About Microcontroller

PIC16f1939 I/PT
Micorocontroller

- A microcontroller is an integrated circuit (IC) device used for controlling other portions of an electronic system, usually via a microprocessor unit (MPU), memory, and some peripherals.
- These devices are optimized for embedded applications that require both processing functionality , responsive interaction with digital, analog, or electromechanical components.
- "Microcontroller" is a well-chosen name because it emphasizes defining characteristics of this product category.
- The prefix "micro" implies smallness and the term "controller" here implies an enhanced ability to perform control functions.
- Abbreviation for "microcontroller unit" is MCU & µC.

Available Microcontroller

Types of Microcontrollers

- Microcontrollers are divided into various categories based on memory, architecture, bits and instruction sets.

Bit

- **8-bit microcontroller** – This type of microcontroller is used to execute arithmetic and logical operations like addition, subtraction, multiplication division, etc. For example, Intel 8031 and 8051 are 8 bits microcontroller.

- **16-bit microcontroller** – This type of microcontroller is used to perform arithmetic and logical operations where higher accuracy and performance is required. For example, Intel 8096 is a 16-bit microcontroller.

- **32-bit microcontroller** – This type of microcontroller is generally used in automatically controlled appliances like automatic operational machines, medical appliances, etc

Types of Microcontrollers

Memory

- **External memory microcontroller** – This type of microcontroller is designed in such a way that they do not have a program memory on the chip. Hence, it is named as external memory microcontroller. For example: Intel 8031 microcontroller.

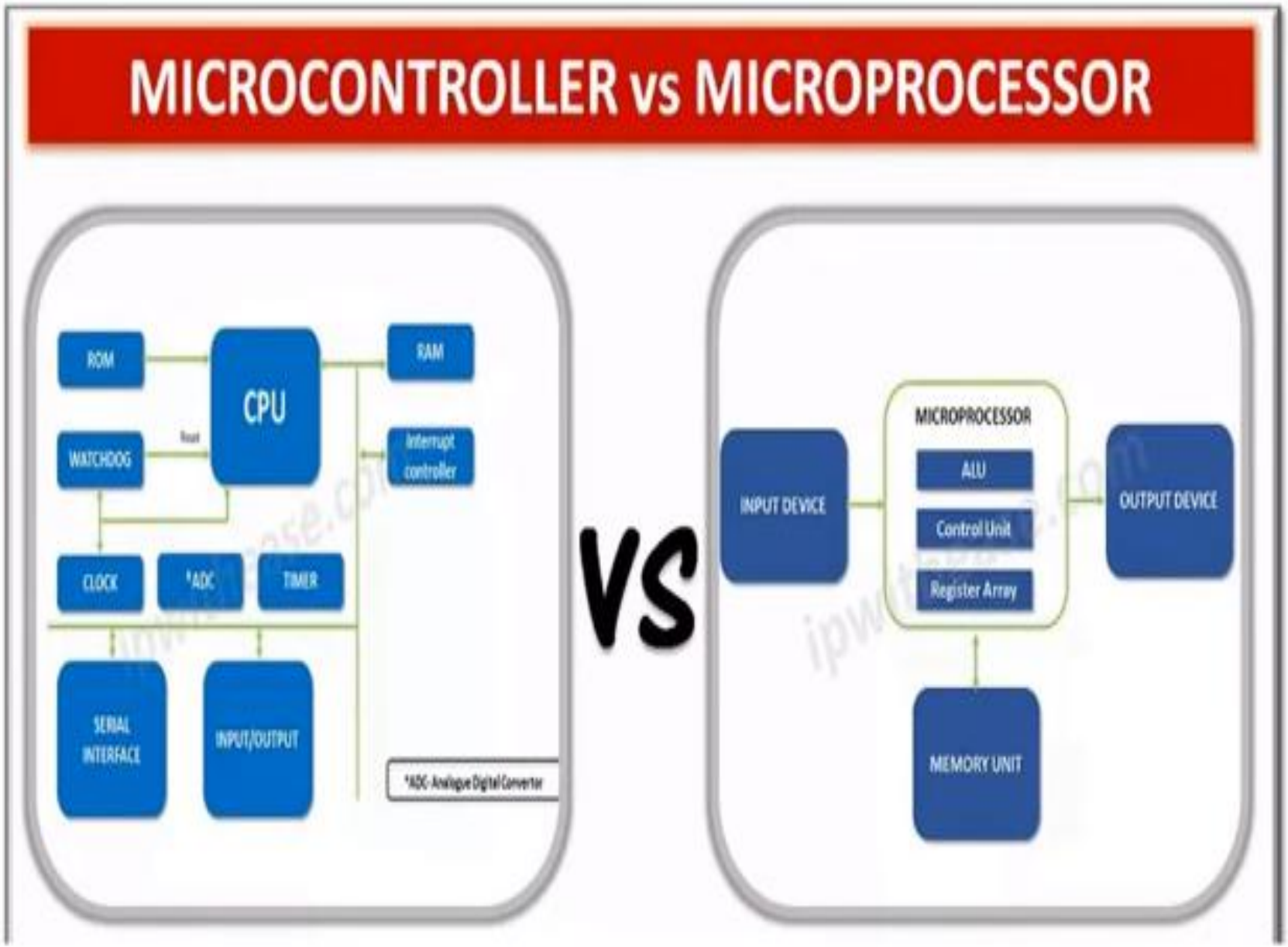
- **Embedded memory microcontroller** – This type of microcontroller is designed in such a way that the microcontroller has all programs and data memory, counters and timers, interrupts, I/O ports are embedded on the chip. For example: Intel 8051 microcontroller & above.

Types of Microcontrollers

Instruction Set

- **CISC** – CISC stands for complex instruction set computer. It allows the user to insert a single instruction as an alternative to many simple instructions.
- **RISC** – RISC stands for Reduced Instruction Set Computers. It reduces the operational time by shortening the clock cycle per instruction.

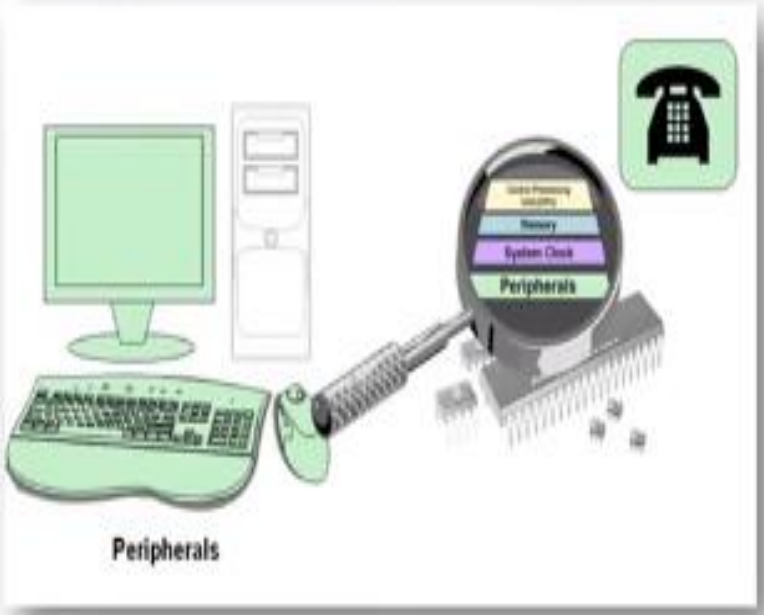
Elements of Microcontroller



Applications of Microcontrollers

Microcontrollers are widely used in various different devices such as –

1. Light sensing and controlling devices like LED.
2. Temperature sensing and controlling devices like microwave oven, chimneys.
3. Fire detection and safety devices like Fire alarm.



Applications of Microcontrollers

in Offices?

- Phone
- FAX
- Scanner
- Photo copier
- Computers
- networking devices
- Attendance recording
- Security Gadgets

in Railways?

- GPS Tracking
- Traffic signaling
- Display boards
- Track Maintenace
- Air conditioning
- public announcement systems
- Security / survelence

in Industries?

- PLCs,
- Robots,
- Security/ surveillance ,
- Bar code readers,
- weighing,
- Public Announcement systems,

in Transport Sector?

- GPS Tracking
- Traffic signaling
- Display boards
- Toll Collection Gadjets
- Security / survelence

Applications of Microcontrollers

Medical Applications

CT Scanner

Infusion Pump

ECG

Blood Sugar Level Monitor

Ultra sound scanner

MRI

Point of Care devices

BP Monitor

Defabrillators

Bed side Monitoring

EEG

X-RAY Generator

Ventilators

Passenger Information System Displays at Mysore Bus Stop

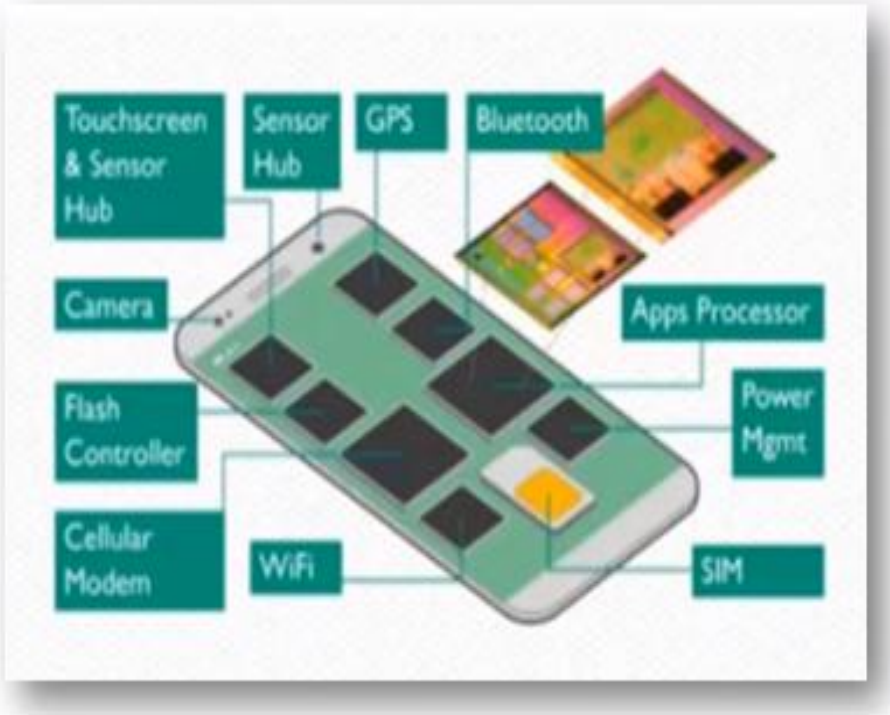
Applications in Defense & Space

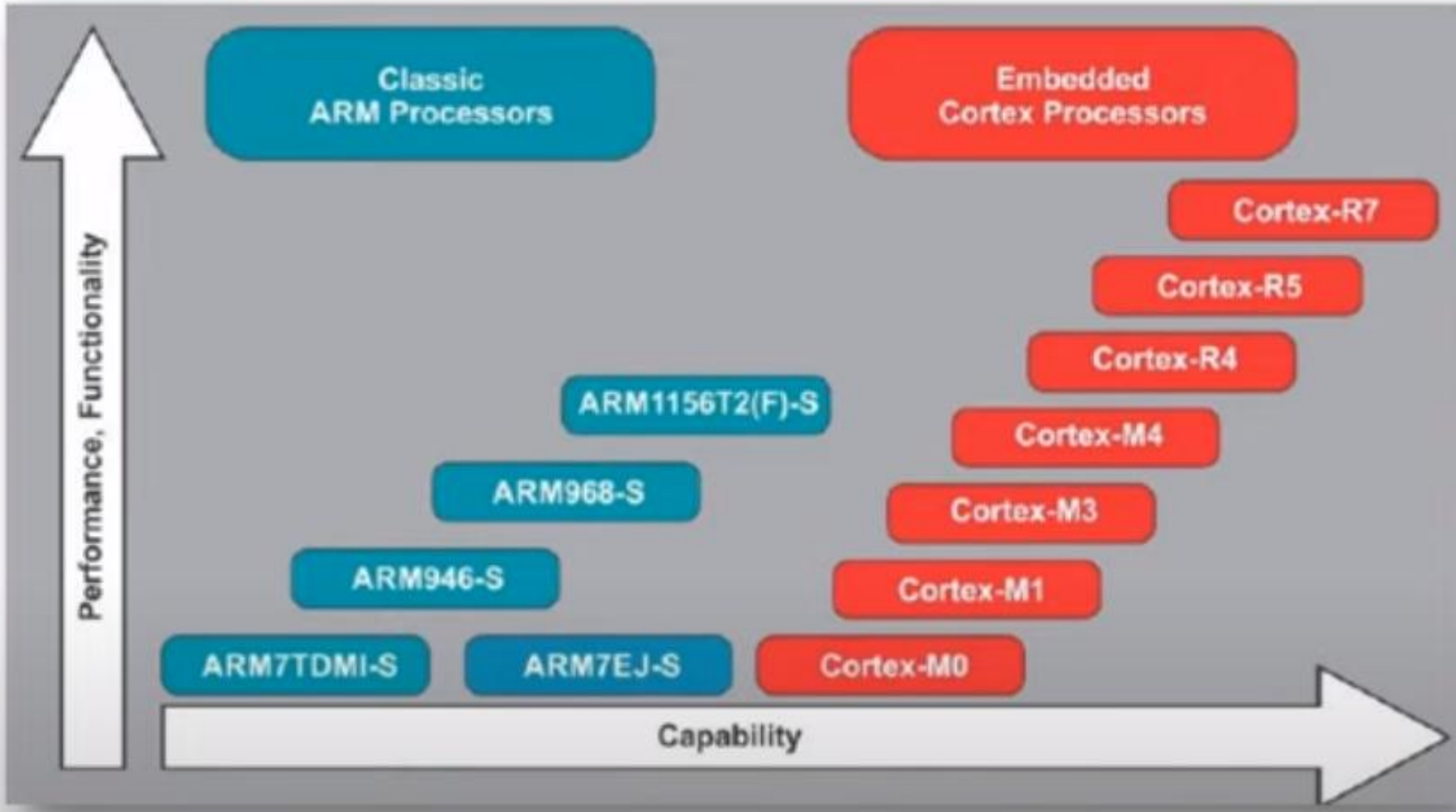
ARM PROCESSOR

- ARM came into existence in the year 1983 and was developed by Acorn Computers.
- The architecture of ARM processor is created by Advanced RISC Machines.
- It is the family of Central Processing Units.
- It is based on RISC architecture.
- This needs very few instruction sets and transistors.
- It has very small size.
- This is reason that it is perfect fit for small size devices.
- It has less power consumption along with reduced complexity in its circuits.
- They can be applied to various designs such as 32-bit devices and embedded systems.

ARM Applications

- It is used in music players, smartphones, wearable's, tablets, digital television, set-top boxes, hard drives, inkjet printers, GPS navigation systems and other consumer electronic devices.
- ARM architecture is implemented on Windows, Unix & other operating systems including Apple iOS, Android, Solaris, WebOS and GNU/Linux.




Classic
ARM Processors
Embedded
Cortex Processors
Cortex-R7
Cortex-R5
Cortex-R4
ARM1156T2(F)-S
Cortex-M4
ARM968-S
Cortex-M3
ARM946-S
Cortex-M1
ARM7TDMI-S
ARM7EJ-S
Cortex-M0
Performance, Functionality
Capability

ARM Versions

Product Family	Features	Cache Memory	MIPS
ARM1	First implementation	1 KB	
ARM2	MUL & swap instructions, Graphics and I/O processor.	MEMC	4-7 MIPS
ARM3	First integrated memory cache	4 KB	12 MIPS
ARM6	Support 32 bit Memory Add, Long Inst, Buses	4 KB	17-28 MIPS
ARM7T	3 Stage Pipeline, Thumb, 26 bit Addressing,	8 KB	15-68 MIPS
ARM 8	5-stage pipeline, static branch prediction, double-bandwidth memory	8 KB	84 MIPS
ARM9T/E	5-stage pipeline, Thumb, enhanced DSP instruction, Clockless processor	16 KB	220 MIPS
ARM10	6-stage pipeline, Thumb, enhanced DSP instructions	16-32 KB	500 MIPS
ARM 11	8 & 9-stage pipeline, Thumb, enhanced DSP instructions	32 KB	745-965 MIPS

ARM Versions

Product Family	Features	Cache Memory	MIPS
Cortex-M	Microcontroller profile, Hardware Multiply Instruction, Thumb, Timer, bit-binding memory, Stack Pointer, single and double precision Operations	64 KB	3.13 DMIPS
Cortex-R	Parity & Internal Buses, Duel Core Processors, 8-stage Pipeline dual-core running, Independent Cores, Low-Latency Peripheral port, Registers Addressing	128 KB	3.41 DMIPS
Cortex-A (32 bit)	Generic Interrupt Controller, Accelerator Coherence Port ,Thumb, Large Physical Address, 8–13 Stage Pipeline, Low-Power Design, Large Physical Address Extensions	1 MB	3.5 DMIPS
Cortex-A (64 bit)	Hardware virtualization, 2-width decode, Dual core lockstep for safety applications, 13 Stage Pipeline	4 MB	13-16 DMIP
Cortex-X	13 Stage Pipeline, L1/L2/L3 Cache Memory	8 MB	20 MIPS

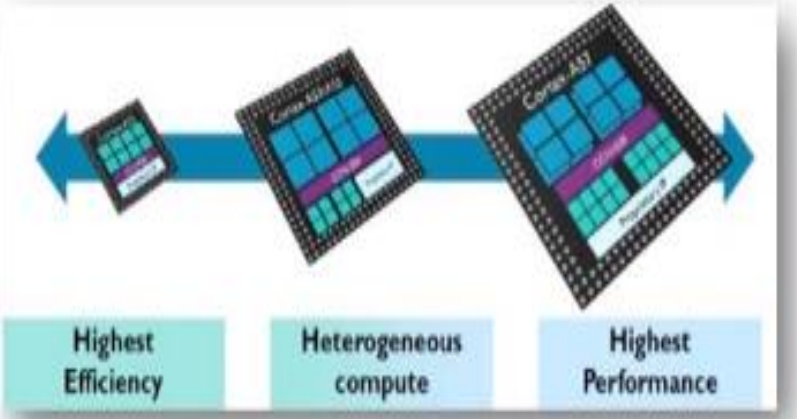
ARM Processor Features

1. Multiprocessing Systems:

- ARM processors are designed so that they can be used in cases of multiprocessing systems where more than one processors are used to process information.

2. Tightly Coupled Memory:

- This has very fast response time.



3. Thumb-2 Technology:

- Thumb-2 Technology was introduced in 2003 and was used to create variable length instruction set.
- It extends 16-bit instructions of initial Thumb technology to 32-bit instructions

ARM Processor Features

4. One cycle execution time:

- Each instruction is of fixed length that allows time for fetching future instructions before executing present instruction.
- ARM has CPI (Clock Per Instruction) of one cycle.

5. Pipelining:

- It is based on 3 stage pipelining, which provides maximum throughput.
- The first instruction is executing, the next one will be decoded and next to next one will be fetched.
- This allows fetching, decode and execution to occur simultaneously.
- This means that on each cycle there is the advancement of one step that saves time.

ARM Processor Features

6. Large number of registers:

- The RISC machines contain large uniform register files.
- It has 37 registers of 32 bits each out of which only 16 can be used at a time.
- Registers contain data and addresses.
- This increases the execution process of the whole system.

7. Load/Store Model:

- In this architecture, all operations take place within the register.
- Through load/store operation, data from the memory is loaded into the register and over that data the operation is performed.
- Once the operation gets done then the result of the same is stored in the memory.

Advantages of ARM Processor

1. Affordable to Create
2. Low Power Consumption
3. Work Faster
4. Multiprocessing Feature
5. Better Battery Life
6. Load Store Architecture
7. Simple Circuits

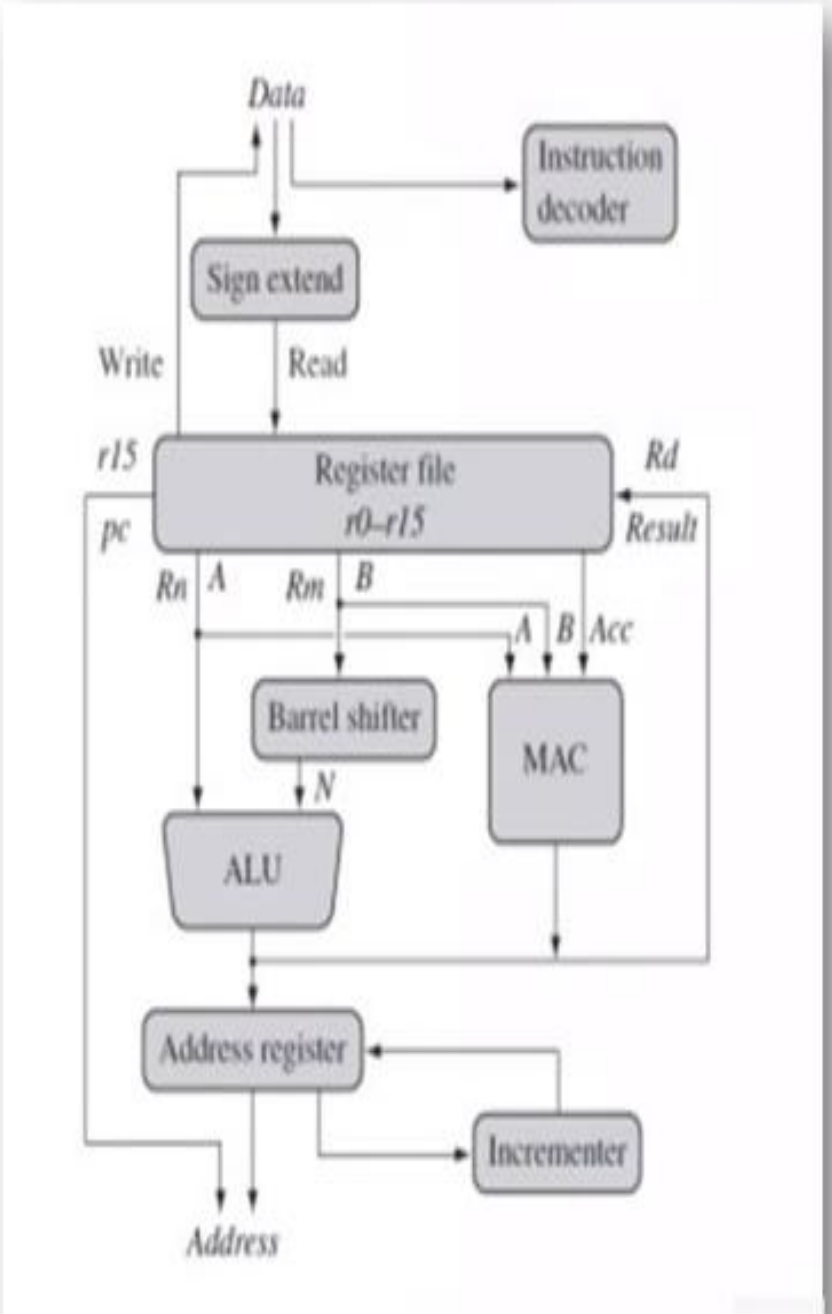
Disadvantages of ARM Processor

1. The speeds are limited in some processors which might create problems.
2. Scheduling instructions is difficult in case of ARM processors.
3. ARM Processor needs very highly skilled programmers because when processor not executed instructions properly then its get slower.

ARM DATA FLOW MODEL

ARM Dataflow Model

- ARM Dataflow model provides an overview of the internal structure of processor.
- It describe how data moves between its different parts.
- It also shows interaction between different components placed in same processor & there functions.



- **Lines:** Represent the buses which carries data.
- **Arrow:** Represents flow of data.
- **Boxes:** Represent operation unit or storage area.

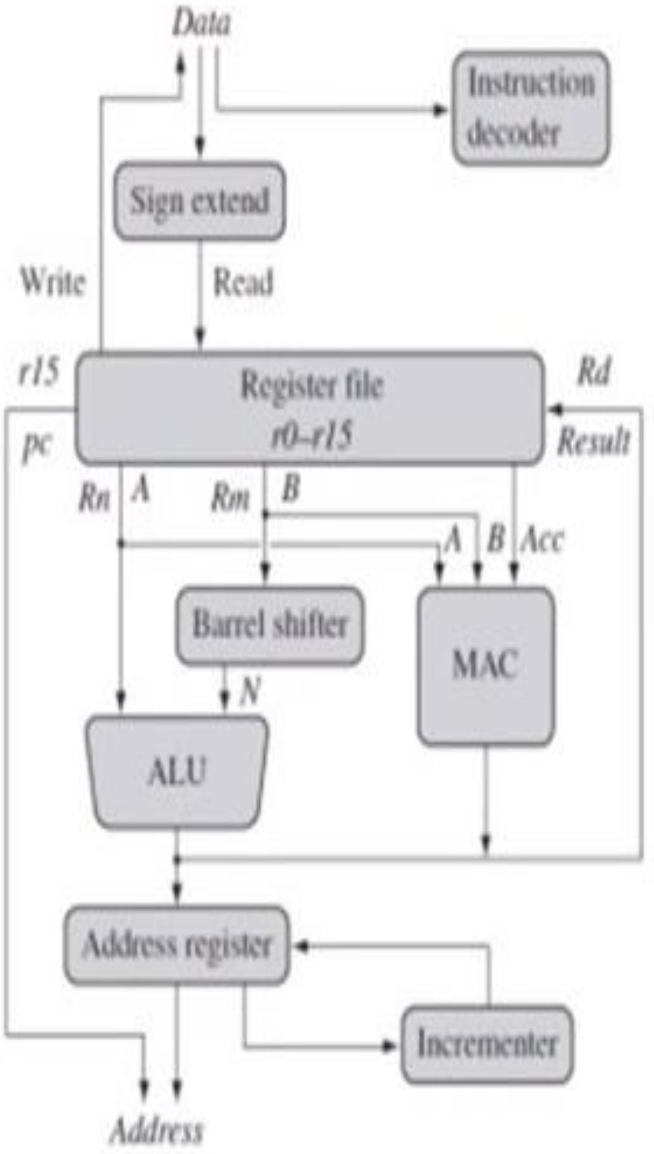
ARM Dataflow Model

➢Data Bus:

- Through data bus (Memory), data enters into the processor core.
- Data may be an instructions to be executed by processor or an data items to be processed.

➢Instruction Decoder:

- It translate the instructions into the address in the micro memory where the micro code for the instruction starts.
- Each instruction executed belongs to particular instruction set.



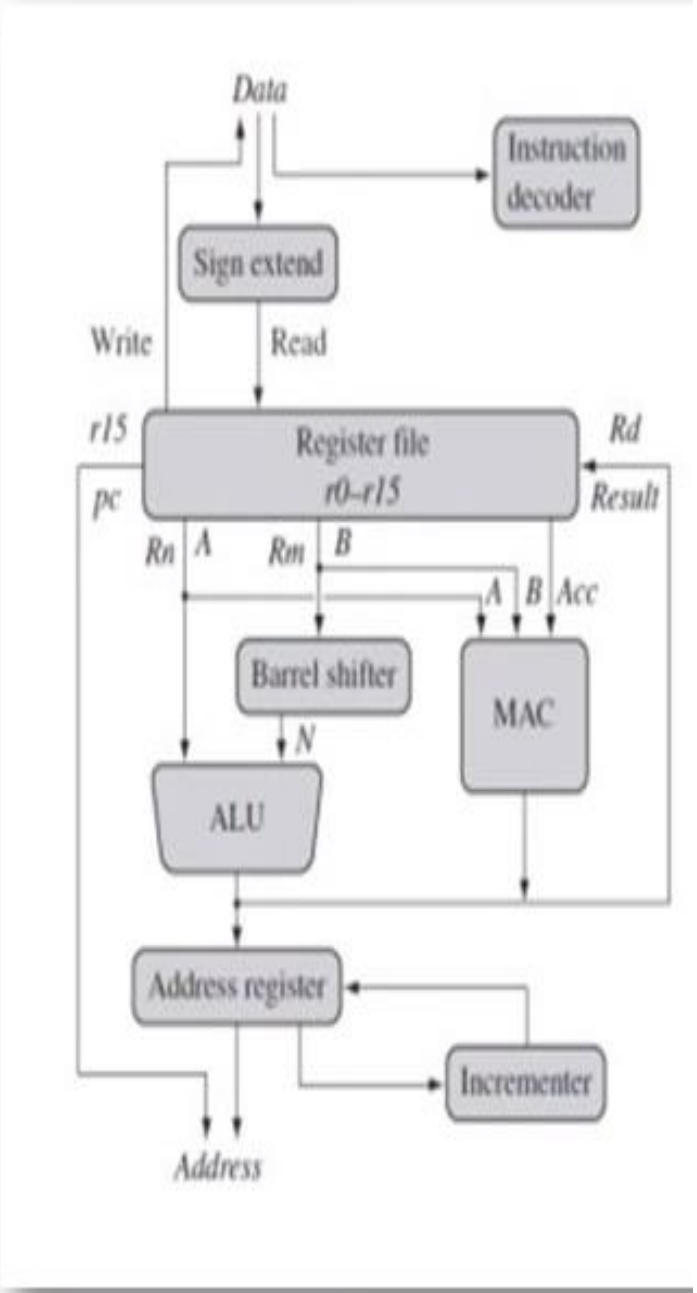
ARM Dataflow Model

➢Sign Extend:

- Data passes in register file through this block.
- This storage bank made up by 32 bit registers.
- Sign extend holds signed or unsigned 32 bit values.
- It converts 8 bit, 16 bit numbers to 32 bit value.

➢ Register File:

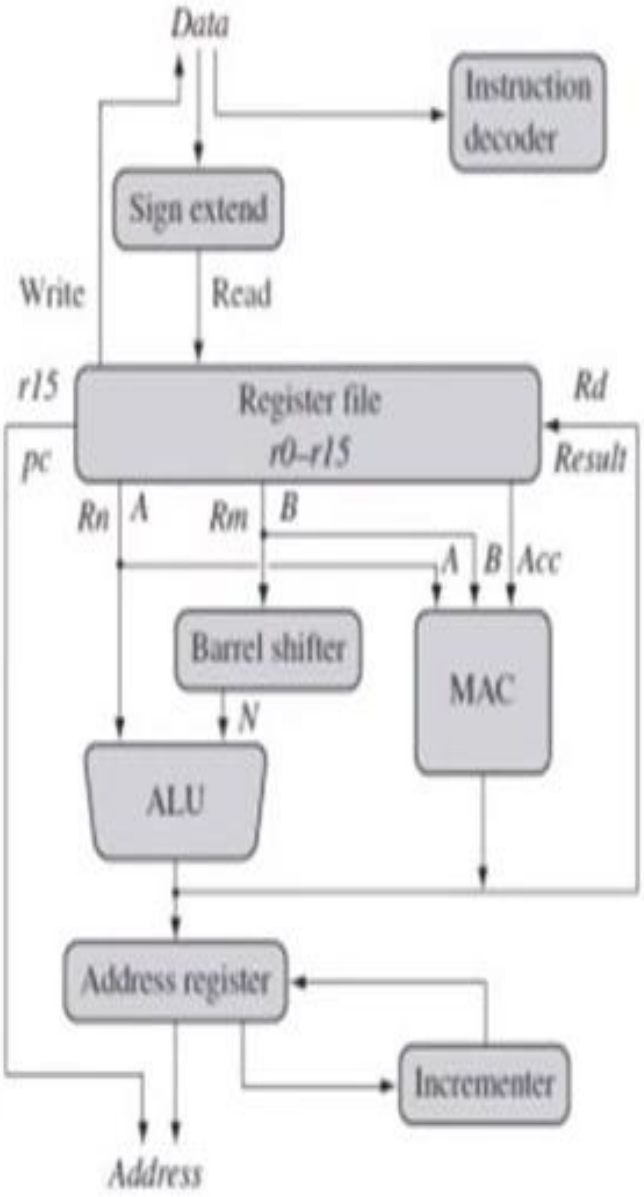
- ARM processor used Load-Store architecture.
- Load instructions copy data from memory to registers in the core. (**Read**)
- Store instructions copy data from registers to memory. (**Write**)



ARM Dataflow Model

➢ **Rn- A, Rm- B, Rd – Result:**

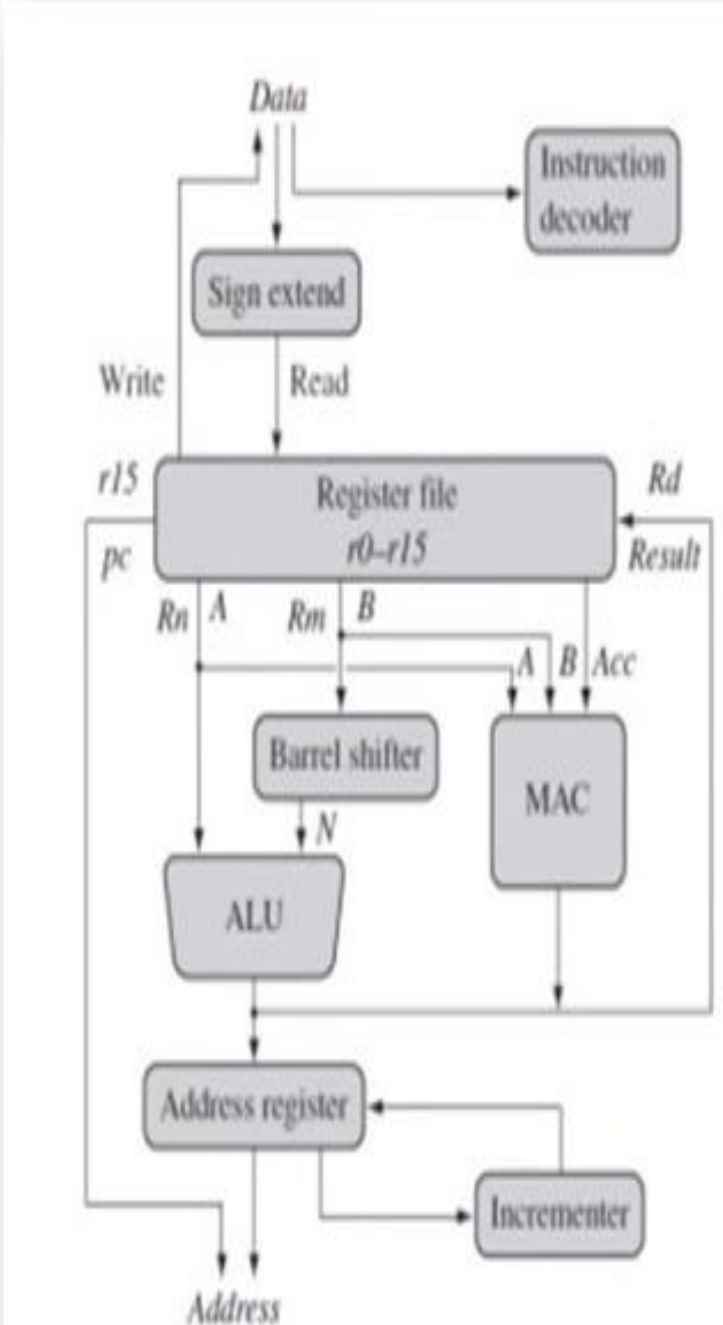
- Rn & Rm are the source registers.
- They carry value of the variables.
- A & B are the internal buses.
- They read source operands, which operations to be performed.
- Rd is the destination register.
- They carry final output from ALU using Result bus.



ARM Dataflow Model

➢ ALU & MAC:

- ARM has two data processing units.
- ALU (Arithmetic & Logic Unit) or MAC (Multiply & Accumulate Unit).
- Both units take registers value Rn & Rm from A & B buses.
- They perform operations & compute the result.
- Store this result directly to Rd register.
- Result bus carry the final output.



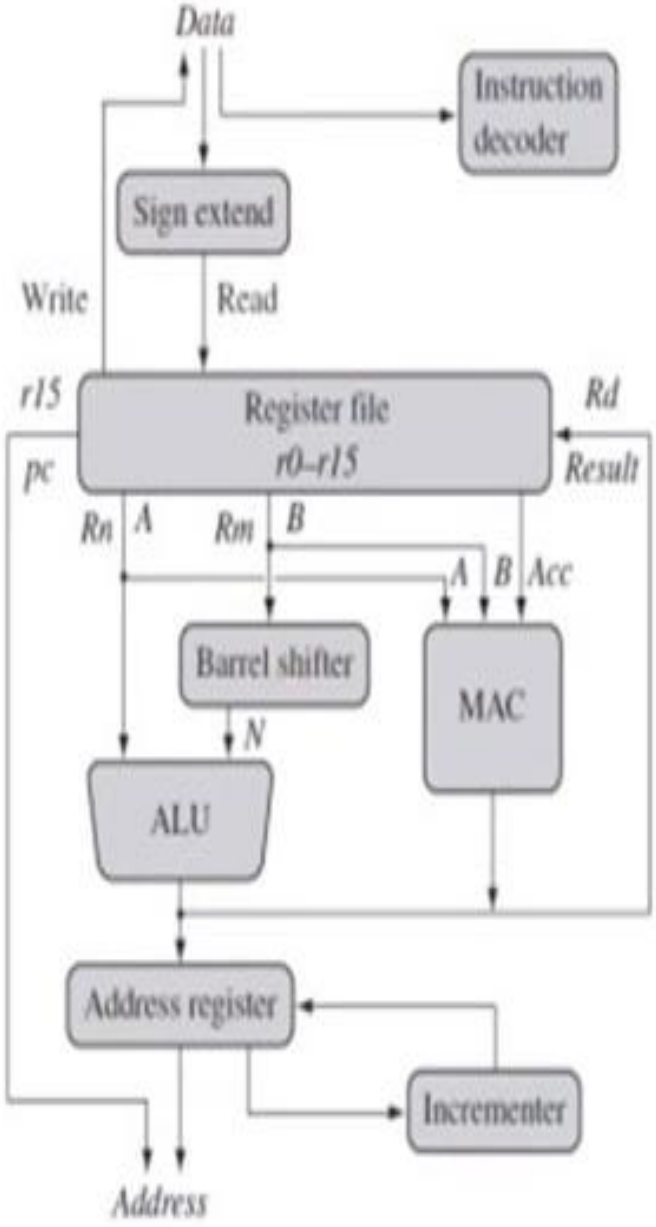
ARM Dataflow Model

➢Address Register:

- Load- Store instructions use the ALU to generate an Address that hold in Address Register.
- Broadcast the address through Address bus.

➢Barrel Shifter:

- Registers Rm can be alternatively preprocessed in the barrel shifter before it enters into ALU.
- Barrel Shifter shift bits by bits data for processing.
- They check wide range of expressions and addresses.



ARM Dataflow Model

➢ **Incrementer:**

- For Load and Store instructions having incrementer for update the next sequential address in Address Register or Memory Location.
- After updating or incrementing (++) next read or write instructions will performed.

- In this way,
- Processor continues executing instructions until an exception or interrupt will generate.
- Otherwise continue normal execution flow is there.