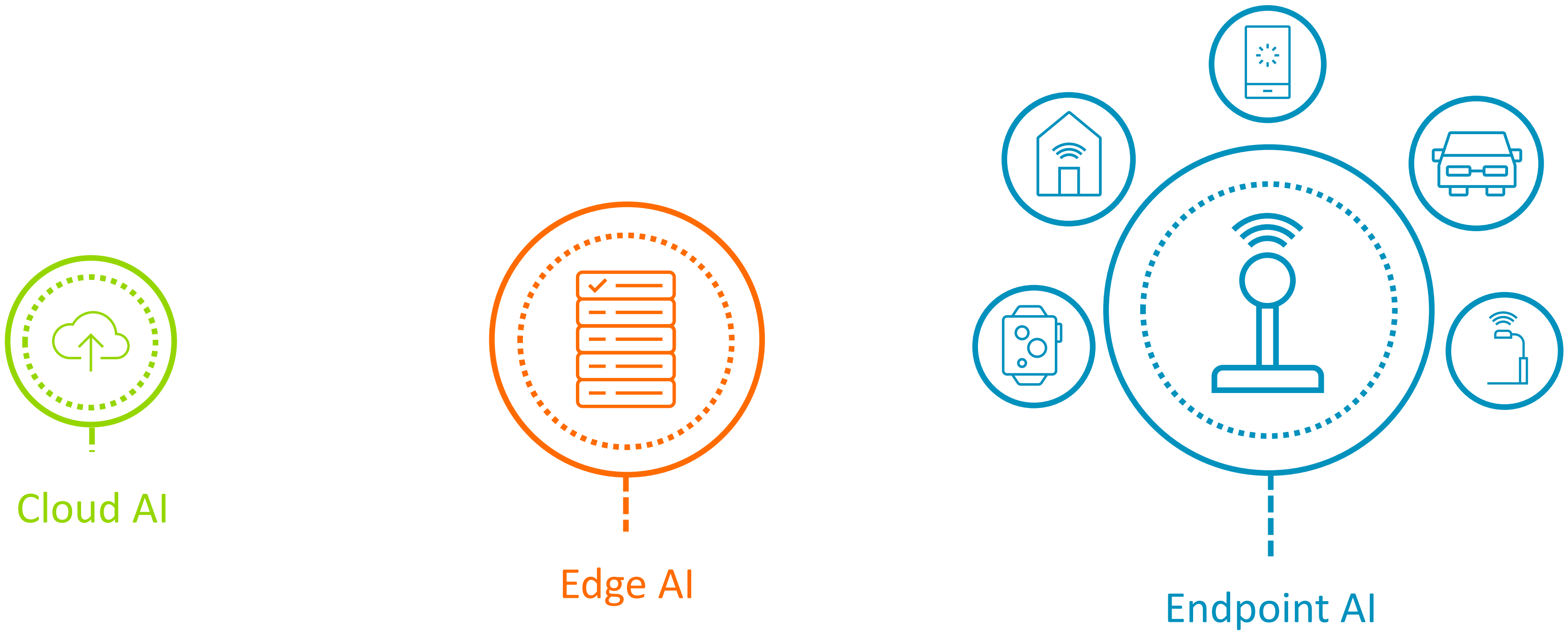
Next-generation endpoint AI for IoT with the new Arm Cortex-M55 and Ethos-U55 processors

Mark Quartermain, Cortex-M55 Product Manager

Arm Enables AI Everywhere, On Any Device

Arm's AI platform delivers comprehensive hardware IP, software frameworks, and ecosystem



Cloud AI

Edge AI

Endpoint AI

AI-enabled IoT device shipments forecast to increase by almost **20% per year** through 2024*

*Source: Arm forecast based on industry data

Best-in-class Solution Optimized for Endpoint AI

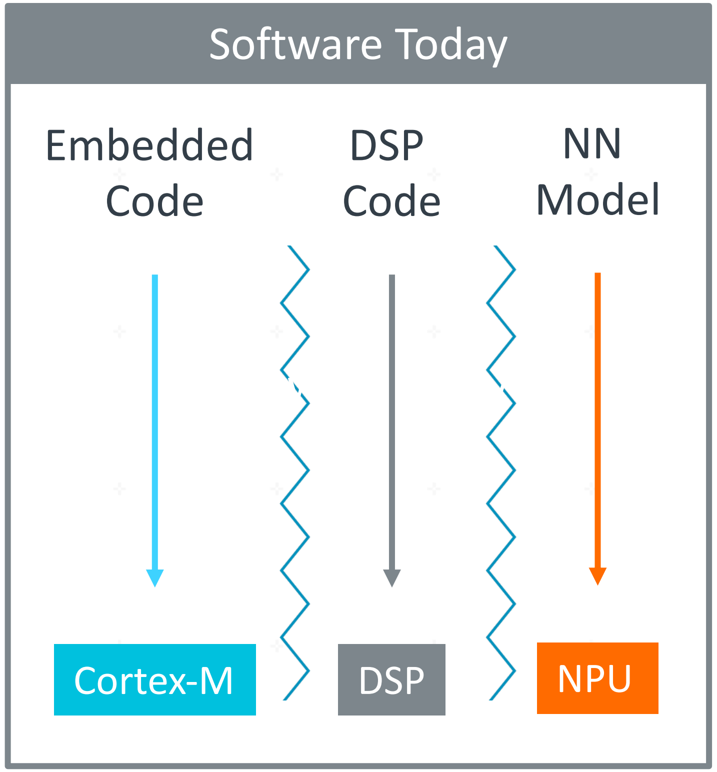
	Cortex-M55 Most AI-capable Cortex-M processor		Ethos-U55 First microNPU for Cortex-M	
Performance	Versatile ML performance: Up to 15x ML uplift*	+	Dedicated ML performance: Additional 32x ML uplift**	= Up to 480x ML performance uplift*
Optimization	Arm Custom Instructions*** and configuration options		Configurable 32-256 MACs	
Accelerated Design and Development	Corstone-300 reference design for faster and more secure system-on-chip development			

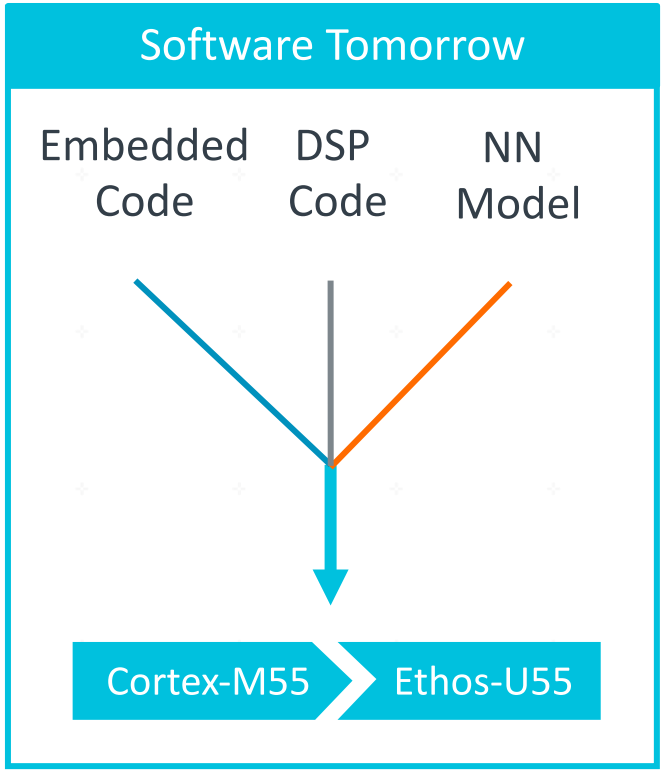
*Compared to previous Cortex-M generations

**Compared to the Cortex-M55

***available in 2021

Unified Software Development: Fastest Path to Endpoint AI





- Multiple software development flows
- Harder to program and debug
- More complex, longer time to market

- Unified software development flow
- Works with common ML frameworks and existing tools
- More productivity, faster time to market

Arm Cortex-M55 Processor

Arm’s most AI-capable Cortex-M processor and the first to feature Arm Helium vector processing technology

Cortex-M55: The Most AI-capable Cortex-M Processor

Cortex-M processor with enhanced DSP/ML compute capabilities

Helium vector processing

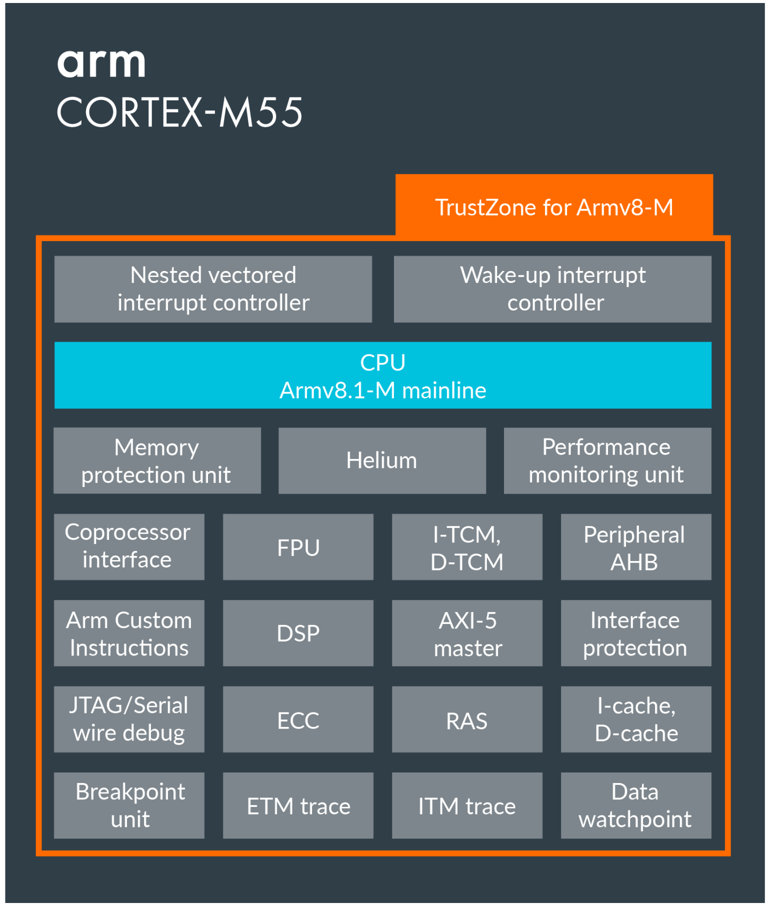
- > 150 new scalar and vector instructions
- Support for complex maths
- Low overhead loops

Vector processing support

- 2 x 32-bit MAC/cycle
- 4 x 16-bit MAC/cycle
- 8 x 8-bit MAC/cycle

Extended datatype support

- Half-precision float
- 8-bit integer
- Floating-point (half, full and double-precision)



arm
CORTEX-M55

TrustZone for Armv8-M

Nested vectored interrupt controller
Wake-up interrupt controller

CPU
Armv8.1-M mainline

Memory protection unit
Helium
Performance monitoring unit

Coprocessor interface
FPU
I-TCM, D-TCM
Peripheral AHB

Arm Custom Instructions
DSP
AXI-5 master
Interface protection

JTAG/Serial wire debug
ECC
RAS
I-cache, D-cache

Breakpoint unit
ETM trace
ITM trace
Data watchpoint

Cortex-M ease of use

- Unified instruction set
- Single toolchain, simplified debug
- No need for separate DSP engine
- Cortex-M ecosystem

High performance system

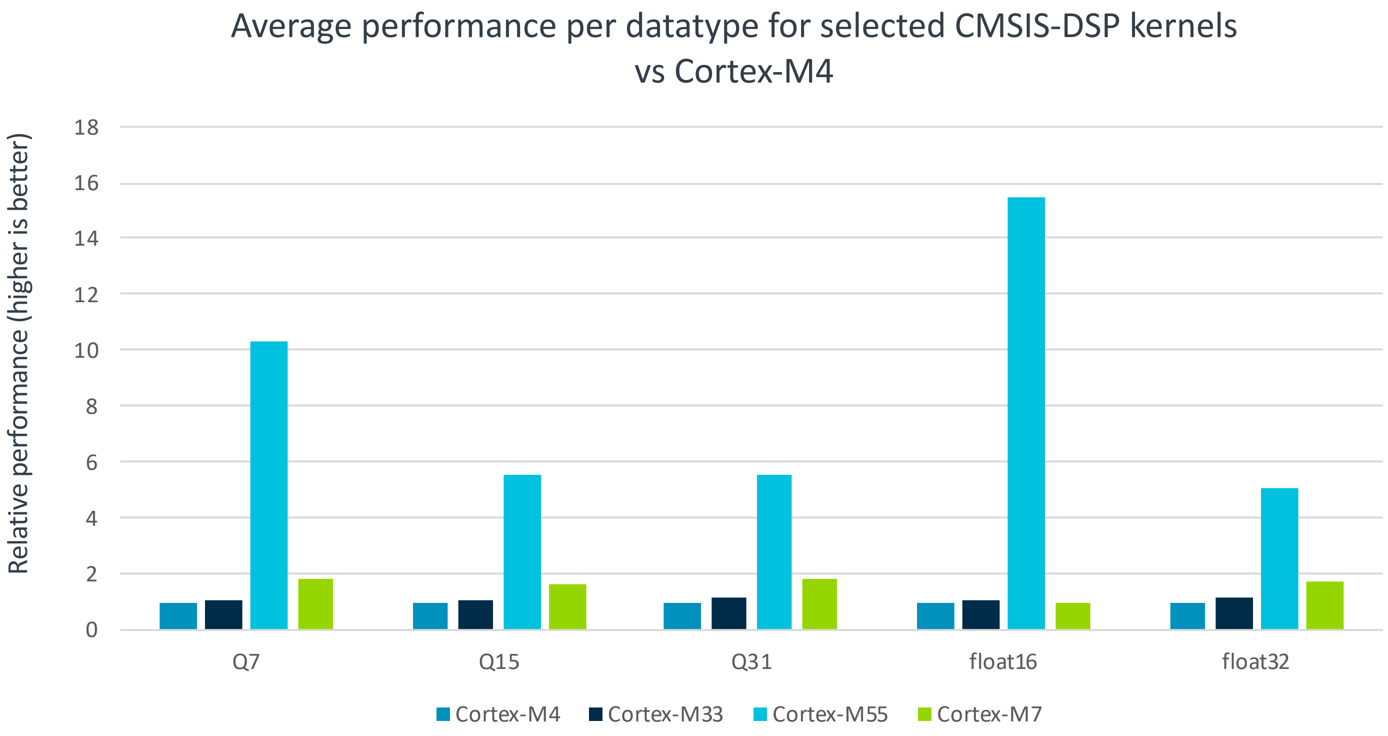
- Memory system designed for DSP and ML applications
- Optional I/D caches
- Optional Tightly Coupled Memory

Security

- TrustZone for system wide security
- Protect software investments

Cortex-M55: Accelerating Embedded DSP/ML Performance

Signal processing



Machine learning

CIFAR10

≈7x higher perf. vs Cortex-M4

Keyword spotting

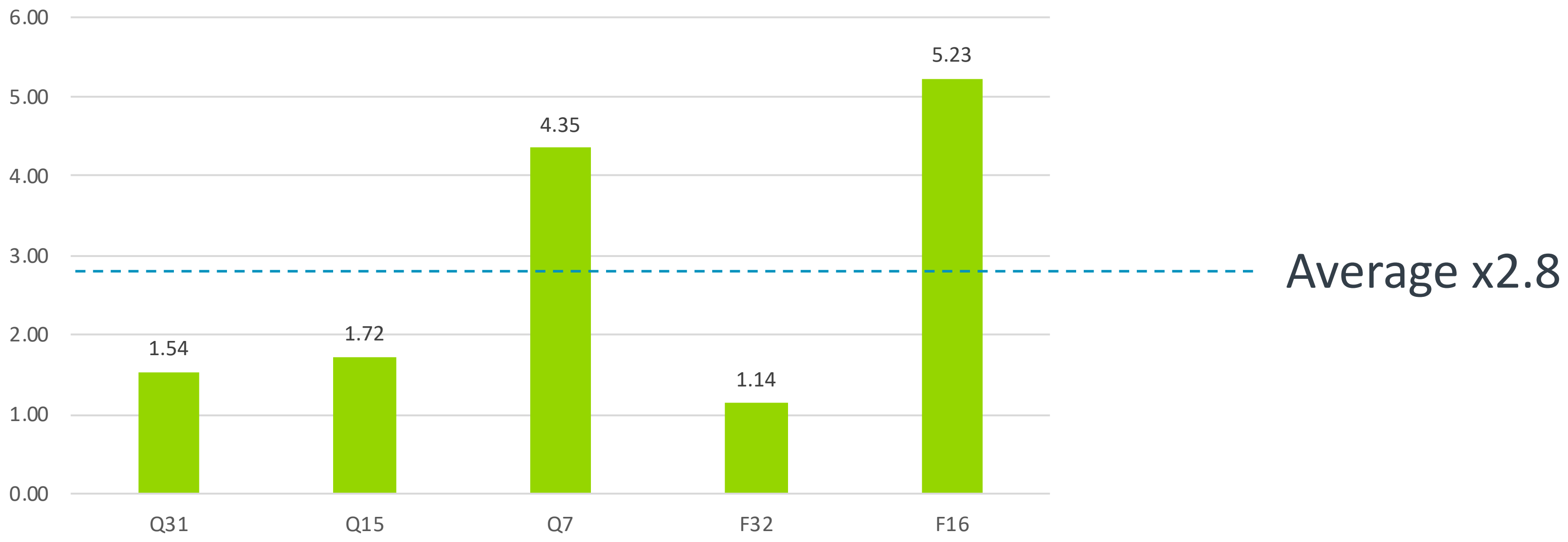
>8x higher perf. vs Cortex-M4

Highest performance and efficiency for ML and signal processing across Cortex-M portfolio

Cortex-M55 performance results are based on selected CMSIS-DSP kernels such as CFFT, FIR, RFFT, matrix mul, vector dot product.
Cortex-M55 data based on LAC RTL and ACC v6.14 compiler in development. Data subject to change.

Cortex-M55 Energy Efficiency by Datatype

Compared to the Cortex-M4 processor



- Measured average energy consumption based on selected DSP kernels from CMSIS-DSP
- Energy efficiency measured as: $\left(\dfrac{Cortex\!-\!M4\ cycles\ to\ complete\ kernel}{Cortex\!-\!M55\ cycles\ to\ complete\ kernel}\right)$ x $\left(\dfrac{Cortex\!-\!M4\ Power}{Cortex\!-\!M55\ Power}\right)$
- > 1 indicates Cortex-M55 energy efficiency is greater than Cortex-M4

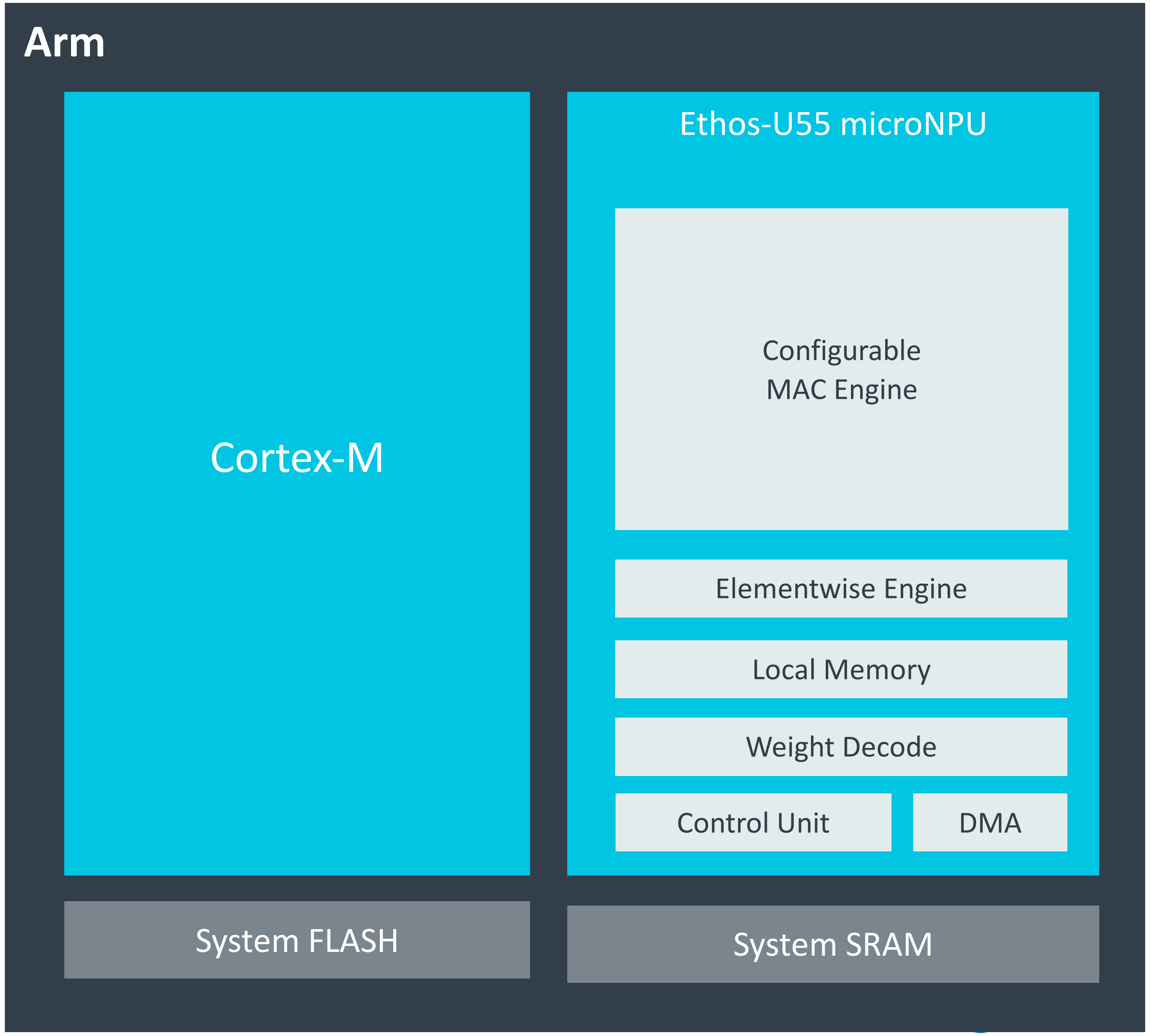
Cortex-M55 data based on LAC RTL. Data subject to change.

Arm Ethos-U55 microNPU

The first Arm microNPU for Cortex-M based systems

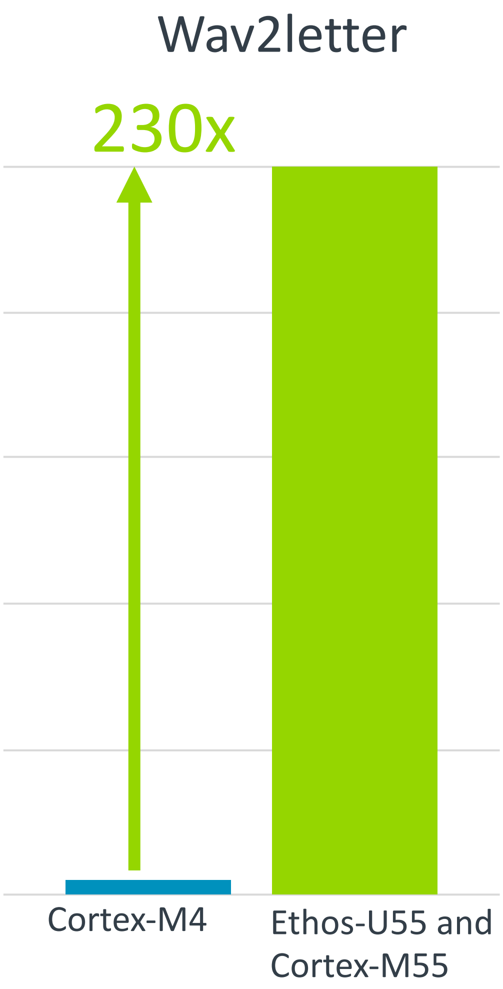
Ethos-U55: The First microNPU for Cortex-M

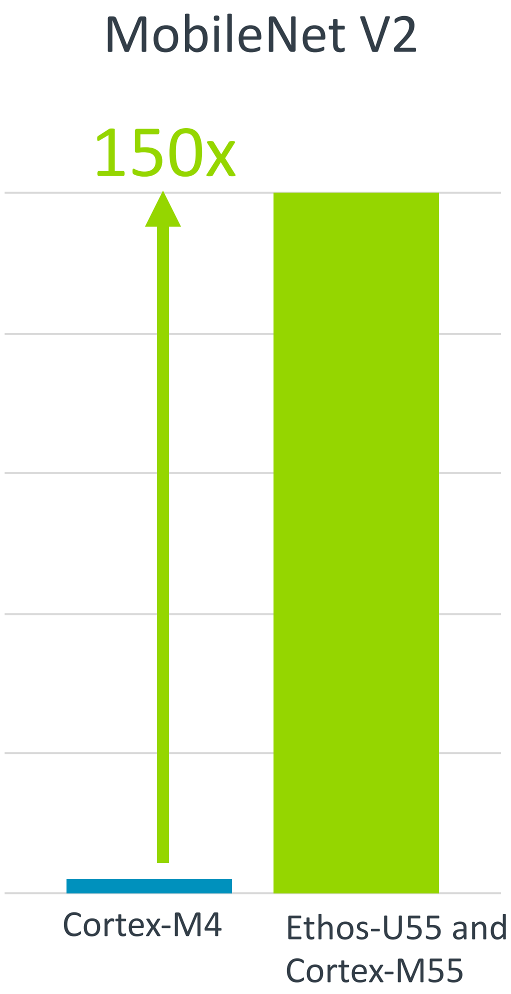
- Configurations 32/64/128/256 MACs
- High compute operators accelerated in hardware. Other operators run on the microcontroller
- Works alongside Cortex-M55, Cortex-M7, Cortex-M33 and Cortex-M4 processors
- Connected to the memory bus
- Uses existing system SRAM and flash storage
- Comes with a high-performance, high-efficiency Mac engine
- Weight decoder and DMA for on-the-fly weight decompression
- 8-bit input x 8-bit weights
- 16-bit input x 8-bit weights



Ethos-U55 Performance Results

Using ***128 MACs/Cycle*** configuration of Ethos-U55

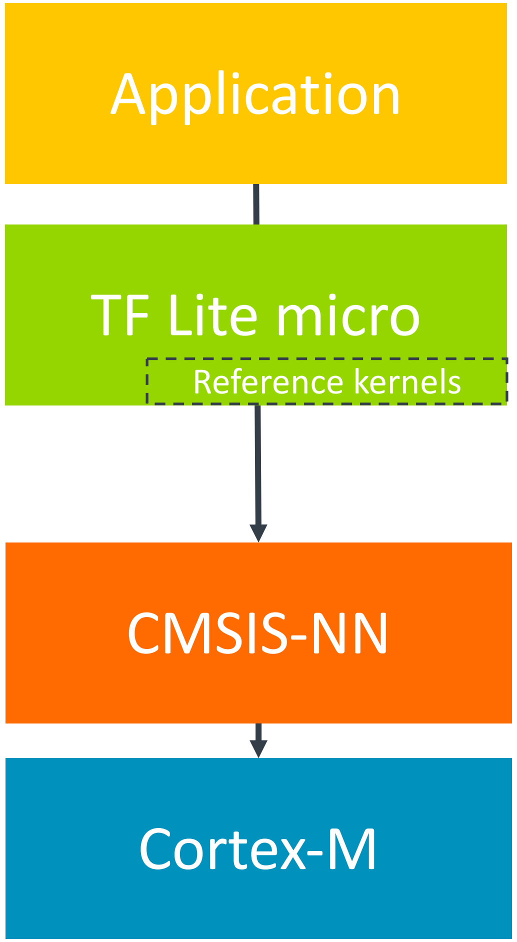




Based on early estimates

CMSIS-NN and TensorFlow Lite Micro for Cortex-M

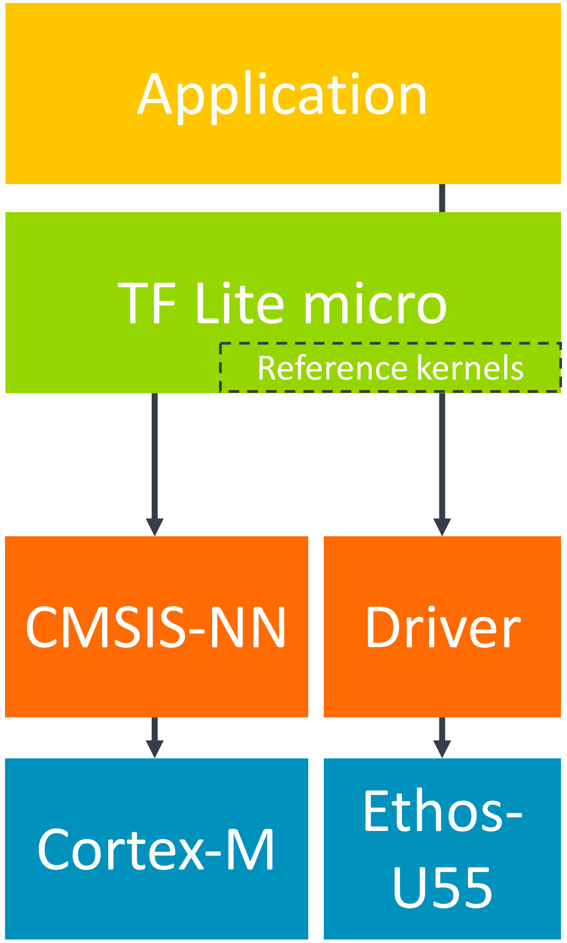
Optimized low-level kernels for the embedded market



- The optimized kernel library for Cortex-M
  - Called from TF Lite Micro or bare metal implementations
  - Offline flow creates a binary for Cortex-M based platforms
- Targets all Cortex-M architectures
  - Armv6-M/Armv7-M/Armv8-M/Armv8.1-M with Helium support
  - Runs on earlier versions of the architecture
- Key operators accelerated by CMSIS-NN
  - Fallback to TF Lite Micro reference kernels
- Open-source, via Apache 2.0 license
  https://github.com/ARM-software/CMSIS_5

Accelerating Embedded Machine Learning

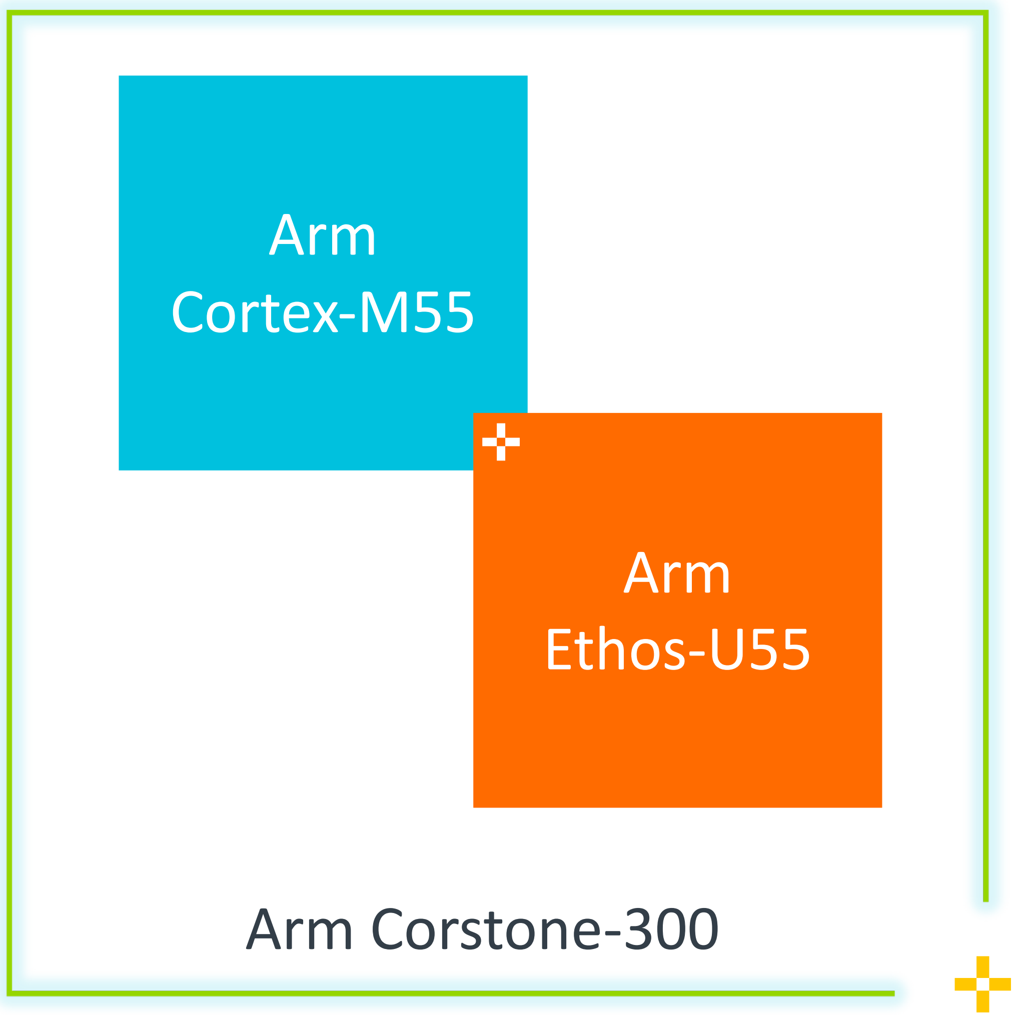
Add Ethos-U55 under the same stack



- Boosts ML performance beyond Cortex-M alone
  - Small memory footprint
  - Low-power for 'always-on' applications
- Operators are accelerated by the microNPU
  - Fallback to CMSIS-NN, then reference kernels
- Tooling for offline optimization
  - Quantize and tune data structures for the microNPU

Summary

Summary: Bringing the Benefits of AI to Billions More - Devices



Arm Cortex-M55

Arm Ethos-U55

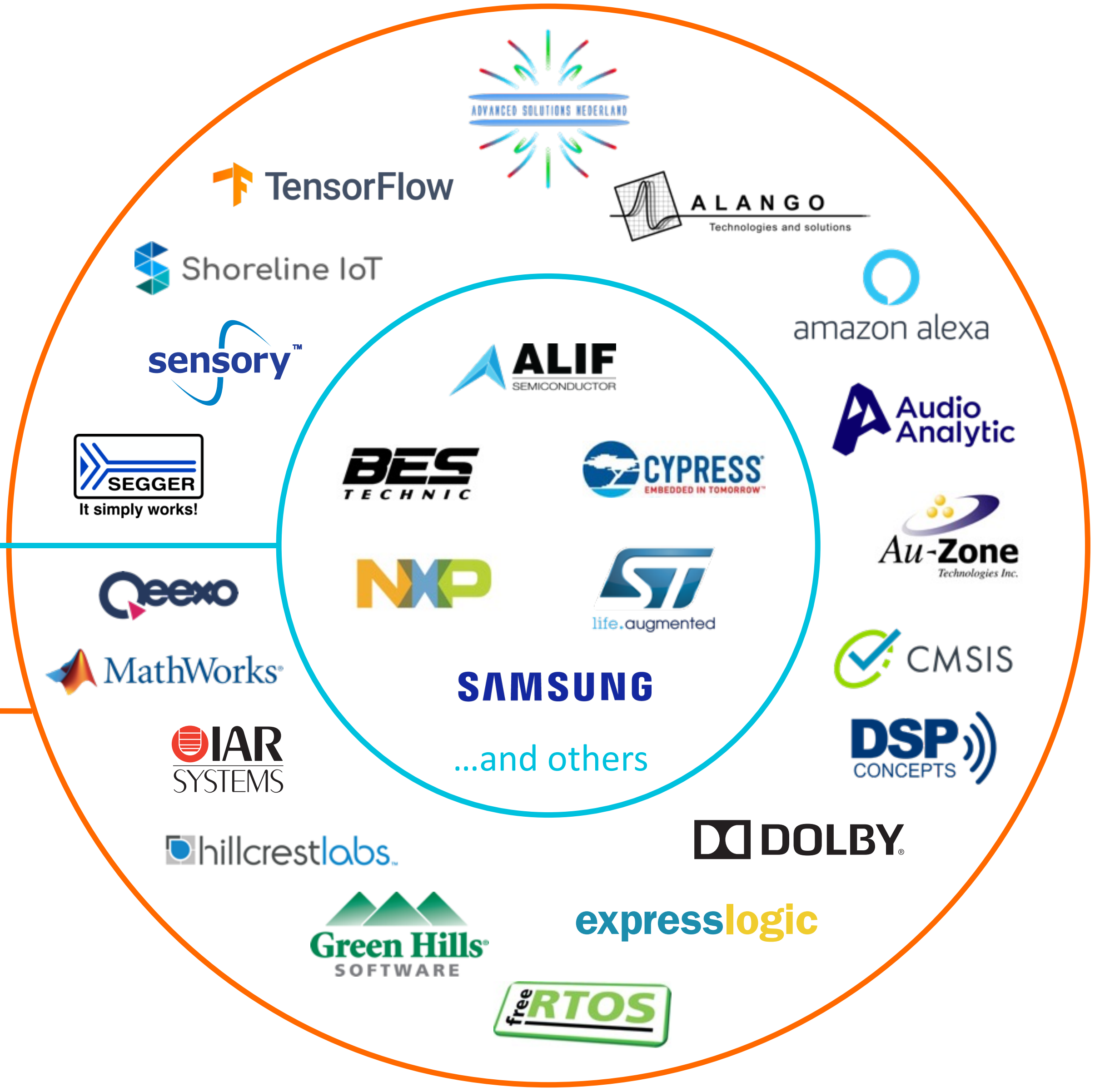
Arm Corstone-300

- ✓ Significant uplift in DSP/ML performance
- ✓ Meets efficiency needs of IoT endpoint
- ✓ Built-in system-wide security
- ✓ Unified toolchain enabling ease-of-use
- ✓ Simplified SoC and software development
- ✓ Industry-leading ecosystem

Industry-wide Effort: The Most Extensive AI Ecosystem

Significant silicon partner collaboration

Algorithm, software, tools and RTOS partners



Find Out More:

Cortex-M55: developer.arm.com/cortex-m55

Ethos-U55: developer.arm.com/ethos-U55

Corstone-300: developer.arm.com/corstone-300

Alternatively, get in touch with an expert to learn more:
pages.arm.com/cortex-M55-consultation

Thank You
Danke
Merci
谢谢
ありがとう
Gracias
Kiitos
감사합니다
धन्यवाद
شكرًا
תודה

arm