



# East West University

## Computer Architecture

### Department of CSE

**Course Name:** Computer Architecture

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## Written Assignment 3

### Submitted To.

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## Part 1 : My Personal Computer

I am currently using HP Elitebook 850 G5 which is running on Windows 11 Pro version. It supports a balance of performance, security and durability. According to the HP company website HP Elitebook 850 G5 was launched in 2018.

According to the sources from the HP company website[1], my computer's specification is given below;

### Processor :

HP Elitebook 850 G5 is containing Intel Core i7-8650U where its architecture is based on the Kaby Lake R architecture, a refinement of the previous Kaby Lake architecture. It features four physical cores, allowing it to handle multiple tasks simultaneously. With Intel's Hyper-Threading technology, it supports eight threads, enabling better multitasking capabilities. The base clock speed is typically around 1.9 GHz. It can dynamically increase its clock speed through Turbo Boost technology, with a maximum boost clock

of up to 4.2 GHz. The processor has 8 MB of Smart Cache, which is shared among the cores. Smart Cache helps improve access to frequently used data, enhancing overall performance. The i7-8650U integrated Intel UHD Graphics 620. While not designed for gaming, this integrated graphics solution is capable of handling everyday tasks and multimedia applications. The TDP for the i7-8650U is typically around 15 watts, making it suitable for ultrabooks and other thin-and-light laptops where power efficiency is crucial. The processor is manufactured using a 14 nm process technology, which contributes to its power efficiency and performance. Supports DDR4 and LPDDR3 memory. Features Intel Virtualization Technology, Intel Quick Sync Video, and other technologies aimed at enhancing performance and efficiency. Intel Core i7-8650U - 4-core processor with a clock frequency of 1900 MHz and 3rd level cache 8192 kB. Processor

is designed for mobile computers, installed in a BGA 1356. Has a built-in memory controller (2 channels, LPDDR3-2133, DDR4 - 2400) and Controller PCI Express 3.0 (12 lines). The Intel Core i7 processor is targeted towards general purpose computing. Multicore performance improvements are achieved by: (1) replicating the core execution unit, (2) adding additional processor instructions, and (3) improving the communication between the cores. Two major changes for the Core i7 architecture include the large shared L3 cache and the QuickPath interconnect bus which is used for inter-process communication between the [2]. Figure 1 provides the high-level block diagram of the Core i7 processor. To enhance the performance of multimedia and data-intensive applications, the i7-8650U incorporates Streaming SIMD Extensions (SSE), a set of instructions that facilitates the parallel processing of multiple data elements. Advanced Vector Extensions (AVX) further

argument this capability, specifically targeting floating-point intensive tasks. Security and encryption tasks benefit from the Advanced Encryption Standard (AES) instruction set, which is providing hardware acceleration for cryptographic operations. Moreover, Virtualization and the virtualization

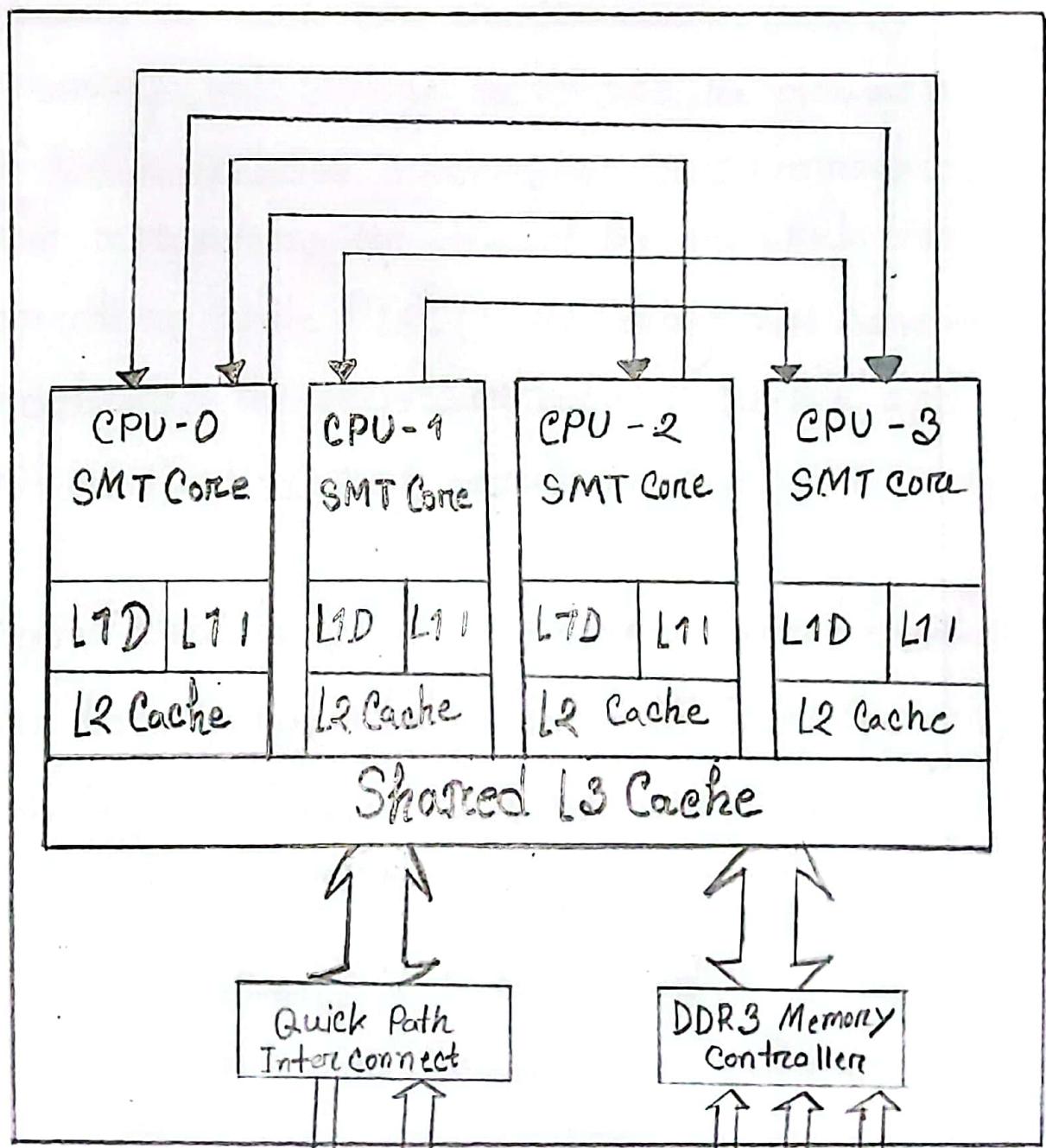


Figure 1: Block diagram Intel Core i7 Processor

Technology for directed I/O (VT-d) enhances the processor's virtualization capabilities, allowing for more efficient execution of multiple virtual machines and improved I/O virtualization support.

Hyper-Threading Technology is another noteworthy feature, enabling the processor to handle multiple threads on each core simultaneously, thereby enhancing multitasking capabilities. The inclusion of Bit Manipulation Instructions (BMI) introduces new instructions for efficient bit manipulation operations, while F16C (16-bit Floating-Point Conversion) accelerates the conversion between 32-bit and 16-bit floating-point formats.

Beyond these, the i7-8650U supports various extensions and technologies, including Enhanced Intel SpeedStep Technology, Intel Turbo Boost Technology, and others. Collectively, these features contribute to the processor's versatility, allowing it to tackle a diverse range of computing tasks with optimal efficiency. For compre-

hensive and precise details, referencing Intel's official technical documentation is recommended [3].

Intel Core i7-8650U processor supports the Intel 64 instruction set shown in Figure 2. The Intel Core i7-8650U boasts a sophisticated instruction set architecture that empowers it to execute a broad spectrum of operations efficiently. At its core, the processor adheres to the x86-64 architecture, an extension of the x86 instruction set, enabling it to handle 64-bit instructions and address substantial memory capacities. Intel 64 is an extension of the x86 architecture, also known as x86-64 or AMD64. It introduces 64-bit capabilities to the traditional x86 architecture, allowing the processor to handle larger amounts of memory and execute 64-bit software. Intel 64 architecture is now standard in modern processors, including the i7-8650U, and it enables the execution of 64-bit operating systems and applications. This extension is backward compatible with 32-bit x86 architecture, allowing the processor to run both 32-bit and

64-bit software. In practical terms, the support for Intel 64 means that the i7-8650U can take advantage of the benefits associated with 64-bit computing, including increased memory addressability, improved performance for certain applications, and better security features [4].

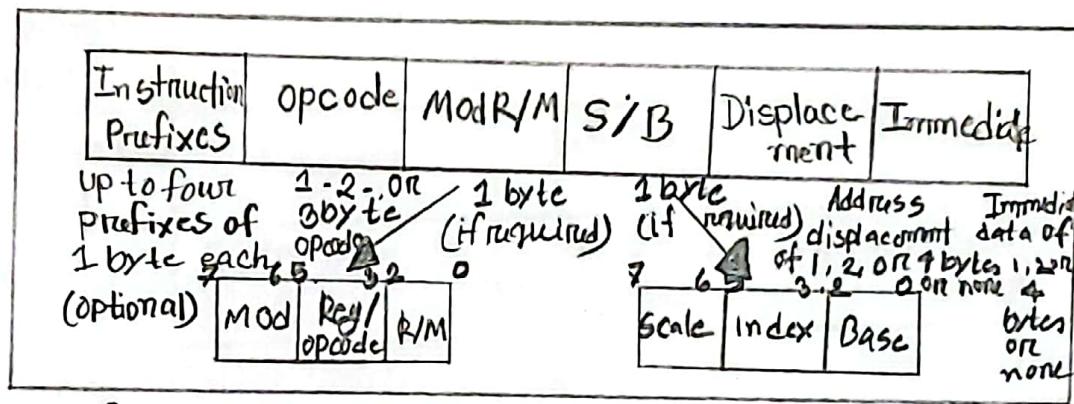


Figure 2 : Intel 64 and IA -32 Architectures Instruction Format

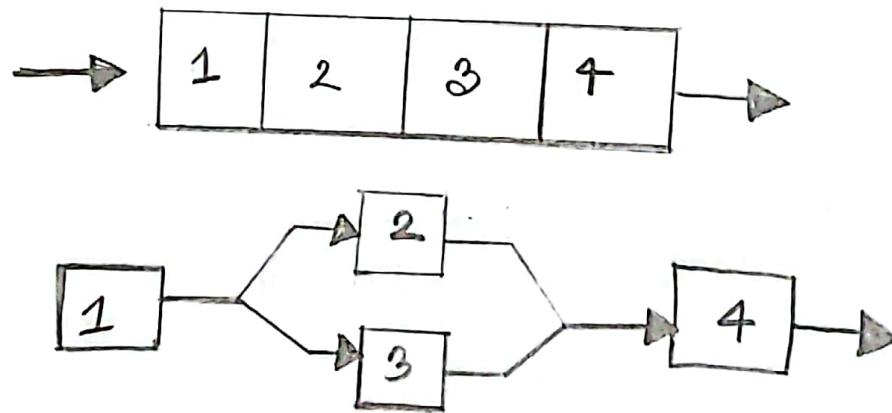


Figure 3 : Single thread pipeline of Intel core i7

Table 1: Comparison table for my computer's processor (Core i7-8650U) with other processors:

Feature	Core i7-8650U	Core i5-8250U	Core i9-8050HK
Processor Family	8th Gen Intel Core (Kaby Lake)	8th Gen Intel Core (Kaby Lake)	8th Gen Intel Core (Coffee Lake)
Cores/Threads	4/8	4/8	6/12
Base Clock Speed	1.9 GHz	1.6 GHz	2.9 GHz
Max Turbo Boost Speed	4.2 GHz	3.4 GHz	4.8 GHz
Cache	8 MB Smart Cache	6 MB Smart Cache	12 MB Smart cache
Graphics	Intel UHD Graphics 620	Intel UHD Graphics 620	Intel UHD Graphics 630
TDP (Thermal Design Power)	15W	15W	45W
Manufacturing Process	14 nm	14 nm	14 nm
Memory Support	DDR4, LPDDR3	DDR4, LPDDR3	DDR4, LPDDR4
Use Case	Ultraportable, Business Laptops	Main Stream Laptops	High-performance Laptops

## Main Memory :

My computer has a standard memory configuration with DDR4-PC4 SODIMMs, offering enhanced performance and efficiency. Equipped with (2) dual-Channel SODIMM slots, both slots are easily accessible and upgradable by the user. The memory operates at 2133 MT/s specifically tailored for Intel 8th generation processors, ensuring optimal compatibility and responsiveness. In its current configuration, the laptop boasts 16 GB DDR4-2400 SDRAM (16 GB x1), providing a bus speed of 2400 MHz and capacity for a seamless computing experience. Thus, the users are having the flexibility to customize and expand the memory to meet their specific requirements, enhancing overall system performance.

## Storage details :

The primary M.2 storage on this device is a

robust 256 GiB PCIe NVMe value TLC solid state drive, ensuring swift data access and efficient performance. The PCIe NVMe interface enhances data transfer speeds, while TLC (Triple-Level Cell) technology optimizes storage capacity and reliability. This solid-state drive is designed to deliver a responsive and reliable storage solution. Contributing to faster boot times, rapid application launches, and an overall seamless computing experience. With a focus on speed and efficiency this storage configuration caters to the demands of modern computing tasks.

### Cache Memory:

The Cache memory configuration for this processor is finely tuned to optimize data access and enhance overall performance. Each core is equipped with a dedicated L1 cache, consisting of a 256 KB instruction cache and a 256 KB data cache, ensuring rapid

access to critical information. Complementing this, the shared L2 cache provides 1 MB of memory that is dynamically allocated between the processor cores, facilitating efficient data retrieval. At the last level, the processor features a spacious 8 MB L3 cache, acting as a shared reservoir of frequently accessed data for all cores. This three-tiered cache architecture, comprising L1, L2 and L3 caches, collectively contributes to minimizing memory latency and accelerating the execution of tasks, resulting in a responsive and high-performance computing experience.

## Part 2 : My Personal Mobile

I am currently using Poco M2 pro which is running on android 12 (Snow Cone) with MIUI Global version 14.0.5. The Poco M2 pro is a compelling smartphone that strikes a balance between affordability and performance. Known for its reliable daily use, it features a versatile camera system for capturing memorable moments.

The device boasts a large and immersive display, ensuring an enjoyable viewing experience. With a robust battery and fast-charging capabilities, it provides convenience for users on the move. The Poco M2 Pro's durable build and thoughtful design contribute to its appeal, making it a solid choice for those seeking a well-rounded and budget-friendly smartphone experience. It has officially launched in 2020.

According to the Xiaomi official website [5], my mobile specification is given below;

#### Processor :

The Poco M2 Pro is equipped with the Qualcomm Snapdragon 720G processor. The Qualcomm Snapdragon 720G processor is built on an 8nm LPP process technology and is a part of the Qualcomm Kryo 465 CPU family. Its octa-core CPU configuration includes two high-performance Kryo 465 Gold cores based on Cortex-A76 architecture, along with six power-efficient Kryo 465 Silver cores based on Cortex-A55 architecture. The Gold

cores typically operate at higher clock speeds compared to the Silver cores, providing a balance between performance and power efficiency. In terms of graphics processing, the Snapdragon 720G is equipped with an Adreno 618 GPU. The processor follows the ARMv8-A instruction set architecture. These specifications highlight key aspects of the CPU architecture, offering a blend of performance and energy efficiency for mobile devices.

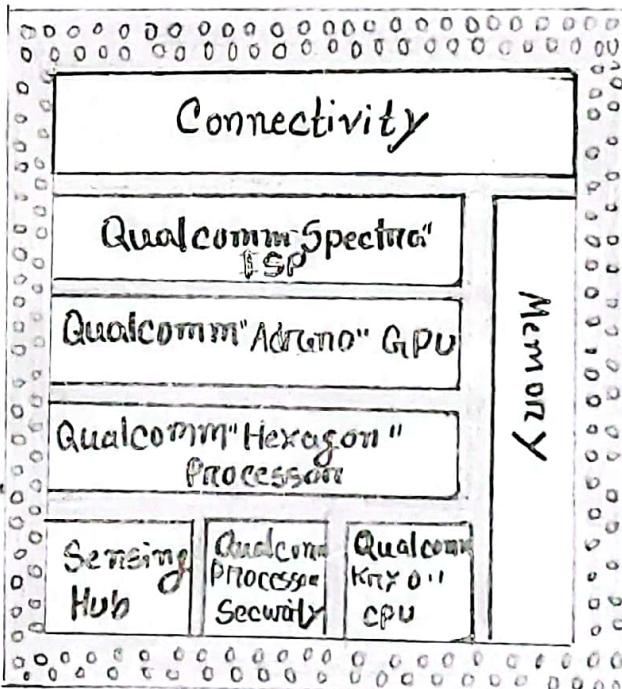
## Snapdragon 720G

### Connectivity

Snapdragon  
X25 LTE Modem  
Qualcomm Fast Connect 6200  
WiFi Ready  
Bluetooth 5.1  
Qualcomm True Wireless Stereo

Adreno 618 GPU  
Up to 75% performance increase  
Latest Gaming APIs  
HDR video playback  
Kryo 465 CPU

60% performance increase  
Dual-core A76 up to 2.3 GHz  
Six core A55 up to 1.8 GHz



### Hexagon 692

Hexagon Tensor Accelerator

### Spectra 350L

Up to 102 MP photo capture  
Smooth zooming 4k video capture

### Security

Qualcomm Processor Security  
DSP Security

### Quick Charge 4+

0-50% in less than 15 minutes  
USB-PD Support

Figure 4: Qualcomm Snapdragon 720G block diagram [6]

The ARMv8-A instruction set architecture (ISA) represents a significant advancement in processor design, transitioning from the 32-bit ARMv7-A architecture to a 64-bit paradigm. This architecture, developed by ARM Holdings, is denoted by the "A" for "Application", indicating its widespread use in application processors across diverse computing devices. One of the primary features of ARMv8-A is its move to a 64-bit structure, offering a larger address space and enhanced data processing capabilities compared to its predecessor. It introduces both AArch64, a 64-bit execution state, and AArch32, a 32-bit execution state, ensuring compatibility and facilitating a seamless transition between 32-bit and 64-bit software.

With an expanded set of 31 general-purpose registers, each 64 bits wide, ARMv8-A provides a robust foundation for processing complex computational tasks. The instruction set is a mix of 32-bit and 64-bit instructions, with AArch64 incorporating a new set of 64-bit instructions and AArch32 maintaining compatibility with existing 32-bit instructions. Additionally,

ARMv8-A supports SIMD (Single Instruction, Multiple Data) through the Neon architecture, optimizing the acceleration of multimedia and signal processing applications by concurrently processing multiple data elements.

Notably, ARMv8-A introduces features that enhance virtualization, facilitating the efficient sharing of resources among multiple operating systems or virtual machines. Security is strengthened with the incorporation of secure and non-secure software execution. The architecture also boasts improvements in exception handling, providing an advanced exception model. The memory model supports both physical and virtual addressing, accommodating the demands of diverse computing environments.

ARMv8-A has proven to be a versatile and widely adopted architecture, finding application in a spectrum of computing devices ranging from mobile devices to servers. Its 64-bit capabilities not

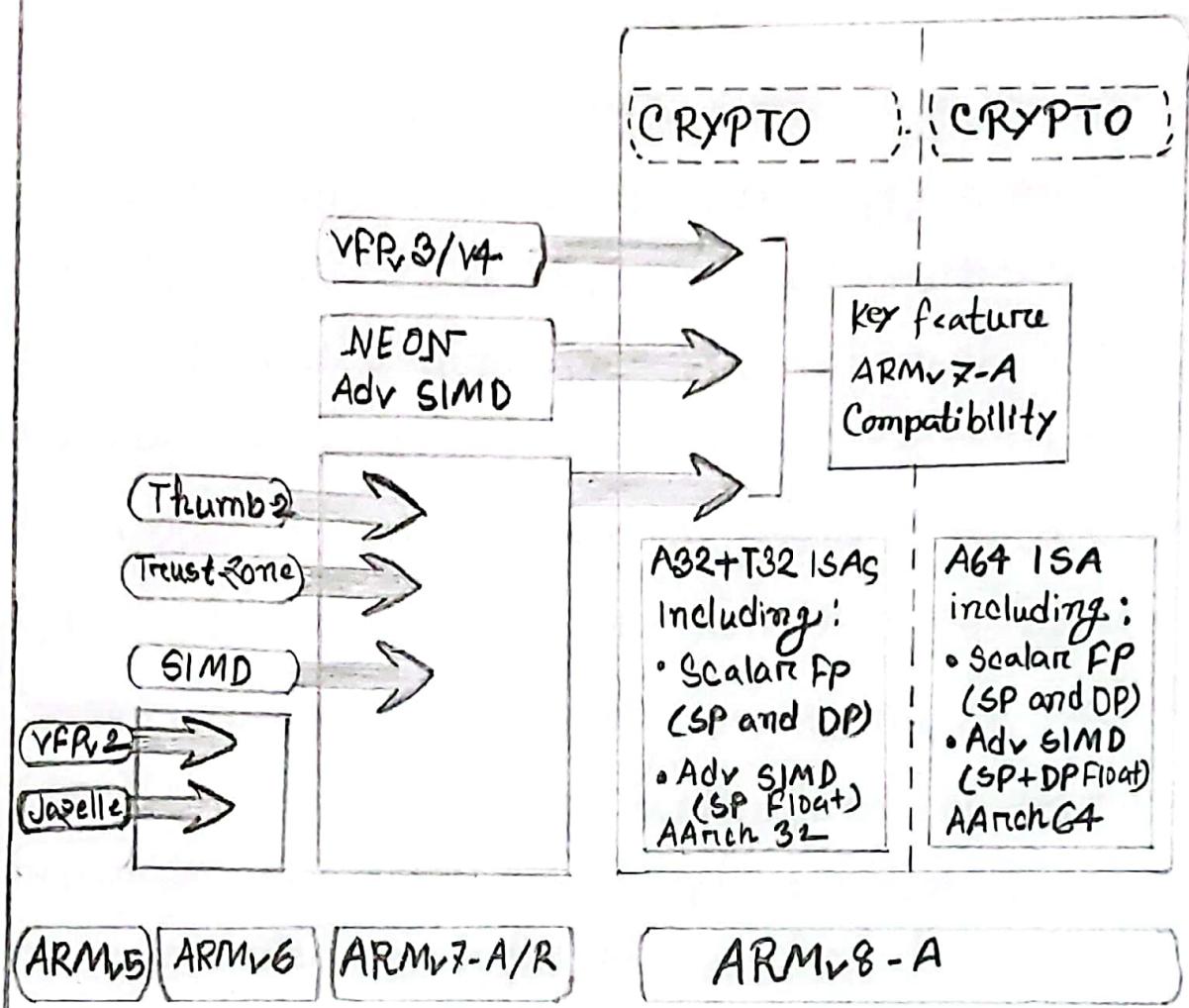


Figure 5: RISC Architecture processors

only offer improved performance but also provide essential support for handling larger memory spaces, making it well-suited for the demands of contemporary computing across various industries.

## Main Memory:

Currently I am using the 6GB RAM variant. The RAM type is likely to be LPDDR4X, which is a low-power and high-bandwidth memory technology commonly used in mobile devices for efficient multitasking and improved performance. The internal storage utilizes eMMC or UFS technology, depending on the model, offering varying levels of data transfer speeds. It's important to note that the specifications can vary depending on the region and specific model of the Poco M2 Pro, and for the most accurate and up-to-date information, it is recommended to refer to the official Poco website or product documentation.

## Storage details:

The 4GB RAM is paired with 64GB internal storage. The internal storage technology employed in smartphones like the Poco M2 Pro commonly includes either eMMC (Embedded Multimedia Card) or UFS (Universal Flash Storage). eMMC provides a cost-effective solution with reliable performance.

for everyday use, while UFS offers faster data transfer speeds, contributing to quicker app launches and file access. The specific storage capacity and technology can vary based on the variant of the Poco M2 Pro, and for the latest and most accurate details, it is advisable to check the official Poco website or product documentation.

### Part 3 : Nodemcu ESP8266 Microcontroller

The NodeMCU ESP8266 is a compact and cost-effective microcontroller widely used in the Internet of things (IoT) and embedded systems. Powered by the ESP8266 chip, it features a 32-bit microcontroller with integrated Wi-Fi connectivity. Its applications range from home automation and industrial monitoring to environmental sensing and precision farming. The NodeMCU is favored for its versatility, allowing for rapid prototyping, educational projects, and seamless integration into various real industry scenarios. With its compatibility with the Arduino IDE,

it simplifies programming and serves as a key component in creating smart devices for data monitoring, control, and automation [7]. The pin diagram of the microcontroller is given below:

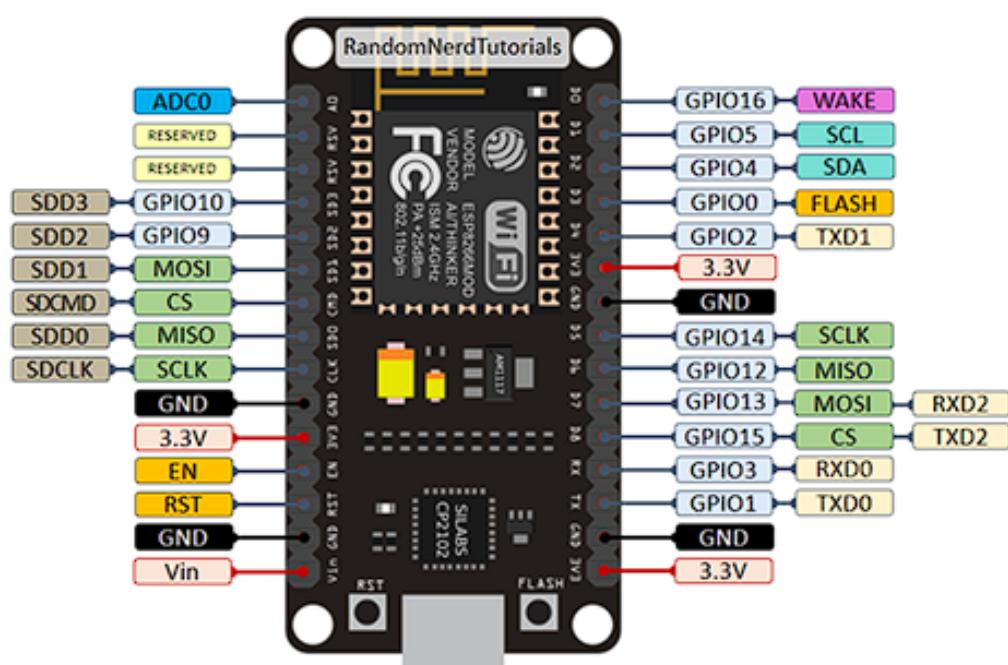


Figure 6: Pin diagram of NodeMCU ESP8266

In terms of its pinout, the NodeMCU ESP8266 typically includes a variety of digital and analog pins. The digital pins, often labeled D0 to D8, serve multiple purposes and can be configured for input or output.

Additionally, some of those pins may have special functionalities such as interrupt capability, PWM (Pulse Width Modulation) support, or communication protocols like I<sub>2</sub>C and SPI. The NodeMCU board also includes analog input pins labeled A0, allowing for analog sensor interfacing. The board is powered through a micro USB port, and it often includes a built-in USB-to-Serial converter for programming and debugging. The pins labeled 3V3 and GND provide power at 3.3 volts and ground, respectively.

Here is a detailed description of its features and applications in real industry scenarios:

### 1. Internet of things (IoT) Applications:

The NodeMCU ESP8266 is a key player in IoT projects, facilitating the connection of devices to the internet for data monitoring, control and automation. It is widely used in smart home systems, industrial IoT solutions, and agricultural monitoring.

### 2. Home Automation:

In the realm of home automation, the NodeMCU enables

the creation of smart devices that can be controlled remotely through the internet. This includes smart lighting systems, temperature and humidity control, and security systems.

### 3. Industrial Monitoring and Control:

The NodeMCU finds applications in industrial settings for monitoring and controlling various parameters such as temperature, pressure and machinery operation. It can be integrated into existing systems for real-time data collection and analysis.

### 4. Environmental Monitoring:

With its ability to interface with a variety of sensors the NodeMCU is employed in environmental monitoring applications. This includes monitoring air quality, pollution levels, and weather conditions in real-time.

### 5. Agriculture and Precision Farming:

In agriculture, the NodeMCU is utilized for precision farming applications. It can monitor soil moisture, temperature, and other environmental factors, allowing for efficient distribution and consumption of electricity.

### 6. Smart Energy Management :

The microcontroller is used in smart energy systems to monitor and optimize energy consumption. It can be integrated into smart grids, allowing for efficient distribution and consumption of electricity.

### 7. Data Logging and Analytics :

NodeMCU ESP8266 facilitates data logging applications where it can collect and store data from sensors. This data can be analyzed to gain insights into system performance, efficiency and potential areas for improvement.

### 8. Industrial Automation and Control Systems :

The NodeMCU is employed in industrial automation to control and monitor machinery and processes. It can be part of a larger automation system, enabling seamless communication between different components.

### 9. Educational Projects :

Its ease of use and affordability make the NodeMCU a popular choice for educational projects. Students and hobbyists can use it to learn about programming

electronics and IoT concepts.

#### 10. Prototyping and Development:

Engineers and developers use NodeMCU for rapid prototyping and development of IoT applications. Its compatibility with the Arduino IDE simplifies the programming process, allowing for quick iteration and testing.

In conclusion, the NodeMCU ESP8266 microcontroller is a powerful and versatile tool that has found applications in a myriad of real industry scenarios. Its impact extends across IoT, home automation, industrial control, agriculture and beyond making it an integral part of the evolving landscape of embedded systems and smart technologies.

#### Working process with an example:

Arduino sketch written for an ESP8266 microcontroller using the Blynk IoT platform. It aims to create a simple gas detection system that interacts with the Blynk app and triggers an

alert if gas is detected.

Code	Process
<pre>#define BLYNK_TEMPLATE_ID "ID" #define BLYNK_TEMPLATE_NAME "NAME" #define BLYNK_AUTH_TOKEN "TOKEN"</pre>	The code starts by defining the Blynk template ID, name, and authorization token. These values are obtained from the Blynk app or platform when you create a project. Replace "ID", "NAME" and "TOKEN" with your actual template ID, project name and authorization token.
<pre>#define BLYNK_PRINT Serial #include &lt;ESP8266WiFi.h&gt; #include &lt;BlynkSimpleEsp8266.h&gt;</pre>	The necessary libraries are included. ESP8266 WiFi.h provides functions for connecting to a Wi-Fi network, and Blynk Simple Esp 8266.h is the Blynk library for ESP8266.
<pre>char ssid[] = "WIFI NAME", char pass[] = "WIFI PASSWORD";</pre>	Wi-Fi credentials (SSID) and password) for connecting the ESP8266 to the local network are specified.
<pre>int LED = D3; int GasSensorPin = D2;</pre>	The gas sensor is connected to pin D2, and a LED light is connected to pin D3.

```

void setup() {
    Serial.begin(9600);
    Blynk.begin(BLYNK_AUTH,
    TOKEN, ssid, pass, "blynk.cloud",
    80);
    PinMode(LED, OUTPUT);
    PinMode(Gas Sensor Pin,
    INPUT);
}

```

The setup function initializes serial communication, begins the Blynk connection using the provided credentials and sets the pin modes for the gas sensor and LED.

```

void loop() {
    Blynk.run();
    if (gasValue == 0) {
        digitalWrite(LED, HIGH);
        Blynk.logEvent("gas alert");
        Serial.println("Gas detected
        ....! Take action immediately")
    } else {
        digitalWrite(LED, LOW);
        Serial.println("No gas
        detected. Stay cool!");
    }
}

```

The loop function continuously runs Blynk tasks and checks the gas sensor's value. If the gas value is 0 (indicating gas detection), it turns on the LED, logs a Blynk event, and prints a message to the Serial monitor. If no gas is detected, it turns off the LED and prints a corresponding message.