



# *Embedded Applications on Intelligent Systems*

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# 1. About This Topic...



- Intelligent Systems
- Embedded Applications



## 2. What are Intelligent Systems?



Intelligent systems are technologically advanced machines that perceive and respond to the world around them.

A synonym word(also a very hot word): Artificial Intelligent.

Intelligent systems can take many forms.

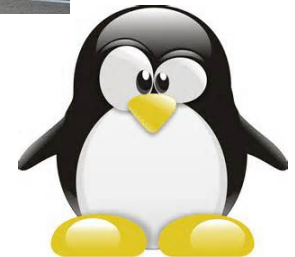
Almost all Intelligent systems are based on computer system.



## 2. What are Intelligent Systems?



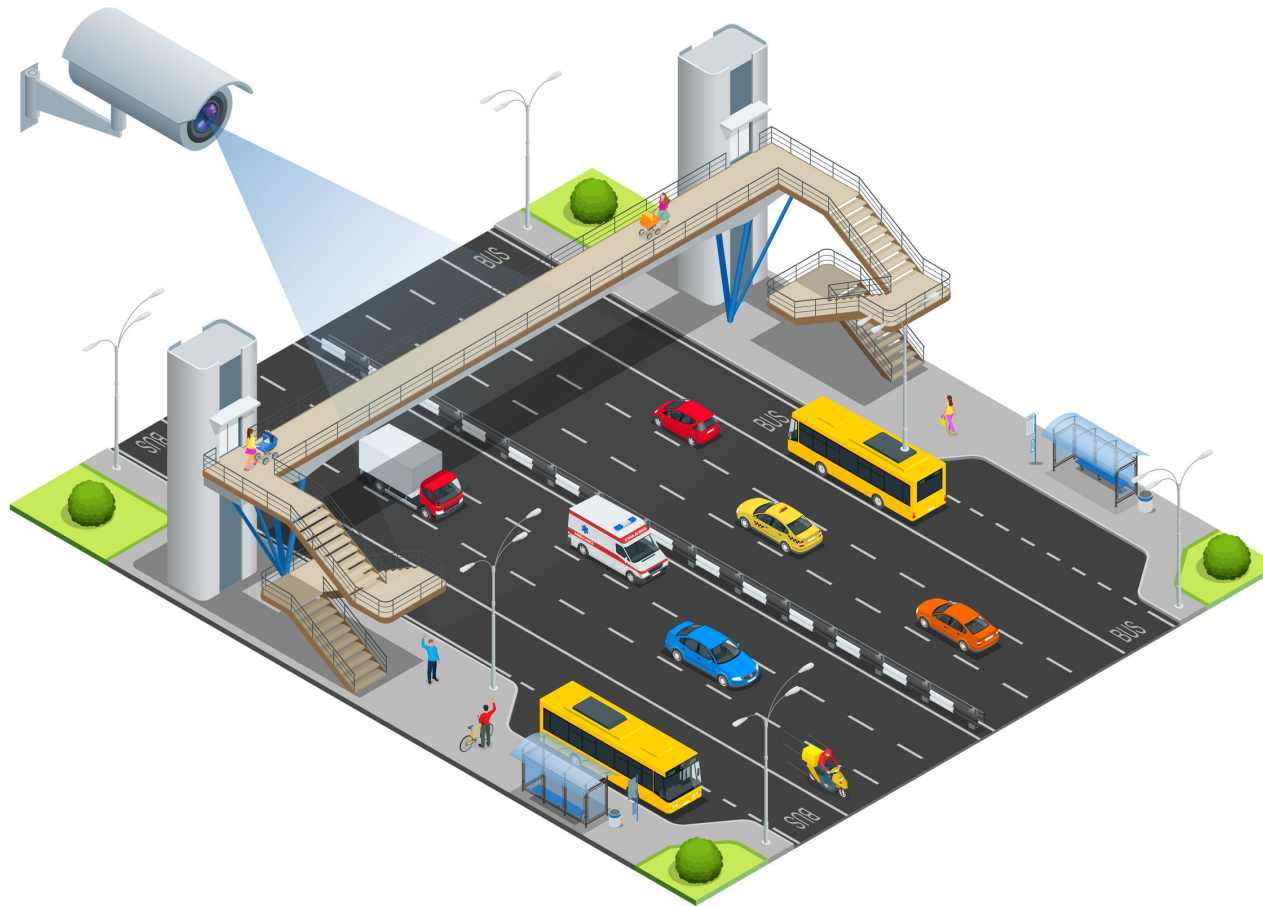
Smart City



## 2. What are Intelligent Systems?



### Intelligent Transportation System





## 2. What are Intelligent Systems?



### Smart House



## 2. What are Intelligent Systems?



### Precision Agriculture



## 2. What are Intelligent Systems?



### Artificial Intelligent





### 3. What are Embedded Systems?



- Embedded systems are application-oriented computer systems.
- A computer system consists of hardware and software.
- Embedded system will deal with embedded hardware (embedded processor, embedded platform, etc) and embedded software (most important of which is embedded OS).



## 4. Typical Embedded Hardwares



- Microcontroller Units ( $\mu$ Cs, or MCUs)
- Digital Signal Processors (DSPs)
- Embedded Microprocessors
- System on Chips (SoCs)



## 4. Typical Embedded Hardwares



### Micro Controllers

A microcontroller is a system that integrates a microprocessor with peripheral circuits and memory.

It is low-cost, low power-consumption with abundant on-chip I/Os.

Widely used in industrial control system.

- Intel 8048 (In PC keyboard)
- Intel 8051 series (Remarkable, widely used in controlling)
- TI MSP430 (Very low powered processor,  $1\mu\text{A}$  in idle mode)
- TI C2000 (Real-time control MCUs)
- 



## 4. Typical Embedded Hardwares



DSPs

A practical digital system needs to be very fast and efficient.

Implementing of digital signal processing algorithm.

Suppose following algorithm:

$$y(n) = \sum_{k=0}^{99} a_k x(n - k)$$

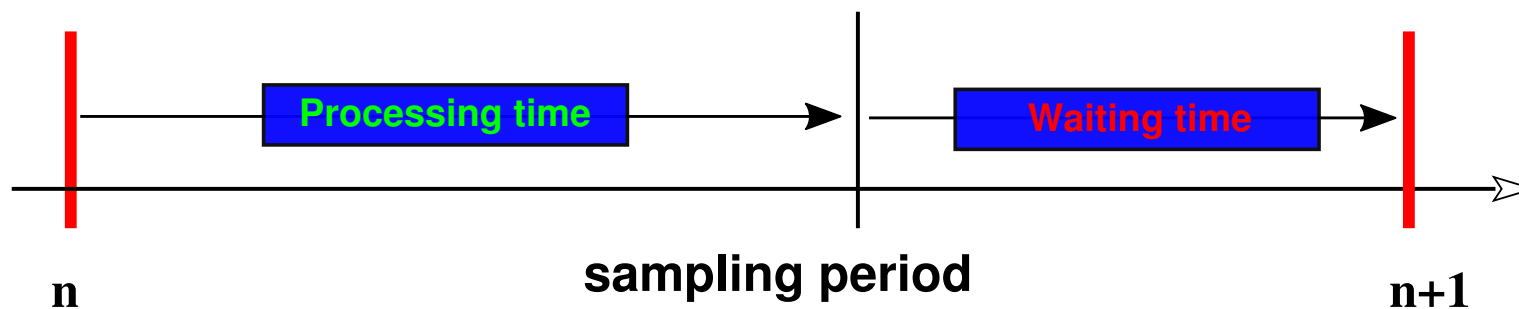


Fig 1: Real-time processing



## 4. Typical Embedded Hardwares



### DSPs

DSPs (Digital Signal Processors) are dedicated designed microprocessors, which are suitable for digital signal processing algorithm:

- Hardware multiplication units
- Advanced bus architecture
- Multiple ALUs (fit for parallel computing)
- Optimized interrupt latency

DSP theories are widely used in audio, video and image processing.





## 4. Typical Embedded Hardwares



### MPUs

Microprocessor is a multipurpose, clock driven, register based digital-integrated circuit

As a general purpose system, MPU incorporates the functions of a CPU on a single IC.

Some Remarkable processor IP cores:

- x86 Atom (Designed by INTEL)
- ARM, Cortex (Designed by ARM Inc.)
- MIPS (Designed by MIPS)
- PowerPC (Apple, IBM and Motorola, AIM alien)
- ...



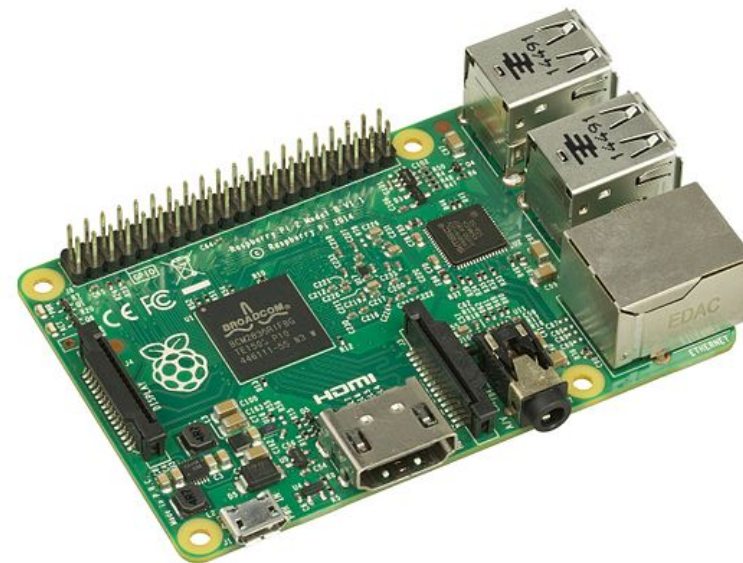
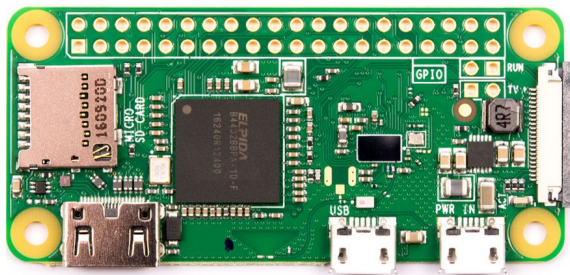
## 4. Typical Embedded Hardwares



### SoCs

An SoC is an IC that integrates all components of a computer or other electronic systems.

SoC integrates a microcontroller (or microprocessor) with advanced peripherals like graphics processing unit (GPU), Wi-Fi module, or coprocessor.



## 4. Typical Embedded Hardwares



### GPU

Modern GPUs are very efficient at manipulating computer graphics and image processing, and their highly parallel structure makes them more efficient than GPP (General-Purpose Processors) for algorithms where the processing of large blocks of data is done in parallel.

As an example, take a look at transform between colorspace RGB and YUV:

$$\begin{pmatrix} Y \\ U \\ V \end{pmatrix} = \begin{pmatrix} 0.299 & 0.587 & 0.114 \\ -0.147 & -0.289 & 0.436 \\ 0.615 & -0.515 & -0.100 \end{pmatrix} \begin{pmatrix} R \\ G \\ B \end{pmatrix}$$

A GPP needs 9 multiplications and 6 additions to finish this transform. This takes too long time.



## 5. Embedded Softwares



### Embedded OS

Operating system is the most important software in a computer.

Most desktops and supercomputers are equipped with Time-sharing operating system, however, embedded applications need real-time performance.

Embedded operating systems are dedicated designed to be resource-efficient and reliable.

A simple list of Embedded OSes:

- VxWorks(The most famous hard real-time OS)
- Windows Embedded(past tense)
- Real-time Linux and other Linux variations
- OpenWRT (home routers)
- RTEMS(military system→multiprocessor system)

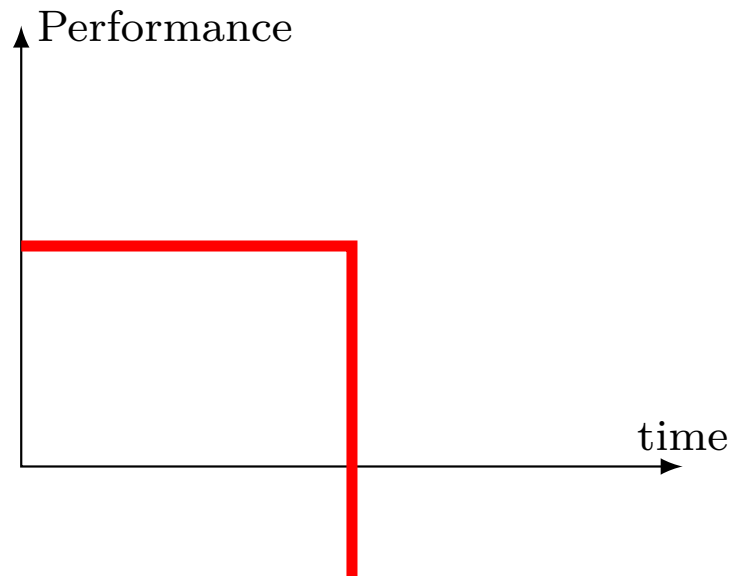


## 5. Embedded Softwares

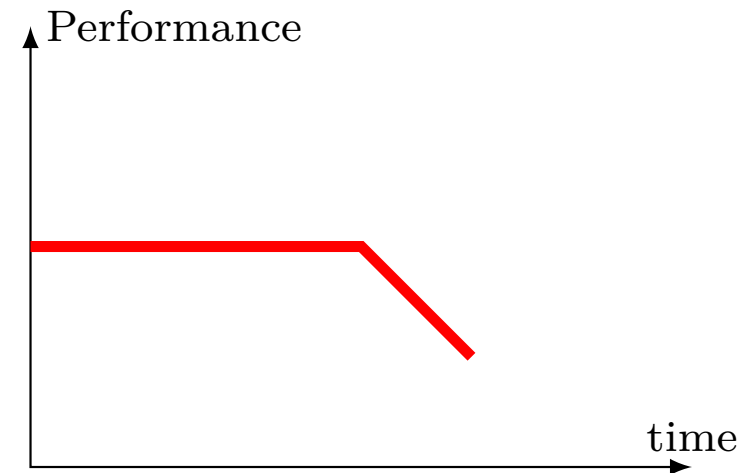


### Embedded OS

Embedded OSes are often considered to be real-time, or RTOS (Real-Time Operating System).



(a) Hard realtime



(b) Soft realtime





## 5. Embedded Softwares



### Scheduling of an OS

An RTOS has an advanced algorithm for scheduling. The most common designs are:

- Event-driven — switches tasks only when an event of higher priority needs servicing. (preemptive priority)
- Time-sharing — switches tasks on a regular clocked interrupt, and on events. (round robin)



## 5. Embedded Softwares



### RTOS

RTOS is valued more for how quickly or how predictably it can respond than for the amount of work it can perform in a given period of time.

- Time sharing systems — The programmed reaction to an event will certainly happen **sometime in the future**.
- Soft Real Time systems — The programmed reaction to an event is **almost always completed** within a known finite time.
- Hard Real Time systems — The programmed reaction to an event **must be guaranteed to be completed** within a known finite time.



## 6. About OS



### Linux

- Because of its free software license, the Linux kernel code is available for study and modification.
- A wide range of computing machinery, from supercomputers (top 385 in Feb.2017, top 500 in Jun. 2018) to wearables.
- Linux runs on dozens of hardware platforms:

alpha	h8300	mips	sh	arc	mn10300	sparc
arm	arm64	x86	ia64	nios2	tile	hexagon
blackfin	m32r	parisc	c6x	m68k	powerpc	arc
cris	openrisc	s390	xtensa	frv	microblaze	

- Linux desktop users are increasing.



## 6. About OS



### Some Features of Linux

- Open source
- POSIX standard
- Plenty of software supports
- Network connectivities
- Reliability, almost virus-free



## 7. Questions



### Questions

- In your opinion, what are intelligent systems, what is different between intelligent system and artificial intelligent?
- Learn more about Linux Operating system. What is different between Linux, Windows and MacOS ?

