



SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
An Autonomous Institution



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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

19ECT312 – EMBEDDED SYSTEM DESIGN

III YEAR/ VI SEMESTER

UNIT 1 – INTRODUCTION TO EMBEDDED SYSTEMS

- TOPIC 1.2 – Structural Units in a Processor



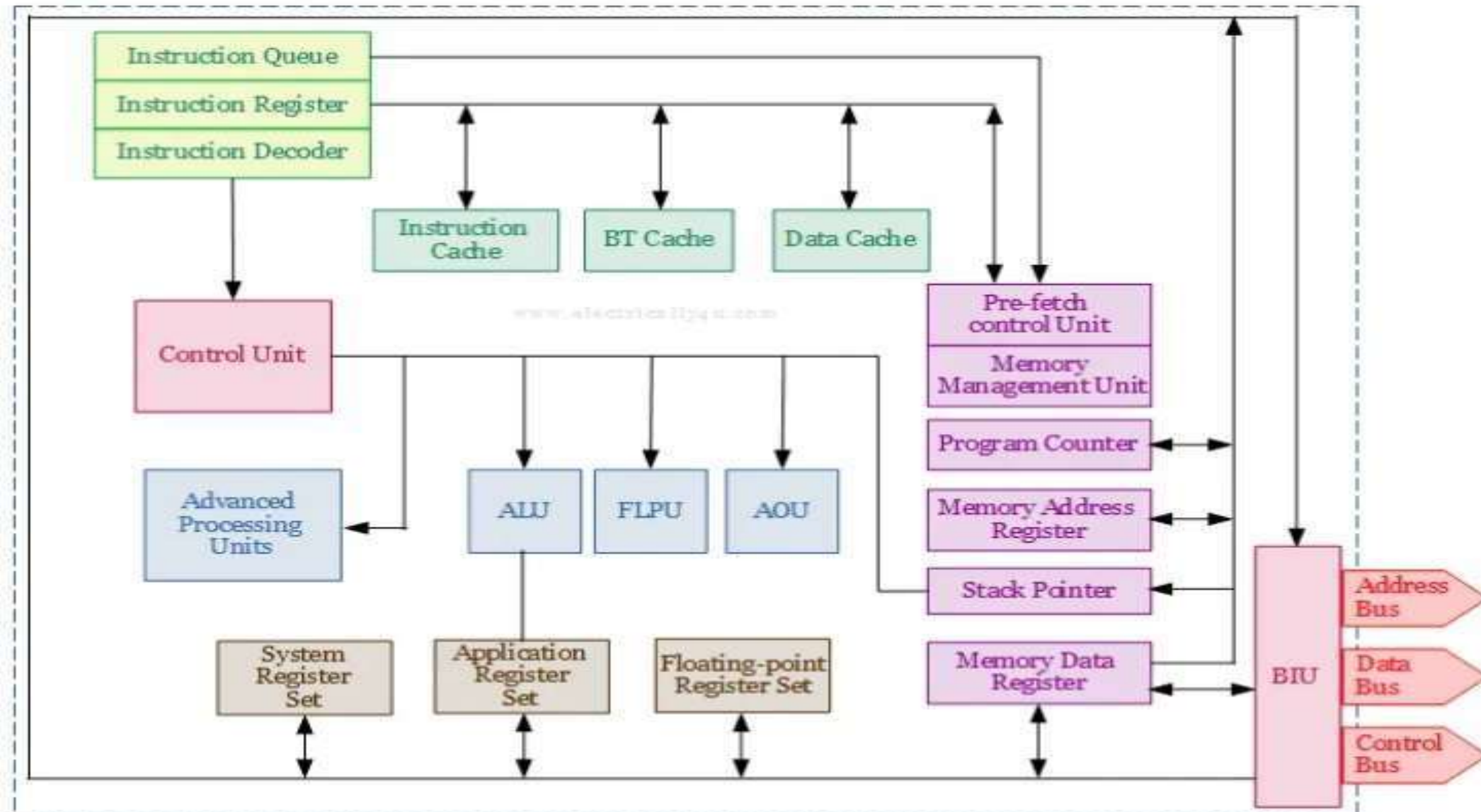
Structural Units in a Processor



- The processor in any embedded system contains various units for its successful and fast operation. Buses, memories, processing units, instructions, registers, control units are some of the structural units that an embedded processor should possess.
- For quick operation, the system may have advanced processing units for superscalar and pipeline processing



Structural Units in a Processor





Structural Units in a Processor

- Internal Buses
- Instruction Units
- Caches
- Control Units
- Processing Units
- Register Sets
- Memory Registers
- Program Counter and Stack Pointer



Structural Units in a Processor



Internal Buses

- It internally connects all the structural units inside the processor. Its width can be of 8, 16, 32 or 64 bits.
- The internal buses include address bus, data bus and control bus.
- All the internal units of the processor are communicated with the external buses through an interface unit called *Bus Interface Unit(BIU)*.



Structural Units in a Processor



- *Address bus* is an external bus that carries the address from the Memory Address Register(MAR) to the memory as well as to the IO devices and other units of the system.
- *Data bus* is an external bus that carries the data from or to the address determined by Memory Address Register(MAR).
- *Control Bus* is an external bus that carries, control signals to or between the processor and memory.



Structural Units in a Processor



Instruction Units

- The processor executes several operations with the help of a piece of code or program called instructions. All these instructions are arranged in a queue called *Instruction Queue(IQ)*.
- This helps the Instruction Register to execute the instructions without the need to wait.
- Instruction Register(IR)* takes the instruction codes(opcodes) sequentially to the execution unit of the processor.
- Instruction decoder(ID)* decodes the instruction opcode received at the Instruction Register and passes it to the processor Control unit for its execution..



Structural Units in a Processor

- **Caches**
- In general, cache is the temporary storage place in the processor, where the data can easily be retrieved by the CPU for quick operation.
- Cache is available in your computers, laptop, mobile phone, browser, app, etc. The embedded processor has three cache memory for fast operation.



Structural Units in a Processor

Instruction Cache(I-Cache) sequentially stores the instructions in FIFO mode. It lets the processor to execute the instructions at a greater speed.

Branch Target Cache(BT Cache) facilitates the ready availability of the next instruction set, when a branch instruction like jump, call or loop is encountered. Its fetch unit foresees a branching instruction in the I – cache.

Data Cache(D – Cache) stores the pre – fetched data from the external memory.

A data cache holds both the address and data together at a location. It also stores the write-through data that is to be transferred to the external memory addresses. Write-through data is nothing but the output data from the execution unit.



Structural Units in a Processor

Control Units

- The *control unit(CU)* is one of the important structural units in an any embedded processor.

- It is responsible for all the control of the bus activities and unit functions needed for processing.

- It directs all the units of a processor to respond to the instruction that is executed.

Pre fetch control Unit(PFCU) controls the fetching of data into the I-Cache and D-Cache in advance from the memory unit.

The instructions and data are delivered when needed to the processor's execution units.

Memory Management Unit(MMU) manages the memories such that the instructions and data are readily available for processing. There are several memory management methods for managing the memory in an embedded processor such as fixed block allocation, dynamic block allocation, dynamic page allocation, etc.



Structural Units in a Processor



Processing Units

Processing units receives the input data, process it and produces the output.

Depending on the function of the embedded system, the processing is done through different units like ALU, FLPU, AOU and advanced units.

Arithmetic Logic Unit(ALU) is used for the execution the arithmetic and logic instructions according to the instruction present at the Instruction Register.

Floating point processing unit(FLPU) is different from ALU, used primarily for floating point processing. It is essential for fast processing mathematical functions in a microprocessor or Digital Signal Processor.

Atomic operation unit(AOU) lets a user (compiler) instruction when broken into number of processor instructions called atomic operations, finish before an interrupt of the processor occurs.

The embedded processor also has **Advanced processing units for multistage pipeline processing**, multi-line superscalar processing to obtain processing speeds higher than one instruction per cycle.



Structural Units in a Processor



Register Sets

Application Register Set(ARS) is a set of on-chip registers used during processing of instructions of the application program of the user.

A register window consists of a subset of registers with each subset storing static variables of software – routine.

System Register Set(SRS) is a set of registers used while processing the instructions of the supervisory system program.

Floating point register set(FRS) is dedicated for storing floating point numbers in the standard format and used by Floating point Processing Units for its data.

Memory Registers

Registers are smallest part of the CPU, where the data and address can be stored and accessed quickly. There are various registers like accumulator, general purpose registers, flag registers, memory address register, memory data register, program counter, stack pointer, etc.

Memory Address Register(MAR) holds the address of the data byte or word that is to be fetched from external memories. *Memory Data*

Register(MDR) holds the data byte or word that is fetched from external memory or stored to the external memory.



Structural Units in a Processor



- **Program Counter** $M \rightarrow \text{ADDRESS}(\text{Next})$
- **and Stack Pointer (Last)**

• **Program counter** is a register that stores the address of the next instruction to be executed from the memory. It generates the instruction cycle to fetch the address from memory through MAR.

• **Stack pointer** is a register that stores the address of the last program request in a stack. It is a pointer for an address which corresponds to a stack top in the memory.



Based on performance and functional requirements



Standalone Embedded Systems

- independent systems that do not depend on other systems.
- It takes the input either in analog or digital form, processes and produces the output.
- It may either control or drive the connected devices.
eg. mp3 players, digital cameras, video game consoles, microwave ovens and temperature measurement systems etc

Real Time Embedded Systems

- gives a required output within a specified time.
- These systems follow the time deadlines for the completion of a task.
- two types - soft real-time and hard real-time embedded systems.
eg. Automotive airbag control systems, flight control systems



Based on performance and functional requirements



Networked Embedded Systems

- related to a network to access the resources from one place.
- connected network can be LAN, WAN or the internet.
- connection can be either wired or wireless.
- fastest growing area in embedded system applications.

Eg. the embedded web server is a type of system wherein all embedded devices are connected to a web server, accessed and controlled by a web browser.

Home security system, ATM machines, card swipe machines

Mobile Embedded Systems

- compact, easy to use and require fewer resources.
- eg. portable embedded devices like mobile phones, digital cameras, mp3 players and personal digital assistants, etc.



Based on deterministic behavior



Hard Real time system

- A real-time operating system should strictly adhere to the timing constraints for a task.
- A hard real-time system must meet the timing deadlines without any delay.
- Missing the deadline would cause serious failure to the system or user

eg. airbag control system and antilock braking system of vehicles are typical examples for hard real-time systems

(When a vehicle is met with an accident, the airbag control system should operate immediately without any delay to safeguard the passenger. If there is any delay in the deployment of airbags, it will lead to the death of passengers in the vehicle.

So for a hard real-time system, *“A late answer is always a wrong answer”*.

Soft Real time system

- deadline is not strictly followed
- Missing deadlines for tasks are acceptable for soft real-time systems, but the frequency of deadlines missing should be within the compliance limit.

eg. ATM - if it takes a few seconds more than the normal operating time, it may not cause any serious problem.

In this case, *“a late answer is an acceptable answer”*, but it could have been done a bit faster



Based on triggering



- time-triggered - activated or triggered based on the pre-defined task or preset time, then such a system is said to be the time-triggered embedded system
- event-triggered- if the system is triggered based on some activity like change in temperature or change in pressure, such system is said to be an event triggered embedded system



THANK YOU