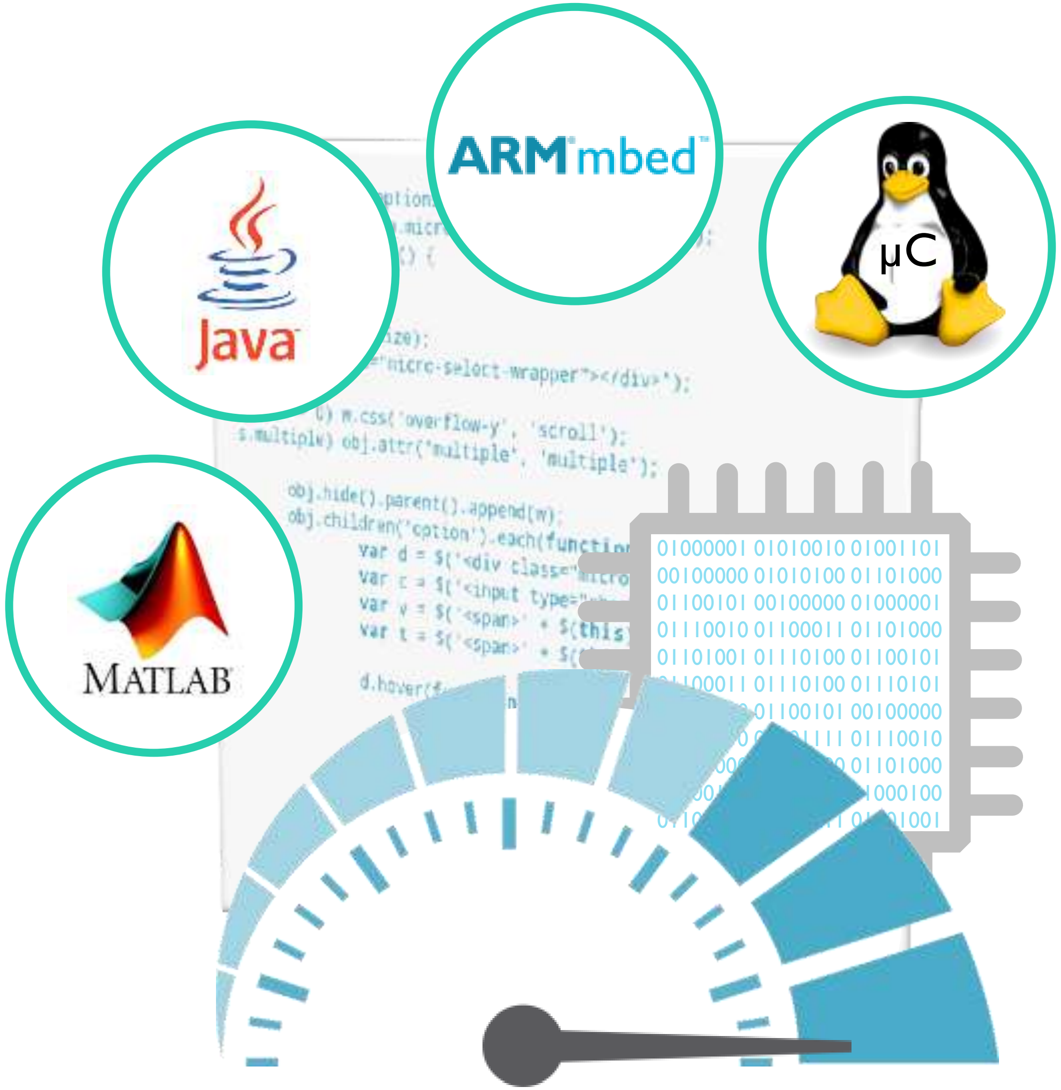
Highest core performance combined with the efficiency of Cortex-M



Source: CoreMark.org, ARM for Cortex-M7

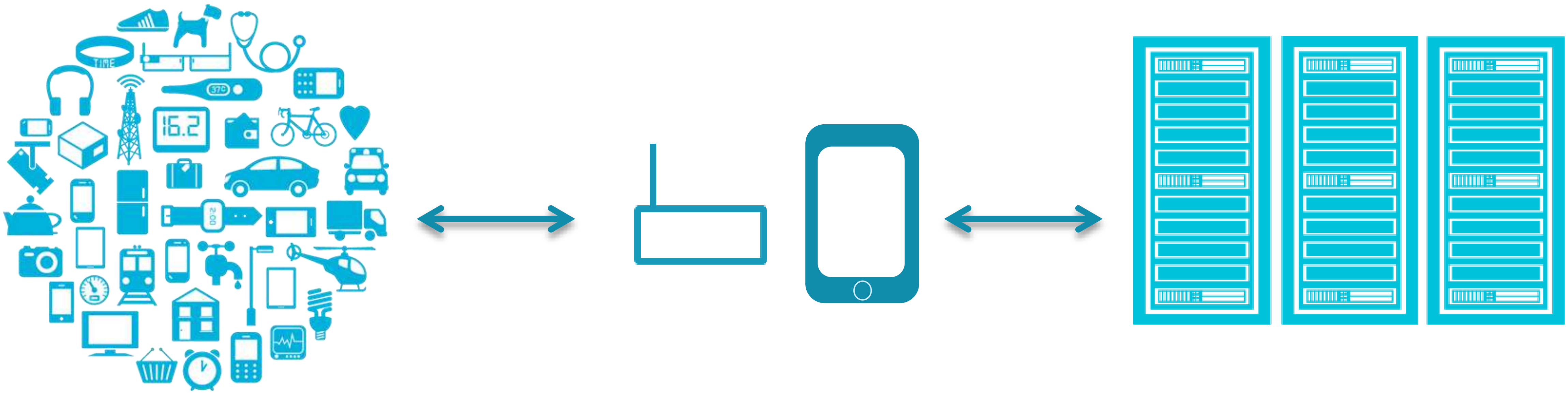
Cortex-M7: Unlock and Unleash Software Productivity

- Focus on application development
  - Exploit optimally tuned range of processors
  - Utilize richer variety of peripherals
  - Harness advanced proven runtime environments
- Spend less time on code optimization
  - More capable hardware resources
  - Optimized and proven libraries
- Develop and deploy software faster



ARM

IoT: Connecting the Physical and Digital Worlds



Sensors and Devices

Wireless Networks

Cloud

ARM

By 2020: explosive growth expected for IoT

Expected number of IoT devices shipped in 2020

2.8B
Smart Mobile
6% CAGR

IoT

1.6B
Smart Home
58% CAGR

1.8B
Smart City
54% CAGR

0.6B
Industrial
21% CAGR

1.1B
Auto.
43% CAGR

New ecosystems and business models are emerging

Source: Gartner, 2015

ARM

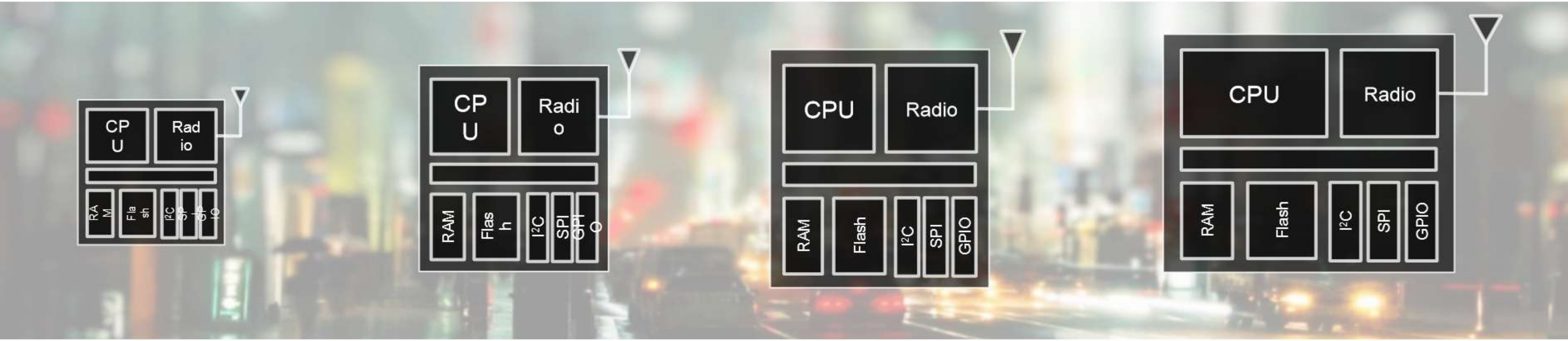
Wide Range of Devices

CLASS 0
ULTRA CONSTRAINED

CLASS 1-2
CONSTRAINED

CLASS 3
MAINSTREAM IOT

CLASS 4
RICH NODE / GATEWAY



ARM Cortex-M0+
16K RAM / 64K ROM
Requires gateway
Disposable, Swallowable
RTOS or bare metal

ARM Cortex-M0+/3
32-64K RAM / 128-256K ROM
Direct to Internet via CoAP
End-to-end DTLS security
Remote management
MBED OS support

ARM Cortex-M3/4/7
128K RAM / 512K ROM

Java ME

ARM Cortex-A7
64MB RAM / 512MB ROM

Java SE

ARM

The Big Picture

What?

- ARM mbed Device Platform consisting of:
  - mbed OS: free operating system for ARM Cortex-M devices
  - mbed Device Server: to connect devices to services

Why?

- To accelerate the pace of IoT by enabling innovators to focus on value-add features
- Pull from silicon and cloud partners for a standards-based software to create IoT solutions

How?

- By providing the necessary building blocks to be able to create standards-based connected IoT solutions for a broad set of market segments

ARM® mbed™

IoT Device Platform

Productivity

Security

Connectivity

Management

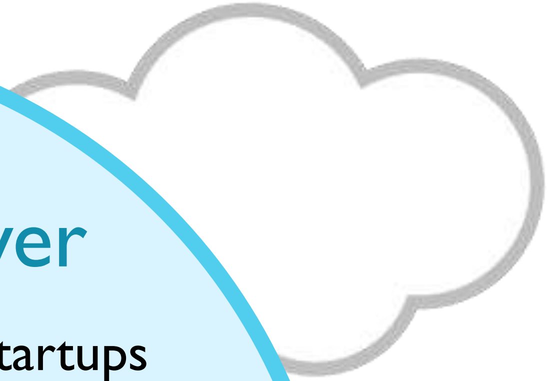
Efficiency

Scalability

End-to-end **software solutions** for IoT applications

ARM® mbed™

IoT Device Platform



mbed Device Server

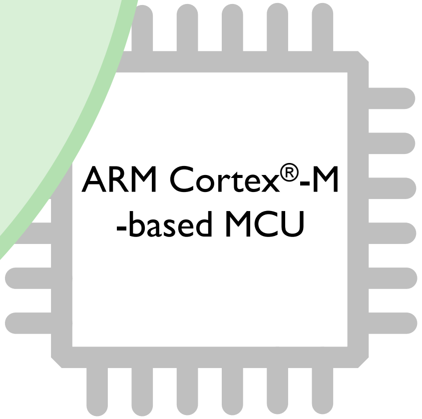
- Freemium model to enable startups
- Application data and device management
- Growth market access for cloud platforms and operators

mbed Ecosystem

- Partners
- Developers
- Enabled Services
- Enabled Products

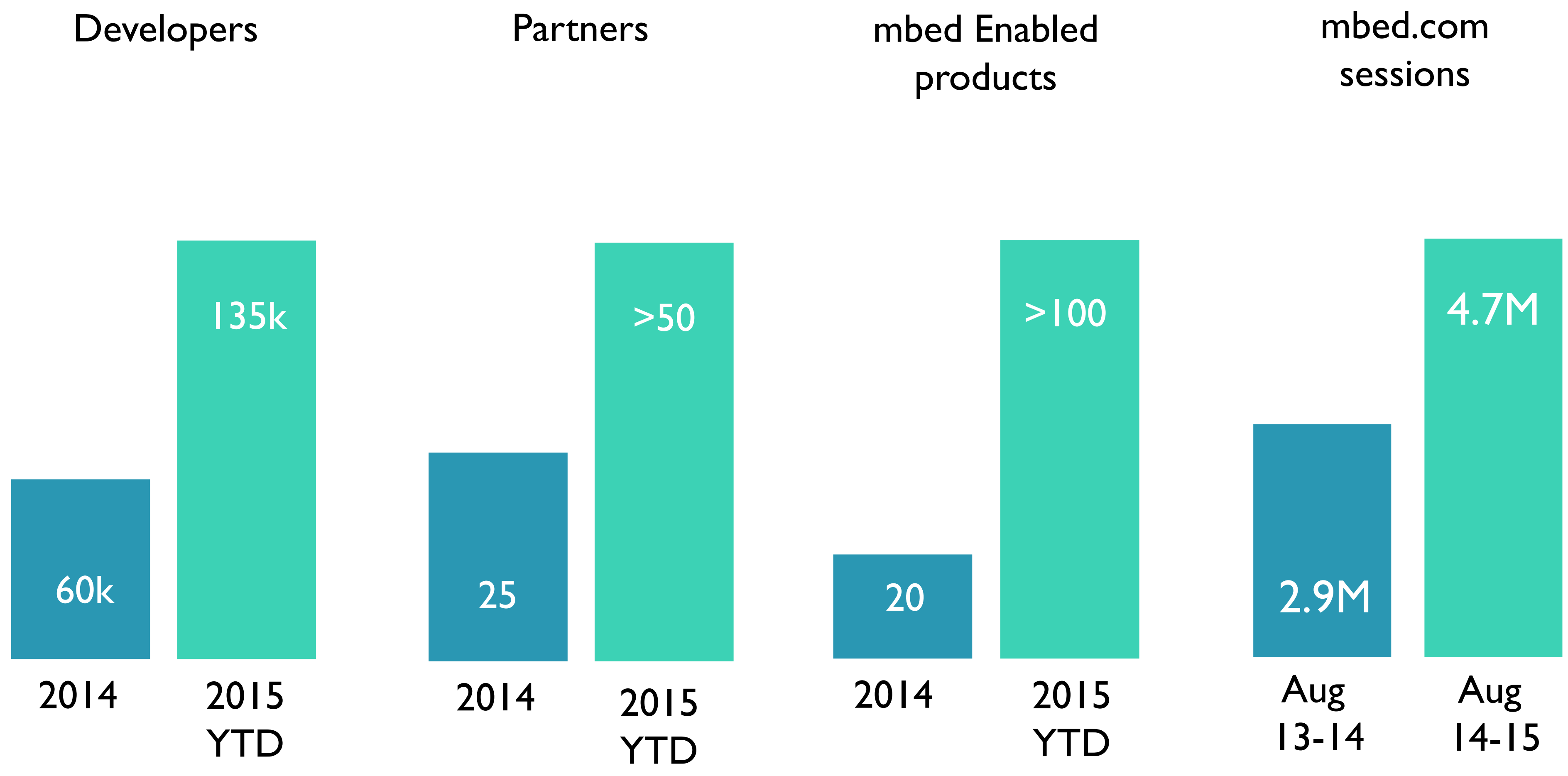
mbed OS

- Free for use on ARM architecture
- Leading connectivity standards
- Productivity, minimized costs
- Built-in management
- Security

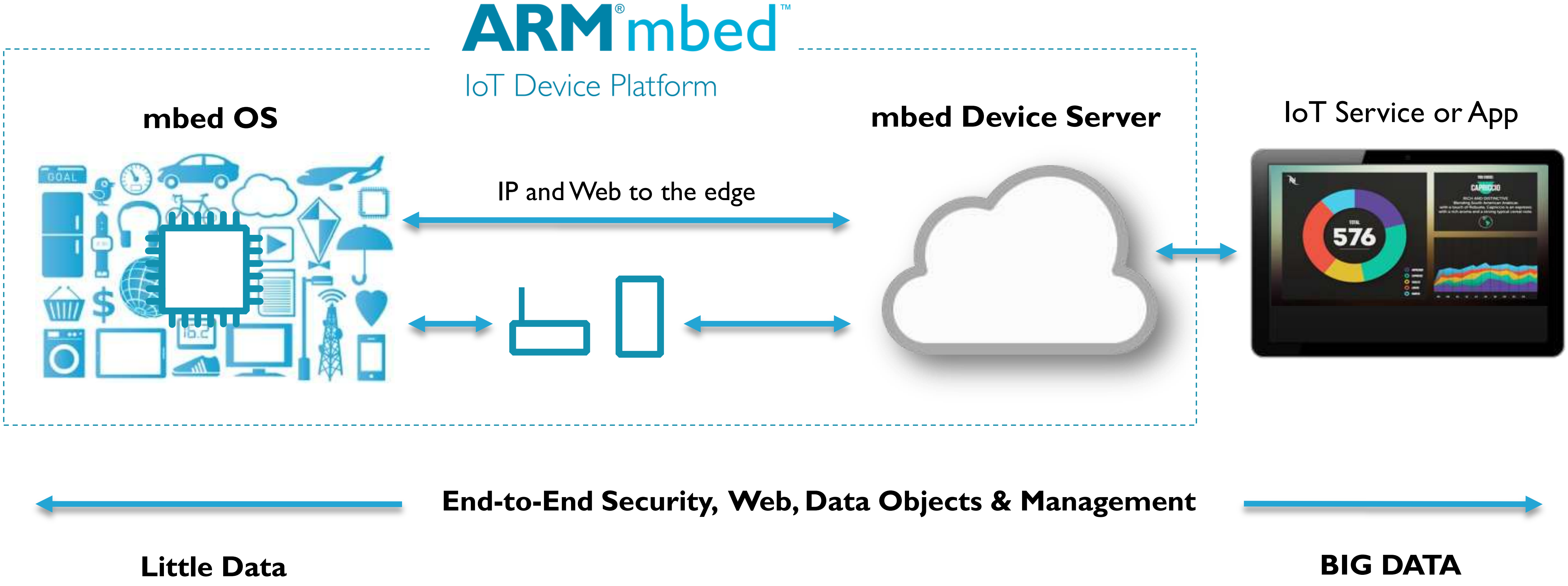


ARM

mbed progress in 2015

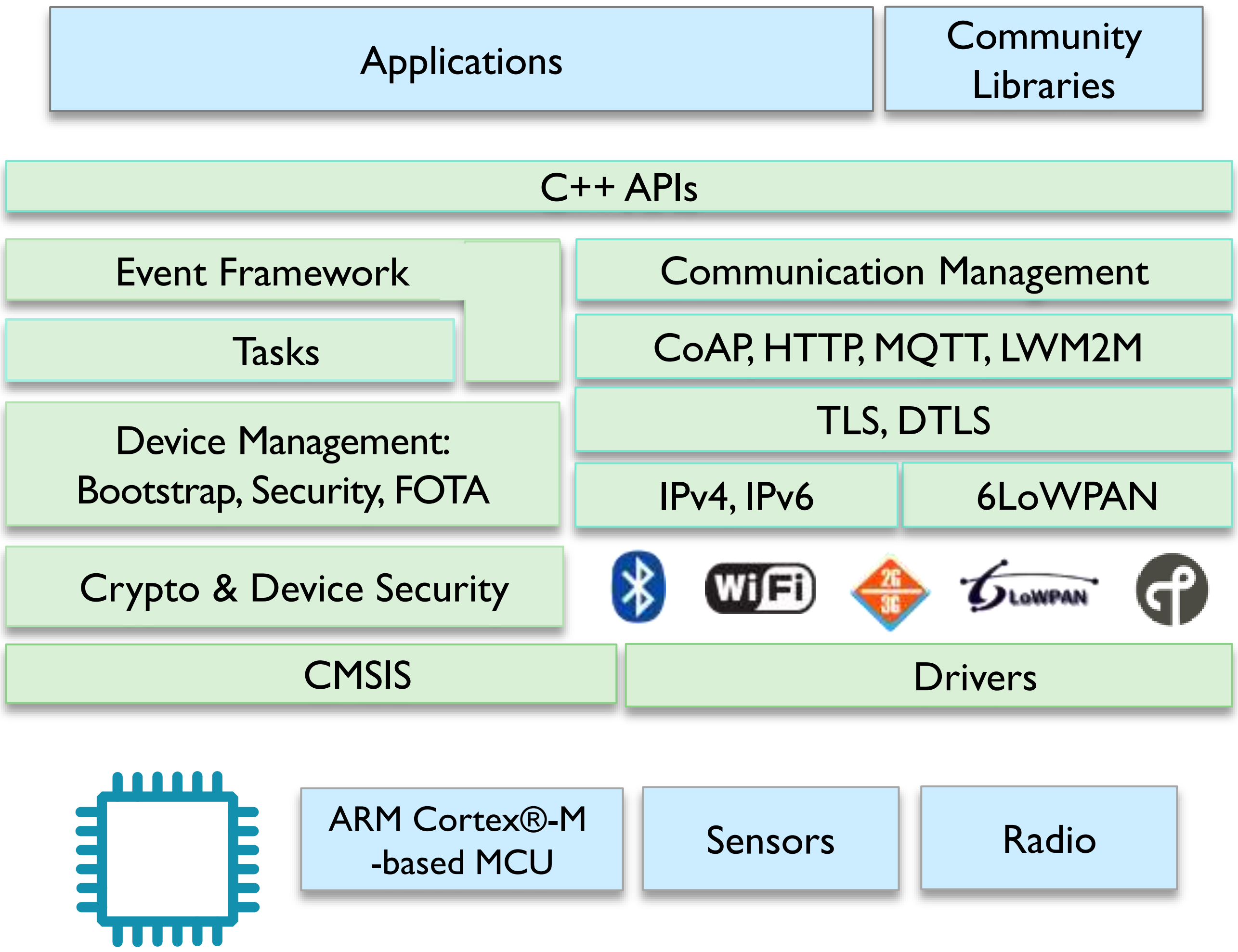


Little Data Enables Big Data



mbed OS

- Minimize time-to-market
- Low-power by design
- Complete security solution
- Top connectivity standards
- Built-in device management



mbed Device Server

- Straightforward integration
- Periodic connectivity support
- Holistic managed security
- Leading open standards
- Lightweight management

mbed Device Server API

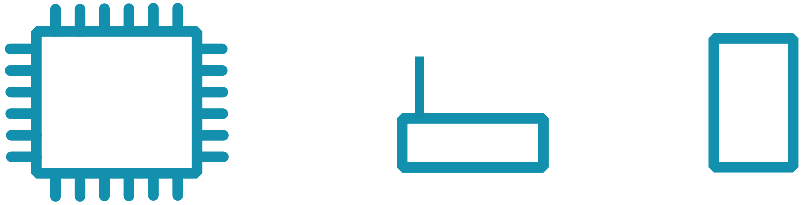
Directory and Subscription | Security, Admin and Multi-tenancy

Device Management and Data Flows - *RESTful and Publish/Subscribe*

mbed Device Interface - *Open Web Standards*

Application Transfer Protocols – *CoAP, HTTP, MQTT*

Security Protocols – *DTLS, TLS*



ARM

Common OS and Connectivity Across Markets

Smart Cities

Smart Home

Basic Wearables

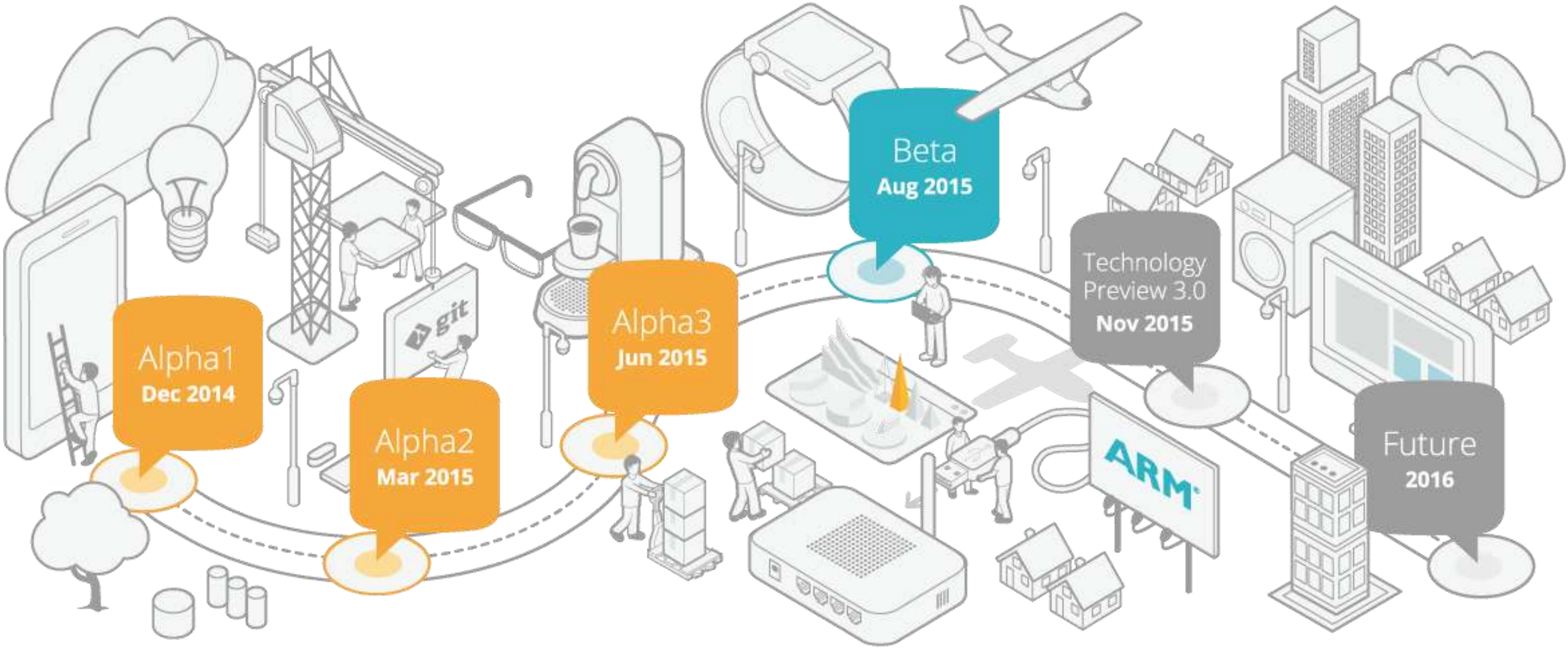
Key connectivity standards with mbed OS

Smart Cities	Smart Home	Basic Wearables
LoWPAN Sub-GHz, Zigbee IP-NAN	WiFi, BT Smart, Thread	BT Smart
Connectivity	Connectivity	Connectivity
Security	Security	Security
OS + Drivers	OS + Drivers	OS + Drivers

Common foundation with mbed OS

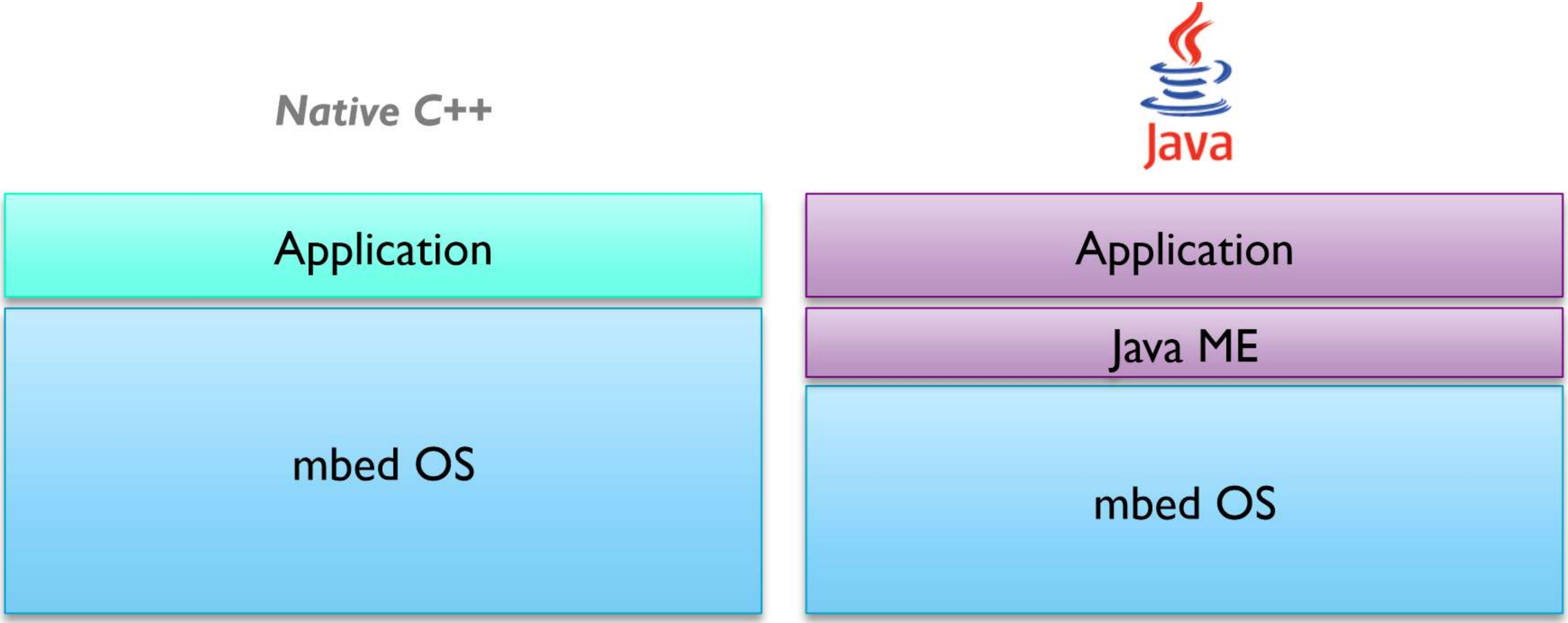
ARM

mbed Platform Roadmap



ARM

Java and mbed



Scaling Embedded SW with Java and mbed

Goal: drive platform consistency, developer productivity, and software intelligence

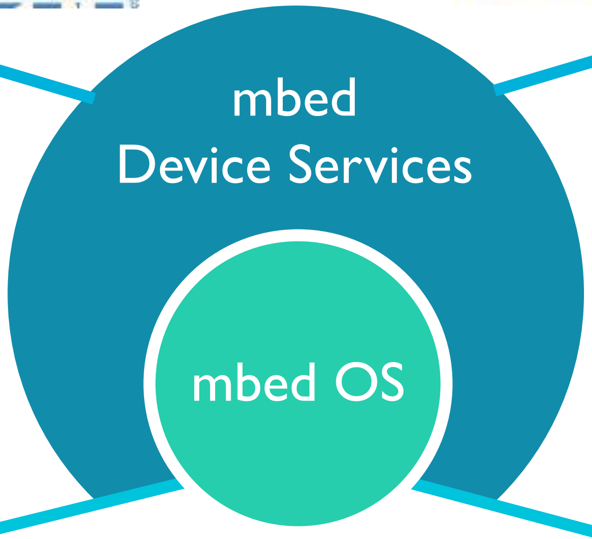
- **Reduce** embedded platform fragmentation and time-to-market
- **Enable** Java Embedded on a growing range of mbed-enabled devices
- **Combine** the strengths of the mbed and Java communities and partners

ORACLE® ARM® mbed™ freescale™ life.augmented

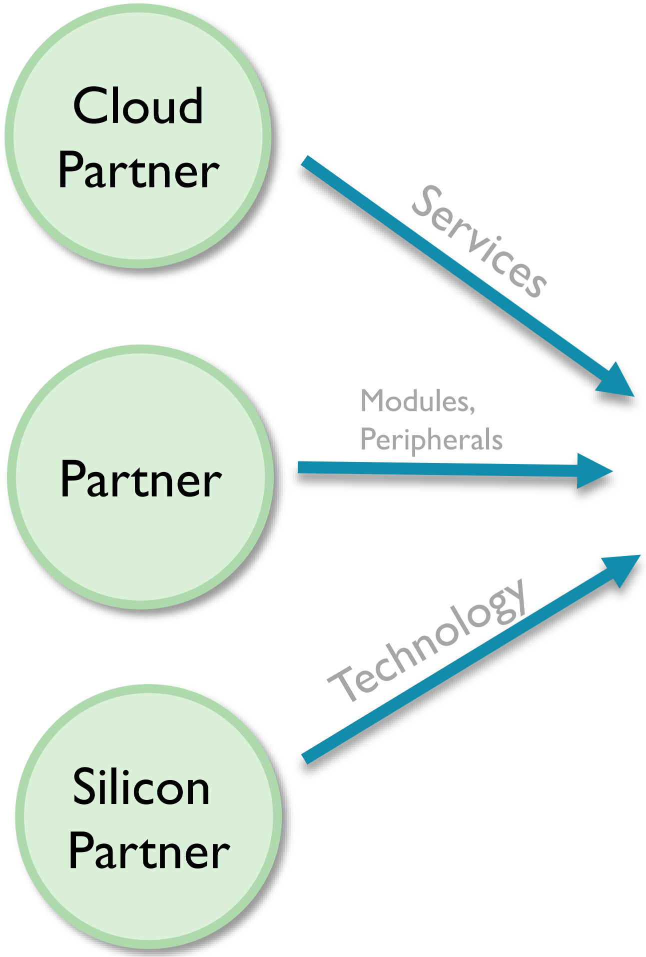
ARM

135,000+ developers

100+ mbed Enabled products



The new mbed Partner Ecosystem: Join Us!



ARM® mbed™

IoT Device Platform

- Shared vision
- Commitment to openness & standards
- Enable scale
- Collaboration

Enable commercial deployment of IoT devices and services

ARM

ARM at JavaOne

- Come visit the ARM booth # 5616!

- Demo of mbedOS and mbed Device Server running on a Nespresso Coffee Machine

ARM® mbed™
IoT Device Platform

- Conference Sessions:
  1. **'Accelerating IoT with ARM'**
     by Vrajesh Bhavsar
     Tuesday 5:30pm, Hilton Ballroom 7/8/9
  2. **'Project Kona: Java Networking Technologies for IoT'**
     by Zach Shelby
     Tuesday 7:00pm Hilton Ballroom 7/8/9
  3. **'Data Center Java Developers, Start Your ARMv8 Engines!'**
     by Jeff Underhill
     Tuesday 11:00am Parc55 – Market Street

Thank you – Questions?