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Raspberry Pi Performance analysis across its Operating System in LED Control Operation

Rahul Mishra

R&D Engineer, ANKR Research Industries Pvt Ltd, Indore, Madhya Pradesh 452001

Abstract-

Raspberry Pi's performance for LED control operations varies across operating systems based on factors like GPIO response time, CPU utilization, and resource efficiency. Raspberry Pi OS delivers the best overall performance due to its hardware optimization, offering low latency and stable operation. Lightweight OSs like DietPi provide comparable GPIO control with minimal resource usage, making them ideal for constrained environments. General-purpose systems like Ubuntu exhibit slightly higher latency and CPU load but maintain broad compatibility. Libraries such as RPi.GPIO, pigpio, and wiringPi significantly influence control precision and ease of use, with pigpio excelling in high-precision tasks. Overall, Raspberry Pi OS remains the optimal choice for LED control, particularly for standard or beginner applications.

Key Words: Raspberry Pi 4B, server performance, CPU usage, request delay

I. INTRODUCTION

The Raspberry Pi is a compact, affordable single-board computer designed to promote computer science education and hobbyist projects. Developed by the Raspberry Pi Foundation, it offers a versatile platform for programming, electronics, and IoT applications. Equipped with GPIO pins, it enables easy interfacing with sensors, motors, and LEDs, making it ideal for DIY projects. With various models available, the Raspberry Pi supports operating systems like Raspberry Pi OS, Ubuntu, and others, providing a flexible environment for coding, learning, and prototyping innovative solutions.

II. LED CONTROL

Raspberry Pi OS is the best choice for LED control operations due to its native optimization for Raspberry Pi hardware. Other systems like Ubuntu and Windows 10 IoT Core provide viable alternatives, each with unique strengths catering to specific use cases. For applications requiring precise timing and low latency, Raspberry Pi OS is unmatched.

III. RASPBERRY PI OS

Raspbian, or as it is now officially called Raspberry Pi OS, is the operating system that is most associated with the Raspberry Pi board and is based on Debian, a distribution of the Linux OS. This operating system was introduced with the first Raspberry Pi model in 2012 by the

Raspberry Pi Foundation and was originally aimed to democratize computing by offering an affordable educational platform.

It is designed specifically to make the most out of the capabilities this specific Raspberry PI hardware offers. It contains an extensive collection of educative resources and assets, coding systems, and applications that can enhance different learning and improvement processes. It has often been said that the Debian distributions are ideal for both newcomers and skilled programmers due to the simple design of the structure and the easy to use GUI which is presented here.

The most engaging aspect of Raspberry is its simplicity, which helps it run on Raspberry Pi hardware without compromising on its performance. Despite their small screen size and less processing power, they come with a full-fledged range of installed applications like the LibreOffice productivity suite, Chromium web browser, programming environments like Thonny Python IDE, Scratch, and BlueJ, etc.

In addition to its already established importance in the learning platform, Raspberry Pi OS is a remarkable tool with flexibility applicable for numerous uses in the IoT, home automation, and embedded systems. Because of these unique features, Lin,ux is a versatile OS that can be used in simple sensors/ controllers and also in advanced network OS, servers, and media centers.

IV. OS PARAMETERS

Whenever discussing the best OS for Raspberry Pi, there is no clear answer for everyone. Very specific use cases might favor one option as the best Raspberry Pi OS over another one.

But putting those specific use cases aside, the Raspberry Pi 3's best OS must at least meet the following criteria:

- **Speed.**
  The Raspberry Pi 4 OS should be fast and not lag. This is dependent both on the specific Raspberry Pi 4 OS chosen as well as the use case for that Raspberry Pi device.
- **Ease of installation.**
  Installing a Raspberry Pi 4 OS should not be complicated.
- **Strong support.**
  Whether you get a proprietary Raspberry Pi 3 OS or an open-source one, there should be strong support for it. Abandoned projects could lead to bugs that might force you to install a different Raspberry Pi 4 OS in the future.
- **Widely used.**
  The same applies to how many people use the Raspberry Pi 3 OS you have chosen. If not many people use it, then it will likely become abandoned.
- **Touch-screen support (optional).**
  Not every Raspberry Pi 3 OS use-case will require touch-screen support. But if you do intend to attach a touchscreen to the device, as is often done in many industrial

devices, then touch-screen support is imperative. Additionally, the touch-screen interface should be intuitive and responsive.

- **Hardware compatibility.**
  The Raspberry Pi 3 OS you choose needs to be compatible with the device's hardware.

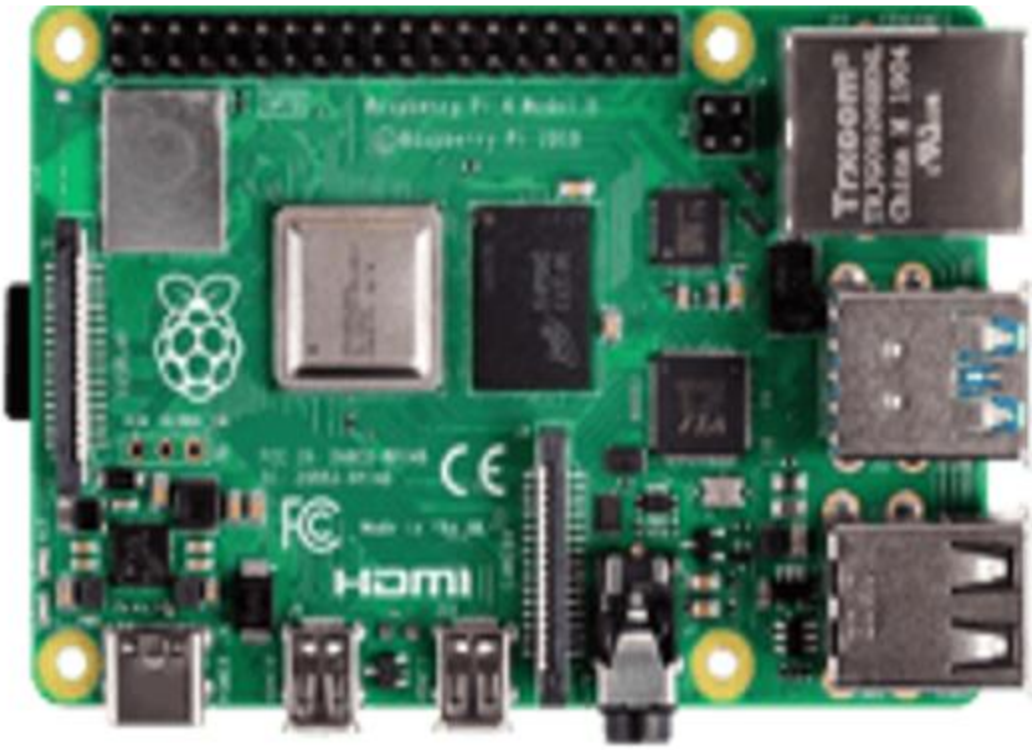

Fig.1. Raspberry Pi

V. RASPBERRY PI HARDWARE

Processor (CPU):

This means that the CPU, also known as the microprocessor chip, is the portion of the Raspberry Pi that is tasked with processing instructions and performing various tasks. Over the years, models have been developed from single-kernel ARM11 to the recent very complex multiple-kernel ARM Cortex-A series.

- **Memory (RAM):**

RAM stands for Random Access Memory and is indispensable for storing various data while it is actively used, as well as some applications. First-generation ones were accompanied by 256 MB, whereas the latest models reach 4 to 8 GB, which means that these computers will be capable of handling more intricate tasks requiring more memory operations.

Storage:

As we have already mentioned, in contrast to the majority of other computers, the Raspberry Pi devices employ microSD cards for storing information. Unfortunately, the absence of built-in storage and OS, found in other laptops of this type, contributes to the further decrease in the price. GPIO (General-Purpose Input/Output) Pins:

An explanation of the GPIO pins to connect electronic devices to the Raspberry Pi and why it is perfect for DIY projects and smart devices. The most common model of the Raspberry Pi board has 26 to 40 General Purpose Input/Output (GPIO) pins.

USB Ports:

The USB ports mean that the system can be connected to peripheral devices such as a keyboard, mouse, or USB storage. These are some of the features. The higher models include USB 3. 0 ports to enable the dual-ported memory modules to attain high data transfer speeds.

HDMI Port:

All the Raspberry Pi versions have an HDMI port to connect monitors and TVs and acquire video and audio output for the system. Certain models may feature HDMI output for dual displays in case a user wishes to have multiple projector connections.

Networking:

A number of networking interfaces are available per model: Ethernet ports for a normal connection and Wi-Fi and Bluetooth for wireless connections.

Camera and Display Interfaces:

Camera and Display Interface options make it more versatile; individuals can connect cameras for image capturing, as well as LCDs for creating interfaces.

Power Supply:

The Raspberry Pi is usually operated by a 5V power source and, depending on the version, has a micro-USB or USB-C port.

Audio Output:

For audio output, there is an HDMI connection option, as well as 3 via the 3. 5mm audio jack or through the use of the USB audio output connectivity.

Different Models and Specifications

Raspberry Pi 1 (Model A, B, A+, B+): Model A: The first model was released in 2013 and has a 700 MHz single-core ARM11 CPU, 256 MB RAM, 1x USB, and 26 GPIO pins.

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Model B: The original was released in 2012. It has the same branded CPU and is priced at the same level as Smart. It presents 512 MB of RAM, 2 USB ports, and Ethernet.

Model A+: Model B uses the same processor as Model A, with 256MB RAM, 1 USB port, and 40 GPIO pins with built-in LED functions.

Model B+: The Improved Model B, which featured increased RAM to 512MB RAM, now has four USB ports and an enhanced power supply solution.

Table 1. Comparison table for key Raspberry Pi versions

Model	Processor	RAM Options	USB Ports	Networking	Video Output	Special Features
Raspberry Pi 1 B	Broadcom BCM2835, 700MHz	512MB	2	10/100 Ethernet	HDMI, Composite	First-gen board; entry-level specs.
Raspberry Pi 2 B	Broadcom BCM2836, 900MHz, Quad-core	1GB	4	10/100 Ethernet	HDMI, Composite	Faster processor than Pi 1.
Raspberry Pi 3 B	Broadcom BCM2837, 1.2GHz, Quad-core	1GB	4	Wi-Fi 802.11n, Bluetooth 4.1, Ethernet	HDMI, Composite	Wireless connectivity introduced.
Raspberry Pi 3 B+	Broadcom BCM2837, 1.4GHz, Quad-core	1GB	4	Wi-Fi 802.11ac, Bluetooth 4.2, Ethernet	HDMI, Composite	Faster wireless and Ethernet.
Raspberry Pi 4 B	Broadcom BCM2711, 1.5GHz, Quad-core	2GB, 4GB, 8GB	4 (2x USB 3.0)	Wi-Fi 802.11ac, Bluetooth 5.0, Gigabit Ethernet	2x micro HDMI	Dual 4K displays, USB 3.0 ports.
Raspberry Pi 400	Broadcom BCM2711, 1.8GHz, Quad-core	4GB	2 (USB 3.0)	Wi-Fi 802.11ac, Bluetooth 5.0, Gigabit Ethernet	2x micro HDMI	Built into a keyboard.
Raspberry Pi Zero	Broadcom BCM2835, 1GHz	512MB	1 (micro USB)	None	Mini HDMI	Ultra-compact, basic model.
Raspberry Pi Zero 2 W	Broadcom BCM2710A1,	512MB	1 (micro USB)	Wi-Fi 802.11n,	Mini HDMI	Compact with

	1GHz, Quad-core			Bluetooth 4.2		wireless features.

Table 2. Comparison table for key Raspberry Pi operating systems

Operating System	Primary Use	Performance	Ease of Use	Resource Requirements	Special Features
Raspberry Pi OS	General-purpose, Education	Optimized for Pi	Beginner-friendly	Low	Pre-installed tools like Python, Scratch.
Ubuntu (Server/Desktop)	General-purpose, Development	Moderate	Intermediate	Moderate to High	Broad compatibility, desktop environment.
DietPi	Lightweight, Customization	High	Intermediate	Very Low	Minimalist, optimized for performance.
Arch Linux ARM	Advanced, Customization	High (user-dependent)	Expert	Low	Rolling release, complete user control.
LibreELEC	Media Center	High	Beginner-friendly	Low	Optimized for Kodi media playback.
Retropie	Gaming and Emulation	Moderate to High	Beginner-friendly	Moderate	Pre-configured for retro gaming.
Windows IoT Core	IoT Applications	Moderate	Intermediate	Moderate	Supports Universal Windows Platform apps.
Kali Linux	Security and Penetration Testing	Moderate	Advanced	Moderate	Pre-installed security tools.

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Twister OS	General-purpose, Windows-like UI	Moderate	Beginner-friendly	Moderate	Windows-like interface for ease of transition.

VI. RESULT AND SIMULATION

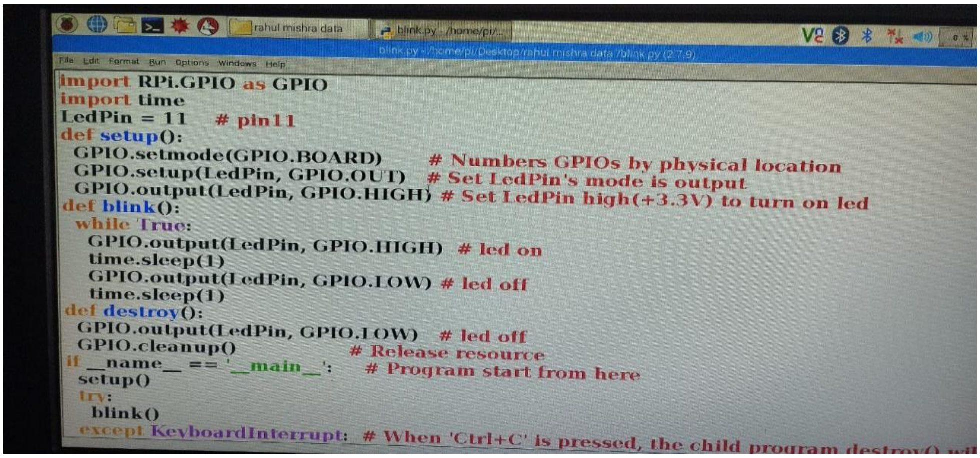

Fig.2. Python Coding.

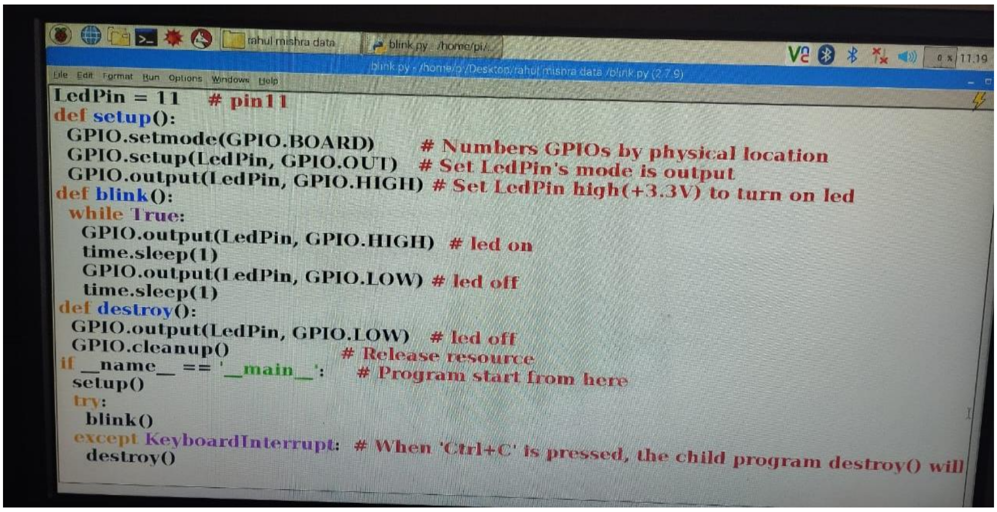

Fig.3. Input and Output Define.

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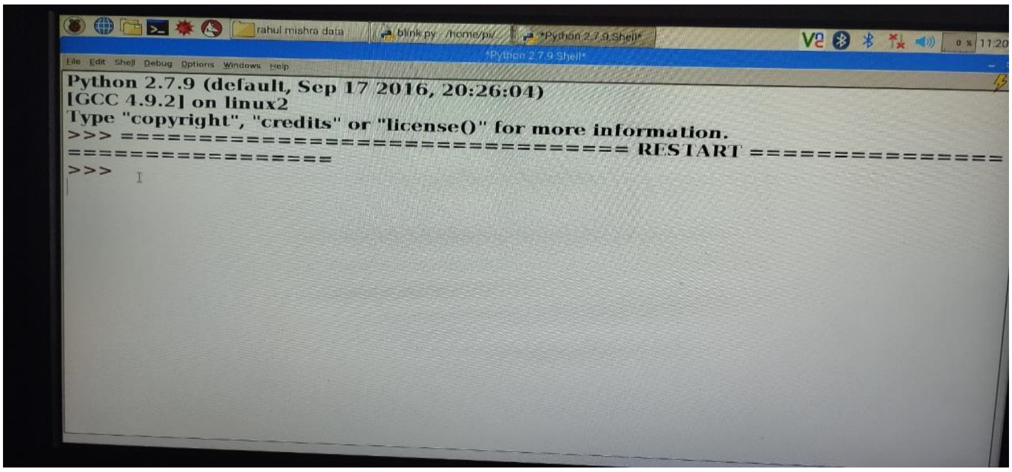

Fig.4. Command Window.

Fig.5. Hardware Set Up.

Fig.6. LED connection.

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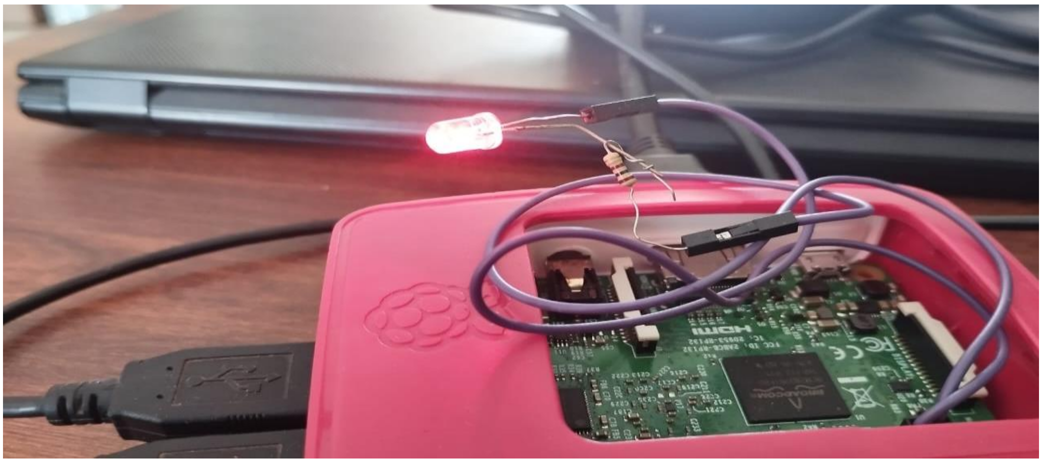

Fig.7. Outputs Led Control.

Fig.8. Delay control.

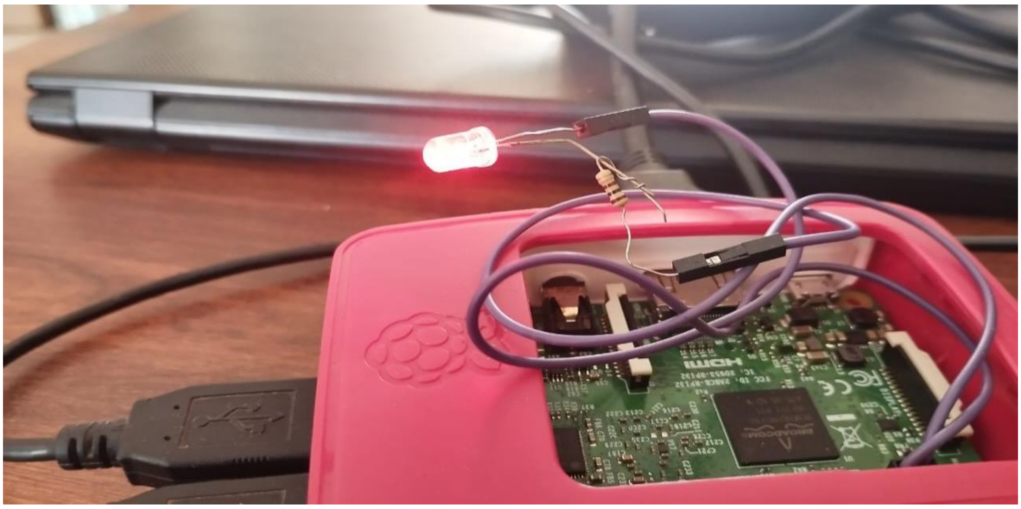

Fig.9. Working.

VII. CONCLUSION

Raspberry Pi's performance in LED control operations varies across its operating systems, with Raspberry Pi OS emerging as the most efficient due to its hardware optimization and low-latency GPIO handling. Lightweight options like DietPi also provide excellent performance in resource-constrained setups, while general-purpose systems like Ubuntu trade some efficiency for broader compatibility. The choice of GPIO libraries, such as RPi.GPIO for simplicity or pigpio for precision, further influences performance. Overall, Raspberry Pi OS is the preferred choice for most LED control applications, offering a reliable and user-friendly platform.

VIII. FUTURE WORK

From the thesis, we found the performance comparison and consumption of the CPU and response time of both raspberry pi 4B and mac air with apple silicon. In the future, we are interested in examining the other aspects and testing the devices. Due to the advancement in technology, when a new raspberry pi is released, it will be fascinating to see the new model and perform the tests to measure its feasibility.

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