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A Review Paper on Raspberry Pi and its Applications

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ABSTRACT: Raspberry Pi, an efficient and powerful minicomputer having the dimension approximately equal to the size of a credit/debit card. It was invented by the United Kingdom Raspberry Pi foundation with the hope of enlightening and empowering the generation of learners to be more creative and efficient. Since its launch, many open-source communities have contributed towards open-source operating systems (OS), apps and various other forms of computers which are similar to Raspberry Pi. Moreover, various embedded system scholars and researchers across the globe are constantly involved in the development of innovative projects using this module which is observed to have out-of-the-box application. Since its inception, Raspberry Pi is under constant up-gradation both in terms of both software and hardware which is thereby making it a "Full-Fledged Computer" with a possibility to compute intense task within a specific timeframe. This review paper shall lay a foundation stone to numerous open-source community and will enable the embedded students to develop projects to a whole new level. Also, we will discuss the application/projects that have built to date.
Index Terms: Raspberry Pi, Arduino, IoT, Linux, Small Form Factor Computer, Raspbian, Open Source, Embedded Systems.

I. INTRODUCTION

The Raspberry Pi is a smaller version of a modern-day computer capable of performing task effectively. The module utilizes various kinds of the processor; therefore, it can only install open-source operating systems and apps on it. Pi also enables the user to browse the internet, send emails, write documents using a word processor, and much more. Raspberry Pi support various programming languages such as Python, C, C++, BASIC, Perl and Ruby [1].

A. History

The foundation stone for the development of Raspberry Pi was laid back in 2006 when researchers of University of Cambridge came forward within aim to raise the number of A level students opting for Computer Science domain[2]. The four researchers behind the development of the first model are Eben Upton, Jack Lang, Rob Mullins, and Alan Mycroft. Raspberry Pi was incorporated in 2009 with the mission and vision of manufacturing an affordable computer so that the young generation could use it to learn basic computer programming. The first Raspberry Pi, model B was launched back in 2012 by the United Kingdom Raspberry Pi foundation. Initially, it used a Broadcom BCM2835 Soc which is integrated with 512 Mb memory storage, 700 MHz ARM ARM1176JZF-S processor and VideoCore IV graphics processing unit (GPU) [3]. The foundation, later on, launched a cheaper model which had lower memory storage, single USB port and no ethernet controller. As of 2019, the company has sold over more than 19 million units making it a 3rd best-selling "general-purpose computer".

II. TECHNICAL SPECIFICATIONS

The below Specifications are of the latest Raspberry Pi 4 Model B

- **Processor:** Broadcom BCM2711, Quad core Cortex-A72 (ARM v8) 64-bit SoC @ 1.5GHz
- **RAM:** 8GB LPDDR4-3200 SDRAM
- **Bluetooth:** Bluetooth 5.0, BLE
- **Wi-Fi:** 2.4 GHz and 5.0 GHz IEEE 802.11ac wireless
- **USB:** 2 USB 3.0 ports; 2 USB 2.0 ports
- **Ethernet:** Gigabit Ethernet
- **HDMI:** 2 × micro-HDMI ports (up to 4kp60 supported)
- **Storage:** MicroSD Card Slot
- **Power Supply:** 5.1V 3A USB Type C Power (Recommended)
- **Dimensions:** 85.6mm × 56.5mm

Raspberry Pi initially has its own operating system previously called Raspbian based on Linux. In the emerging software world, there are few non-Linux based OS options available in the market [4]. The

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preferred OS for the Pi are Linux distribution (Debian, Puppy Linux, Arch Linux, Fedora Remix and OpenELEC) as they are easily available at no cost, but majorly owing to their capability to function on the Raspberry Pi's ARM processor.

III. RASPBERRY PI BOOT PROCESS [5]

a) When the Raspberry Pi is first turned on, the ARM core is off, and the GPU core is on. At this point the SDRAM is disabled.
b) The GPU starts executing the first stage bootloader, which is stored in ROM on the SoC. The first stage bootloader reads the SD card, and loads the second stage bootloader (**bootcode.bin**) into the L2 cache, and runs it.
c) **bootcode.bin** enables SDRAM, and reads the third stage bootloader (**loader.bin**) from the SD card into RAM, and runs it.
d) **loader.bin** reads the GPU firmware (**start.elf**)
e) **start.elf** reads **config.txt, cmdline.txt** and **kernel.img**

SoCSystem on a Chip
ARM Advanced RISC Machine
GPU Graphics Processing Unit
SDRAM Synchronous Dynamic Random-Access Memory

IV. PROS & CONS OF RASPBERRY PI [6]

A. Pros

Some of the key merits of Raspberry Pi are mentioned by

- Inexpensive device and is available easily across worldwide
- Extensive peripheral support: Raspberry Pi has 26 GPIO (General Purpose Input/Output) pins, which makes it easy for the user to connect a greater number of external hardware devices. Moreover, it also supports almost all kind of peripherals supported by Arduino.

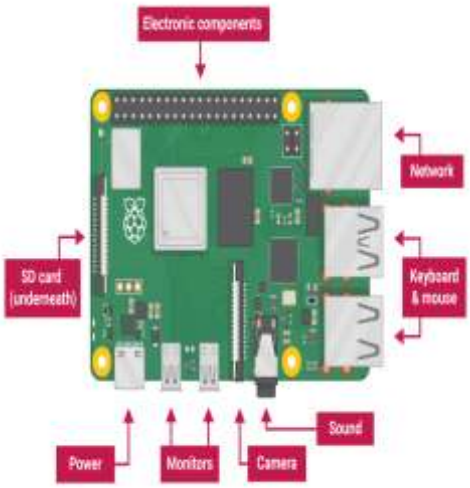

Figure 1: Extensive Peripheral Support

- Multiple Sensors: It can support and connect multiple sensors at a time, enabling the embedded system enthusiasts to create/develop innovative projects.
- Supports all kind of Codes: This board supports codesof almost any language, starting from C,C#,C++,Ruby,Python,Java,etc….
- Fast Processor: When compared to Arduino and other microcontroller modules, Raspberry Pi has faster processor. Raspberry Pi is integrated with 1.6 GHz Processor in its 4B variant, whereas Arduino board is integrated with a controller. Therefore, this board has a faster and quick response time when compared to other modules.
- Can be Used a Portable Computer: If the user attaches a display/monitor to it, then it becomes a pocket friendly computer. Moreover, various popular apps like VLC and Google Chrome are also available in Raspbian.

B. Cons

Some of the demerits of Raspberry Pi while using it are as follows

- Missing eMMC Internal Storage: The major disadvantage of Raspberry Pi is that it does not have any internal memory storage and SD card works as internal storage for the device. Since the read and write speed of SD Card is much slower than eMMC (Embedded Multimedia Card), it increases the boot time of the board.
- Missing Graphics Processor: As we all know that graphics processor plays an important role if the handler is into video editing, photo editing, and gaming. Whereas, its competitors are providing in-built GPU unit for streamlined

experience while running various graphics-built apps/software.

- Overheating: The board does not come with integrated heat-sinks or cooling fan. With the deployment of a powerful processor and multiple features, the board starts to heat-up with the average usage of 6-7 hours mainly due to smaller board size, and no heat dissipation unit available onboard.
- Unable to Install Windows OS: As we all know Windows is the most common operating system and is also very user friendly, for gaming, video editing, photo editing and much more alike software. Due to this reason, Raspberry Pi faces tough competition with counter devices.
- Real-Time Clock (RTC): The board does not have an RTC with a backup battery.

V. APPLICATIONS

Raspberry Pi's main aim is to fascinate people towards computing and programming and even to solve their complex mathematical problems. Some of the applications are mentioned below.

- Home Automation System: The system can easily host some of the home automation applications with the interfacing of relays, sensors and lights with smartphones or computers. The operator can easily operate the system remotely.
- Zero-Powered Smartphone: The developer/engineer can easily develop a homemade smartphone by assembling various electrical parts that are easily available within the vicinity.
- AI Assistant: It enables the user to easily integrate common language voice commands viaGoogle Assistant SDK as well as Google's Cloud Speech API.
- Motion Capture Security Camera: Raspberry Pi Camera module can get easily connected to a generic USB webcam to develop a motion capture security system.
- Live bots: Live bot is a system that enables the user to handle/control many robots based on Pi over the internet [7].

VI. CONCLUSIONS

1. Number of users supports the fact that the device needs some improvement in terms of availability of internal storage and integration heat sink which will further enhance the efficiency of the product.
2. By providing an external case and an appropriate User guide will further boost the product demand across the globe.
3. To run a full version of Windows directly over Raspberry Pi it requires GPU unit, and if that is integrated with the device, then Pi will be on a whole new level.
4. The combination of embedded systems and traditional computer features makes Raspberry Pi a perfect board for interfacing a wide range of external peripherals.
5. The programming of General-Purpose Input/Output (GPIO) pin is very simple when compared to traditional microprocessor or FPGA.
6. Enhanced flexibility and endless possibility of Raspberry Pi, enables the end-user to program it according to their needs and budget.
7. Lastly, Raspberry Pi can be used as an individual computer but cannot replace the traditional computer, owing to its specific limitations.

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