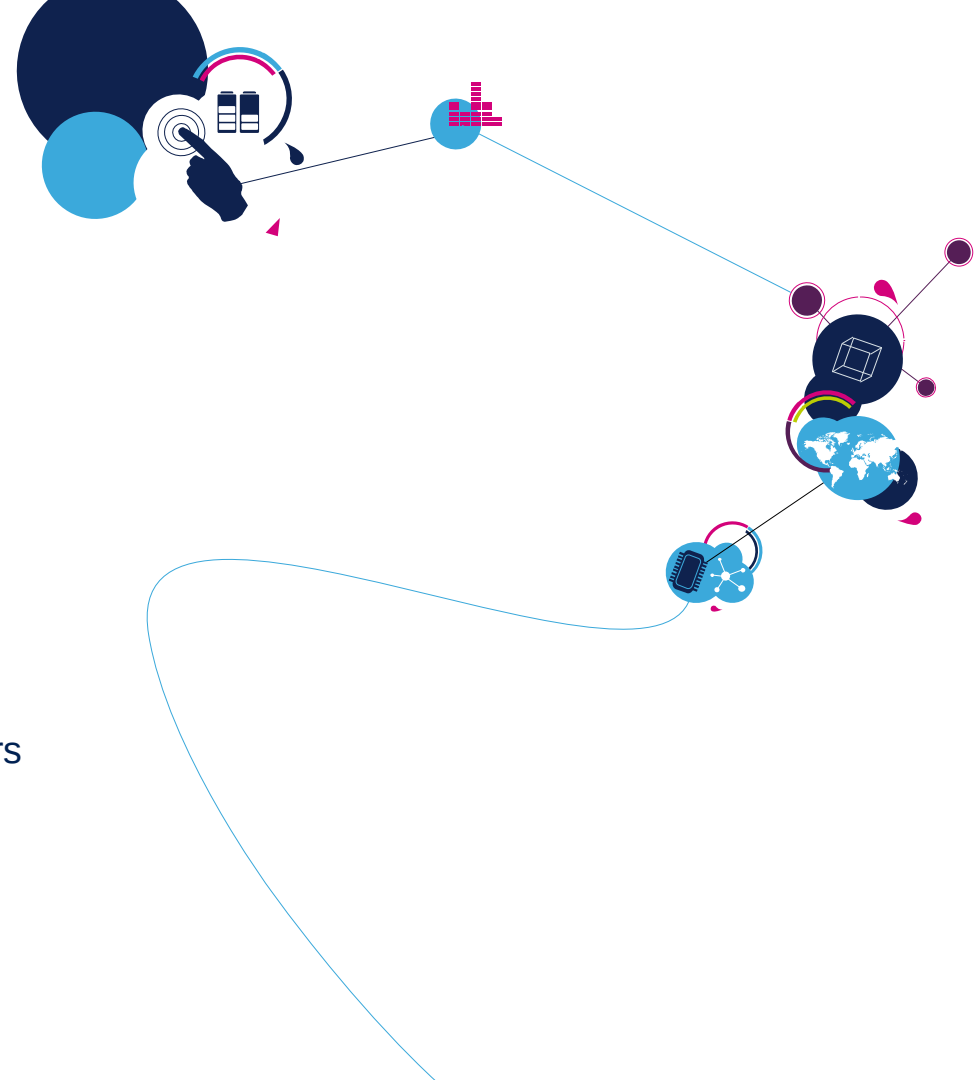

Microcontrollers

-Definition, Basics and Trends

Anders Pettersson
Technical Marketing Manager Microcontrollers
Nordic and Baltic

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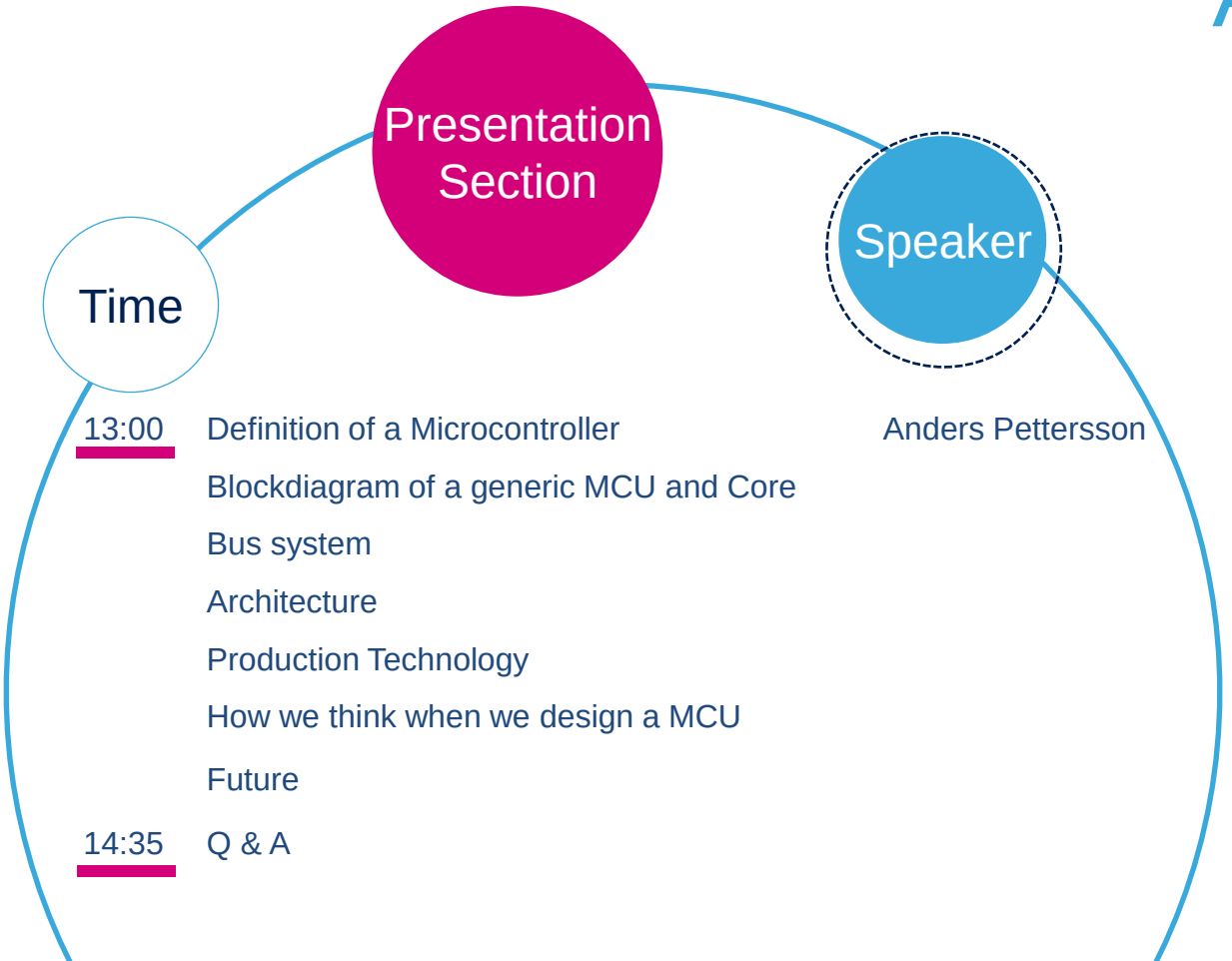
Agenda



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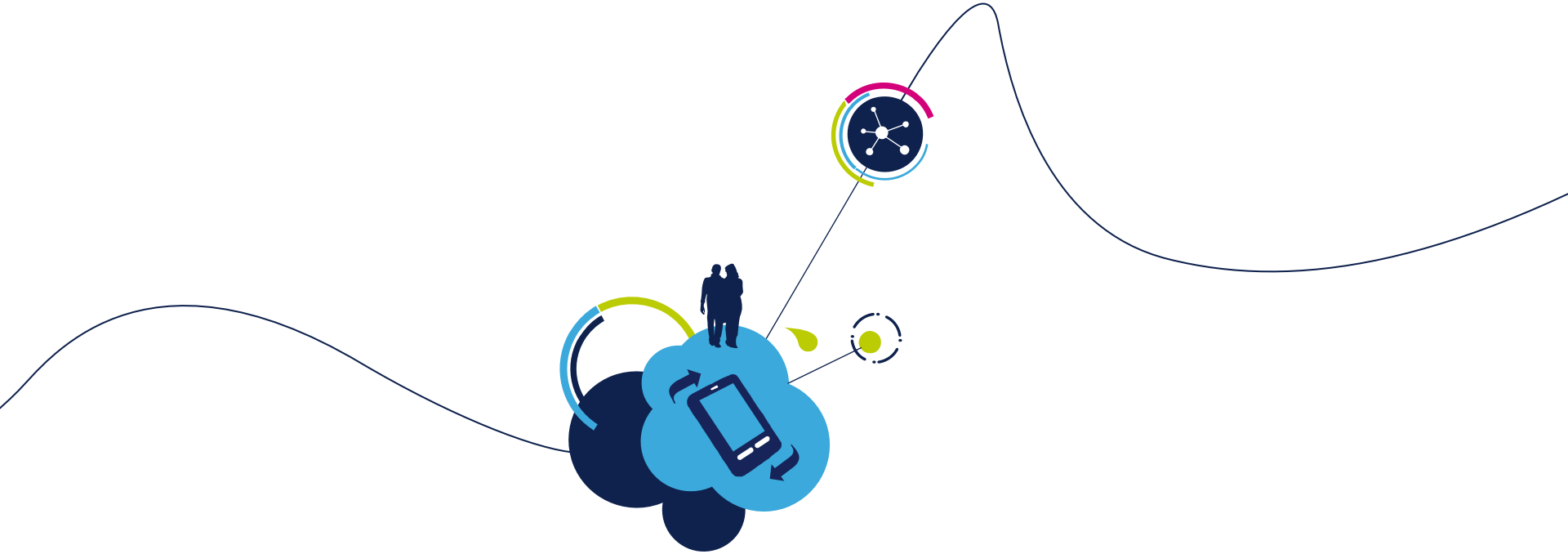
After the session you should have learnt..

- Know the difference between a MCU and a MPU and a CPU.
- Differences between a 8 bit and 32 bit MCU.
- Differences between Risc and Cisc architecture
- Differences between Harvard and Von Neuman Architecture
- Temporary production technologies



Definition of a Microcontroller

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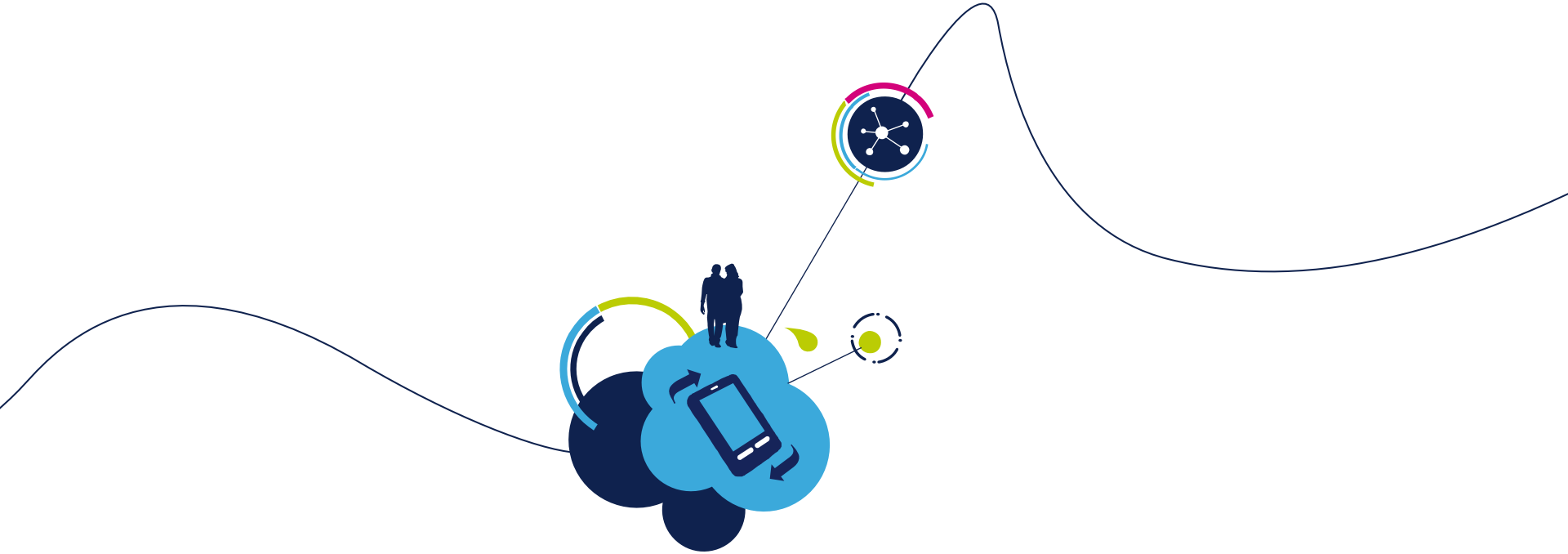
Definition of a Microcontroller

- What is the Definition of a Microcontroller?

- There is no absolut definition...

A **microcontroller** (sometimes abbreviated **µC**, **uC** or **MCU**) is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. Program memory in the form of NOR flash or OTP ROM is also often included on chip, as well as a typically small amount of RAM. Microcontrollers are designed for embedded applications, in contrast to the microprocessors used in personal computers or other general purpose applications.

....from Wikipedia



Architecture

Cisc and Risc

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CISC vs RISC

CISC

- Emphasis on HW
- Includes Multi-clock complex instructions
- Memory-to-memory: "LOAD" and "STORE" incorporated in instructions
- Small code sizes, high cycles per second
- Transistors used for storing complex instructions

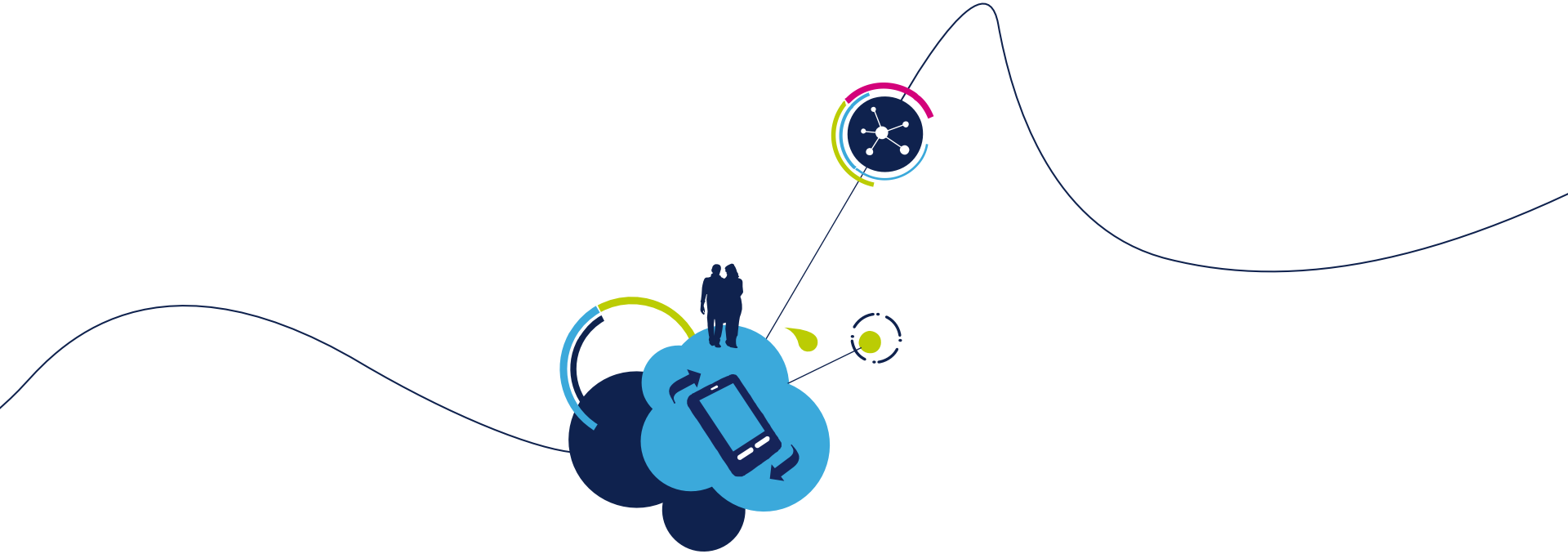
RISC

- Emphasis on SW
- Single-clock, reduced instructions only
- Register-to-register: "LOAD" and "STORE" and independent from instructions
- Low cycles per second, larger code size
- Spends more transistors on memory registers

Example: Multiply (MULT) , considered as a complex instruction

CISC: MULT 2:3, 5:2

RISC:
LOAD A, 2:3
LOAD B, 5:2
PROD A, B
STORE 2:3, A



Block diagram and the Core

Essential block diagram of a MCU

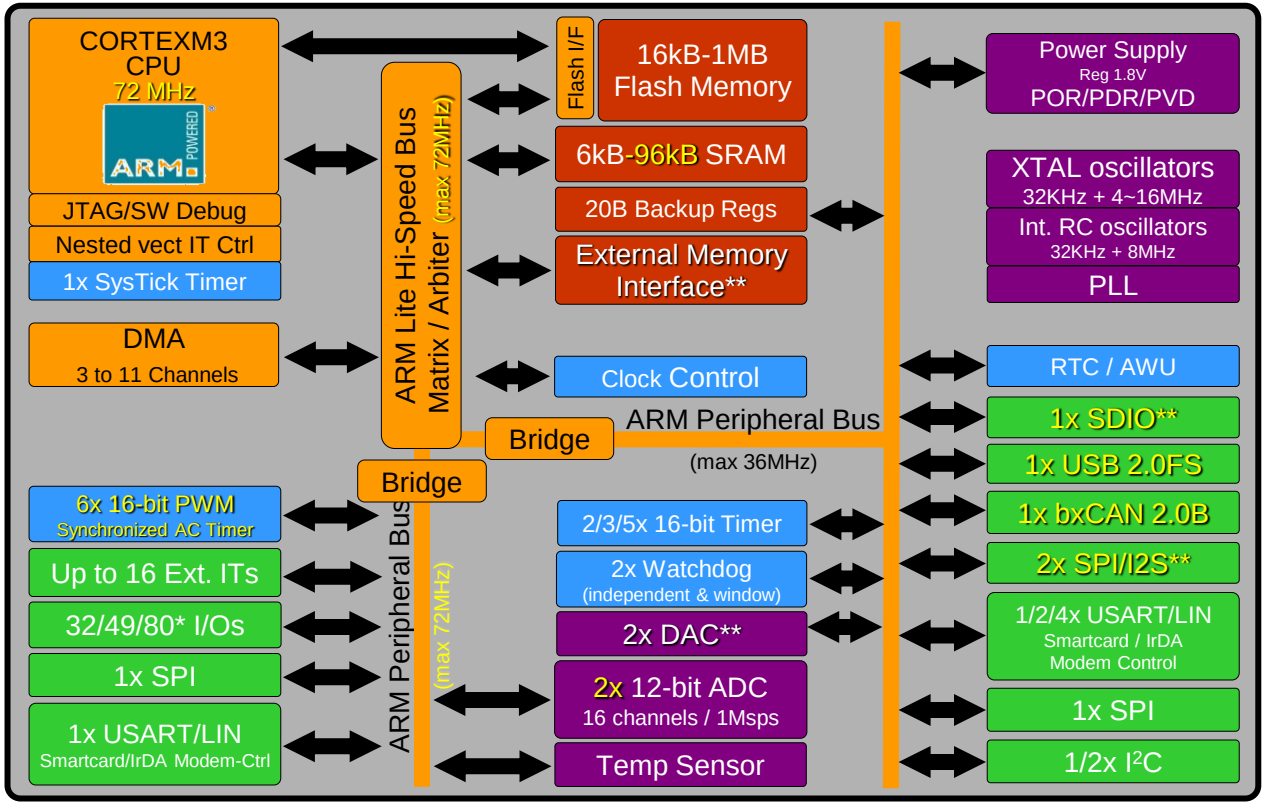
ROM (FLASH)

RAM

CPU

Clocks

Peripherals



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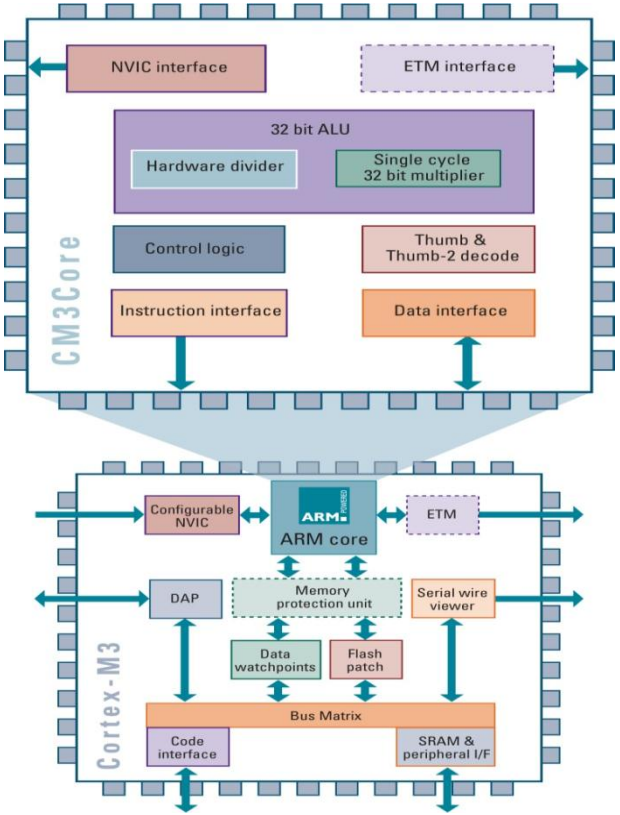
Cortex-M3 Microprocessor

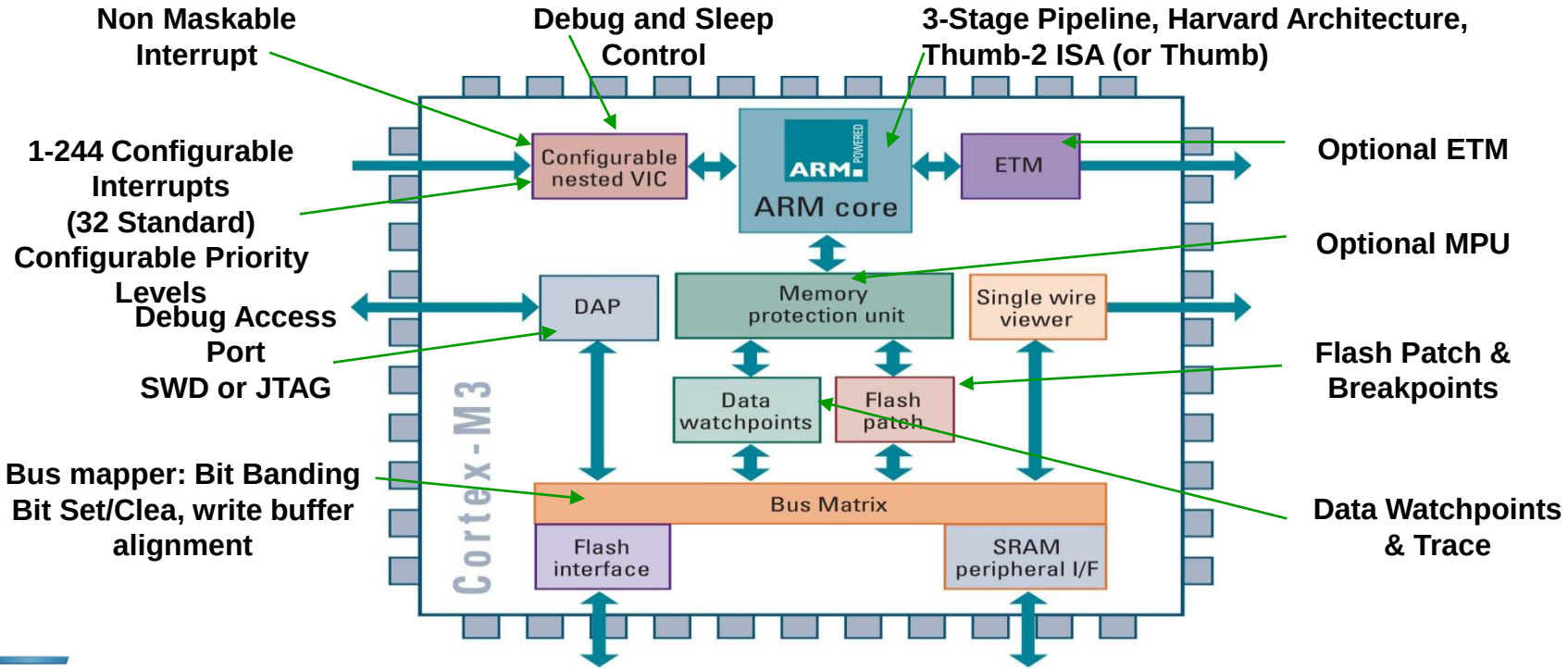
- Hierarchical processor integrating core and advanced system peripherals

- Cortex-M3 core
  - Harvard architecture
  - 3-stage pipeline w. branch speculation
  - Thumb®-2 and traditional Thumb
  - ALU w. H/W divide and single cycle multiply

- Cortex-M3 *Processor*
  - Cortex-M3 core
  - Configurable interrupt controller
  - Bus matrix
  - Advanced debug components
  - Optional MPU & ETM (Not available in STM32F10x)



Cortex-M3 Microprocessor



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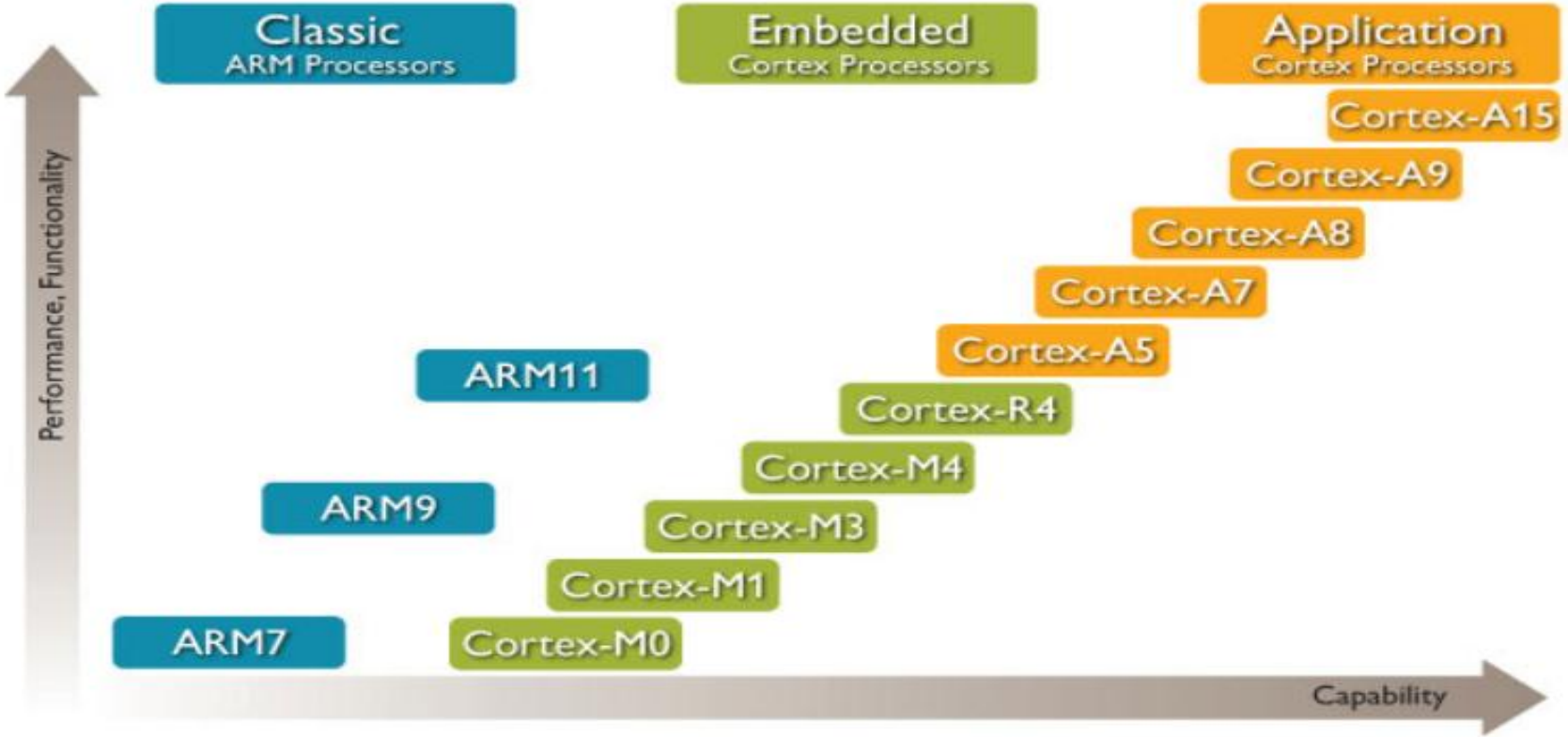
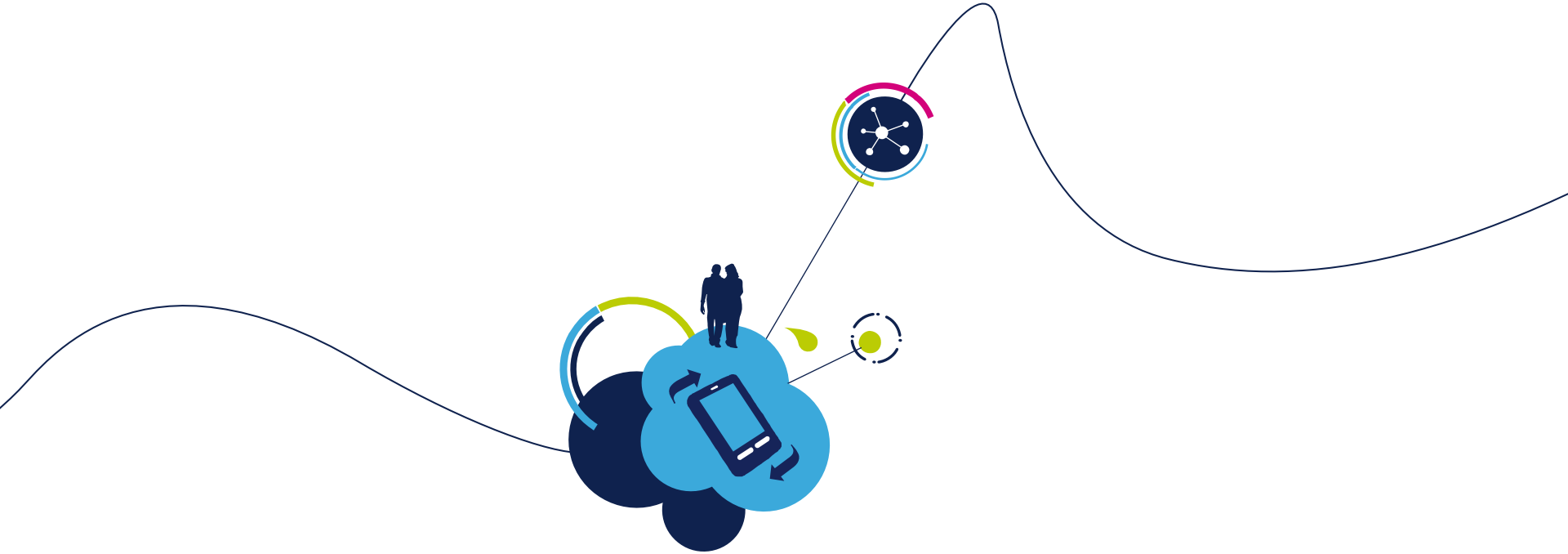
Processors for All Applications



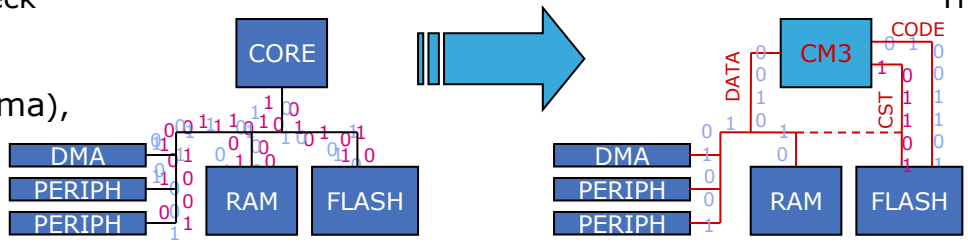


Bus system

Architecture of the bus

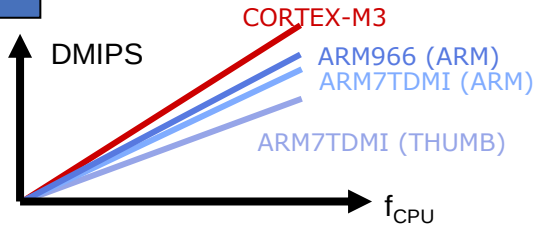
- Cortex M3 Architecture: Harvard benefits with Von Neumann single memory space

Von Neumann "bottleneck"
Single 32bit bus for:
- code execution,
- data transfer (core/dma),
- peripheral control



Three 32bit buses for a parallel
- code execution,
- data transfer (core/dma),
- peripheral control

- Outstanding efficiency of 1.25 DMIPS/MHz



- THUMB2 instruction set provides 32bit performance with 16bit code density

THUMB 16bit Instruction Set	Full THUMB compatibility
ARM 32bit Instruction Subset	Complete ARM instruction set for better performance
New 16/32bit Instructions	1 cycle MAC and Hardware Divide Unaligned data, Bit banding

THUMB-2

- Single POWERFUL instruction set → No more mode switching
- 25% smaller code
- 25% lower RAM requirement

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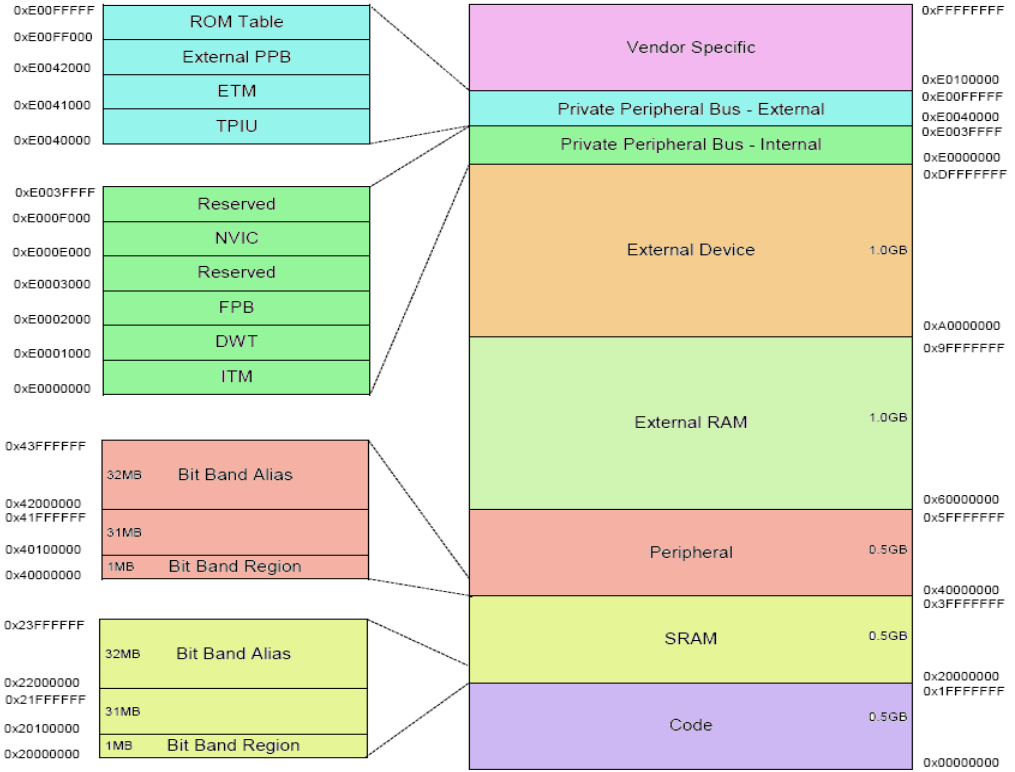
Cortex-M3 Memory Map

- **Vendor Specific (0.5GB)**
  - **Set aside to enable vendors to implement peripheral compatibility with previous systems**
- **Private Peripheral Bus (1M)**
  - **Address space for system components (CoreSight, NVIC etc.)**
- **External Device (1GB).**
  - **Intended for external devices and/or shared memory that needs ordering/non-buffered**
- **External RAM (1GB)**
  - **Intended for off chip memory**
- **Peripheral (0.5G)**
  - **Intended for normal peripherals. The bottom 1MB of the 32MB peripheral address space (0x40000000 – 0x400FFFFF) is reserved for bit-band accesses. Accesses to the peripheral 32MB bit band alias region (0x42000000 – 0x43FFFFFF) are remapped to this 1MB**
- **SRAM (0.5GB)**
  - **Intended for on-chip SRAM. The bottom 1MB of the SRAM address space (0x20000000 - 0x200FFFFF) is reserved for bit-band accesses. Accesses to the SRAM 32MB bit band alias region (0x22000000 – 0x23FFFFFF) are remapped to this 1MB address space.**
- **Code(0.5GB)**
  - **Reserved for code memory (flash, SRAM). This region is accessed via the Cortex-M3 ICode and DCode busses.**



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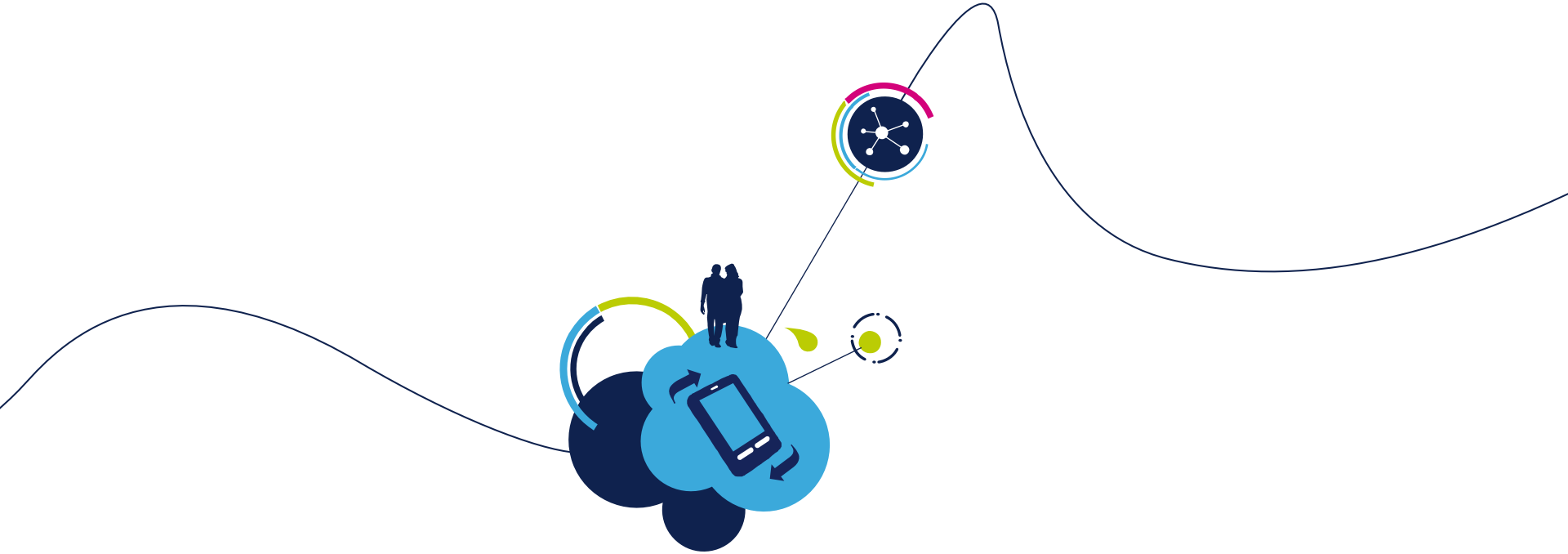

Production Technologies

- The road to success...

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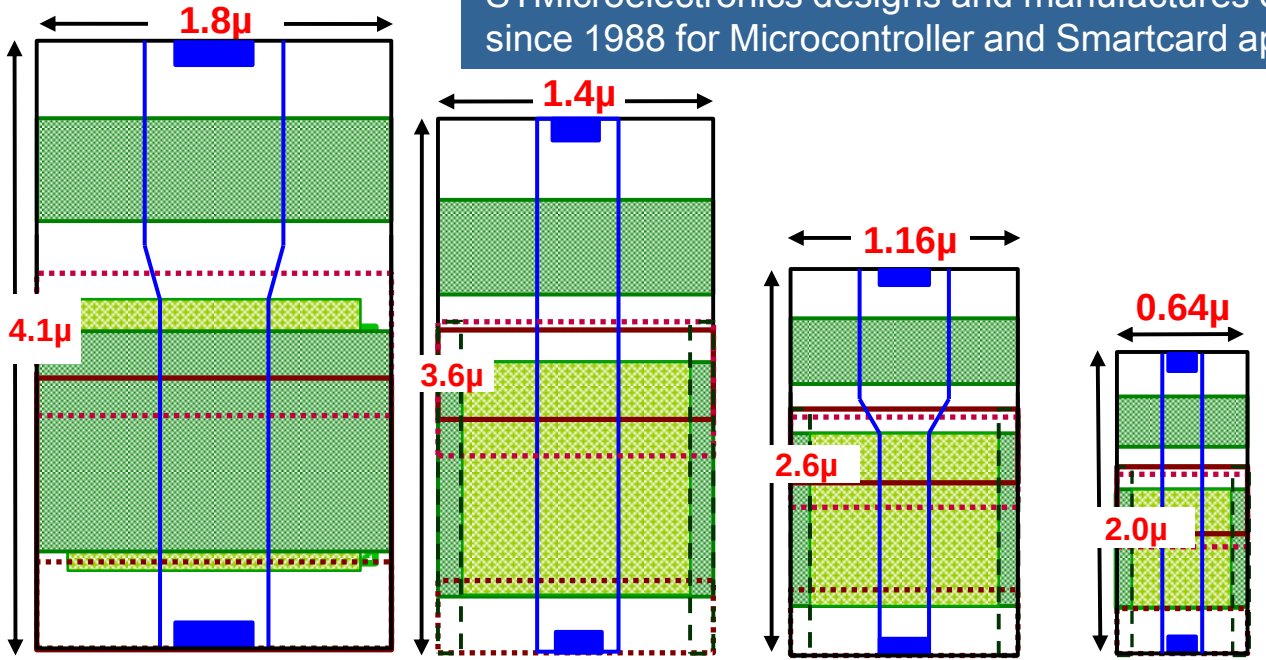
CMOSF9 eEEPROM Technology History

STMicroelectronics designs and manufactures embedded EEPROM products since 1988 for Microcontroller and Smartcard applications.



0.35µ
F6Y s=7.4µ²

0.18µ
F8 s=5.04µ²

0.15µ
F8N s=3.02µ²

0.13µ
F9 1.28µ²

Beside embedded EEPROM each technology node contains also a sister technology with embedded flash.

Today the 65nm node is being developed.

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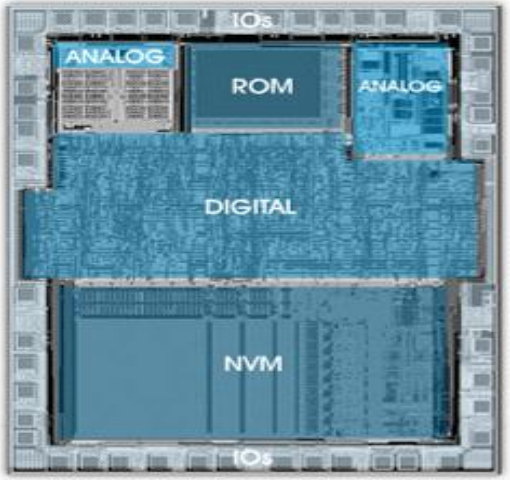
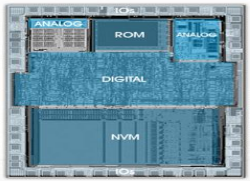
Technology to Break Price Barriers

- Technology driven development
- Breakthrough with 130nm lithography
- E^2 non-volatile memory, analog and digital peripherals

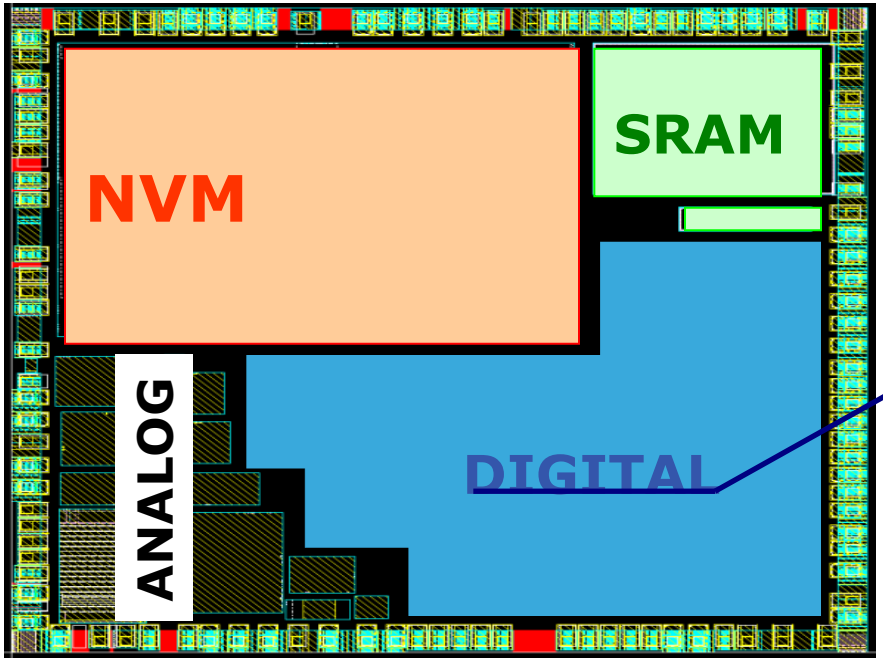
0,4µM



0,13µm



What part can be shrunk with production technologies?



Total digital bloc is **25% of the die size**

The CPU represents **30% of the digital area**

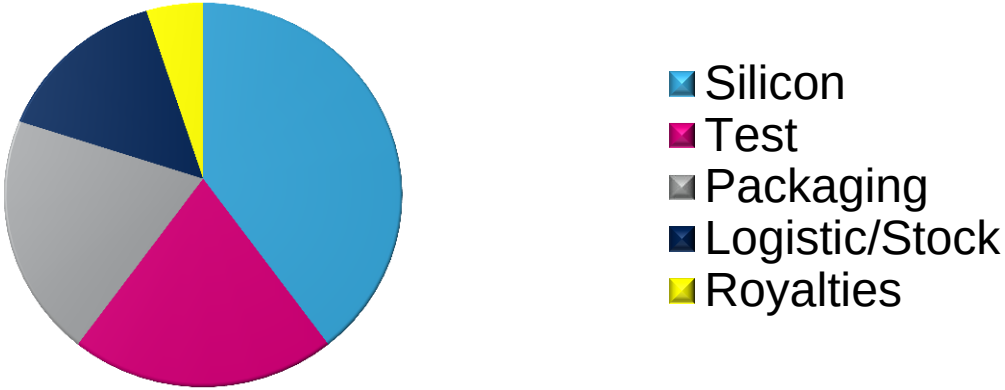
Cortex M0 is half gate count of M3 for the same configuration

Using M0 instead of M3 would lead to :

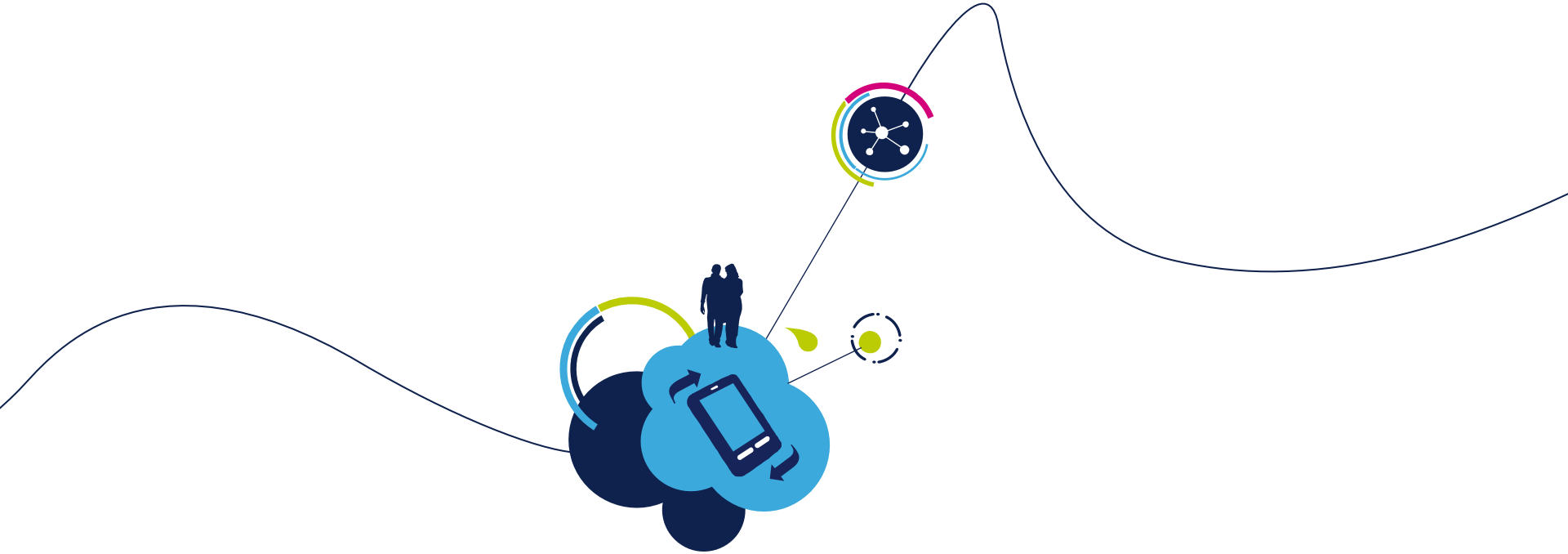
- **Less than 4% die area gain**
- **Less than 2% product cost gain**

Example of Cost Distribution for a MCU

Cost share



- Majority of the cost is not coming from the silicon itself
- The smaller the die size, the higher the non silicon cost
- Focusing all the innovation in the silicon is not the only way to decrease the cost



How do we think when we design a MCU?

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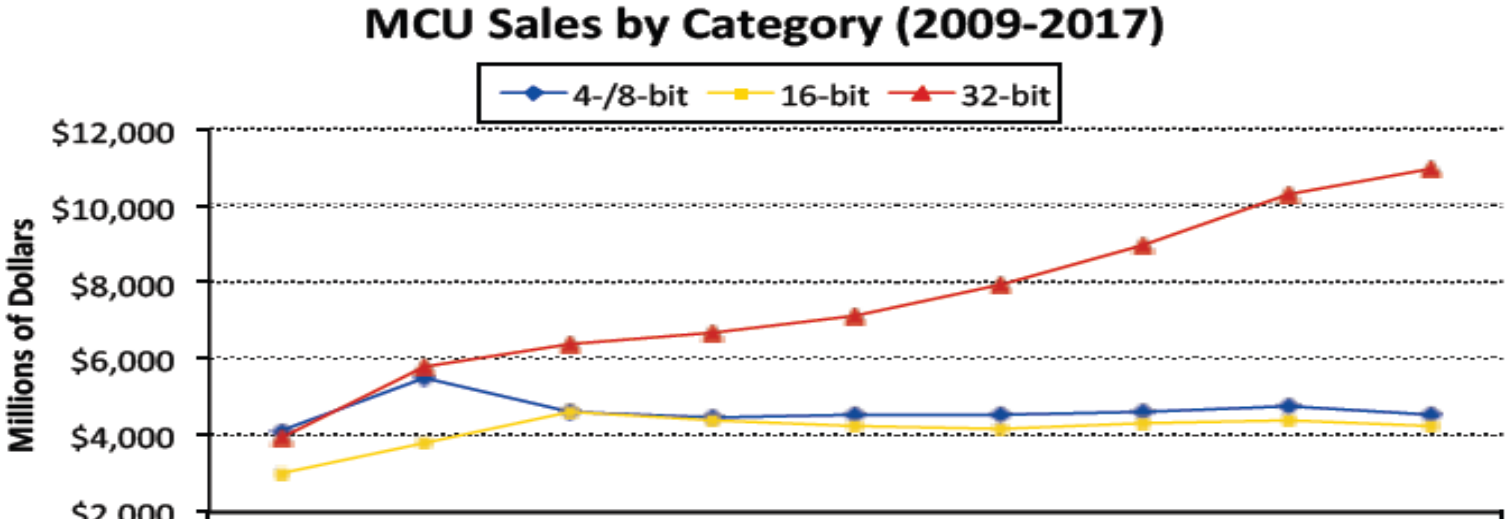
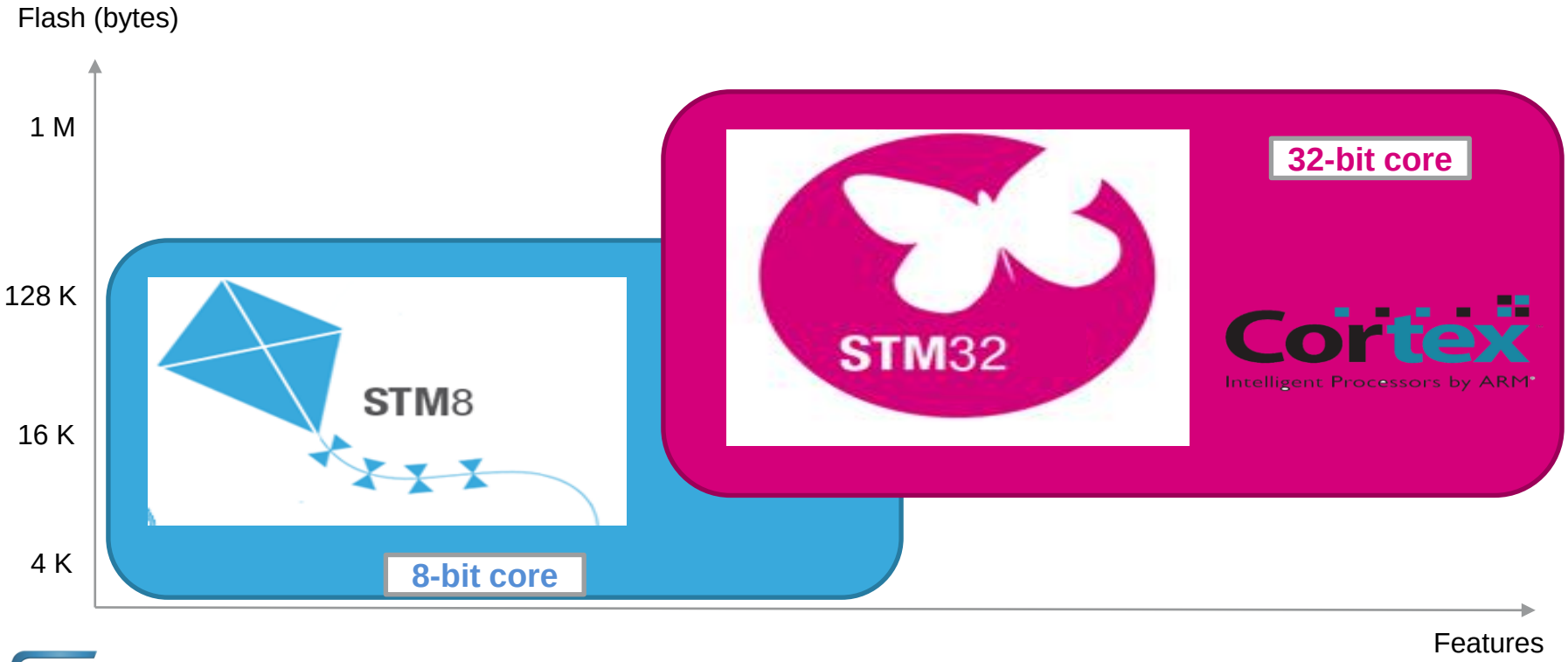
MCU market forecast



	09	10	11	12	13F	14F	15F	16F	17F
4-/8-bit	4,141	5,545	4,647	4,475	4,520	4,565	4,656	4,749	4,559
16-bit	3,020	3,841	4,648	4,383	4,251	4,209	4,293	4,422	4,245
32-bit	3,956	5,780	6,422	6,698	7,167	7,955	8,989	10,337	10,958

Source: IC Insights

ST MCUs – strategy



Minimal External Components

- **Built-in Supervisor reduces need for external components**
  - Filtered reset input, Power-On reset, Low-Voltage Detect, Brown-Out Detect, Watchdog Timer with independent clock
- **One main crystal drives entire system (with help from PLL)**
  - Inexpensive 4-16 MHz crystal drives CPU, USB, all peripherals
- **Embedded 8 MHz RC can be used as main clock**
  - Optional 32 kHz crystal needed additionally for RTC, can run on internal 40 kHz RC
- **Only 7 external passive components for base system on LQFP100 package!!**

ST has licensed all Cortex-M processors

- **Forget traditional 8/16/32-bit classifications and get**
  - Seamless architecture across all applications
  - Every product optimized for ultra-low power and ease of use

Cortex-M0	Cortex-M3	Cortex-M4
8/16-bit applications	16/32-bit applications	32-bit/DSC applications

Binary and tool compatible

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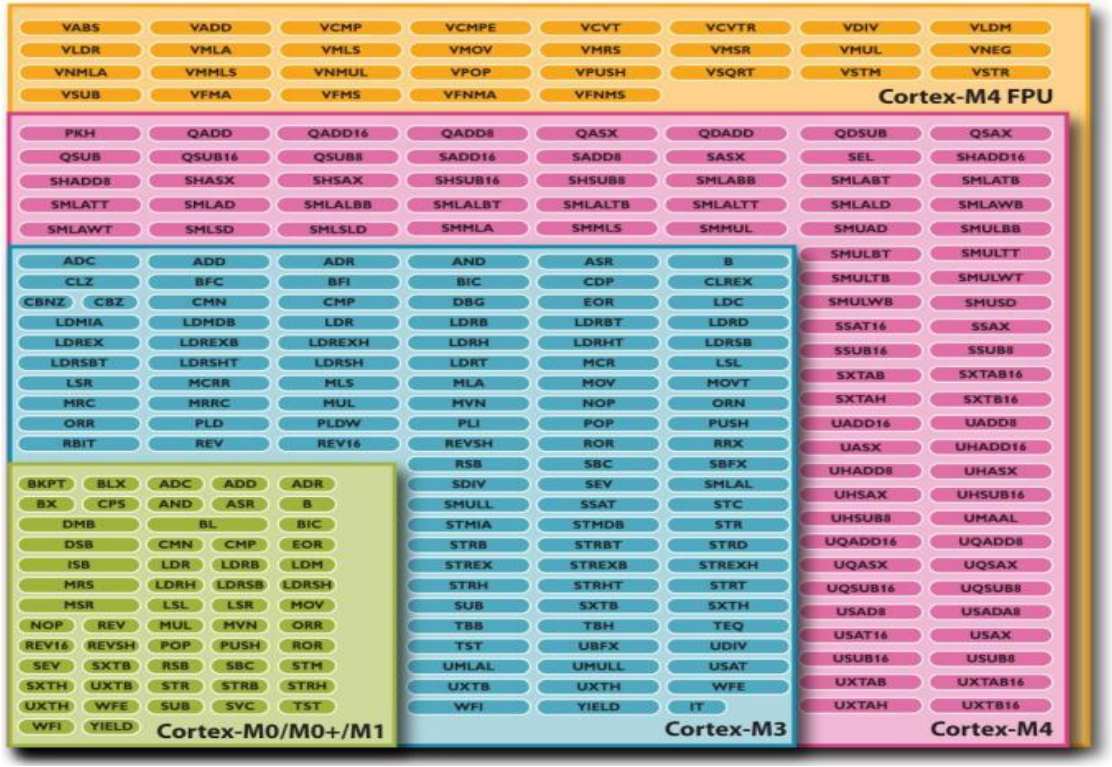
Cortex-M Powerful & scalable instruction set

Floating Point Unit

DSP (SIMD, fast MAC)

Advanced data processing
Bit field manipulations

General data processing
I/O control tasks



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ARM Cortex
Low-Power Leadership from ARM

STM32 – 7 product series

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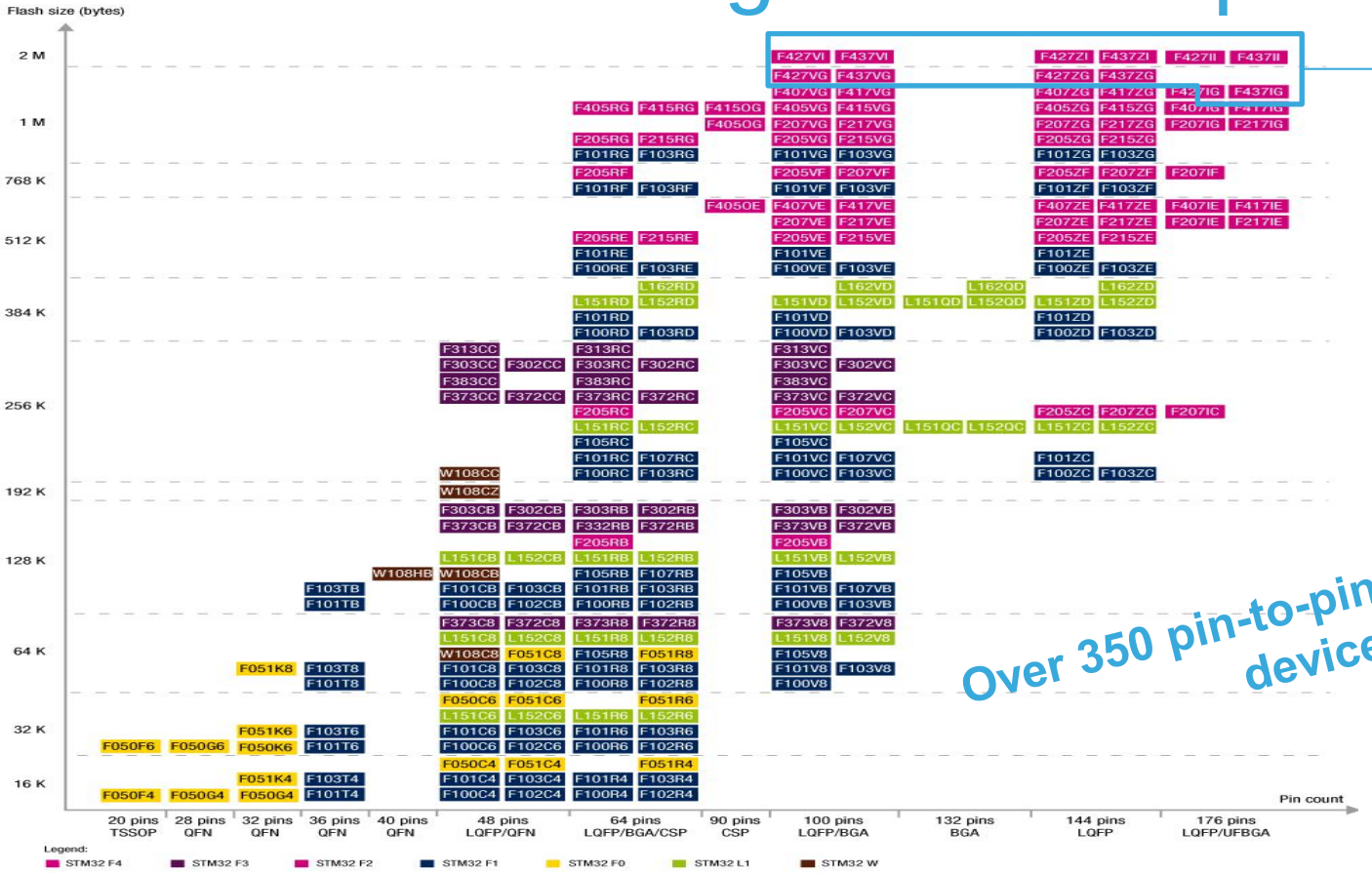
STM32 – leading Cortex-M portfolio



STM32 F4

NEW 2 MB

Over 350 pin-to-pin compatible devices

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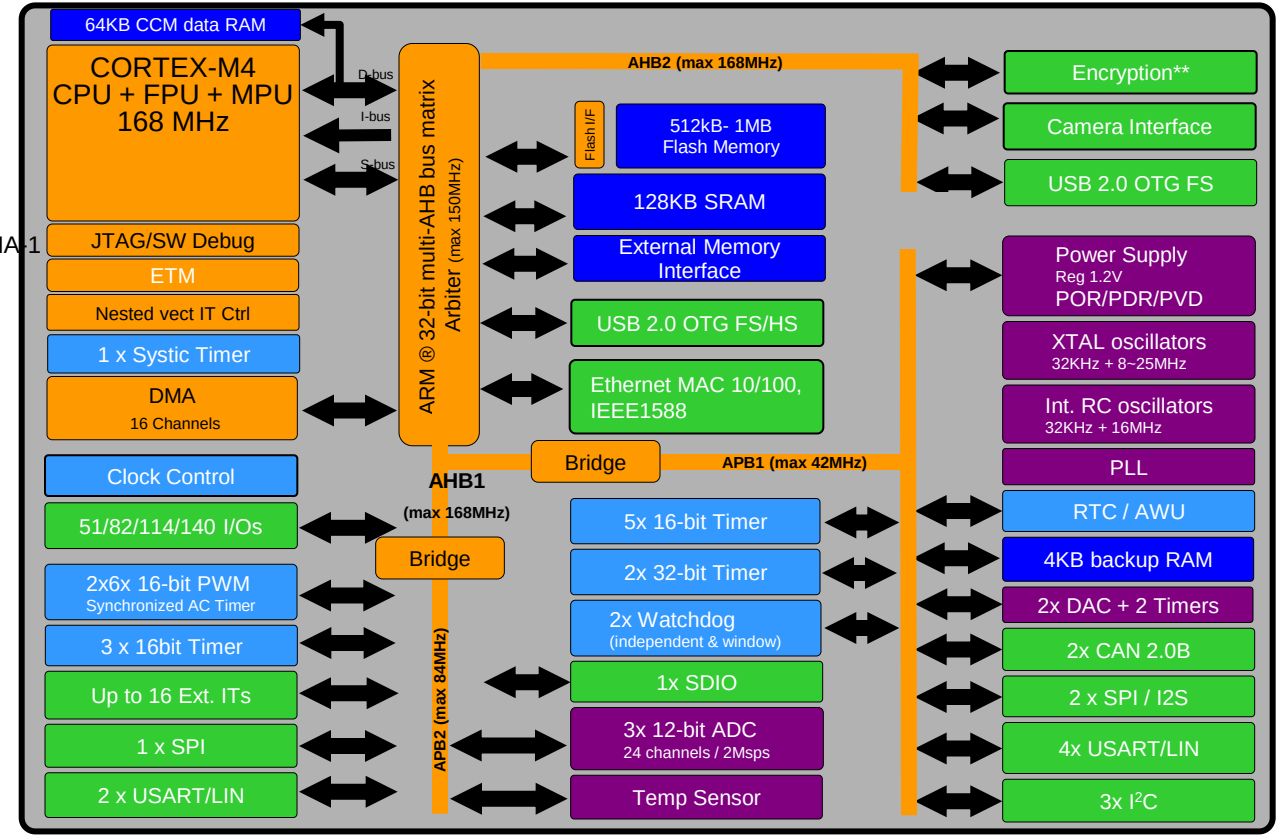
STM32F4xx Block Diagram

- **Cortex-M4 w/ FPU, MPU and ETM**
- **Memory**
  - Up to 1MB Flash memory
  - 192KB RAM including 64KB CCM data RAM
  - FSMC up to 60MHz
- **New application specific peripherals**
  - USB OTG HS w/ ULPI interface
  - Camera interface
  - HW Encryption**: DES, 3DES, AES 256-bit, SHA-1 hash, RNG.
- **Enhanced peripherals**
  - USB OTG Full speed
  - ADC: 0.416µs conversion/2.4Msps, up to 7.2Msps in interleaved triple mode
  - ADC/DAC working down to 1.8V
  - Dedicated PLL for I2S precision
  - Ethernet w/ HW IEEE1588 v2.0
  - 32-bit RTC with calendar
  - 4KB backup SRAM in VBAT domain
  - Pure 1% RC
  - 2 x 32bit and 8 x 16bit Timers
  - high speed USART up to 10.5Mb/s
  - high speed SPI up to 37.5Mb/s
- **RDP (JTAG fuse)**
- **More I/O:s in UFBGA 176 package**



HS requires an external PHY connected to ULPI interface,
** Encryption is only available on STM32F415 and STM32F417

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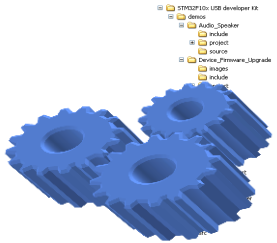
Free software solutions from ST



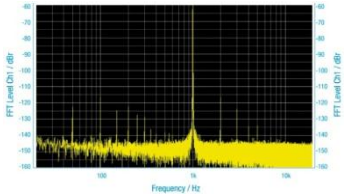
Standard Peripheral Library

USB device library

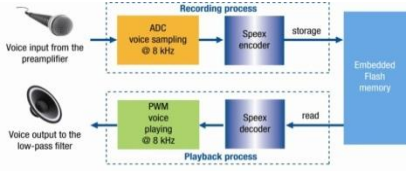
USB Host Library

Motor Control Library

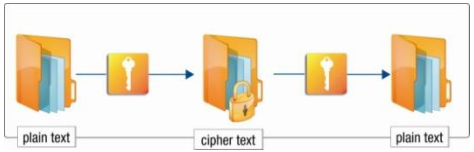
Self-test routines for EN/IEC 60335-1 Class B



DSP Library



SPEEX Codec



Encryption Library

STM32 Audio Engine

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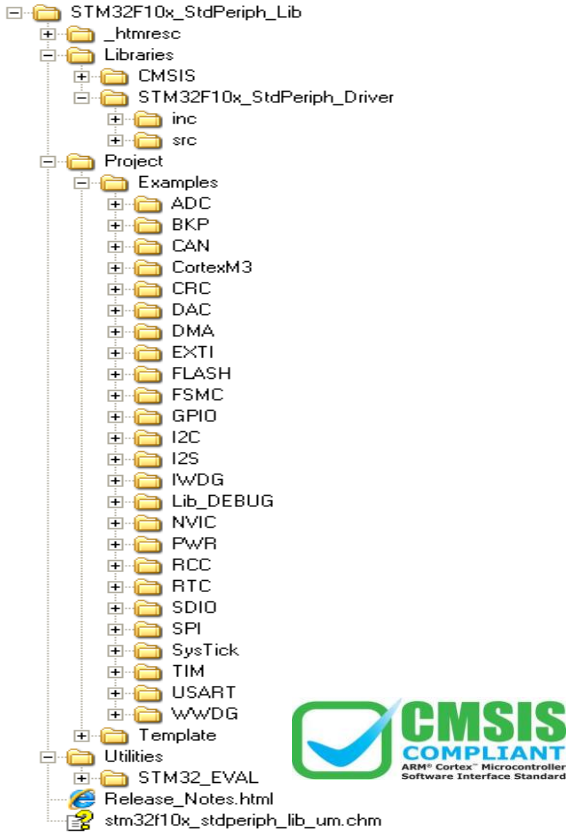
Software libraries – speed time to market

- **ST software libraries free at www.st.com/mcu**

  C source code for easy implementation of all STM32 peripherals in any application

  - **Standard library** – source code for implementation of all standard peripherals; code implemented in demos for STM32 evaluation board
  - **Motor control library –** sensorless vector control for 3-phase brushless motors
  - **USB Device Library** – Supporting HID,CDC, Audio, Mass Storage, DFU…)
  - **USB Host Library** – Supporting Mass Storage and HID
  - **DSP Library** – PID, IIR, FFT, FIR
  - **Graphics Library** – Drop down menus, radio buttons, sliders, …

- **Software Solutions for**
  - Ethernet TCP/IP
  - Bluetooth
  - SpeexCodec
  - And many others.



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Ecosystem

- Evaluation board for full product feature evaluation
  - **Hardware evaluation platform for all interfaces**
  - **Connection to all I/Os and all peripherals**

STM32303C-EVAL
STM32373C-EVAL
Available in Q4-2012

(For any support before please contact our local ST office)

STM32F3DISCOVERY
Available End Q3-2012

(For any support before please contact our local ST office)

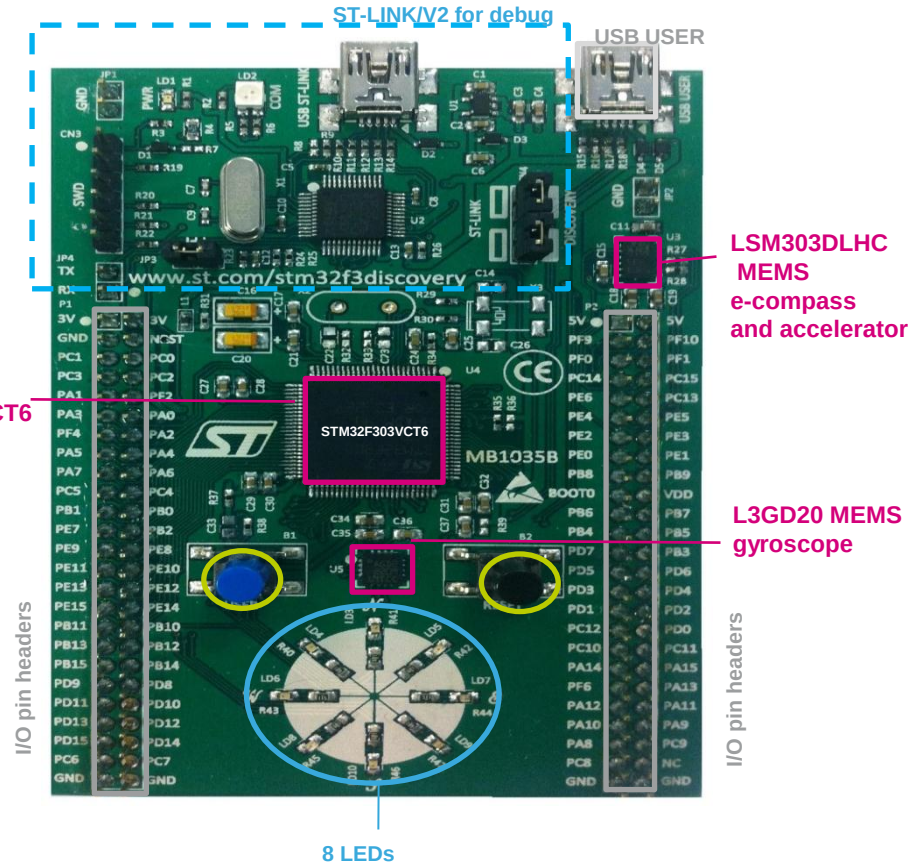
- Discovery kit for cost-effective evaluation and prototyping
- Large choice of IDE solutions from the STM32 and ARM ecosystem:

RAISONANCE Embedded Systems Development Tools · hitex DEVELOPMENT TOOLS · TASKING · SIGNUM SYSTEMS · atollic · i SYSTEM · Green Hills SOFTWARE

expresslogic · IAR SYSTEMS · KEIL Tools by ARM · LAUTERBACH DEVELOPMENT TOOLS · aiji SYSTEM 아이지시스템 · CMX SYSTEMS

STM32F3-Discovery kit

- Includes everything for a quick start with the STM32F3 for less than $11
- Ideal for evaluation, learning, prototyping
- The kit combines ST's STM32 F3 MCU with 9-axis MEMS sensors (gyroscope and e-compass),
  ready for 3D motion-sensing application development
- Dedicated web page:
  www.st.com/stm32f3discovery with SW example and documents



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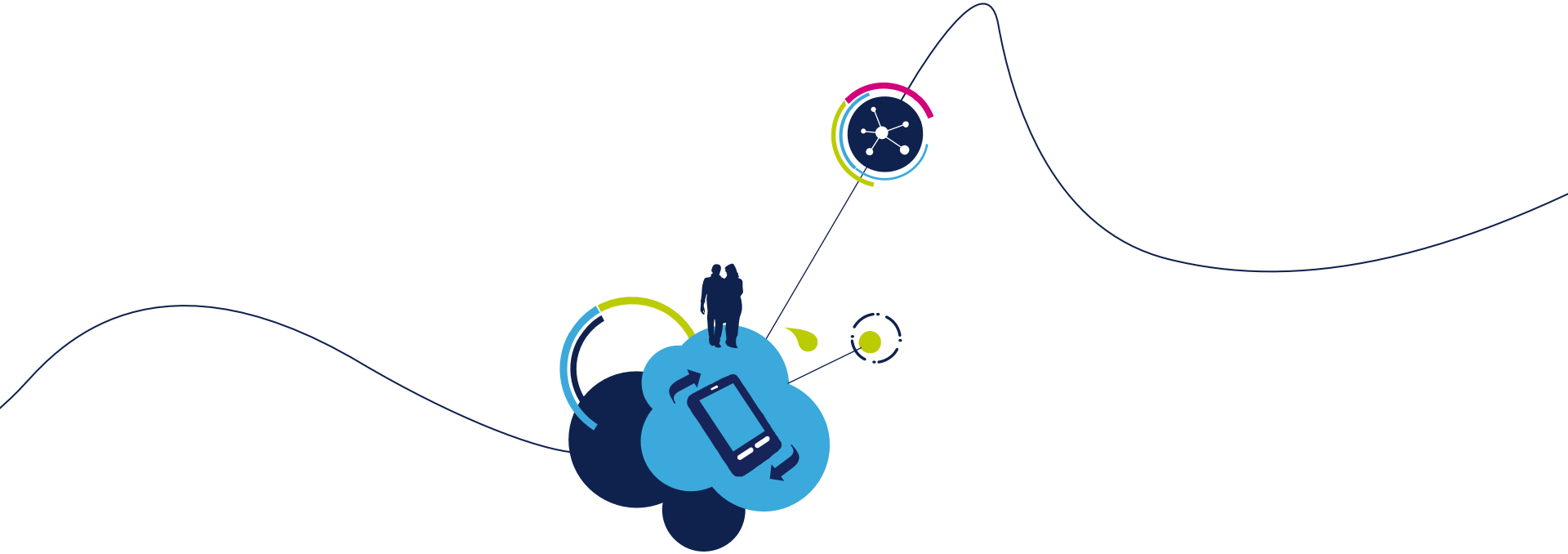

Future

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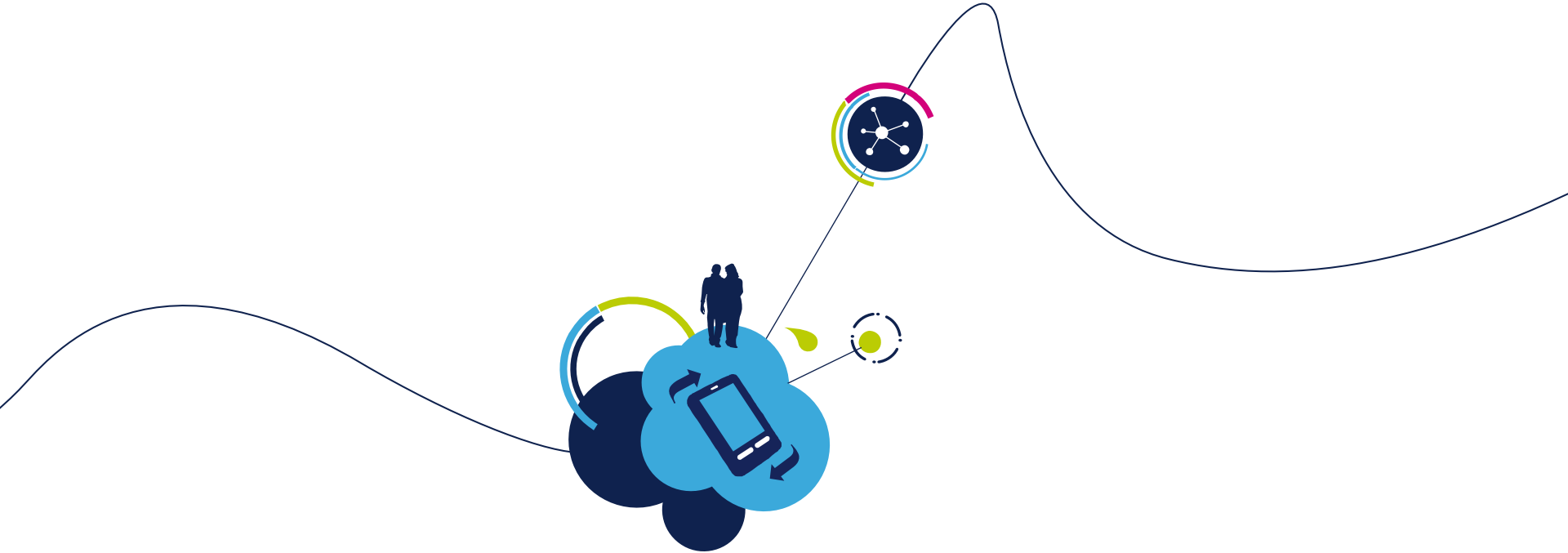
MCU Trends – a selection of topics

- Price → Technology
- Performance → Low Power and MIPS
- Memory size → Larger flash and RAM
- Peripheral Integration → analog, RF
- Industry standard cores → Cortex Mx
- Advanced Peripherals → USB Ethernet LCD SDRAM
- Predefined Libraries + RTOS → Abstraction from the hardware



Q & A

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Thank you

www.st.com/stm32