QB- ET & IoT

1- What is UART?

Ans- UART represents Universal Asynchronous Receiver Transmitter. It is dedicated to hardware related to serial communication. UART is one of the most generally used serial communication techniques. UART is being used in several applications like GPS Receivers, Bluetooth modules, GSM and GPRS Modems, Wireless Communication Systems, RFID-based applications etc.

Functions of the UART- There are various functions of UART which are as follows-

a) It can change parallel data into serial data for outbound communications
b) It can change serial data into parallel data for inbound communications.
c) It can add a parity checking bit on outbound communications transmissions and tests the parity bit for inbound transmissions
d) It can handle interrupt requests and device administration, which can need the computer and the device to organize the speed of operation.

UART Communication- In this communication, there are two types of UARTs such as transmitting UART and recieving UART, and the communication b/w these two can be

done explicitly by each other. The data transmissio of a UART can be completed by using a data bus in the form of parallel by other devices such as a microcontroller, CPU, memory etc. After recieving the parallel data from the bus, it forms a data packet by inserting 3 bits like start, stops, and parity. It reads the data packet bit by bit and converts the recieved data into the parallel form to remove the 3 bits of the data packet.

→ Packet ←

1 start bit	Data bits (5-9)	0 to 1 (Parity bit)	1 to 2 (stop bits)

→ Data Frame ←

Start Bit Start-bit is also referred to as a synchronization bit that is located before the actual data. Usually, an inactive data transmission line is reserved at a high voltage level. To start the data transmission the UART transmission bender the data line from a high voltage level (1) to a low voltage level (0).

Stop Bit The stop bit is located at the ending of the data packet. Generally, this bit is 2 bits lengthy but commonly on bit only used. It can stop the broadcast, the UART maintains the data-line on high voltage.

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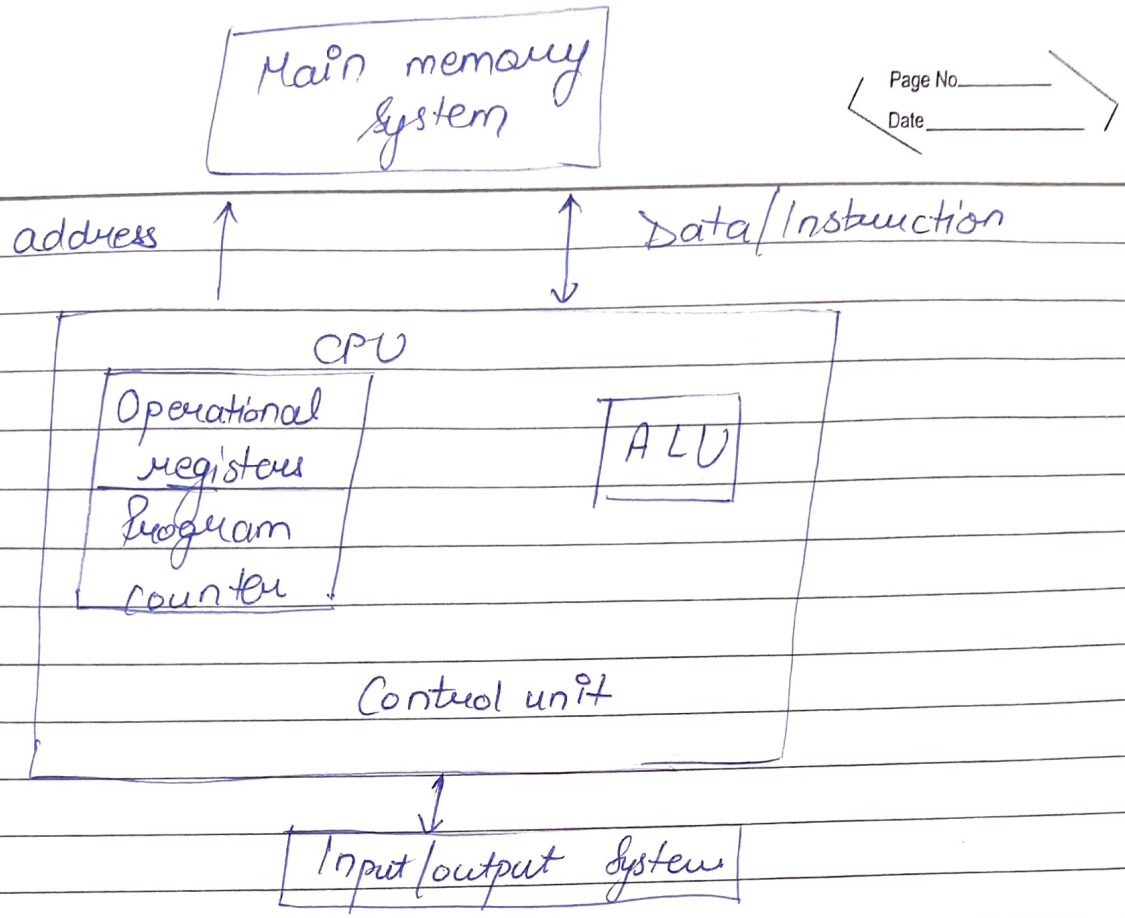
Parity Bit Parity bit allows the reciever to provide whether the collected record is right or not. It is a low-level fault checking system and parity bit is accessible in two ranges including even parity and odd parity

Data Bits or Data Frame The data bits involve the real data being transfered from the sender to the reciever. The data frame length can be b/w 5 & 8. If the parity bit is not used when the data frame length could be 9-bit long. Usually, the LSB of the data to be sent first then it is very beneficial for transmitting.

2) What is the difference b/w Von Neumann architecture and Harvard Architecture?

Ans - Von Neumann Architecture - is a digital computer architecture whose design is based on the concept of stored program computers where program data and instruction data are stored in the same memory. This architecture was designed by the famous mathematician and Physicist John Von Neumann in 1945



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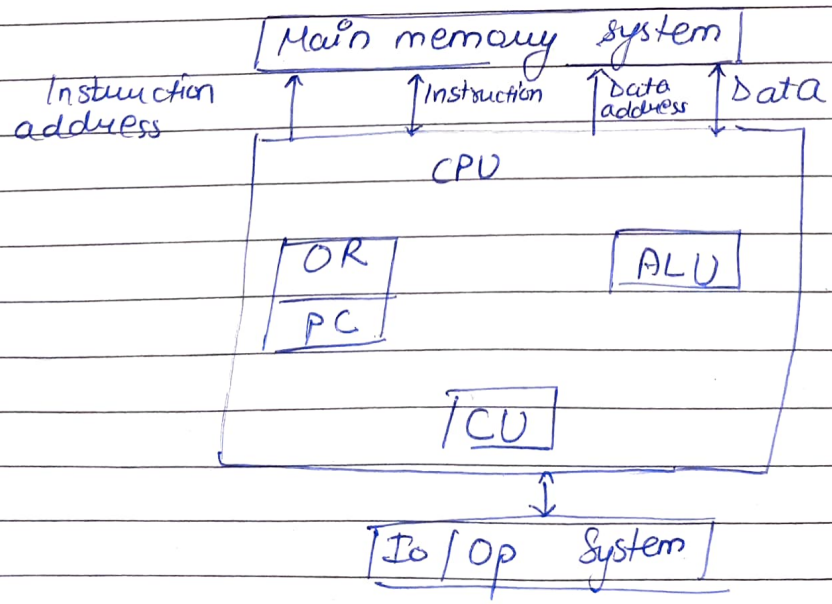
Harvard Architecture – is the digital computers architecture whose design is based on the concept where there are separate storage and separate buses (signal path) for instruction and data. It was basically developed to overcome the bottleneck of Von Neumann architecture.



	Von Neumann	Harvard
1)	It is ancient computer architecture based on stored program computer concept	1) It is modern computer architecture based on Harvard Mark I relay based model
2)	Same physical memory address is used for instructions and data	2) Separate physical memory address is used for instructions and data
3)	There is common bus for data and instruction transfer	3) separate buses are used for transferring data and instruction
4)	Two clock cycles are required to execute single instruction	4) An instruction is executed in a single cycle
5)	It is cheaper in cost	5) Costly than Von Neumann architecture
6)	CPU cannot access instructions and read/write at the same time	6) CPU can access info and read/write at the same time
7)	It is used in personal computers and small computers	7) It is used in micro controllers and signal processing

3) What do you mean by hard real time Embedded system? Mention two applications where we can use this type of Embedded systems?

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RTES combines the technologies of ES and real-time computing. To achieve the most complete and accurate description, we begin with a deeper look at the defining features of these technologies

→ RTES combine the functionality of a real-time operating system with a microcontroller (hardware) and unique application (software) to solve a buiness problem. There are 3 type of RTOS that differ in "fun" based on the time constraints associated with their application.

Hard RTOS A hard RTOS is implemented when it is crucial that no deadlines are missed and all tasks are completed within the prescribed time frame. In a hard RTOS, delays in the system are strictly time bound to ensure that deadlines are met at a 100% rate and any missed deadline is considered as a system failure.

→ In these type of ES time/deadline of task is strictly followed. Task must be completed in b/w time frame (defined time interval) otherwise result/output may not be accepted.

&- i) Traffic control system
ii) Military usage in defense sector
iii) Medical usage in health sector

4) What is a large scale Embedded Systems?

Ans - The ES have highly complex hardware and software, built around 32 bit or 64 bit processors/ controllers, RISC processors, SoC, scalable and configurable processors. They are also called sophisticated ES.

They are used for cutting-edge applications that need hardware and software co-design, where components have to be assembled into the final system. They also contain a high-performance real-time operating system for task scheduling, prioritization and management.

OR

→ Sophisticated or complex ES are designed using multiple 32-bit or 64-bit micro-controllers. These systems are developed to perform large scale complex functions. These systems have high hardware and software complexities. We use both hardware and software components to design final systems or hardware products.

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5) Architecture of Microcontroller used in Arduino UNO.

Ans- Basically, the processor of the arduino board uses the Harvard architecture where the program code and program data have separate memory. It consists of two memories such as program memory and data memory. Wherein the data is stored in data memory and the code is stored in the flash program memory. The Atmega328 microcontroller has 32kb of flash memory, 2kb of SRAM, 1kb of EPROM and operates with a 16 MHz clock speed.

Basic Functions of Arduino Technology

→ digital read pin reads the digital value of the given pin
→ digital write pin is used to write the digital value of the given pin
→ pin mode pin is used to set the pin to I/o mode
→ analog read pin reads and returns the value
→ analog write pins writes the values of the pin
→ Serial begins pin sets the beginning of serial communicating by setting the rate of pin

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[Advantages of Arduino Technology]

→ It is cheap
→ It comes with an open supply hardware feature that permits users to develop their own kit
→ The software of the arduino is well-suited with all kinds of in operations systems like linux, windows, etc
→ It also comes with open supply software system feature that permits tough software developers to use the arduino code to merge ~~the~~ with the prevailing programming language libraries and maybe extended and changed
→ For beginners, it is very simple to use.

6) Explain about the details of other hardware units available in Embedded System.

Ans - Processor - Brain of an Embedded System. It is the one which has control unit and execution unit

Control Unit - controls program flow and data path
→ Includes a fetch unit - to fetch program instructions from memory

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Execution unit- includes arithmetic & logic unit
→ execute instructions for a program control task like interrupt, halt, reset, call jump
→ execute application program instructions

→ A processor is mostly in the form of an IC chip. It could be in the form of ASIC or SoC. Processor core is a part of functional circuit on a chip. Processor chip or core can be
a) General Purpose Processor (GPP)
b) Application specific System Processor (ASSP)
c) Multiprocessor using GPP and ASIP Instruction Processor (ASIP)
d) GPP cores or ASIP cores integrated into an ASIC or VLSI chip
e) FPGA core integrated with processor units in a VLSI chip

General Purpose Processor A processor having a general purpose instruction set and readily available compilers to enable programming in a high level language is called GPP. It can be a microcontroller, Embedded Processor, and Digital Signal Processor

Microprocessor It has CPU on a chip. It may include additional units like cache memory and floating point processing units for faster processing.

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Microcontrollers It has CPU, memory and other functional units on a chip. It includes peripherals like interrupt handler, IO ports, Timer, ADC etc

Embedded Processors These are special microprocessors and microcontrollers for fast, precise and intensive calculations. It is for complex real time applications. It is specifically designed for fast context switching, power latencies and atomic ALU operations.

Digital Signal Processor - A special processor designed for signal processing. It provides fast, discrete-time signal processing instructions. It is for fast execution of algorithms for signal analyzing, filtering, noise cancellations, compression and decompression.

Application Specific System Processor - These are the specially designed application specific processor. It is mainly used for video compression and decompression. It can be interface to other processors.

Power Sources - a) System own power supply
b) Supply from a system to which the Embedded system interface
c) Proper power dissipation management implementation in hardware and software

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Oscillator and Clockings- a) crystal oscillator circuit
b) Timers and RTC for software

Reset- a) Reset on powerup
b) External and internal reset
c) Reset of time out, watchdog timer

Memory- a) Program, code memory - Internal or external ROM, EPROM, Flash
b) Data, stack, Heap memory - volatile Internal, external or buffer RAM memory
c) Log, configuration, Lookup Table - Non volatile EEPROM or Flash
d) Cache memory

Interrupt Handler- Interrupt handler for peripheral IO and timer interrupts.

7) Describe in detail about Embedded system on chip with necessary sketch.

Ans- A system on chip, also known as an SoC, is essentially an integrated circuit or an IC that takes a single platform and integrates an entire electronic or computer system onto it. It is, exactly as its name suggests, an entire system on a single chip. The components that an SoC generally looks to incorporate within itself include a central

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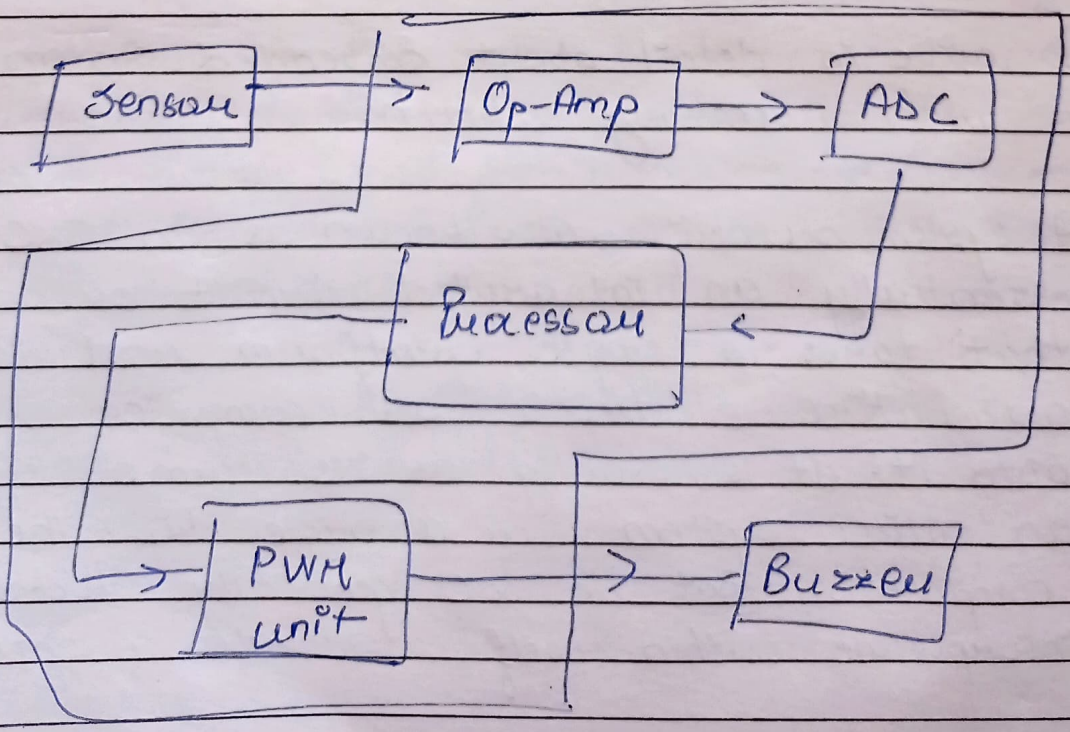
processing unit, input and output ports, internal memory, as well as analog input and output blocks among other things. Depending on the kind of system that has been reduced to the size of a chip, it can perform a variety of functions including signal processing, wireless communication, artificial intelligence and more.

SoC Advantages → Essentially the great benefits of using an SoC are: power saving, space saving and cost reduction

→ SoCs are also much more efficient as systems as their performance is maximised per watt

→ SoC also tend to minimize the latency provided the various elements are strategically placed on the motherboard in order to maximize interference and interconnection delays as well as speed up the data transmission process



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SoC Building Blocks → a SoC must have a processor at its core which will define its fun^n. Normally, an SoC has multiple processor cores. It can be a microcontroller, a microprocessor, a digital signal processor, or an application specific instruction set processor

→ The chip must have its memories which will allow it to perform computation. It may have RAM, ROM, EEPROM, or even a flash memory

→ The next thing an SoC must possess are external interfaces which will help it comply with industry standard communication protocols such as USB, Ethernet, and HDMI. It can also incorporate wireless technology and involve protocols pertaining to wifi and Bluetooth.

→ It will also need a GPU in order to visualize the Interface

→ Other stuff includes voltage regulators, phase lock loop control systems and oscillators, clocks and timers, analog to digital and D-A converters etc

→ Internal interface bus or a network to connect all the individual blocks.

8) Discuss about the factors to be considered for selection of processor in ES?

Ans- a) Performance Considerations
b) Power Considerations
c) Peripheral Set
d) Operating Voltage
e) Specialized Processing units.

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a) Performance Considerations - The first and foremost considerating in selecting the processor is its performance. The performance speed of a processor is dependent primarily on its architecture and its silicon design. Evolution of fabrication techniques helped packing more transistors in same area there by reducing the propagation delay.

b) Power Considerations - Increasing the logic density and clock speed has adverse impact on power requirement of processor. A higher clock implies faster charge and discharge cycles leading to more power consumption. More logic leads to higher power density there by making the heat dissipation difficult.

c) Peripheral Set - Every system design needs, apart from the processor, many other peripherals for I/o & o/p operations. Since in an ES, almost all the processors used are SOCs, it is better if the necessary peripherals are available in the chip itself.

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d) Operating Voltages - Each and every processor will have its own operating voltage condition. The operating voltage maximum and minimum ratings will be provided in the respective data sheet or user manual.

e) Specialized Processing - Apart from the core, presence of various co-processors and specialized processing units can help achieving necessary processing performance. Co-processors execute the instructions fetched by the primary processor thereby reducing the load on the primary.

9) Illustrate with example the techniques used for Memory devices?

Ans-

10). Write the need for software in ES?

Ans- → ES software can be defined as specialized programming tool in Embedded devices that facilitate the functioning of the machines.

→ The software manages various hardware devices and systems. The basic idea behind ES software is to control the functioning of a set of hardware devices without

compromising on the purpose or the efficiency.

→ ES software can be compared to the OS in computers. Much like how the OS control the software applications in computers, ESS control various devices and ensure their smooth functioning. Ideally, these software don't require user input and can run independently on preset parameters

→ Devices ranging from something as simple as a microwave to the more complex ones like detorators can all be controlled by ESS. The software can be adjusted and calibrated per need and the device can also be connected with remotely or with other devices. It is for this reason that ES hacking is a risk

→ The complexity of ESS vary according to the devices they are controlling and also on the basis of the usage and end goal. Compared to firmware, which acts as a liaison with OS, Embedded software are more self-reliant and directly coded.

11) What is Flash memory and EEPROM?

Ans - Flash Memory- Flash memory is a non-volatile memory chip used for storage and for transferring data b/w a personal computer (PC) and digital devices.

It has the ability to be electronically reprogrammed and erased. It is often found in USB flash drives, MP3 players, digital cameras and solid-state drives.

→ Flash memory is a type of EEPROM, but may also be a standalone memory storage device such as a USB drive. EEPROM is a type of data memory device using an electronic device to erase or write digital data. Flash memory is a distinct type of EEPROM, which is programmed and erased in large blocks.

EEPROM - is user modifiable ROM that can be erased and reprogrammed (written to) repeatedly through the application of higher than normal electrical voltage. Unlike EPROM chips, EEPROMs do not need to be removed from the computer to be modified. However, an EEPROM chip ~~has to be erased do not need to be removed from the~~ has to be erased and reprogrammed in its entirety, not selectively. It also has a limited life - that is, the number of times it can be reprogrammed is limited to tens or hundreds of thousands of times. In an EEPROM that is frequently reprogrammed while the computer is in use, the life of the EEPROM can be an important design consideration

→ A special form of EEPROM is flash memory, which uses normal PC voltages for erasure and reprogramming.

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12) What do you mean by System-on-Chip (SoC)? Mention one example.

Ans - SoC is a single Integrated Chip (IC) that includes the components normally found in a standard computer system. For example, on an SoC you may find a CPU, RAM, storage, I/O ports and more.

→ Examples include smartphones, tablets, and wearable devices, such as smartwatches. A smartwatch SoC, for example, may include a primary CPU, graphics processor, DAC, ADC, flash-memory, and voltage regulator. All of these components fit on a single chip roughly the size of a quarter.

13) What are the different memory devices used in embedded systems?

Ans -

Memory devices
- Volatile
- Non-Volatile

Volatile Memory Module (RAM) - Volatile memory devices are types of storage devices which hold their content till power is supplied to them. When power is switched off, these memories will lose their content.

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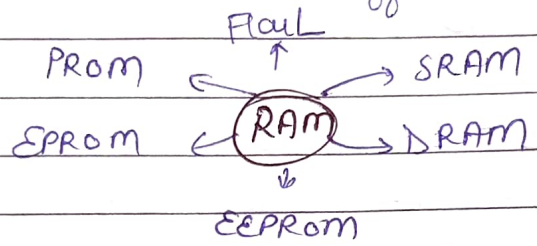
Non-Volatile Memory - ROM memory - are permanent storage types of memory chips which can get back stored information even when the power is switched off.



Static RAM - is a type of RAM that retains the data bits in its memory as long as power is being supplied. SRAM does not need to be refreshed periodically. The static RAM provides faster access to the data and is more expensive than DRAM.

Dynamic RAM - is a type of RAM module that stores each bit of data within a separate capacitor. This is an efficient way to store data in memory because it requires less physical space to store the data.

Programmable ROM - can be modified only once by the user. The PROM is manufactured with series of fuses. The chip is programmed by the PROM programmer wherein some fuses are burnt. The open fuses are read as ones, while the burned fuses are read as zeros.

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Erasable PROM- is one of the special types of memory modules that can be programmed to any number of times to correct the errors. It can retain its contents until exposed to UV light

Electrical EPROM- is a new modified rom chip that can be erased and programmed for a number of times

→ These memory devices are used in computers and other electronic devices to store small amount of data that must be saved when power supply is removed. Content of EEPROM is erased by exposing it to an electrical charge

Flash Memory- is the most widely used device for electronics and computer devices. The flash memory is among the special types of memory that can be erased and programmed with a block of data. The flash memory keeps its data even with no power at all. The FM is popular because it works fast and efficiently than EEPROM.

14) Explain input output devices used in ES?

15) Distinguish b/w Microprocessor & Microcontroller -

Ans-

Microprocessor	Microcontroller
→ Microprocessor is heart of computer system	→ Microcontroller is a heart of Embedded System
→ It is just a processor. Memory and I/O components have to be connected externally	→ Micro controller has a processor (external) along with internal memory and i/o components
→ cannot be used in compact systems and hence insufficient	→ Can be used in compact systems and hence it is an efficient technique
→ Since memory and i/o has to be connected externally, the circuit becomes large	→ Since memory and i/o are present internally, the circuit is small
→ cost of the entire system increases	→ cost of the entire system is low
→ due to external components, the entire power consumption is high. Hence it is not suitable to used with devices running on stored power like batteries	→ Since external components have power saving modes like idle mode and power saving mode. This helps to reduce power consumption even further.

→ Since memory and i/o components are all external, each instruction will need external operation, hence it is relatively slower	→ Since components are internal, most of the operations are internal instructions, hence speed is fast
→ MP has less no. of registers, hence more operations are memory based	→ MC have more no. of registers, hence the programs are easier to write
→ MP are based on Von Neumann model/ architecture where program and data are stored in same memory module	→ MC are based on Harvard architecture where program memory and data memory are separate
→ mainly used in personal computers	→ used mainly in washing machine, MP3 player.

16) What is system on chip? Explain Embedded systems change with system on chip.

Ans- An SoC always includes a CPU, but it might also include system memory, peripheral controllers (for USB, storage), and more advanced peripherals such as graphics processing units (GPUs), specialized neural network circuitry, radio modems (for Bluetooth or WiFi), and more.

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→ A system on a chip approach is in contrast with a traditional PC with a CPU chip and separate controller chips, a GPU, and RAM that can be replaced, upgraded, or interchanged as necessary. The use of SoCs makes computer smaller, faster, cheaper, and less-power hungry.

Why use a SoC? - Putting more elements of a computer system on a single piece of silicon lowers power requirements, reduces cost, increases performance, and reduces physical size. All of that helps dramatically when trying to create even-more powerful smartphone, tablets, and laptops that uses less battery life.

→ until recently, SoCs rarely appeared in desktop computers. In 2020, apple introduced the M1, its first SoC for desktop and notebook Macs. The M1 combines a CPU, GPU, memory, and more on one piece of silicon. In 2021, apple improved on the M1 with the M1 Duo and M1 max. All 3 of these chips give MaCs impressive performance while sipping power relative to the traditional discrete microprocessor architecture found in most PCs.