

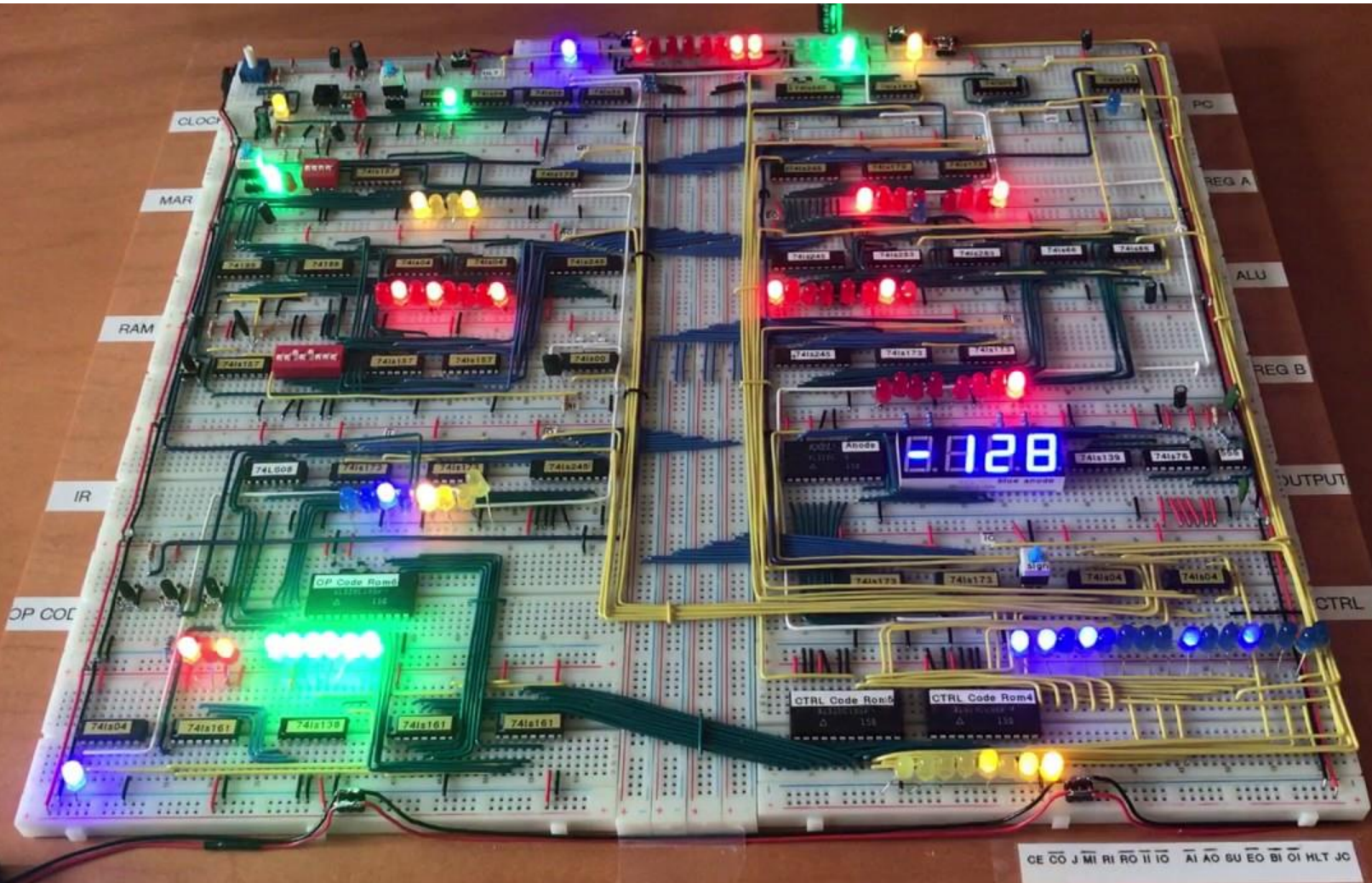
به نام خدا

# میکروپروسسور و میکروکنترلر

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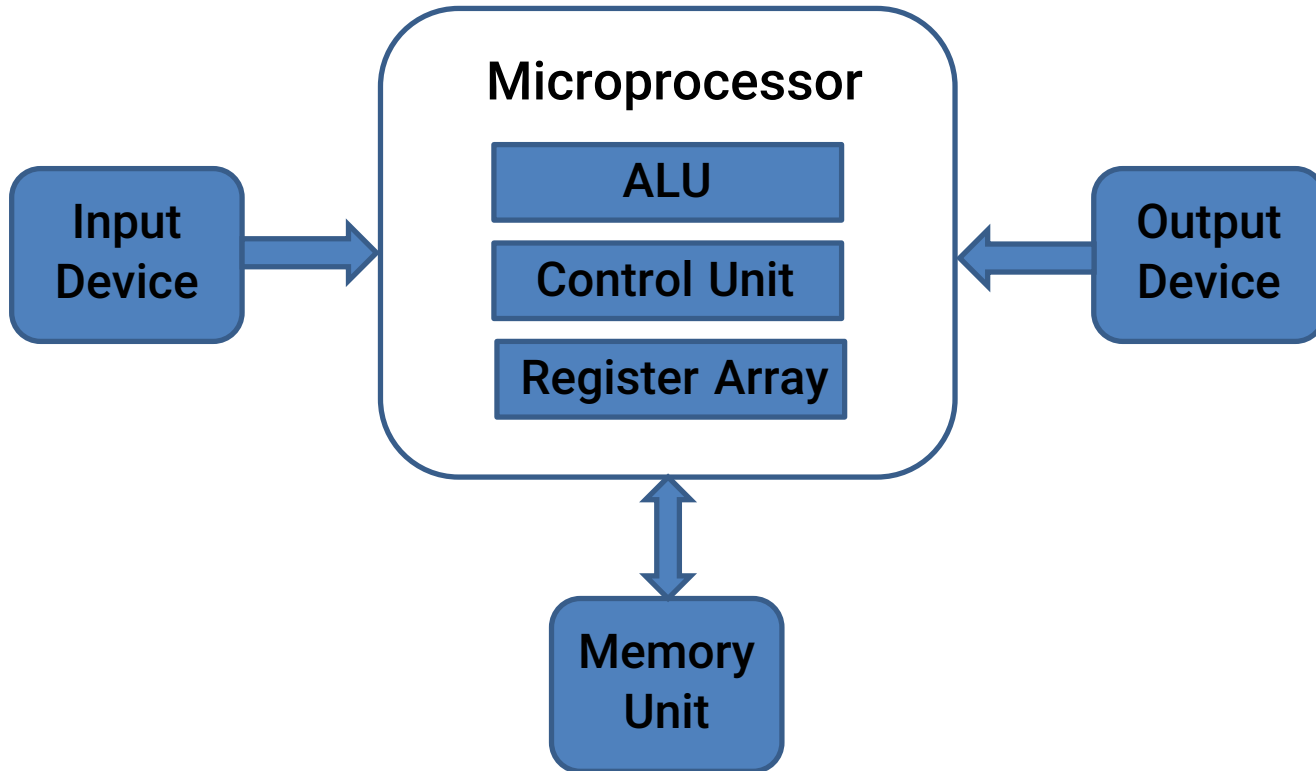
# 8 bit breadboard computer



# CPU Board

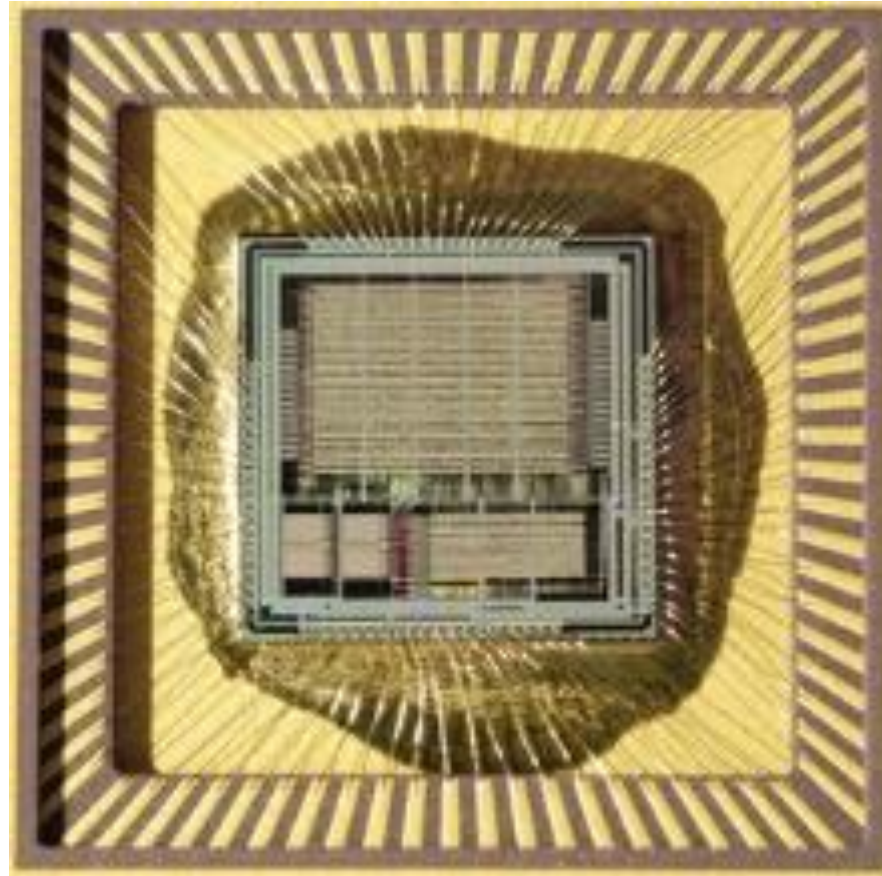
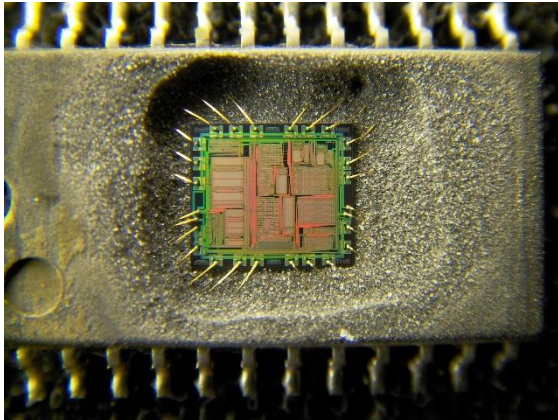


# میکروپروسسور

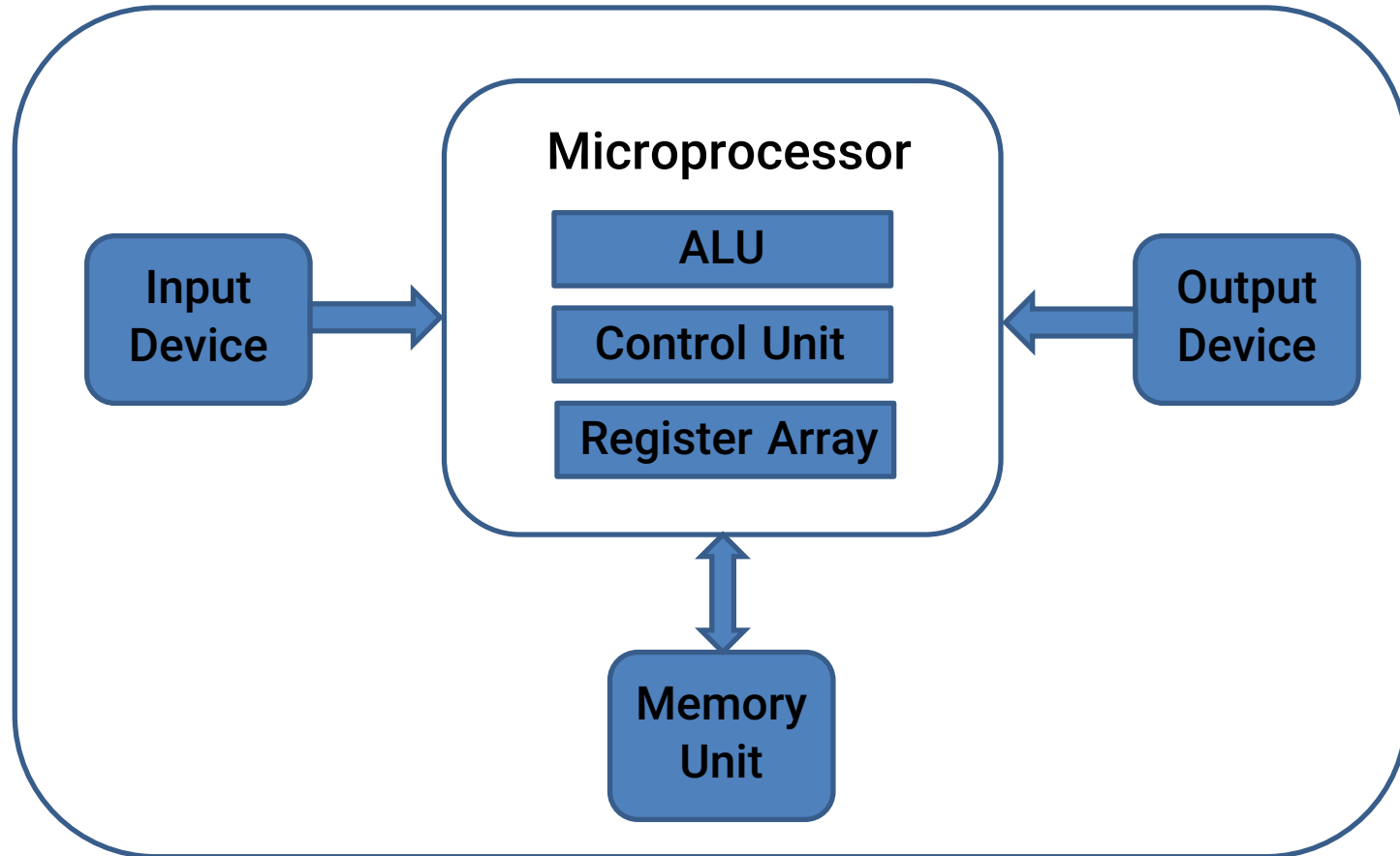




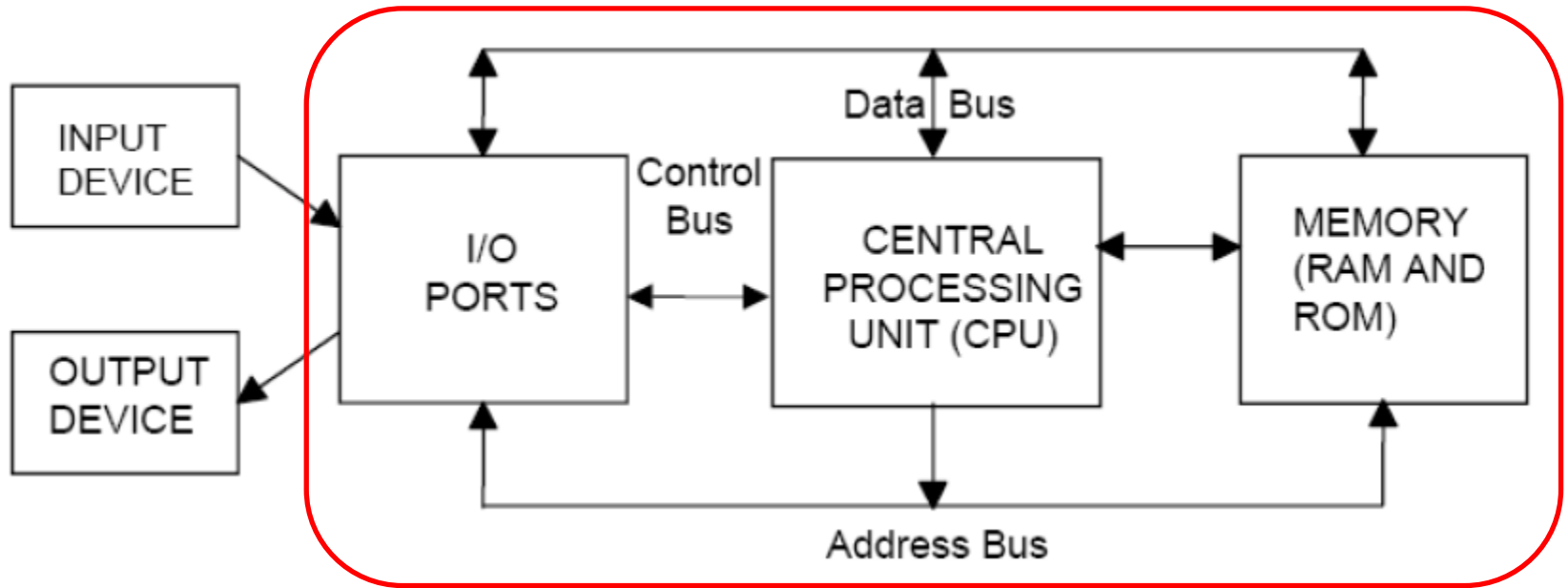
# میکروپروسسور



# میکروکنترلر

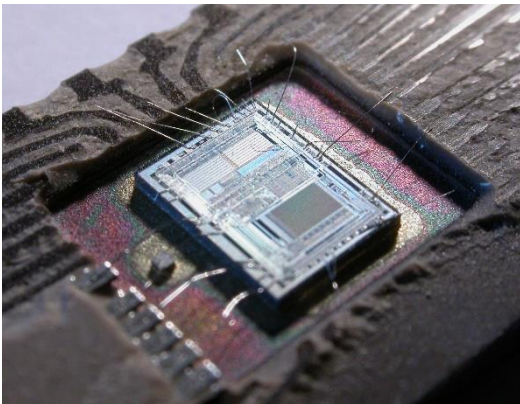
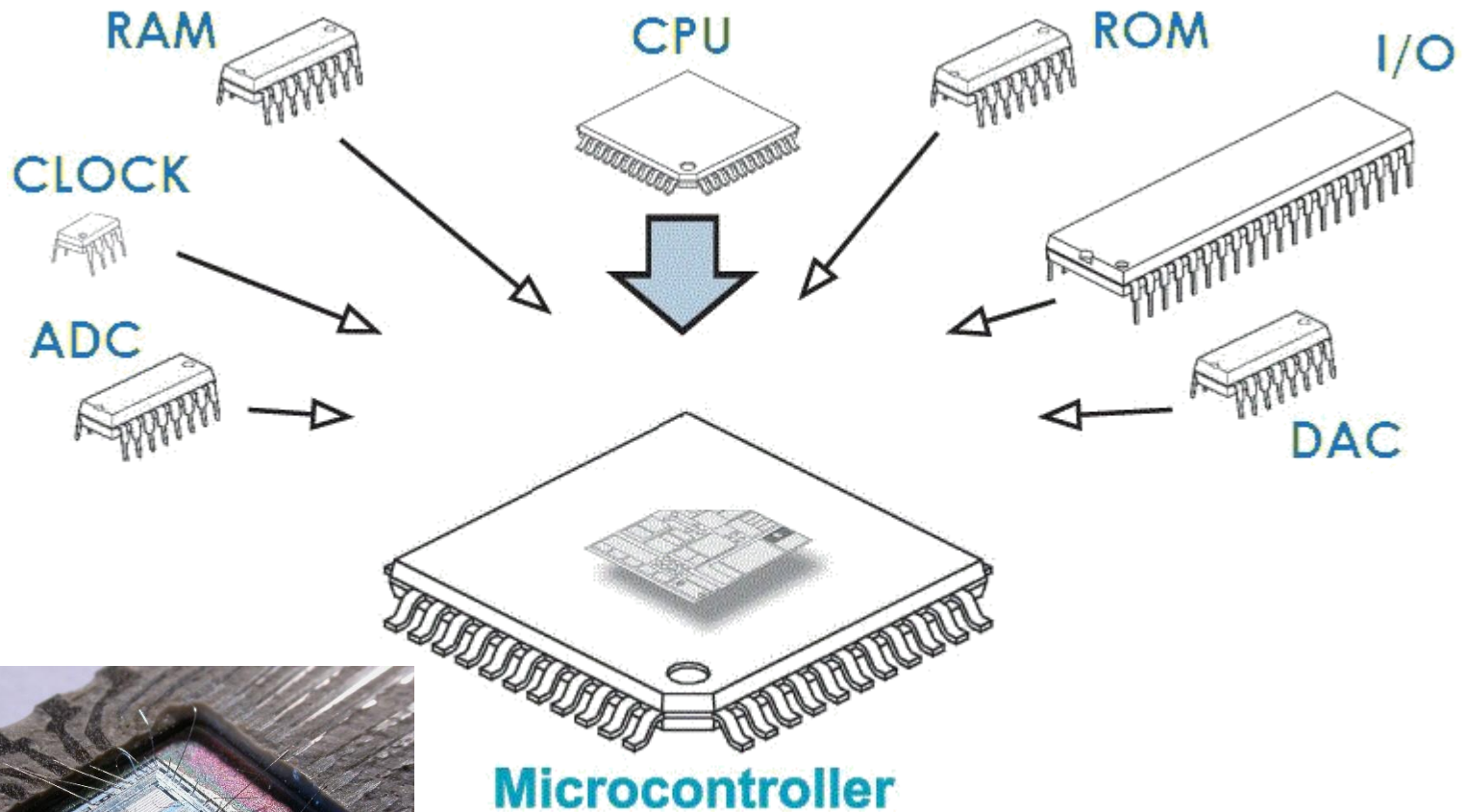


# میکروکنٹرلر



microcontroller

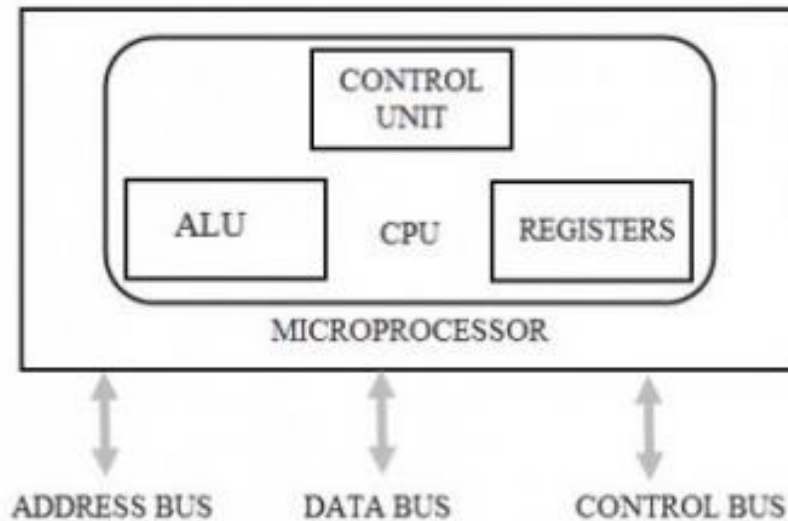
# میکروکنترلر





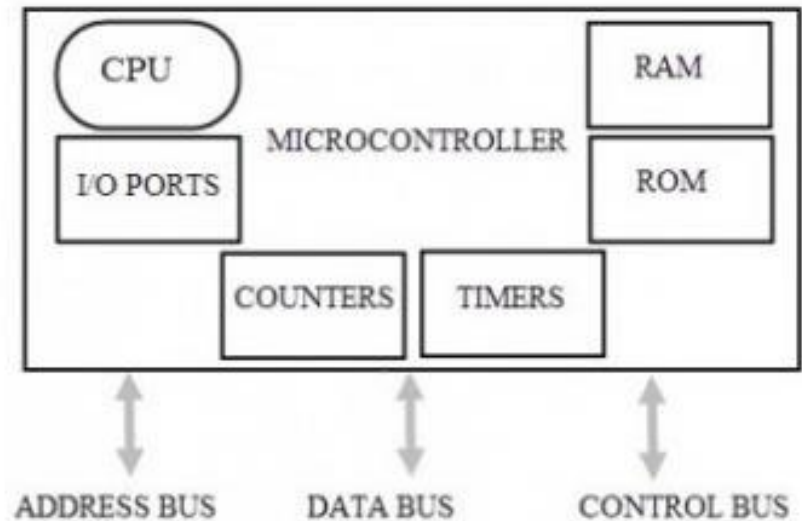
# میکروپروسسور و میکروکنترلر

## Microprocessor



A central processing unit on a single integrated circuit chip containing millions of very small components including transistors, resistors, and diodes that work together.

## Microcontroller








A small computer on a single chip. A microcontroller contains one or more CPUs (processor cores) along with memory and programmable input/output peripherals.

Summary	Microprocessor	Microcontroller
<b>Applications</b>	Advanced data processing, video, computer vision, personal computers, fast communications, multi-core computation.	Embedded devices, control systems, smartphones, consumer electronics.
<b>Processing Power</b>	Higher	Lower
<b>Memory</b>	External - Flexible	Internal – Limited Size
<b>Power Consumption</b>	Higher	Lower
<b>Size</b>	Larger	Smaller
<b>Price</b>	Expensive	Cheaper
<b>I/O</b>	Need external peripherals with I/O pins	Programmable digital and analog I/O pins

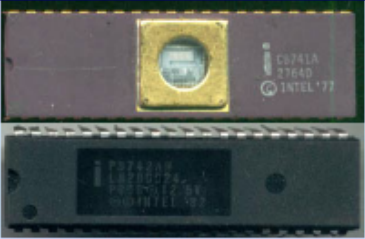
## Microcontroller vs Microprocessor

Manufacturer	Processor	Date of introduction	Number of transistors	Process	Area [mm <sup>2</sup> ]
Intel	Intel4004	1971	2,300	10 μm	12
	Intel8008	1972	3,500	10 μm	14
	Intel8080	1974	4,400	6 μm	20
	Intel8085	1976	6,500	3 μm	20
	Intel8086	1978	29,000	3 μm	33
	Intel80286	1982	134,000	1.5 μm	44
	Intel80386	1985	275,000	1.5 μm	104
	Intel80486	1989	1,180,235	1 μm	173
	Pentium	1993	3,100,000	0.8 μm	294
	Pentium Pro	1995	5,500,000	0.5 μm	307
	Pentium II	1997	7,500,000	0.35 μm	195
	Pentium III	1999	9,500,000	0.25 μm	128
	Pentium 4	2000	42,00,000	180 nm	217
	Itanium 2 McKinley	2002	220,000,000	180 nm	421
	Core 2 Duo	2006	291,000,000	65 nm	143
	Core i7 (Quad)	2008	731,000,000	45 nm	263
	Six-Core Core i7	2010	1,170,000,000	32 nm	240
	Six-Core Core i7/8-Core Xeon E5	2011	2,270,000,000	32 nm	434
	8-Core Itanium Poulson	2012	3.100,000,000	32 nm	544
	R2000	1986	110,000	2.0 μm	80
	R3000	1988	150,000	1.2 μm	56

# Introduced 1976








Device	RAM (bytes)	ROM	Speed	Timers	Ports	Picture
8021 8021H**	64	1024	100-400KHz	2	2x8, 1x4	
8022 8022H**	128	2048	100-400KHz	2	3x8	Has an ADC
8035	64	-	11MHz			
8038	64	-			3x8	
8039	128	-	11MHz		3x8	
8040	256	-	11MHz			
8048	64	1024	11MHz	2	3x8	
8049	128	2048	11MHz	2	3x8	
8050	256	4096	11MHz			

# Introduced 1979




Device	RAM (bytes)	ROM	Speed	ADCs	Timers	Ports	Picture
8041	128	1024	6MHz		2	3x8	
8042	256	2048	12.5MHz		2		



# Introduced 1980

Device	RAM (bytes)	ROM	Speed	Timers	Ports	Picture
8031	128	-	12MHz	2	4x8	
8032	256	-	12MHz	2	4x8	
8044*	192	4096	12MHz	2	4x8	
8051	128	4096	12MHz	2	4x8	
8052	256	8192	24MHz	2	4x8	
8054	256	16K	24MHz	3	4x8	
8058	256	32K	33MHz	3	4x8	
<b>MCS-251</b>						
8x251SA	1k	8k	16MHz	3	32	
8x251SB	1k	16k	16MHz	3	32	
8x251SP	512	8k	16MHz	3	32	
8x251SQ	512	16k	16MHz	3	32	
8x251TB	1K	16k	24MHz	3	32	
8251TQ	512	-	24MHz	3	32	

# Introduced 1982

Device	RAM (bytes)	ROM	Speed	ADCs	Timers	I/O Lines	Picture	
8395	232	8192	12MHz	4	2	5x8		
8096	232	-	12MHz	-	2	5x8		
8396	232	8192	12MHz	-	2	5x8		
8097	232	-	12MHz	8	2	5x8		
8397	232	8192		8	2	5x8		
Next Generation								
87C196KR	488/256	16K	16MHz	8	2	56		
87C196KQ	360/128	12K	16MHz	8	2	56		
87C196JV	1.5K/512	48K	16MHz	6	2	41		
87C196JT	1K/512	32K	16MHz	6	2	41		
87C196JR	488/256	16K	16MHz	6	2	41		
87C196JQ	360/128	12K	16MHz	6	2	41		
87C196LA	768	24K	20MHz	6	2			
87C196LB	768	24k	20MHz	6	2			
83C196LC	1K/512	32K	22MHz	6	2			
83C196LD	384	16K	22MHz	6	2			
High Speed I/O Family								
8x196KB	232	8k	16MHz	8	2	48		
8x196KC	488	16k	20MHz	8	2	48		
8x196KD	1000	32k	20MHz	8	2	48		

# میکروکنترلرهای جدید

Microcontroller	Package	Program Memory	SRAM	EEPROM	I/O Pins	Timers	A/D	SPI	I <sup>2</sup> C	PWM	USART
28 Pin PDIP											
ATMEGA48V-10PI	PDIP28	4k	512	256	23	2x8,1x16	6x10-bit	Yes	Yes	6	Yes
ATMEGA8A-PU	PDIP28	8k	1024	512	23	2x8,1x16	6x10-bit	Yes	Yes	3	Yes
ATMEGA8L-8PU	PDIP28	8k	1024	512	23	2x8,1x16	6x10-bit	Yes	Yes	3	Yes
ATMEGA88-20PU	PDIP28	8k	1024	512	23	2x8,1x16	6x10-bit	Yes	Yes	6	Yes
ATMEGA88PA-PU	PDIP28	8k	1024	512	23	2x8,1x16	6x10-bit	Yes	Yes	6	Yes
ATMEGA88V-10PU	PDIP28	8k	1024	512	23	2x8,1x16	6x10-bit	Yes	Yes	6	Yes
ATMEGA168-20PU	PDIP28	16k	1024	512	23	2x8,1x16	6x10-bit	Yes	Yes	6	Yes
ATMEGA168V-10PU	PDIP28	16k	1024	512	23	2x8,1x16	6x10-bit	Yes	Yes	6	Yes
ATMEGA328-PU	PDIP28	32k	2048	1024	23	2x8,1x16	6x10-bit	Yes	Yes	6	Yes
ATMEGA328P-PU	PDIP28	32k	2048	1024	23	2x8,1x16	6x10-bit	Yes	Yes	6	Yes

# اولین میکروپروسورها

- Intel 4004 (اولین  $\mu p$  تجاری)

– 1971

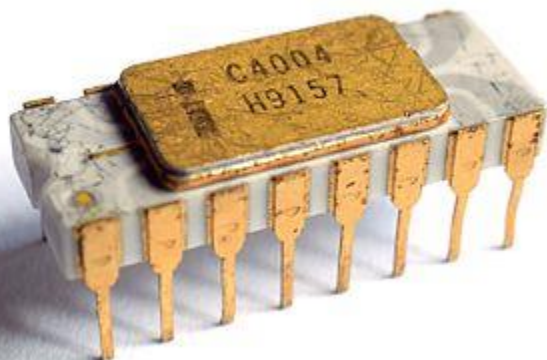
– 4-bit central processing unit

– استفاده در یک ماشین حساب

– مشخصات

- 740-750 kHz

– 46250 to 92500 instructions per second



# اولین میکروپروسسورها

Intel 8008 •

1972 –

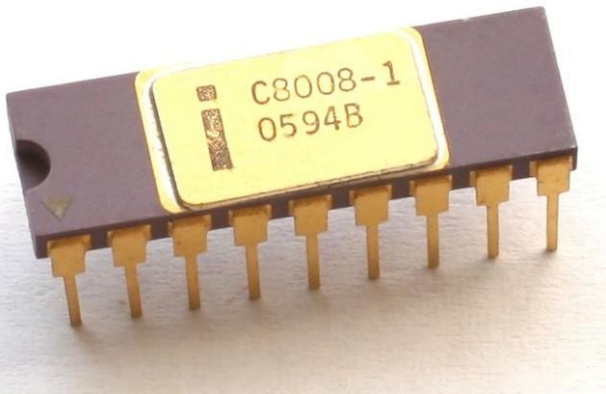
8-bit central processing unit –

first commercial non-calculator personal –  
computers

– مشخصات

200 kHz to 800 kHz •

36,000 to 80,000 instructions per second –





# اولین میکروپروسورها

• IMP-16 (by National Semiconductor)

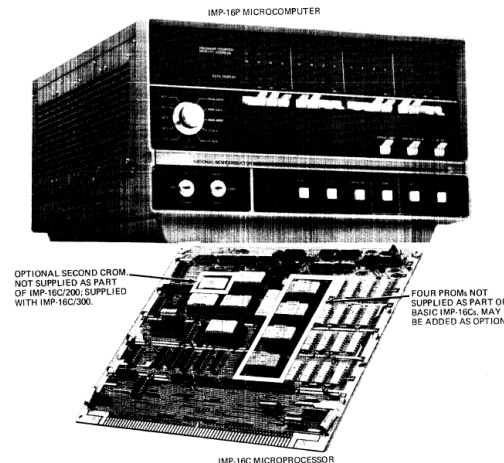
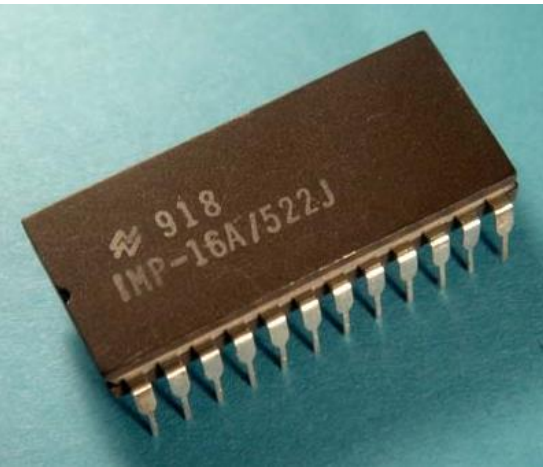
– 1973

– 16-bit central processing unit

– microcomputers

– مشخصات

• 715 kHz



# اولين ميکروپروسسورها

• **Motorola 68000**

– 1979

– 32-bit central processing unit

– new generation of personal computers

– مشخصات

• 8–20 MHz



# اولین میکروپروسورها

• R4000

– 1991

– 64-bit central processing unit

– new generation of personal computers

– مشخصات

• 100, 133, 150, 200, and 250 MHz



# اولين ميکروپروسسورها

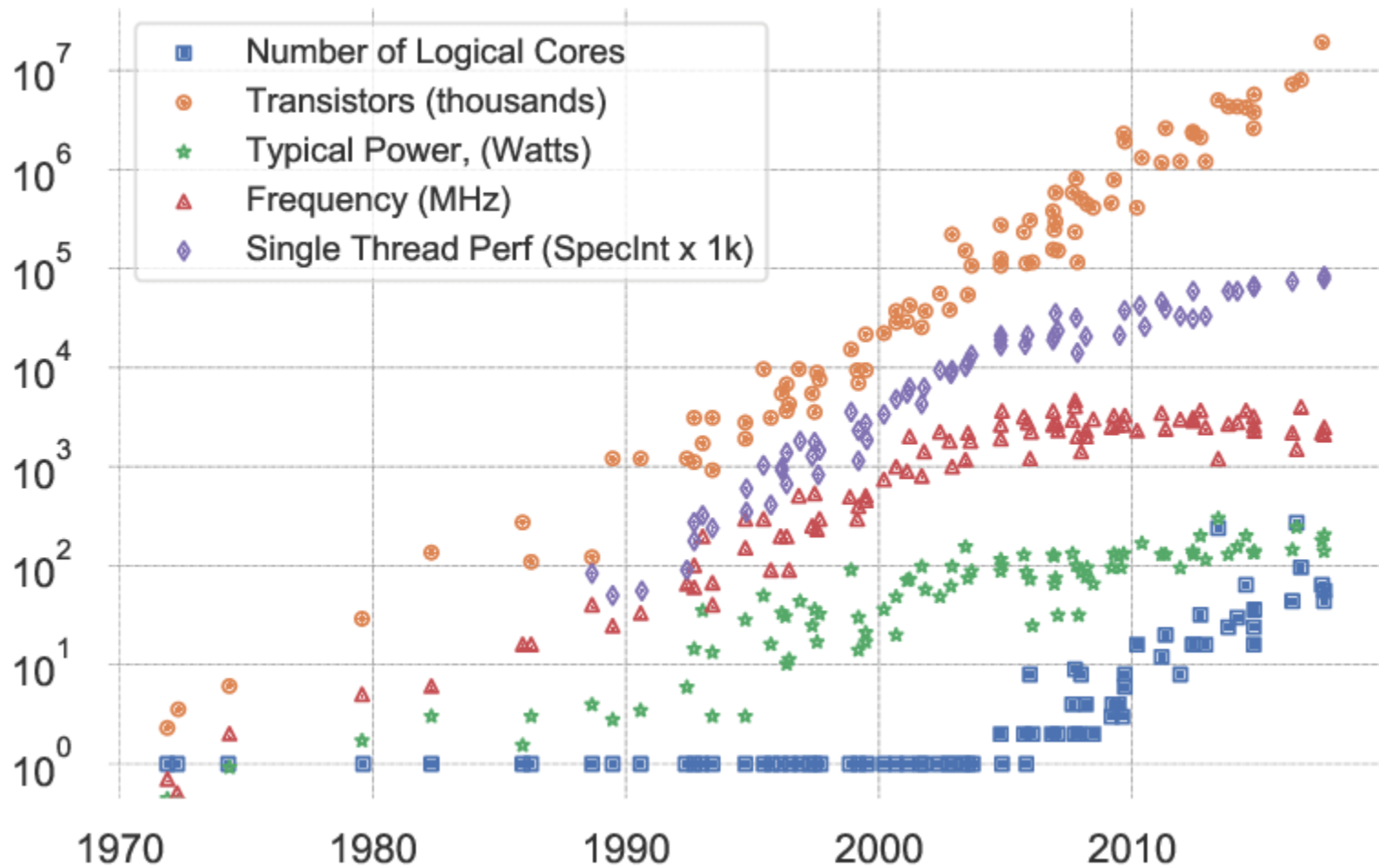
- 16-bit Microprocessor
  - 8086: 4.7MHz, 8MHz, 10MHz
  - 8088: more than 5MHz
  - 80186/80188: 6MHz
  - 80286: 8MHz
- 32-bit Microprocessor
  - INTEL 80386: 16MHz to 33MHz
  - INTEL 80486: 16MHz to 100MHz
  - PENTIUM: 66MHz

# اولین میکروپروسسورها

- 64-bit Microprocessor
  - INTEL CORE-2: 1.2GHz to 3GHz
  - INTEL i7: 2.66GHz to 3.33GHz
  - INTEL i5: 2.4GHz to 3.6GHz
  - INTEL i3: 2.93GHz to 3.33GHz
- We do not have any 128-bit Microprocessor at work at present
  - we are a long way from exhausting the 64-bit address
    - we use it at a constant rate of roughly 2 bits every 3 years
    - we have only used 48 bits of 64 bits
  - 128-bit Microprocessor would be much slower than the 64 bit Microprocessor



# Trend



# انواع میکروپروسسورها

- **Reduced Instruction Set Computer (RISC)**
  - Instruction is simple and designed to get executed quickly
  - Instructions get completed in one clock cycle
  - Example:
    - 1. IBM RS6000
    - 2. MC88100
    - 3. DEC Alpha 21064
    - 4. DEC Alpha 21164
    - 5. DEC Alpha 21264

# انواع میکروپروسسورها

- **Complex Instruction Set Computer (CISC)**
  - Single instruction can execute multiple low-level operations
  - Example:
    - 1. Intel 386
    - 2. Intel 486
    - 3. Pentium
    - 4. Pentium Pro
    - 5. Pentium II
    - 6. Pentium III
    - 7. Motorola 68000
    - 8. Motorola 68020
    - 9. Motorola 68040

# اولین میکروکنترلرها



• TMS1000 (اولین  $\mu$ C تجاری)

– 1974

– 4-bit central processing unit

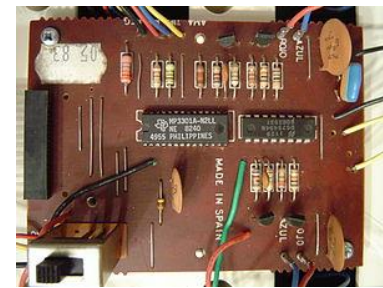
– استفاده در اسباب بازی (یک بازی هوش و ...)

– مشخصات

• ROM (1024 x 8 bits)

• RAM (64 x 4 bits)

• I/O lines (23)



# اولین میکروکنترلرها

## • Intel MCS-48 (اولین $\mu$ C تجاری Intel)

– 1976 ← (اولین عضو 8048)

– 8-bit central processing unit

– استفاده در

• Magnavox Odyssey video game console

• keyboard, joystick ports, RS-232 inputs and audio

– مشخصات

• ROM ( $1K \times 8$ )

• RAM ( $64 \times 8$ )

• I/O lines (27)



رئیس وقت Intel: تولید (این) میکروکنترلر یکی از موفقترین محصولات این شرکت بوده است



# اولین میکروکنترلرها

• Intel 8051 (one of the most popular  $\mu$ c)

– 1980

– 8-bit central processing unit

– استفاده در

• embedded systems

– مشخصات

• ROM (4 K  $\times$  8)

• RAM (128  $\times$  8)

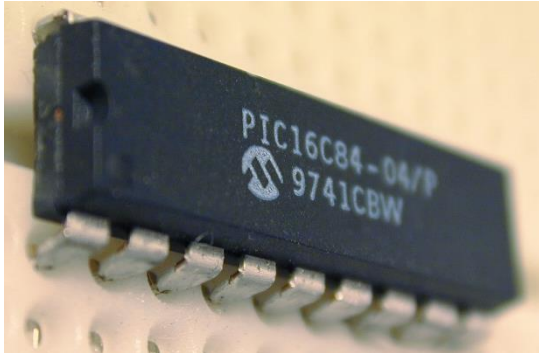
• 32 input/output pins



ادعا می‌شود که بسیاری از میکروکنترلرهای پرکاربرد بر مبنای هسته این میکروکنترلر ساخته شده است

It is even used now and is considered to be one of the most long-lived microcontrollers

# اولین میکروکنترلرها



• PIC16C84 (اولین میکروکنترلر PIC)

– 1993

– 8-bit central processing unit

– استفاده در

• smart-card to decode the signals of Sky Television

– مشخصات

• ROM (1K × 8)

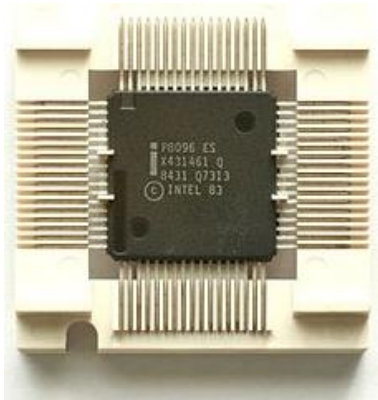
• RAM (64 × 8)

• I/O lines (13)

• 64 bytes **EEPROM**, 1× time



# اولین میکروکنترلرها



• Intel MCS-96

– 1982 (80196)

– 16-bit central processing unit

– استفاده در

• commonly used in hard disk drives

– مشخصات

• ROM (2K × 8)

• RAM (256 × 8)



# اولین میکروکنترلرها

Motorola 68332 •

1989 –

32-bit central processing unit –

– استفاده در

embedded systems •

– مشخصات

• RAM (2Kb)

• EPROM (128K)



# آمار و ارقام

- فروش

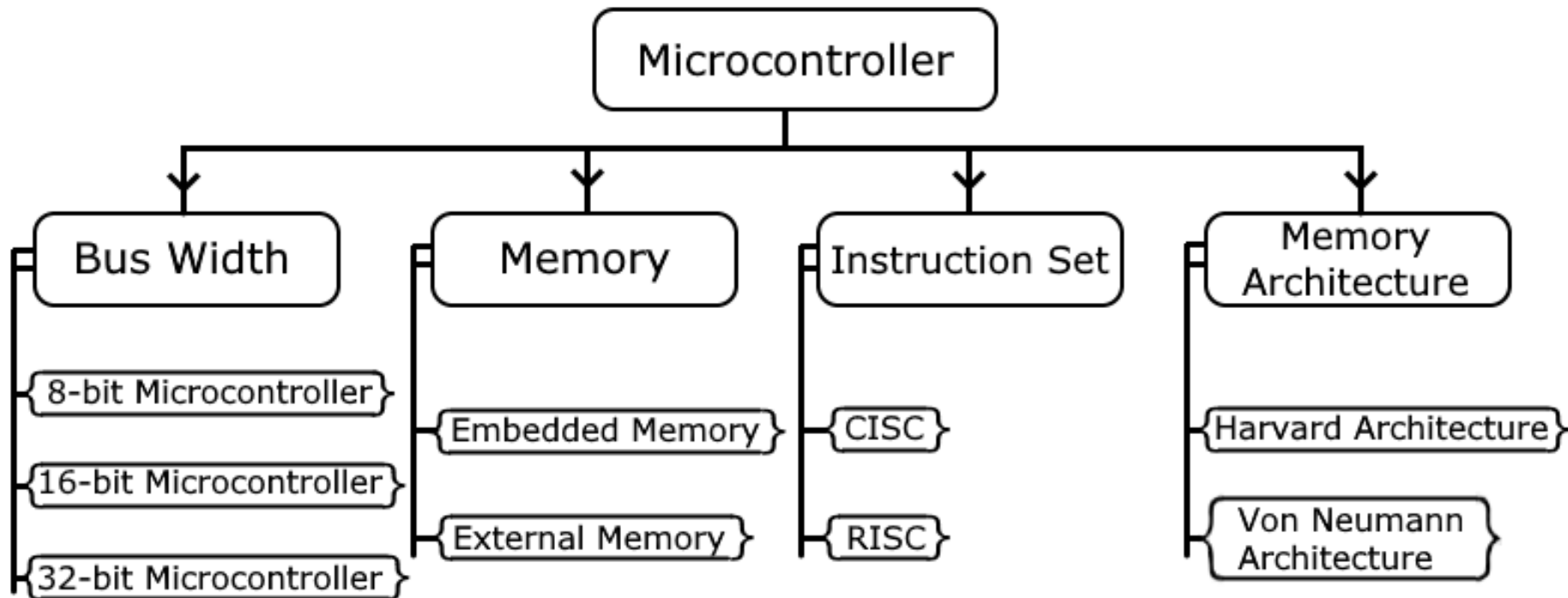
- 1997: Over two billion 8-bit  $\mu\text{c}$  were sold
- 2006: Over four billion 8-bit  $\mu\text{c}$  were sold
- market grew 36.5% in 2010 and 12% in 2011

- به صورت نوعی در یک خانه

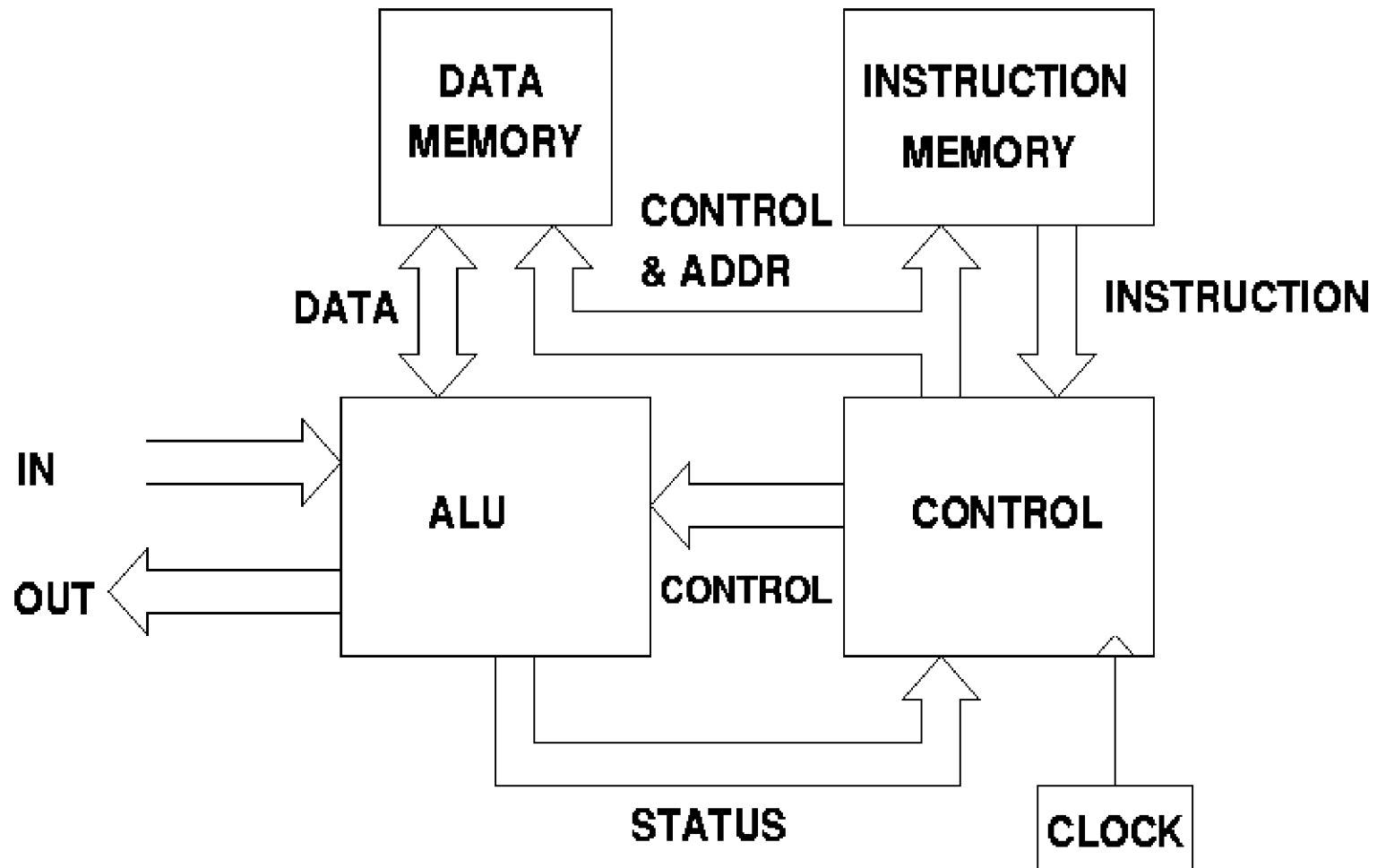
- four general-purpose microprocessors
- three dozen microcontrollers

- The predominant family of  $\mu\text{c}$  are 8-bit
- popular for the vast majority of tasks

# انواع میکروکنترلر

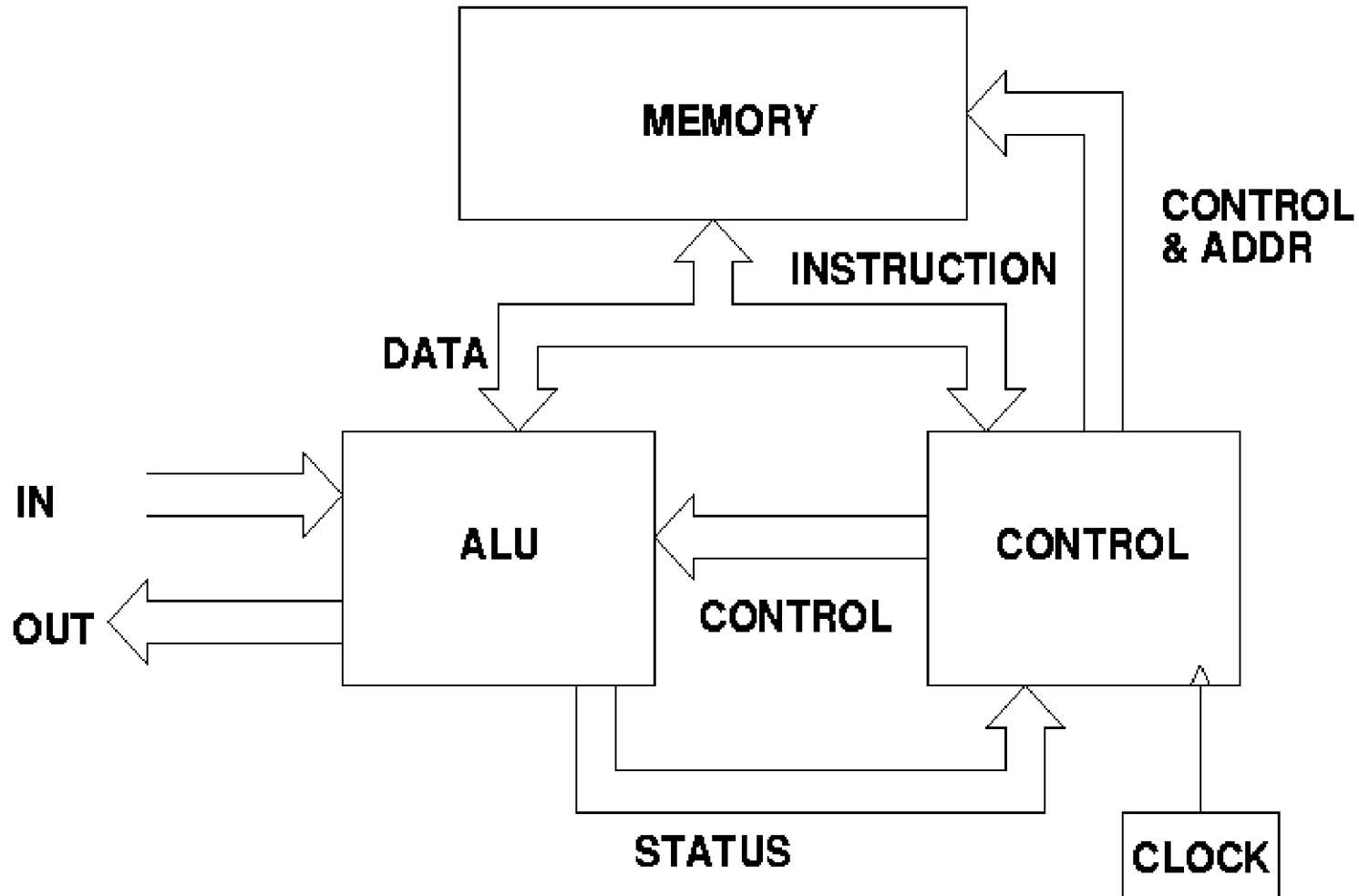


# Harvard Architecture





# Von-Neumann Architecture



# خانواده‌های مختلف میکروکنترلر

• خانواده‌های:

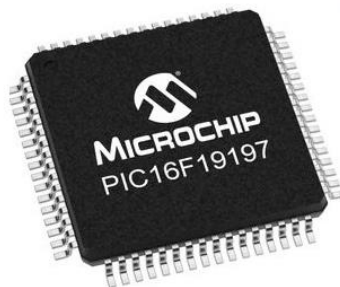
PIC •

ARM •

8051 •

AVR •

MSP •



# خانواده PIC

- Peripheral Interface Controller (PIC)
  - by Micro-chip Technology
  - Harvard architecture
  - 8-bit, 16-bit, and 32-bit
  - RISC
  - Wide range of interfaces
    - I<sup>2</sup>C, SPI, USB, USART, A/D, programmable comparators, PWM, LIN, CAN, PSP, and Ethernet

# خانواده PIC

- ویژگیها:

- در میان میکروکنترلر های ۸بیتی ازجمله موفقترین نوع است
- پشتیبانی از برنامه نویسی C، اسمبلی و بیسیک
- تراشه PIC در میان صنعتگران بسیار محبوب است.
- از سایر ویژگی های آن هزینه کم، مصونیت در برابر نویز، قابلیت برنامه ریزی سریال و دسترسی گسترده است

# خانواده PIC

## • دسته بندی

### – Base Line Architecture

- This architecture is perfect for battery enabled gadgets
- PIC10F200 series
  - reasonably priced 8 bit flash  $\mu$ C with a 6 pin package

### – Mid Range Architecture

- broad variety of package alternatives (8 to 64 package)
- with low to high levels of peripheral incorporation
  - SPI, USART, I2C, USB, LCD & A/D converters

### – High Performance Architecture

- with 18 to 100 pin package alternatives
- high performance

# خانواده ARM

- Advanced RISC Machines (ARM)
  - By Acorn Group of Computers
  - Modified Harvard architecture
  - Mostly 32-bit
  - RISC
  - Wide range of interfaces
    - I<sup>2</sup>C, SPI, USB, USART, A/D, programmable comparators, PWM, LIN, CAN, PSP, and Ethernet

# خانواده ARM

- ویژگیها:
- در میان میکروکنترلر های 32بیتی ازجمله موفقترین نوع است
- پشتیبانی از برنامه نویسی C، اسمبلی
- تراشه هایی با قیمت پایین
- نسبت به امکانات ارابه شده
- پشتیبانی از بیشترین تعداد پروتکل ارتباطی



# خانواده 8051

- Intel MCS-51
  - By Intel
  - Von Neumann architecture
  - 8-bit for standard core
  - CISC
  - Interfaces
    - UART, USART, SPI, I2C

# خانواده 8051

- ویژگیها:
- طولانی ترین بکارگیری از زمان ظهور
- پشتیبانی از برنامه نویسی C، اسمبلی
- تراشه هایی با قیمت بسیار پایین
- مصرف توان بیشتر نسبت به سایرین

# خانواده AVR

- Alf and Vegard's RISC processor (AVR)
  - By Atmel
  - Modified Harvard architecture
  - 8/32-bit
  - RISC
  - A range of interfaces
    - UART, USART, SPI, I2C, (special purpose AVR support CAN, USB, Ethernet)

# خانواده AVR

- ویژگیها:
- تعدد نرم افزارها و ابزارهای مورد نیاز
- پشتیبانی از برنامه نویسی C، اسمبلی
- تراشه هایی با قیمت متوسط
- جامعه کاربری بسیار زیاد

# خانواده MSP

- mixed-signal microcontroller (MSP)
  - by Texas Instruments
  - Von Neumann architecture
  - 16-bit
  - RISC
  - A range of interfaces
    - I<sup>2</sup>C, SPI, UART, USART, LIN

# خانواده MSP

- ویژگیها:
- سرعت به نسبت مناسب
- پشتیبانی از برنامه‌نویسی C، اسمبلی
- تراشه‌هایی با قیمت متوسط
- توان مصرفی بسیار پایین

	ARM	8051	AVR	PIC	MSP430
<b>Bus Width</b>	32-bit mostly also available in 64-bit	8-bit for standard core	8/32-bit	8/16/32-bit	16-bit
<b>Communication Protocols</b>	UART, USART, LIN, I2C, SPI, CAN, USB, Ethernet, I2S, DSP, SAI (serial audio interface), IrDA	UART, USART, SPI, I2C	UART, USART, SPI, I2C, (special purpose AVR support CAN, USB, Ethernet)	PCI, UART, USART, LIN, CAN, Ethernet, SPI, I2S	UART, USART, LIN, I2C, SPI, I2S, IrDA
<b>Speed</b>	1 clock / instruction cycle	12 clock / instruction cycle	1 clock / instruction cycle	4 clock / instruction cycle	6 clock / instruction cycle
<b>Memory</b>	Flash, SDRAM, EEPROM	ROM, SRAM, FLASH	Flash, SRAM, EEPROM	SRAM, FLASH	SRAM, FLASH
<b>ISA</b>	RISC	CISC	RISC	Some feature of RISC	Some feature of RISC
<b>Memory Architecture</b>	Modified Harvard architecture	Von Neumann architecture	Modified Harvard	Harvard architecture	Von Neumann architecture
<b>Power Consumption</b>	Low	Average	Low	Low	Ultra Low
<b>Families</b>	ARMv4,5,6,7 and Cortex series	8051 variants	Tiny, Atmega, Xmega, special purpose AVR,	PIC16, PIC17, PIC18, PIC24, PIC32	MSP430X, MSP430FR57xx, MSP430x1xx to x6xx series
<b>Community</b>	Vast	Vast	Very Good	Very Good	Average
<b>Manufacturer</b>	Apple, Nvidia, Qualcomm, Samsung Electronics, and TI, etc.	NXP, Atmel, Silicon Labs, Dallas, Cypress, infineon, etc	Atmel	Microchip	TI
<b>Cost (as compared to feature provided)</b>	Low	Very Low	Average	Average	Average
<b>Other Feature</b>	High speed operation	Known for its Standard	Cheap, effective	Cheap	Known for Ultra low power operation
<b>Popular Microcontrollers</b>	LPC2148, ARM Cortex-M0 to ARM Cortex-M7, etc	AT89C51, P89v51, etc	Atmega8,16,32, Arduino Community	PIC18fXX8, PIC16f88X, PIC32MXXX	MSP430G2553, MSP430 launchpad.



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