EMBEDDED SYSTEMS & CONTROLLERS

UPSKILLING CONTENT FOR STUDENT

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DEFINITION

Embedded System is an electronic/electro-mechanical system designed to perform a specific function and is a combination of both hardware and software.

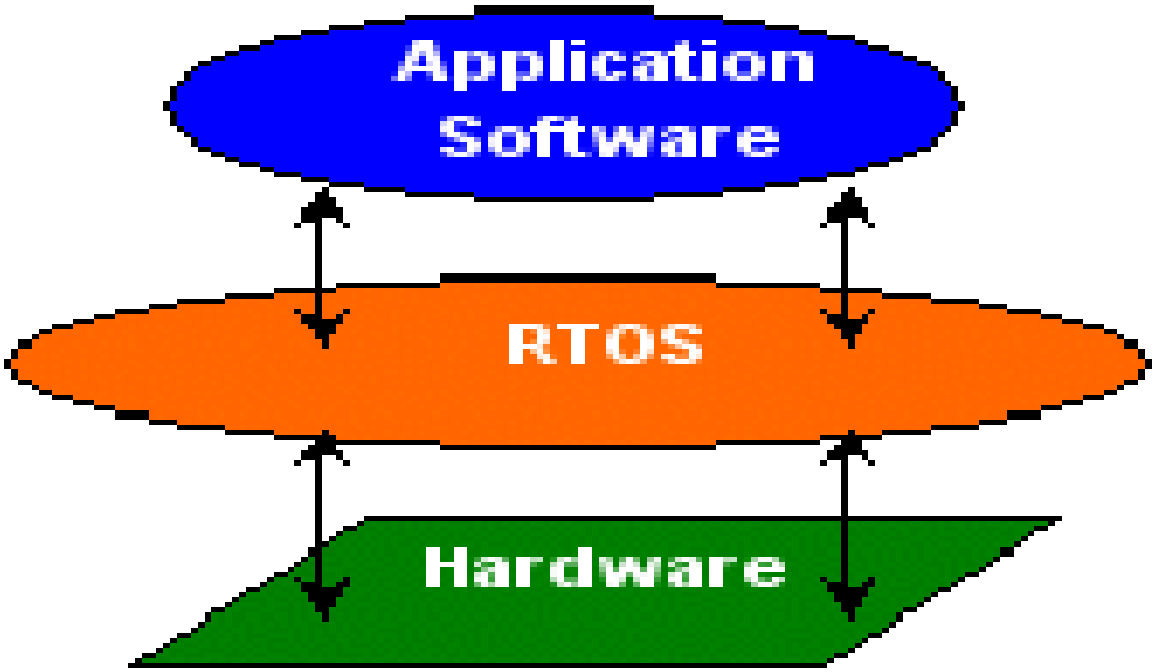
Examples;

Microwave ovens, Refrigerator, DVD players, Music Systems, Modern Vehicles, Mobile Phones, Digital Camera, Computer systems etc.

EMBEDDED PROCESSOR :

An Embedded Processor is a Special Microprocessor or Microcontroller that allows for Fast, Precise and Intensive Calculations for Complex Real Time Applications.

Source	Digital Signal Processor
Motorola	5600xx
Analog Devices	SHARC
Texas Instruments	TMS320Cxx



- Above Figure shows an RTOS Kernel provides an Abstraction Layer between Application Software and Embedded Hardware

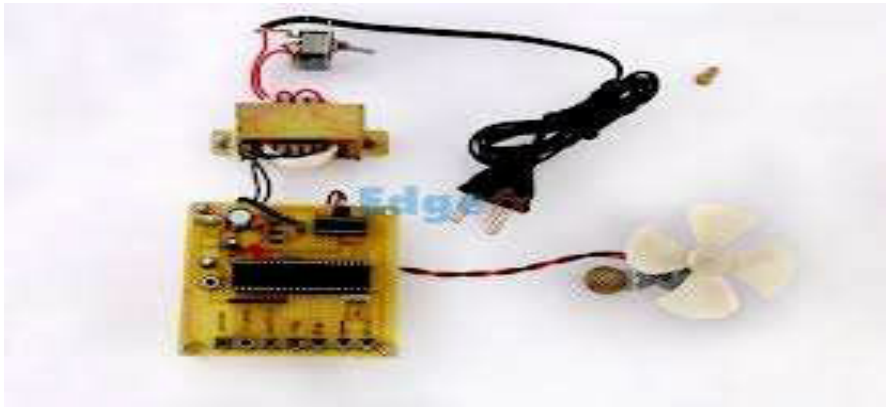
CLASSIFICATION OF EMBEDDED SYSTEM

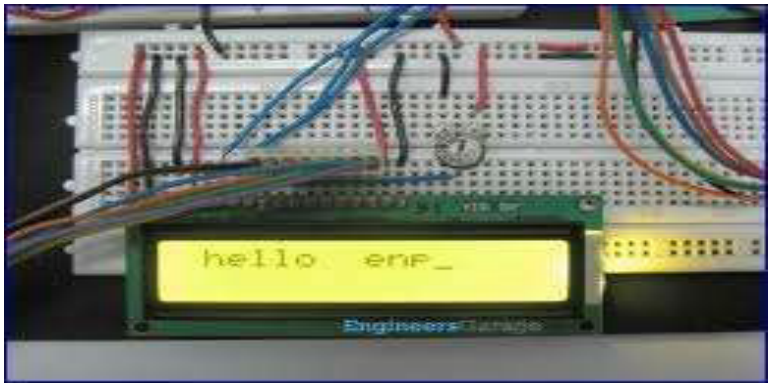
Classify Embedded Systems into three types as follows:

1. Small Scale Embedded Systems
2. Medium Scale Embedded Systems
3. Sophisticated Embedded Systems

Small scale Embedded System - Single 8 or 16 bit microcontroller, little hardware and software complexities, C or Java as development platform.

Applications:

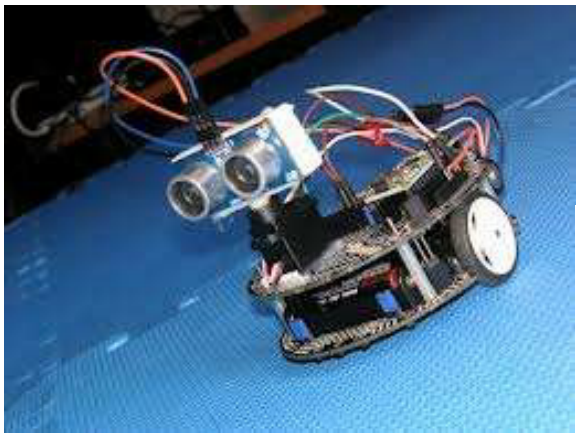




Medium Scale System -

Single or few 16 or 32 bit microcontrollers or DSPs or RISCs, may also employ the readily available ASSPs and IPs in the hardware, use complex software design tools: 'C', Source code engineering tool, RTOS, IDE (Integrated Development Environment) as the development platform.

APPLICATIONS:



SOPHISTICATED SYSTEM - THEY HAVE ENORMOUS HARDWARE AND SOFTWARE COMPLEXITIES, MAY ALSO EMPLOY SCALABLE OR CONFIGURABLE PROCESSORS AND FPGAS, NEEDS HARDWARE AND SOFTWARE CO-DESIGN AND INTEGRATION IN THE FINAL SYSTEM.

Applications Areas

Where in our daily life do we use embedded systems?

Automobiles

How many embedded systems are in a modern car?

- trip computer (fuel cons.,etc.)
- electronic ignition
- airbag
- immobiliser, keyless entry
- ABS
- ESP
- …

Automobiles

2002: Opel Vectra has over 40 sensors (25 types)

System On Chip (SOC)

- Technological Advances
  - today's chip can contains more than 500M transistors .
  - approximately every 18 months the number of transistors on a chip

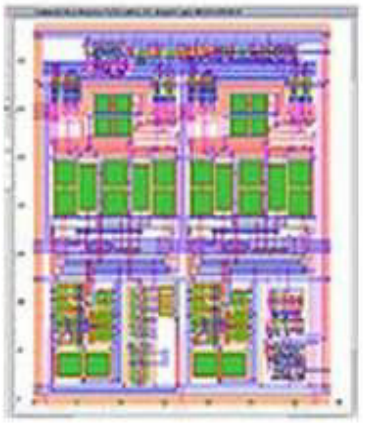
doubles – Moore's law .

- The Consequences
  - components connected on a Printed Circuit Board can now be

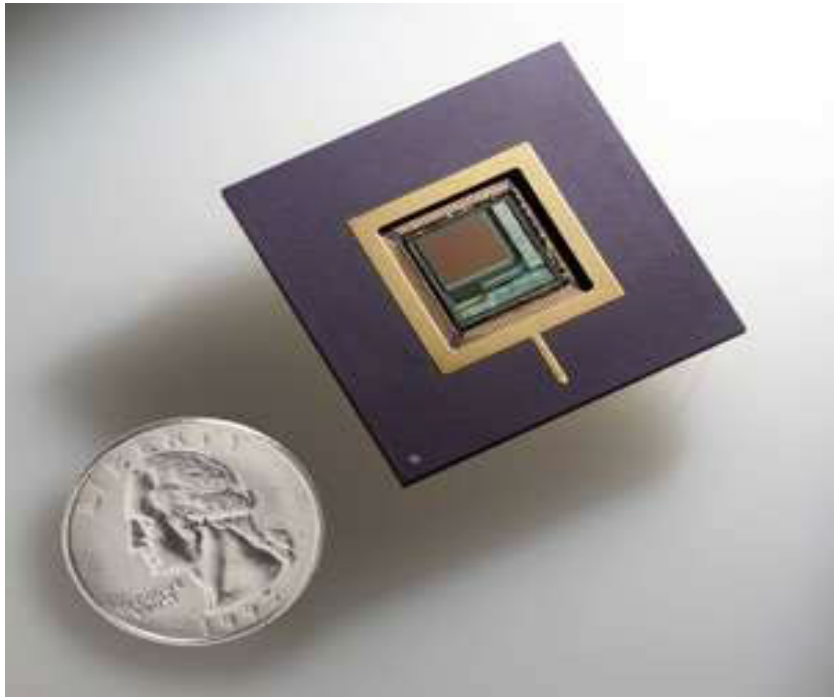
integrated onto single chip .

  - hence the development of **System-On-Chip** design .

From PCB to SoC



SOCS EXAMPLES



Camera-on-chip (Bell Labs)

Solar-power Wireless Sensor (Berkeley)

SYSTEM-IN-PACKAGE (SIP) or (MCM)

- **System-in-Package** *(SiP)* , is a number of integrated circuitsenclosed in a single package or module.

- The SiP performs all or most of the functions of an electronic system such as a mobile phone ,PC, digital music player, etc.

- The chips may be stacked vertically or placed horizontally

alongside one another inside the package.

- They are internally connected by fine wires that are buried in the package, or using solder bumps to join stacked chips together.

Advanced Microcontroller Bus Architecture

- The **Advanced Microcontroller Bus Architecture** was introduced in 1996 and is widely used as the on-chip bus for ARM processors.
- The first AMBA buses were Advanced System Bus (**ASB**) and Advanced Peripheral Bus (**APB**).
- As an example SoC based on the MIPS architecture.

Embedded Processors and Controllers

ARM Processors

ARM PROCESSORS

- The **ARM** architecture (**Advanced RISC Machine**, and prior to that **Acorn RISC Machine**) is a 32-bit RISC processor architecture developed by ARM Limited that is widely used in a number of embedded designs.

- Because of their power saving features, ARM CPUs are dominant in the mobile electronics market, where low power consumption is a critical design goal.

WHY ARM HERE?

- ARM is one of the most licensed and thus widespread processor cores in the world
- Used especially in portable devices due to low power consumption and reasonable performance (MIPS / watt)
- Several interesting extensions available or in development like Thumb instruction set.

ARM ARCHITECTURE

- The ARM architecture includes the following RISC features
  - Load/store architecture
  - No support for misaligned memory accesses (now supported in ARMv6 cores)
  - Orthogonal Instruction set (where all instructions have the same format and all registers and addressing modes can be used interchangeably)
  - Large 16 × 32-bit register file
  - Fixed instruction width of 32 bits to ease decoding and pipelining.

ARM ARCHITECTURE

- 32-bit RISC-processor core (32-bit instructions)
- 37 pieces of 32-bit integer registers (16 available)
- Pipelined (ARM7: 3 stages)
- Von Neuman-type bus structure (ARM7), Harvard (ARM9)
- 8 / 16 / 32 -bit data types
- Simple structure -> reasonably good speed / power consumption ratiO

MIPS

A BRIEF HISTORY

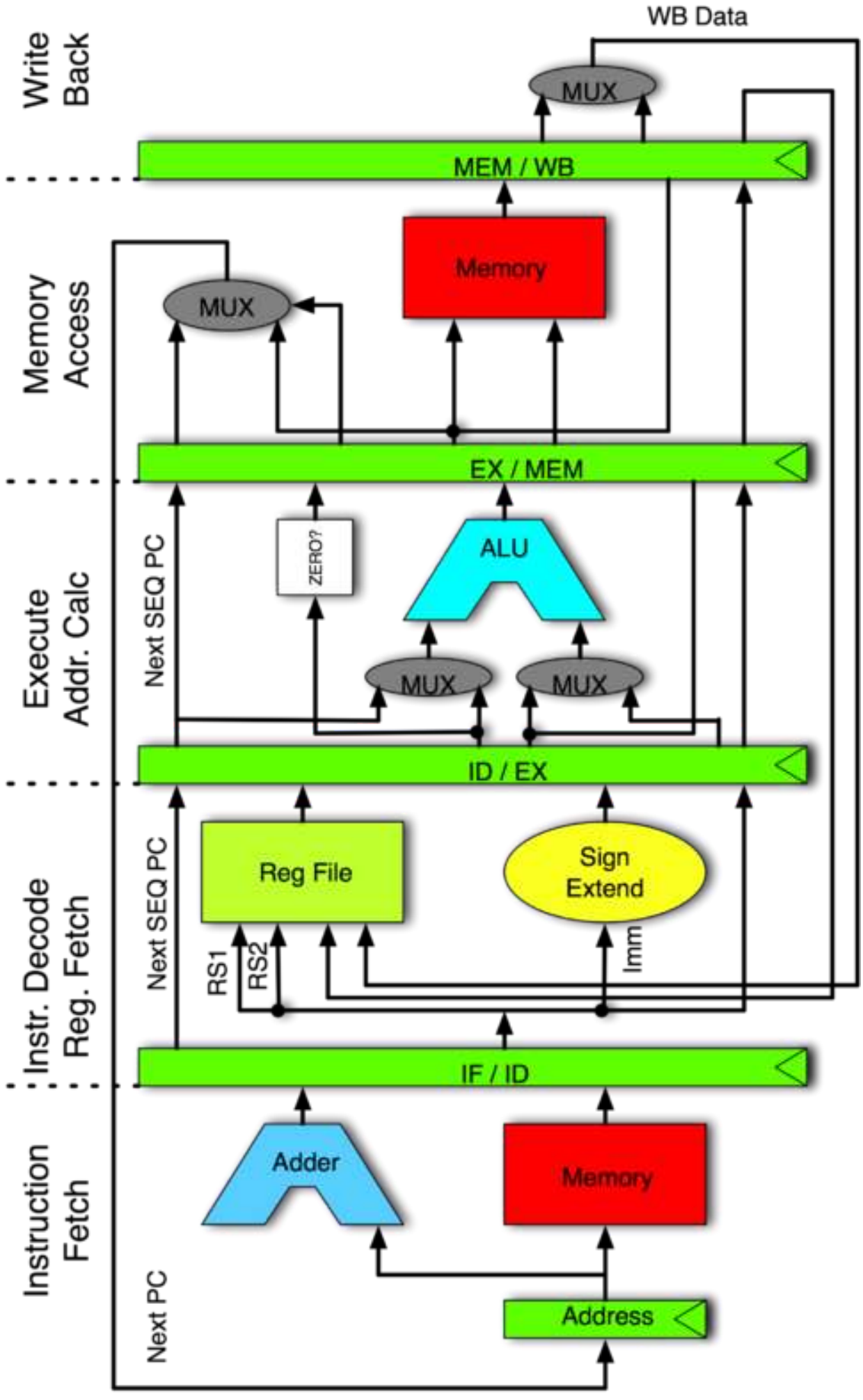
- In 1981, a team led by John L. Hennessy at Stanford University started work on what would become the first MIPS processor. The basic concept was to dramatically increase performance through the use of deep instruction pipelines.

PIPELINING VS SEQUENTIAL EXECUTUION

- In a pipeline architecture, Modules inside CPU work in parallel so that CPU will load and start executing an instruction before the preceding instruction is complete
- In contrast, traditional designs of the era waited to complete an entire instruction before moving on, thereby leaving large areas of the CPU idle as the process continued

EMBEDDED MARKET OF MIPS

- computer networking/ telecommunications
- video arcade games
- computer printers
- digital set-top boxes
- digital televisions
- cable modems
- personal digital assistants.


WB Data
Write Back
MUX
MEM / WB
Memory
Memory Access
MUX
EX / MEM
ZERO?
ALU
Next SEQ PC
MUX
MUX
Execute Addr. Calc
ID / EX
Reg File
Sign Extend
Next SEQ PC
RS1
RS2
Imm
Instr. Decode Reg. Fetch
IF / ID
Adder
Memory
Address
Next PC
Instruction Fetch

FIVE STAGES

- IF - Instruction Fetch unit
  - typically referred to as "the load unit" in modern terminology
- ID - Instruction Decode unit
  - this unit gets instruction from IF, and extracts opcode and operand from that instruction. It also retrieves register values if requested by the operation.
- EX - Execution unit
  - runs the instructions, typically referred to as the ALU in modern terminology
- MEM - Memory access unit
  - the MEM unit fetches data from main memory, under the control of the instructions from ID and EX.
- WB - WriteBack unit
  - typically referred to as "the store unit" in modern terminology

MMX Procesosrs

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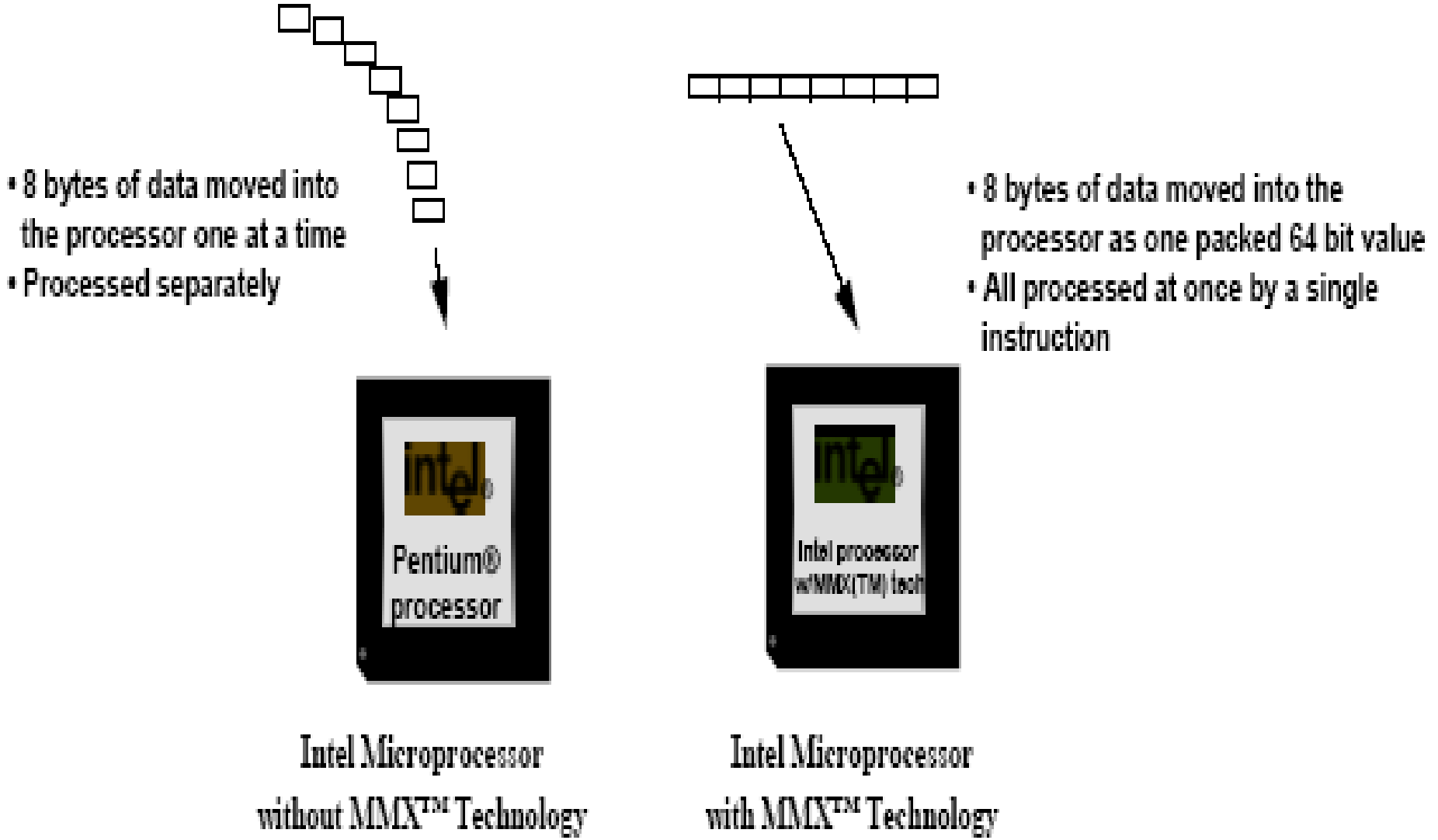
MMX

- **Short for *Multimedia Extensions* , a set of 57 multimedia instructions , introduced in 1997 , built into Intel microprocessors and other x86-compatible microprocessors.**
- MMX-enabled microprocessors can handle many common multimedia operations, such as digital signal processing (DSP), that are normally handled by a separate sound or video card.

MMX TECHNOLOGY

- MMX™ technology is a major enhancement to the Intel Architecture designed to accelerate multimedia and communications software.
- MMX technology includes new data types and 57 new instructions to accelerate calculations common in audio, 2D and 3D graphics, video, speech synthesis and recognition, and data communications algorithms.



PARALLEL PROCESSING

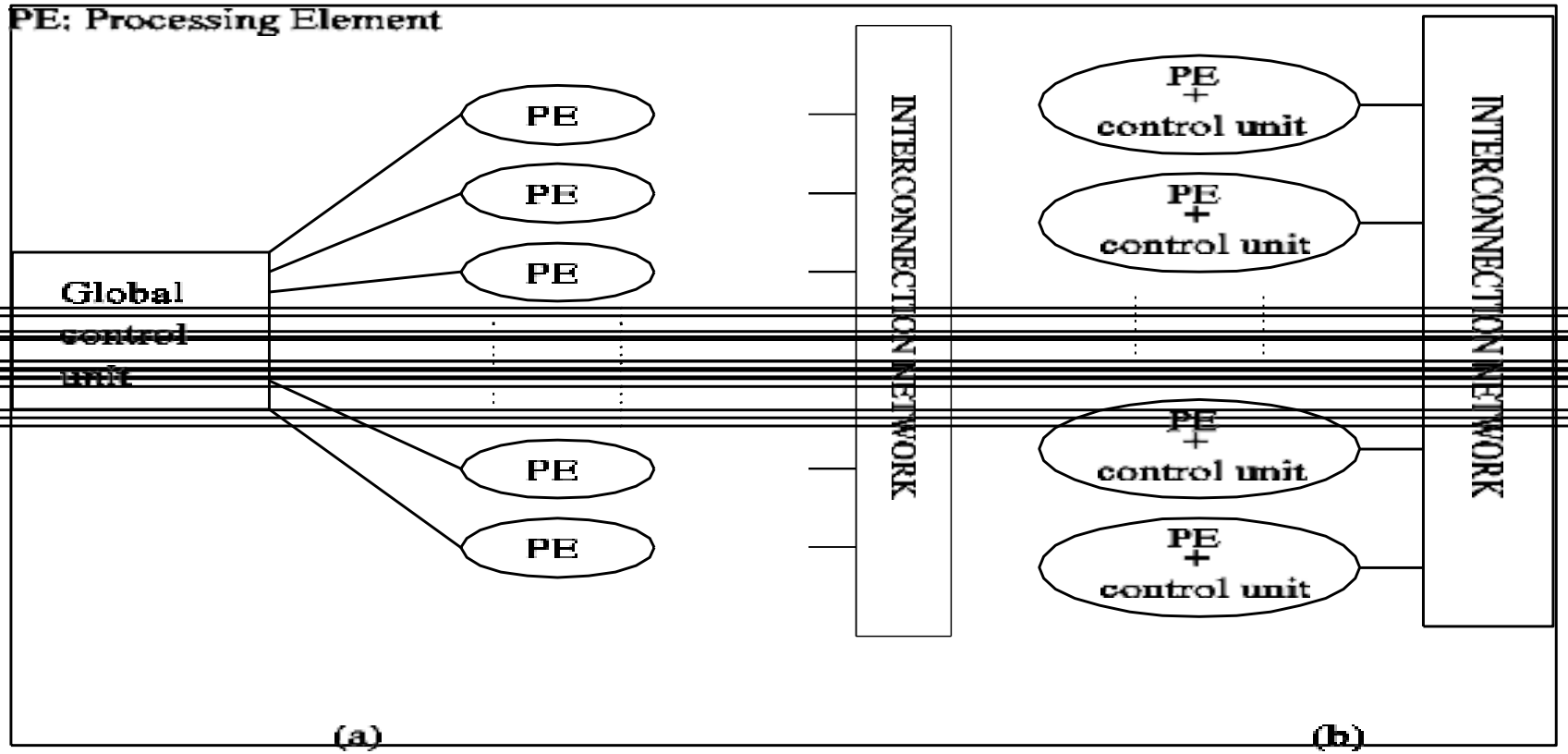
- Parallel processing means more than single process in parallel.
- The system posses parallel processing capabilities are also known as multiprocessing systems.
- Multiprocessing systems require special feature of Interlock and Synchronization.

METHODOLOGIES OF PARALLELISM

There are four classification of methods of parallelism in terms of parallelism in ***Instruction stream*** and in terms of ***Data stream*** .

- **SISD**-Single Instruction, Single Data.
- **SIMD**-Single Instruction, Multiple Data.
- **MISD**- Multiple Instruction, Single Data.
- **MIMD**-Multiple Instruction, Multiple Data.

SIMD AND MIMD PROCESSORS



(a) A typical SIMD architecture, and (b) A typical MIMD architecture.

THANK YOU!

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