

CS301

Embedded System and Microcomputer Principle

Lecture 1: Introduction

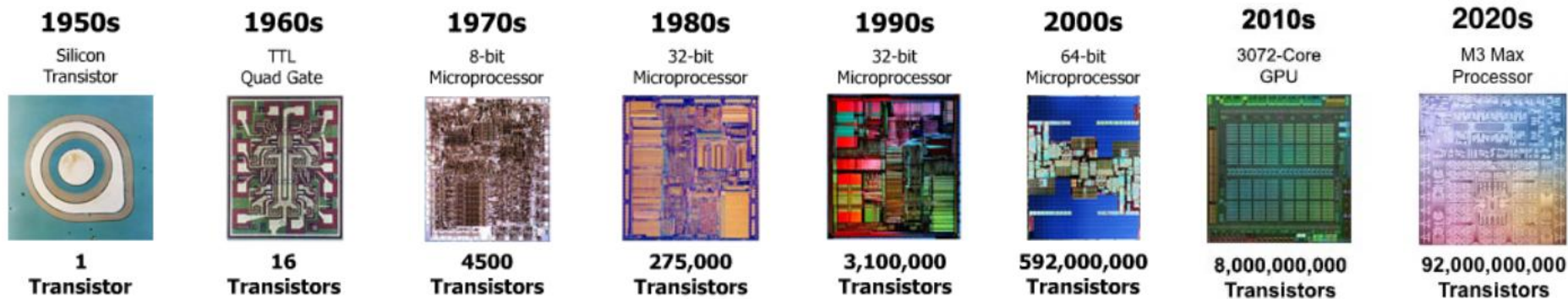
2024 Fall

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The Generations of Computers

- First Generation (1940s - 1950s)
 - **Vacuum Tubes**
- Second Generation (1950s - 1960s)
 - **Transistors**
- Third Generation (1960s - 1970s)
 - **Integrated Circuits**
- Fourth/Now Generation (1970s - Present)
 - **Microprocessors**

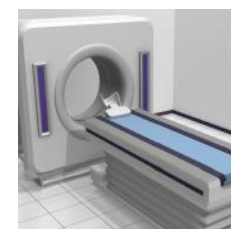
MOORE'S LAW "Transistor density on integrated circuits doubles about every two years." *



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Transistor Evolution

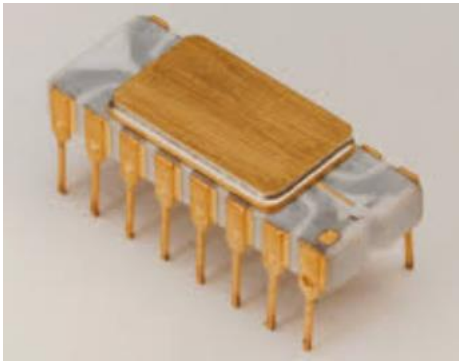
- Scaling option #1 (component driven scaling)
 - Microprocessors, GPUs
 - Pre-2005: Deeper pipelines, more complex logic for instruction level parallelism, more cache
 - 2005- : More cores, more cache
 - Memory chips
 - Keep increasing capacity
- Scaling option #2 (system driven scaling)
 - SoC
 - Integrate more and more system functions onto a chip



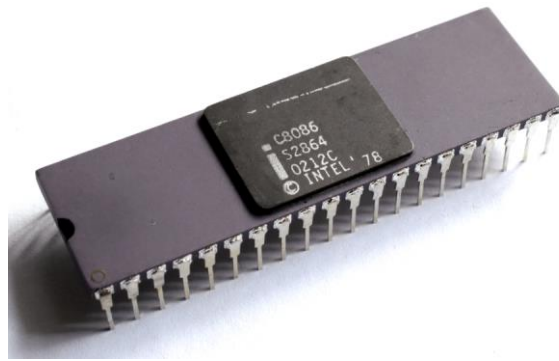
98% of “computing” systems are embedded

MPU, MCU, SOC

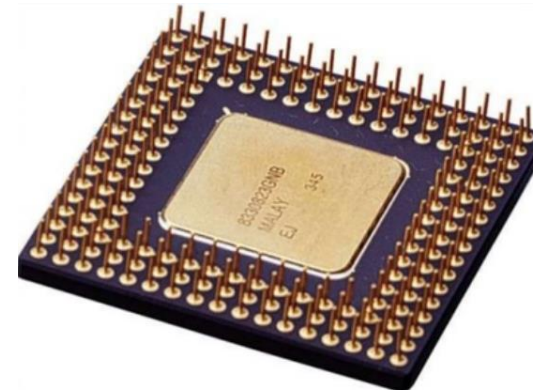
- Microprocessor (MPU)
 - A computer processor where the data processing logic and control is included on a single integrated circuit.



4-bit Intel 4004
First monolithic
microprocessor
1971



Intel 8086 First
16 bit
microprocessor
1978



Bellmac 32
First 32 bit
microprocessor
1980



AMD Opteron
First 64 bit x86
microprocessor
2001

MPU, MCU, SOC

- Microcontroller (MCU)



TI TMS 1000
First high volume
microcontroller



PIC16F877A
One of the most
popular MCU



ATmega328P
The chip at the heart of
the Arduino Uno

MPU, MCU, SOC

- System on a chip (SoC)
 - A system on a chip is an integrated circuit that integrates all or most components of a computer or other electronic system.
 - An SoC integrates an MCU, MPU or perhaps several processor cores with peripherals like a GPU, WiFi and cellular network radio modems, and/or one or more coprocessors all on a single substrate or microchip
 - An SoC can be seen as integrating an MCU with more advanced peripherals.

1974: DIGITAL WATCH IS FIRST SYSTEM-ON-CHIP INTEGRATED CIRCUIT

THE MICROMA LIQUID CRYSTAL DISPLAY (LCD) DIGITAL WATCH IS THE FIRST PRODUCT TO INTEGRATE A COMPLETE ELECTRONIC SYSTEM ONTO A SINGLE SILICON CHIP, CALLED A SYSTEM-ON-CHIP OR SOC.



A System-On-Chip (SOC) integrated circuit incorporates all the electronic components, including analog and interface circuitry, required to implement a system on a single chip. The first SOC solution evolved from the \$2,100 Hamilton Pulsar "Wrist Computer" digital watch unveiled on the Johnny Carson Show in 1970. Designed by George Thiess and Willy Crabtree at Electro-Data, Inc., the watch containing 44 chips and 4,000 bonding wires was notoriously unreliable until RCA engineers reduced the timekeeping circuitry to one chip. External transistors were still required to drive power-hungry light emitting diode.

Microma Watch
First SoC



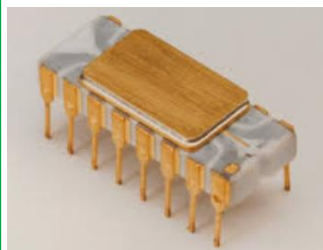
AMD286ZX/LX
First Largescale SoC

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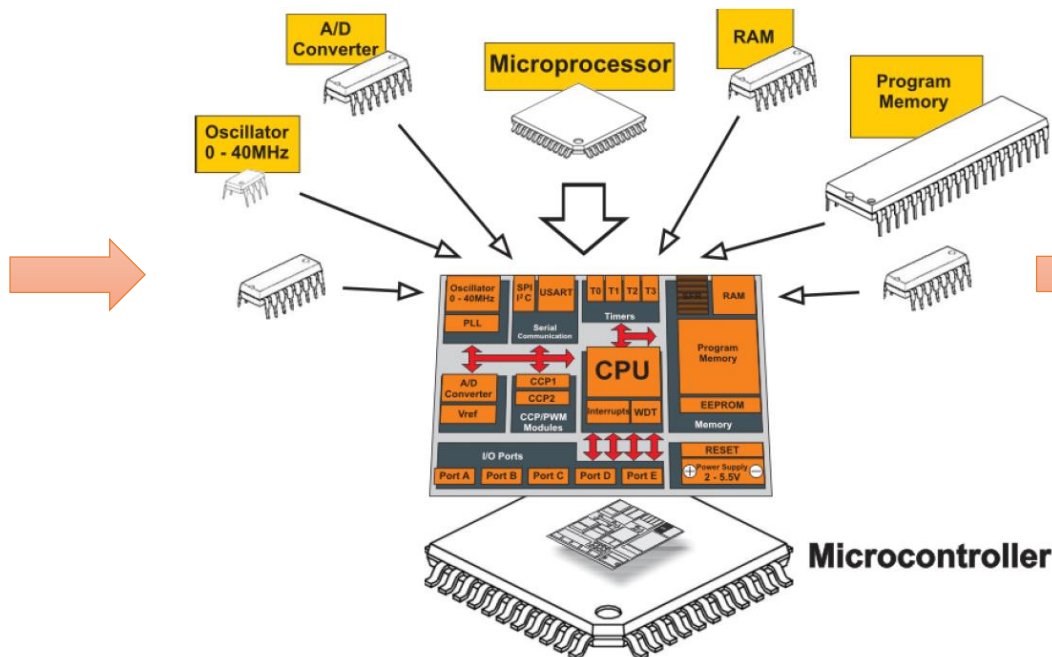


Apple M1
First Apple Silicon Mac

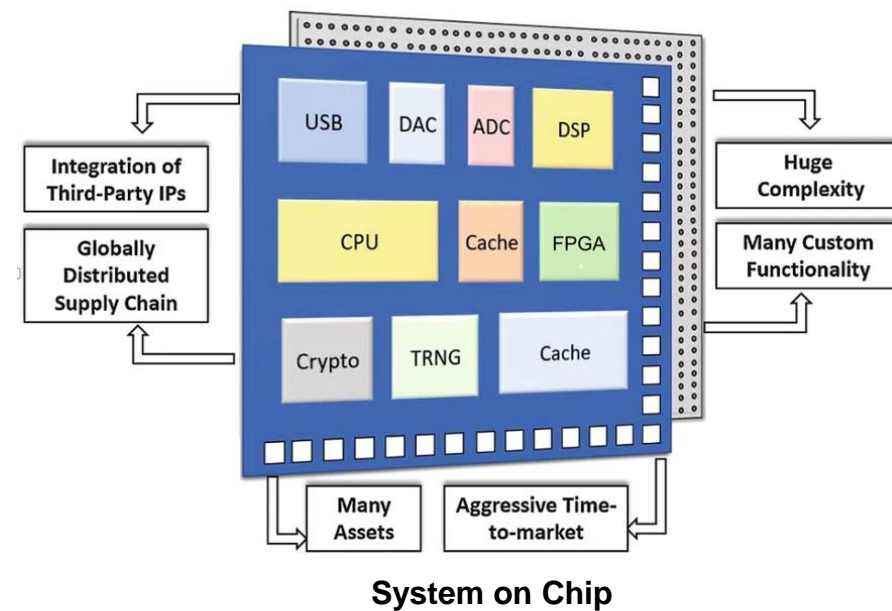
MPU, MCU, SOC



Microprocessor



Microcontroller



System on Chip

• CPU:

- Is a single processor core
- Used for general purposes
- It needs to be supported with memories and IOs

• MCU:

- Typically has a single processor core.
- Has memory blocks, basic IOs, and other basic peripherals
- Mainly used for basic control purposes, e.g., embedded applications

• SoC:

- Single or multiple processors
- Larger memory blocks, a variety of IOs, and other peripherals
- Integrated with more powerful blocks, e.g., GPU, DSP, FPGA
- Capable of running OSs
- Mainly used for advanced applications (e.g., smartphones, tablets).

What is Embedded System?

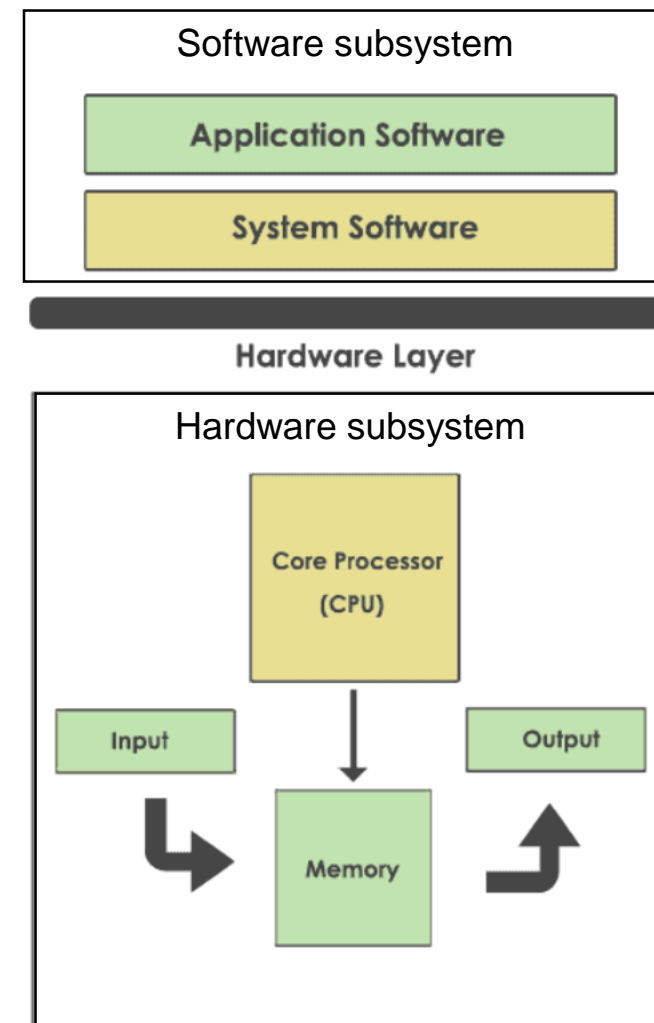
- An embedded system is designed to handle a particular task.
 - e.g, washing machines, electronic shavers, digital cameras, air conditioning etc.
- However, some embedded devices may perform variety of functions.
 - such as a Smartphone, Digital TV etc.
- “Embedded systems are information processing systems that are embedded into an **enclosing product**”
 - Peter Marwedel, *Embedded System Design*
 - Main reason for buying is **not** information processing

Market	Embedded Device Example
Home	Washing Machine
	Refrigerator
	Microwave Oven
	Thermostat/Central heating controller
	Electronic Shaver
Automotive	Clusters
	Ignition control
	Braking System
	Engine Control
Office and Commerce	Printer
	Photocopier
	Coffee Machine
Medical	Infusion pumps
	Blood Pressure Monitor
	Dialysis machine
Industrial	Robotics
	Industrial Motors
	Elevator Control
	Energy Meter and Smart Grid
Consumer Electronics	Digital Television
	Cellphone/PDA/Pagers
	Set-Top Box
	Digital Watch
	Toys/games
Networking	Routers
	Gateways
	Hubs

What is Embedded System?

- “An embedded system is an application that contains at least one **programmable computer** ... and which is used by individuals who are unaware that the system is computer-based.” -- Michael J. Pont, *Embedded C*
 - Programmable computers require programs -- embedded software
- The main loop of an embedded system software:

```
while (1) {  
    // Embedded Program  
}
```



General vs. Embedded Computer System

- General Computer System

- Microprocessor
- Large Primary Memory
- (RAM, ROM, Cache)
- Large Secondary Memory
- (HDD, SSD)
- Operating System (OS)
- General purpose user interfaces and application software.



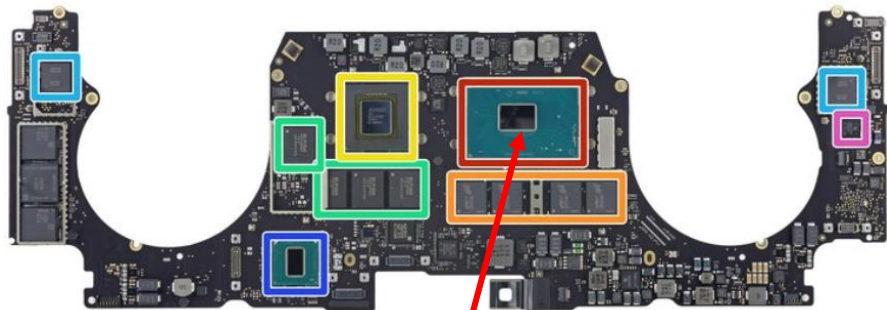
- Embedded Computer System

- Hardware that includes the core and necessary I/O for a specific function.
- Embeds main application software into embedded Flash.
- Embeds (not necessary) a real time operating system (RTOS) which supervises the application software tasks running on the hardware.



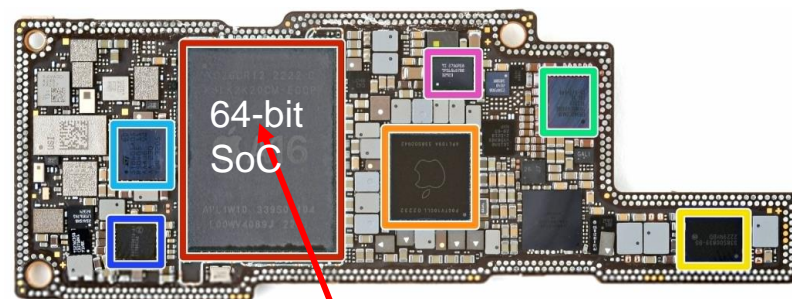
Teardown of MacBook vs iPhone 14

Macbook



- Intel [Core i7-6700HQ](#) 2.6 GHz (up to 3.5 GHz) quad-core processor
- Micron [MT52L1G32D4PG-093](#) 4 GB LPDDR3 (four chips for 16 GB total)
- AMD Radeon Pro 450 GPU
- Elpida (Micron) [EDW4032BABG-70-F](#) 512 MB GDDR5 RAM (four chips for 2 GB total)

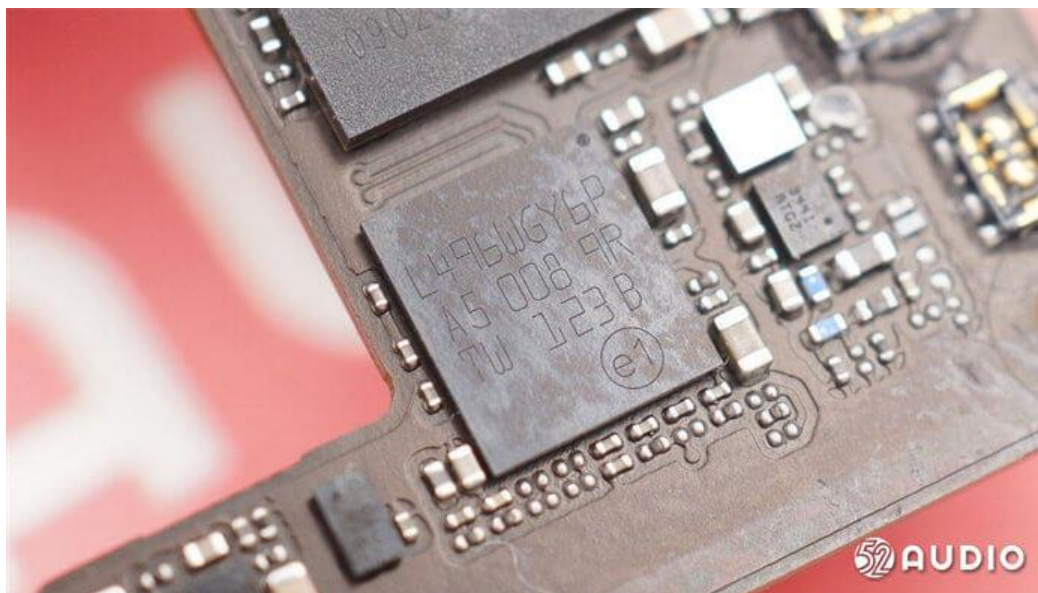
iPhone 14



- Apple APL1W10/339S01104 A16 64-bit hexa-core applications processor w/ penta-core GPU layered underneath most likely Samsung K3LK2K20CM-EGCP 6 GB LPDDR5 SDRAM memory
- Apple APL109A/338S00942 power management
- Apple/Dialog Semiconductor 338S00839-B0 power management

Apple AirPods

- On Charge Station: STM32L496: ARM Cortex-M4 32-bit MCU+FPU



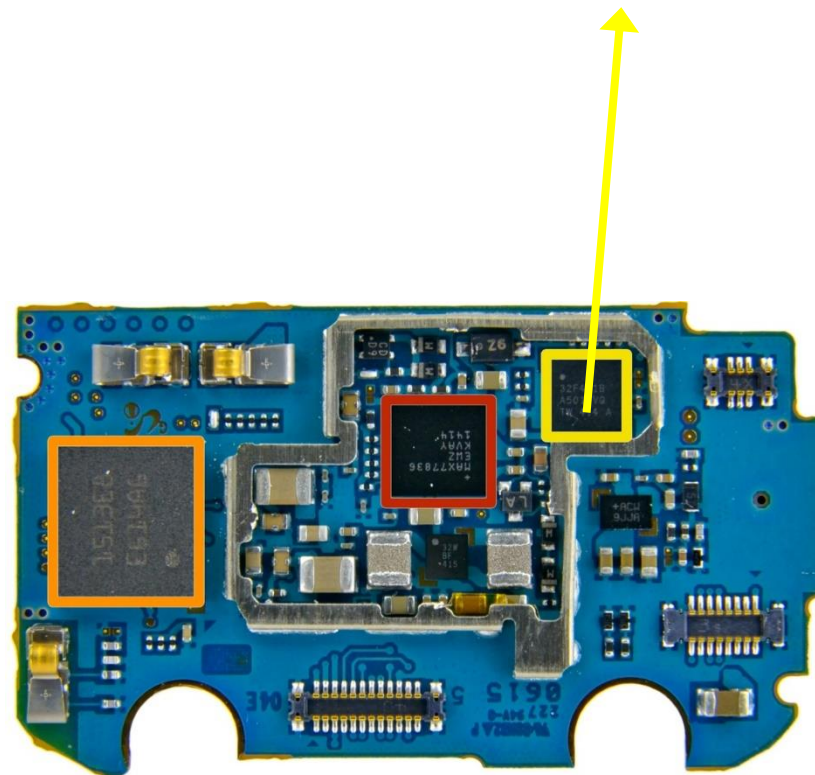
Apple TV

- ST Microelectronics STM32L 151QD ultra-low-power ARM Cortex-M3 MCU



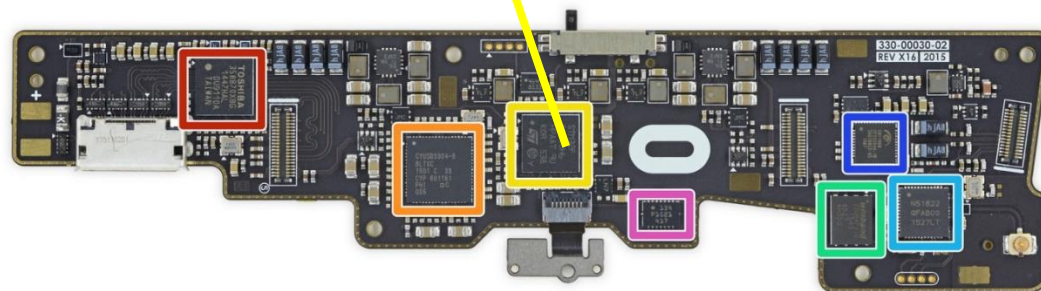
Samsung Galaxy Gear

- STMicroelectronics STM32F401B ARM-Cortex M4 MCU with 128KB Flash



Oculus VR

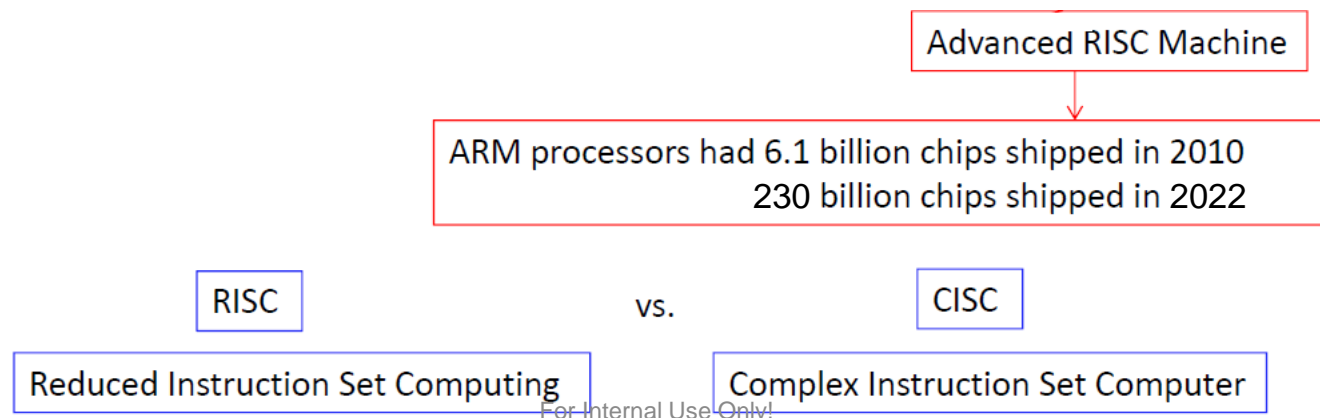
- Facebook's \$2 Billion Acquisition Of Oculus in 2014
- ST Microelectronics STM32F072VB ARM Cortex-M0 32-bit Microcontroller



ARM based Microcontroller



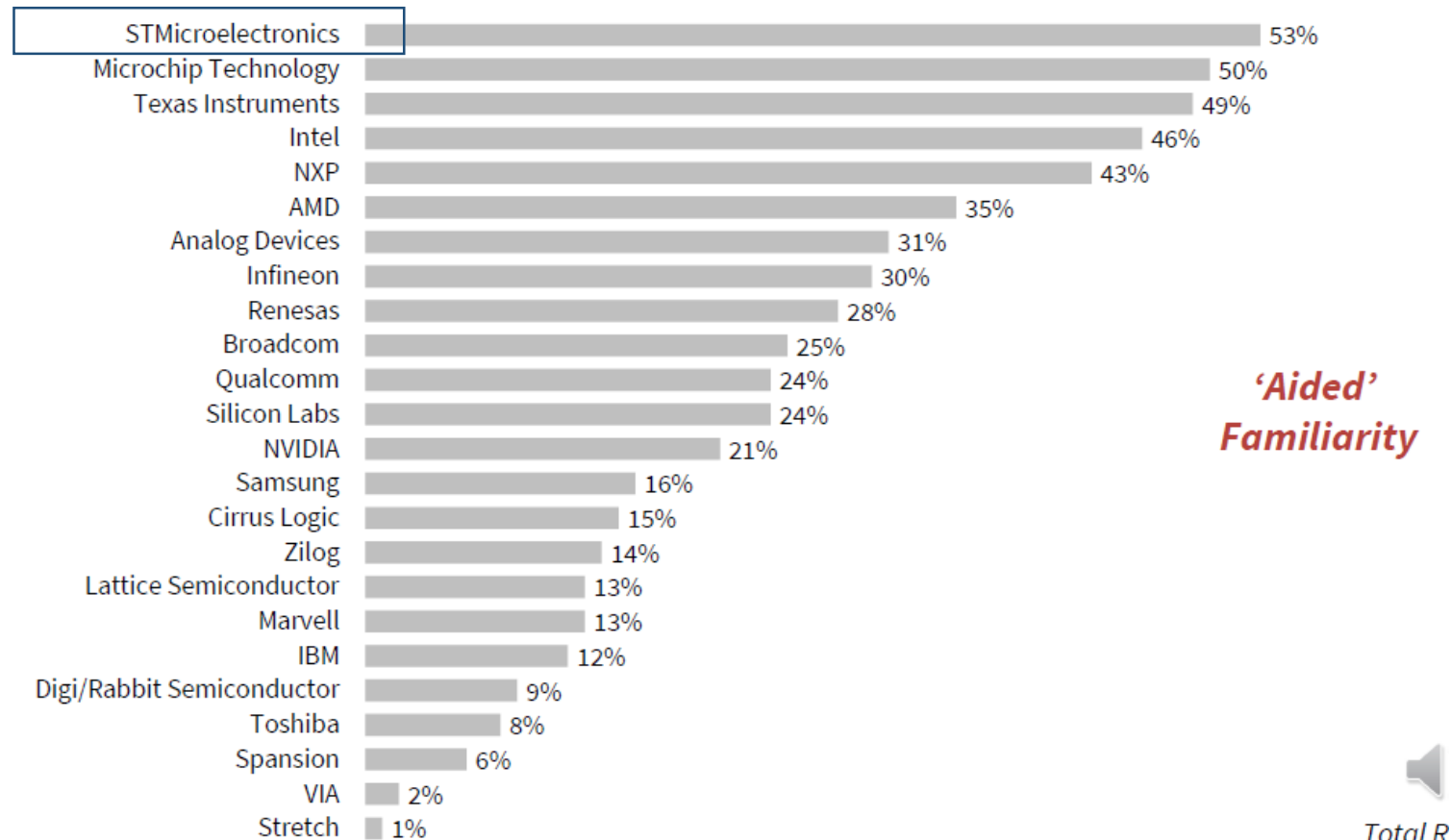
- Acorn Computers Ltd. was a British computer company established in Cambridge, England, in 1978.
- In 1983 the Acorn started its Acorn RISC Machine project and the resulting Reduced Instruction Set Computing (RISC) processor would eventually become known as the 32-bit ARM1
- The company's name was later rebranded simply as "**ARM**"
- Many companies (Intel, Marvell, Qualcomm, Apple, etc) paid for "architectural license" which allows to design own cores.



Microcontroller vendors



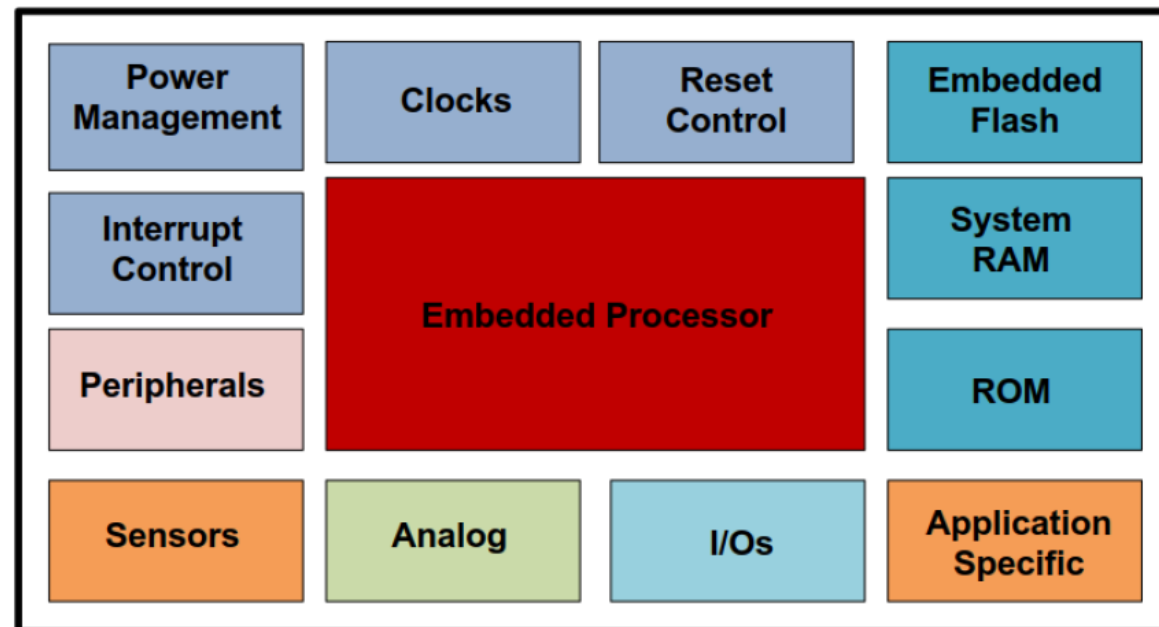
- STMicroelectronics, Microchip, TI, Intel, and NXP are the most well-known processor vendors



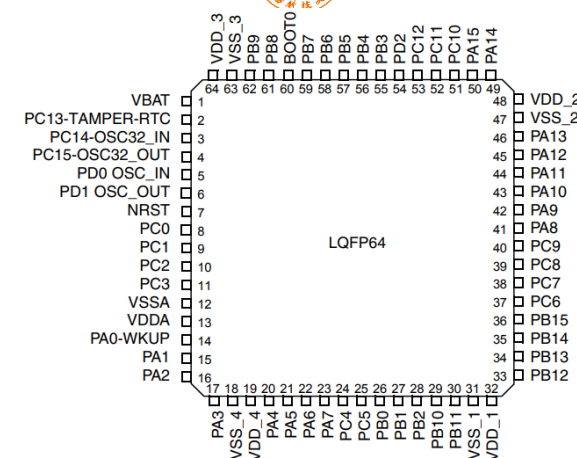
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Why MCU

- Smaller board area
- Low cost
- Low power consumption
- High reliability
- Dedicated for special purpose application
- Microcontrollers save time and money!

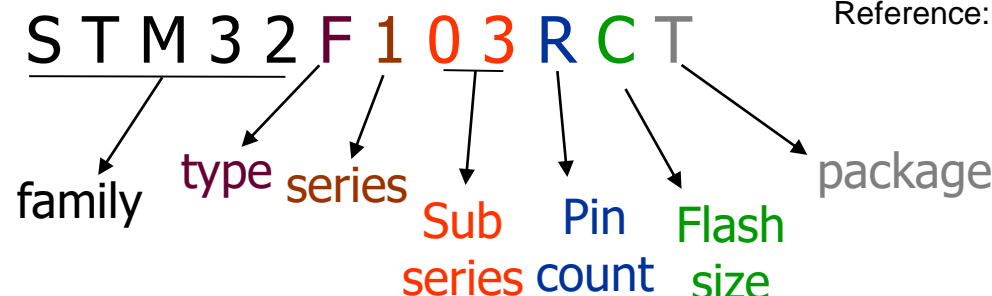


STM32F103RCT6 MCU



Reference: STM32F103RCT6 Datasheet.pdf

- Family
 - Names of the new Arm products of ST begin with STM32.
- Type
 - L: Low Power
 - F: Mainstream (Foundation)
 - H: High performance
 - W: Wireless
- Series
 - 0: Cortex-M0
 - 1,2: Cortex-M3
 - 3,4: Cortex-M4
 - 7: Cortex-M7
- Sub series
 - Chips with higher sub-series numbers have richer configurations
- Package
 - H: BGA (Ball Grid Array)
 - T:LQFP (Low-profile Quad Flat Pack)
 - U:QFN (Quad Flat No-leads)
 - Y:WLCSP



- Pin count

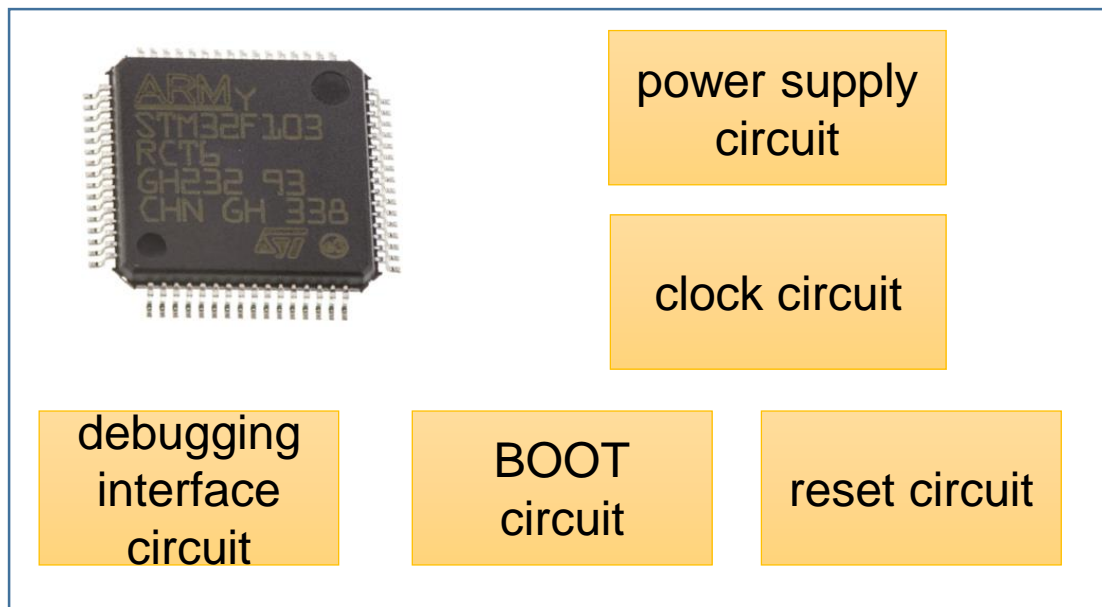
	F	G	K	T	S	C	R	V	Z
# of pins	20	28	32	36	44	48	64	100	144

- Flash size

	4	6	8	B	C	D	E	F	G	H	I
Group	Low density			Medium density		High density					
Flash	16K	32K	64K	128K	256K	384K	512K	768K	1M	1.5M	2M

Minimum System

- A minimal system refers to a system with the minimum resources required to enter the correct execution mode.

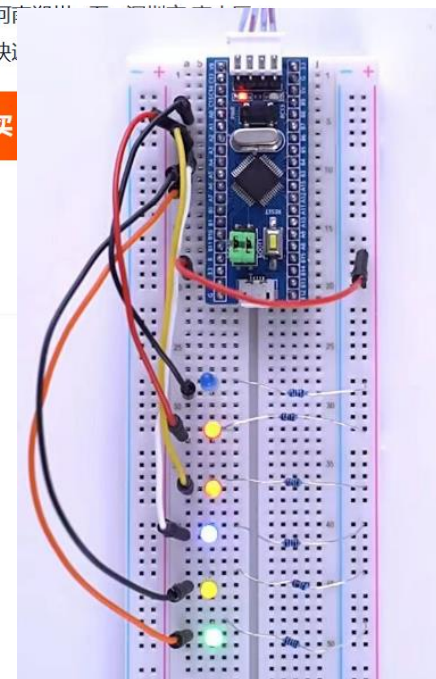


STM32F103C8T6核心板 C6T6开发板
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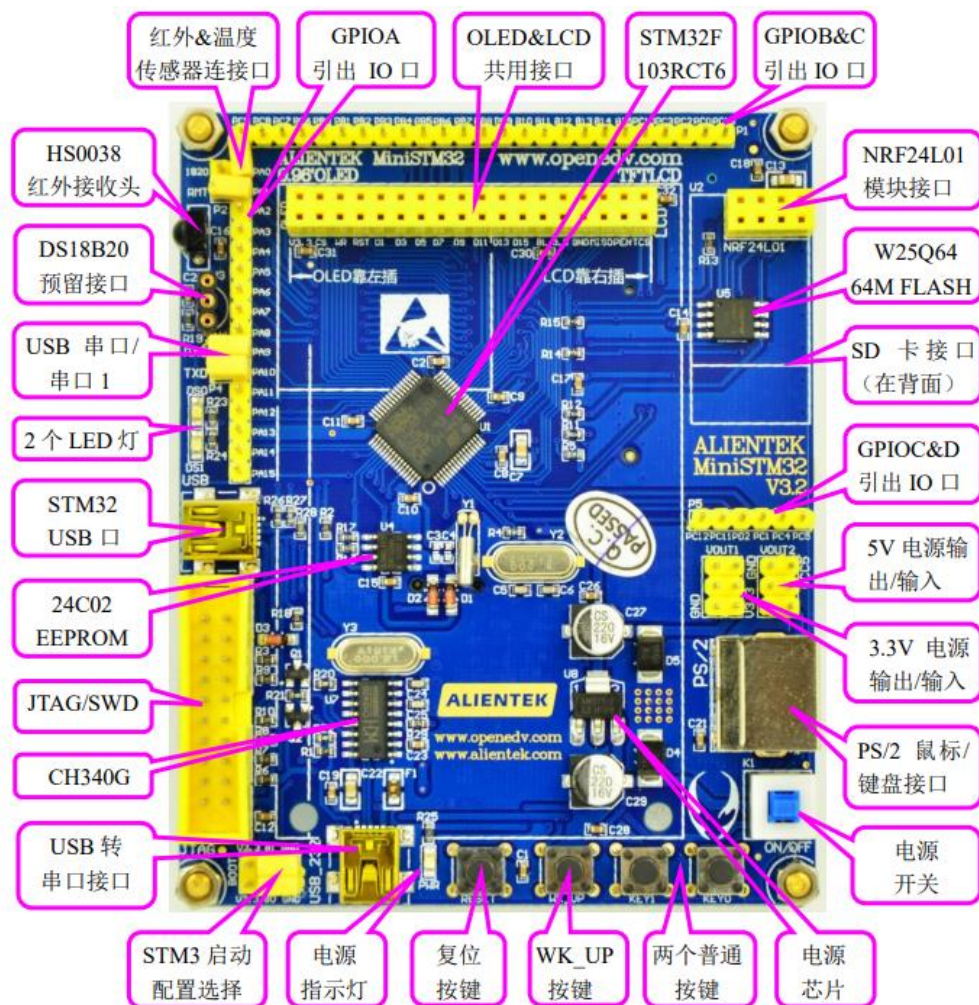
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立即购买



What we use in Lab

- ST Microelectronics STM32F103 (正点原子miniSTM32)



Development Environment

- Development board:
 - Before real hardware is built, software can be developed and tested using development boards
 - Development boards usually have the same CPU as the end product and provide many IO peripherals for the developed software to use as if it were running on the real end product
- Tools for program development
 - *Integrated Development Environment* (IDE): cross compiler, linker, loader, ...
 - OS and related libraries and packages

