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1. RASPBERRY PI BASICS

The Raspberry Pi is a series of credit card-sized single-board computers developed in the United Kingdom by the Raspberry Pi Foundation to promote the teaching of basic computer science in schools and developing countries.

1.1. What is Raspberry Pi and IoT?

A Raspberry Pi 3 is a $35 computer system that is on the cusp of challenging the modern personal computer. With the processing power of the latest machine, according to its co-creator is elevated to perform to task where it can comfortably be used as a desktop computer.

The first version of the Pi looks attractive only to real geeks. It is a single- board computer without a case, and it's the size of a credit card. It somewhat resembles the innards of the many electronic devices you might have opened when you were a child.

A Raspberry Pi is a credit-card sized computer originally designed for education, inspired by the 1981 BBC Micro. Creator Eben Upton's goal was to create a low-cost device that would improve programming skills and hardware understanding at the pre-university level. But thanks to its small size and accessible price, it was quickly adopted by tinkerers, makers, and electronics enthusiasts for projects that require more than a basic microcontroller (such as Arduino devices).

The Raspberry Pi is slower than a modern laptop or desktop but is still a complete Linux computer and can provide all the expected abilities that implies, at a low-power consumption level.

Main benefits of Raspberry Pi

- ✓ It's small. You don't need a computer desk or anything to place it.
- ✓ It's quiet. You don't have to worry about noise at all.
- ✓ Want to learn about hardware + software integration? No problem, you can get an Arduino setup with a Pi as well.
- ✓ It's cheap! Yes, you do need only a monitor and keyboard for initial setup.

IoT Evolution

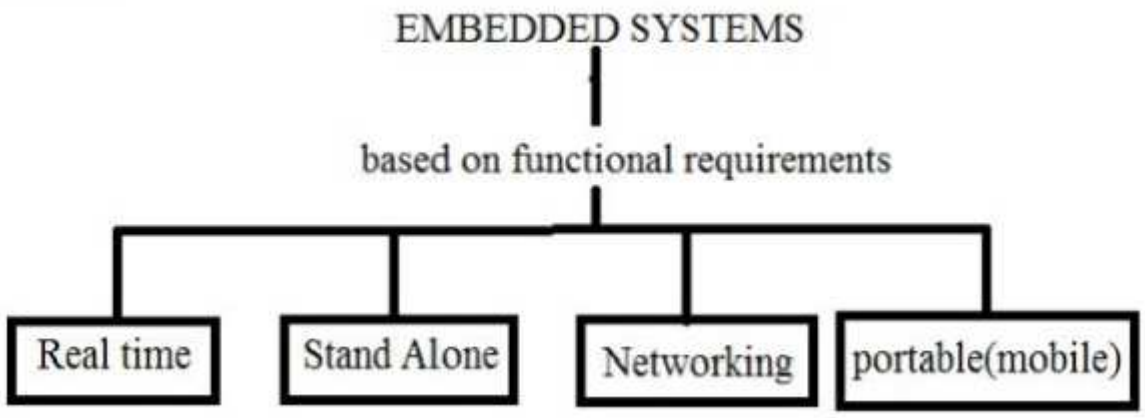
In the current world embedded systems play a vital role in day-to-day human life. The world of Electronics has evolved from manual control to semi-automatic and now we have complete smart automations. So what will be the next evolutionary step?

Today, we have complete automated systems that once programmed can work on their own. Still there are few aspects in these systems that cannot be completely automated. Here, the major deciding factors are human judgment and desire.

Let's see an example; consider a system to control your room temperature - it can be designed to maintain certain temperature but that certain temperature needs to be set by user. It won't be able to start itself prior you enter your room. You first need to enter the room and then set the

temperature. So the next step in evolution is IOT. It would allow you to control your room temperature from any place you are. You can setup your air conditioner when you are 15 minutes away from your home. So that by the time you reach home your room temperature will be already set at a degree you prefer.

This information is simply about automation but embedded systems have influence over all aspects of our life from T.V. to Cars, from radio tower to satellite - nearly all our day to day life is connected with embedded systems. With these vast application, comes variability



The above diagram shows a small possible division of embedded systems but this can be further classified in many more ways like appliance systems, automobile embedded etc. To develop any project its future development must also be kept in mind along with present requirements. To develop systems many development boards are available in market. Few examples are Arduino, Raspberry Pi etc.

The concept – IOT was coined in 1999 and it has currently became more relevant to the practical world majorly because of the exponential growth in technology, medical devices, embedded system, cloud computing and data analytics.

From 1999 to till now, many visionaries have seized on the phrase "Internet of Things" to refer to the general idea of things, especially everyday objects, that are readable, recognisable, locatable, addressable, and/or controllable via the Internet, irrespective of the communication means (whether via RFID, wireless LAN, wide- area networks, or other means). Everyday objects include not only the electronic devices we encounter or the products of higher technological development such as vehicles and equipment but things that we do not ordinarily think of as electronic at all - such as food, transportation, logistics and clothing.

These day to day things of the practical world can be effortlessly integrated into the virtual world facilitating anytime, anywhere connectivity. In 2010, the number of everyday physical objects and devices connected to the Internet was around 12.5 billion. Cisco forecasts that this figure is expected to double to 25 billion in 2015 as the number of more smart devices per person increases, and to a further 50 billion by 2020.

To develop projects we need systems with many peripherals like ADC, DAC, GPIO and UART etc as per our requirement. But when we are developing we must test it on certain assured development devices like development boards. Once we have complete assurance of our working project we can move for development of self designed boards. One such board is Raspberry Pi. Raspberry Pi boards are credit card sized single board computers developed by Raspberry Pi Foundation in United Kingdom. Raspberry Pi was launched with intention to encourage teaching computer basics in schools and developing countries.

1.2. Raspberry Pi Evolution

In 2006, early concepts of the Raspberry Pi were based on the Atmel ATmega644 microcontroller. Its schematics and PCB layout are publicly available. Foundation trustee Eben Upton assembled a group of teachers, academics and computer enthusiasts to devise a computer to inspire children. The computer is inspired by Acorn's BBC Micro of 1981. The Model A, Model B and Model B+ names are references to the original models of the British educational BBC Microcomputer, developed by Acorn Computers. The first ARM prototype version of the computer was mounted in a package the same size as a USB memory stick. It had a USB port on one end and an HDMI port on the other.

The Foundation's goal was to offer two versions, priced at US$25 and 35. They started accepting orders for the higher priced Model B on 29 February 2012, the lower cost Model A on 4 February 2013 and the even lower cost (US$20) A+ on 10 November 2014. On 26 November 2015, the cheapest Raspberry PI yet, the Raspberry PI Zero, was launched at US$5 or £4.

Pre-launch

- ✓ July 2011: Trustee Eben Upton publicly approached the RISC OS Open community in July 2011 to enquire about assistance with a port. Adrian Lees at Broadcom has since worked on the port, with his work being cited in a discussion regarding the graphics drivers. This port is now included in NOOBS.
- ✓ August 2011 – 50 alpha boards are manufactured. These boards were functionally identical to the planned Model B, but they were physically larger to accommodate debug headers. Demonstrations of the board showed it running the LXDE desktop on Debian, Quake 3 at 1080p, and Full HD MPEG-4 video over HDMI.
- ✓ October 2011 – A version of RISC OS 5 was demonstrated in public, and following a year of development the port was released for general consumption in November 2012.
- ✓ December 2011 – Twenty-five Model B Beta boards were assembled and tested from one hundred unpopulated PCBs. The Beta boards were demonstrated booting Linux, playing a 1080p movie trailer and the Rightware Samurai OpenGL ES benchmark.
- ✓ Early 2012 – During the first week of the year, the first 10 boards were put up for auction on eBay. One was bought anonymously and donated to the museum at The Centre for Computing History in Cambridge, England.

Launch

- ✓ 19 February 2012 – The first proof of concept SD card image that could be loaded onto an SD card to produce a preliminary operating system is released. The image was based on Debian 6.0 (Squeeze), with the LXDE desktop and the Midori browser, plus various

programming tools. The image also runs on QEMU allowing the Raspberry Pi to be emulated on various other platforms.

- ✓ 29 February 2012 – Initial sales commence 29 February 2012 at 06:00 UTC. At the same time, it was announced that the model A, originally to have had 128 MB of RAM, was to be upgraded to 256 MB before release.
- ✓ March 2012 – Shipping delays for the first batch were announced in March 2012, as the result of installation of an incorrect Ethernet port, but the Foundation expected that manufacturing quantities of future batches could be increased with little difficulty if required. The first batch of 10,000 boards was manufactured in Taiwan and China.
- ✓ 8 March 2012 – Release Raspberry Pi Fedora Remix, the recommended Linux distribution, developed at Seneca College in Canada.
- ✓ March 2012 – The Debian port is initiated by Mike Thompson, former CTO of Atomz. The effort was largely carried out by Thompson and Peter Green, a volunteer Debian developer, with some support from the Foundation, who tested the resulting binaries that the two produced during the early stages. Thompson and Green set out to build the 19,000 Debian packages for the device using a custom build cluster.

1.3. Raspberry Pi Versions

Several generations of Raspberry Pis have been released. The first generation (Raspberry Pi 1 Model B) was released in February 2012. It was followed by a simpler and inexpensive model Model A. In 2014 the foundation released a board with an improved design in Raspberry Pi 1 Model B+. The model laid the current "mainline" form-factor. Improved A+ and B+ models were released a year later. A cut down "compute" model was released in April 2014, and a Raspberry Pi Zero with smaller size and limited input/output (I/O) and general-purpose input/output (GPIO) abilities was released in November 2015 for US$5. The Raspberry Pi 2 which added more RAM was released in February 2015. Raspberry Pi 3 Model B released in February 2016 is bundled with on-board WiFi and Bluetooth. As of 2016, Raspberry Pi 3 Model B is the newest mainline Raspberry Pi. These boards are priced between US $20–35.

All models feature a Broadcom system on a chip (SoC), which includes an ARM compatible central processing unit (CPU) and an on chip graphics processing unit (GPU, a VideoCore IV). CPU speed ranges from 700 MHz to 1.2 GHz for the Pi 3 and on board memory range from 256 MB to 1 GB RAM. Secure Digital (SD) cards are used to store the operating system and program memory in either the SDHC or MicroSDHC sizes. Most boards have between one and four USB slots, HDMI and composite video output, and a 3.5 mm phone jack for audio. Lower level output is provided by a number of GPIO pins which support common protocols like I²C. The B-models have an 8P8C Ethernet port and the Pi 3 has on board Wi-Fi 802.11n and Bluetooth.

The Foundation provides Raspbian, a Debian-based Linux distribution for download, as well as third party Ubuntu, Windows 10 IOT Core, RISC OS, and specialised media center distributions. It promotes Python and Scratch as the main programming language, with support for many other languages. The default firmware is closed source, while an unofficial open source is available.

In February 2016, the Raspberry Pi Foundation announced that they had sold eight million devices, making it the best-selling UK personal computer, ahead of the Amstrad PCW. Sales reached ten million in September 2016.

Many versions of raspberry Pi are available in the market for more than 4 years and have continuously been evolving. The first version i.e. first generation Pi 1 was released in February 2013. This version was launched with two models A and B. But a year later A+ and B+ models were launched.

Later on in February of 2015 Raspberry Pi 2 was launched and a year later i.e. February 2016 Raspberry pi 3 was launched. Pi zero which was almost half the size of Pi 2 was launched in November 2015 with smaller footprint and less GPIO. The lower specification version of Raspberry Pi is the Module A. It has 256 MB of RAM, a single USB port but no port for Ethernet. Model B is a variant with higher specification of Raspberry Pi 1. It has 512 MB of RAM, two USB Ports and additional 100mb Ethernet port. Later on in November 2014, a bit more advance version of Raspberry Pi 1model A was launched as Model A+. This version compared to Model A had 14 more GPIO pins header. So it has GPIO header of 40 pins whereas previous version had 26 pins. SD card socket was upgraded to push- push micro SD version. Reduced power consumption by 0.5W to 1W compared to previous model. A dedicated low noise power supply was incorporated in audio circuit.

Final version of first series was Model B+. In addition to features from model B it has 2 more USB compared to model B. thus model B+ has total of 4 USB 2.0 ports. It also provided better over-current behaviour. It has all the features from Model A+ i.e. 40 GPIO, better socket for SD card, lower power consumption and better audio.

Raspberry Pi 2 B replaced the Raspberry Pi 1 Model B+ completely. Because of its advanced features and complete backward compatibility, it's easily adapted in electronics market. Raspberry Pi 2 B has the following major features:

- ✓ A 900 MHz quad core ARM cortex A-7 CPU
- ✓ 1GB of RAM

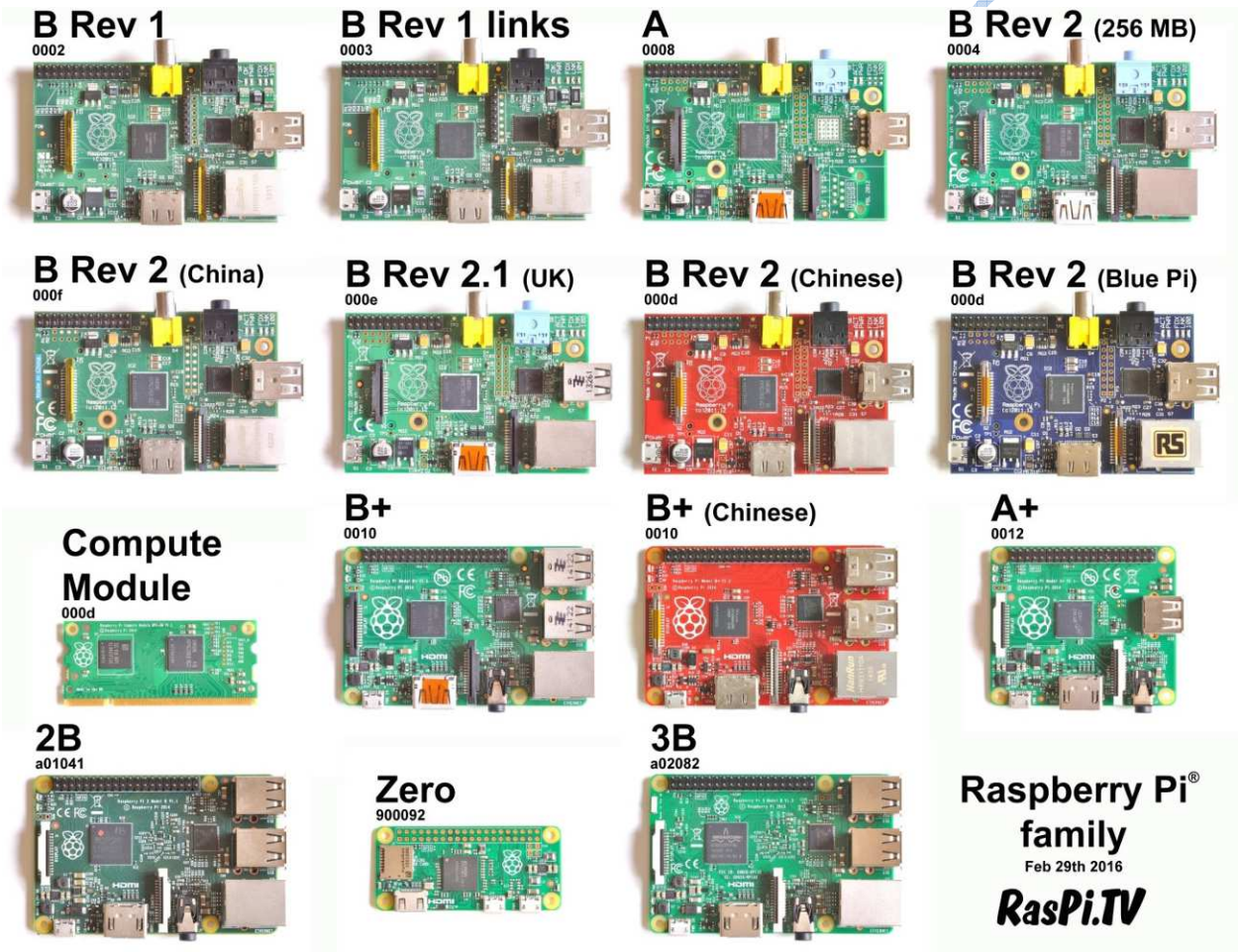
Because of its ARM 7 processor it can host all the ARM GNU/Linux distributions including Snappy Ubuntu and Windows 10. Apart from these it has other features as noted bellow:

- ✓ 4 USB port
- ✓ 40 GPIO
- ✓ Full HDMI port
- ✓ Ethernet Port
- ✓ Camera interface
- ✓ Display interface
- ✓ Micro SD card slot
- ✓ Video Core IV 25 graphics core

In February 2016 Raspberry Pi 3 replaced all the previous models of Raspberry Pi. It has the features of:

- ✓ A 1.2 GHz 64 bit quad core ARMv8 CPU
- ✓ 802.11n Wireless LAN

- ✓ Bluetooth 4.1
- ✓ Bluetooth Low Energy (BLE)
- ✓ Like Raspberry Pi 2 it has:
- ✓ 4 USB port
- ✓ 40 GPIO
- ✓ Full HDMI port
- ✓ Ethernet Port
- ✓ Camera interface
- ✓ Display interface
- ✓ Micro SD card slot
- ✓ Video Core IV 25 graphics core



	Raspberry Pi	Raspberry Pi 2	Raspberry Pi 3
Released	February 2012	February 2015	February 2016
CPU	ARM1176JZF-S	ARM Cortex-A7	ARM Cortex-A53
CPU speed	700MHz single core	900MHz quad core	1,200MHz quad core
RAM	512MB	1GB	1GB

	Raspberry Pi	Raspberry Pi 2	Raspberry Pi 3
	256MB Rev 1		
GPU	Broadcom Videocore IV	Broadcom Videocore IV	Broadcom Videocore IV
Storage	SDHC slot MicroSDHC Model A+ and B+	MicroSDHC slot	MicroSDHC slot
USB Ports	2 on Model B	4	4
WiFi	No built-in wifi	No built-in wifi	802.11n and Bluetooth 4.1

Raspberry Pi Zero

The most talked about addition to the Raspberry Pi system is the Raspberry Pi Zero released at the end of 2015. All of the core features of the Raspberry Pi Model B come together in a package that's only 65mm by 30mm! That size does come at a cost though. Whilst clocking in at a 1 Ghz CPU, it's only a single core processor, which rules it out of distributions like Windows 10 IoT. 512MB of SDRAM is included, however gone is the Ethernet port, and full size peripheral connections. Instead we find 2 Micro-USB connectors, 1 for power, the other for USB devices, a mini-HDMI port, and no soldered headers. This makes it more suited to compact projects, or projects that don't require easy access to peripheral connection. It is incredibly hard to argue with the price of Pi Zero given what's on offer!

Raspberry Pi Zero W

It is a new variant of Raspberry Pi Zero with wireless LAN and Bluetooth, priced at only $10. It's almost identical to the previous Raspberry Pi Zero v1.3 (the one that added the camera connector) – importantly, all the chips and components are still only on the top side of the board. Zero W integrates more functionality into the core product. It uses the same Cypress CYW43438 wireless chip as Raspberry Pi 3 Model B to provide 802.11n wireless LAN and Bluetooth 4.0 connectivity.

While the radio chip on the Raspberry Pi Zero W is the same as the one on the Raspberry Pi 3, the antenna is completely different. Instead of a little white chip that contains it, the antenna on the Pi Zero W is printed into the board.

The specifications of the device are

- ✓ Dimensions: 65mm × 30mm × 5mm
- ✓ SoC: Broadcom BCM2835
- ✓ CPU: ARM11 running at 1GHz
- ✓ RAM: 512MB
- ✓ Wireless: 2.4GHz 802.11n wireless LAN
- ✓ Bluetooth: Bluetooth Classic 4.1 and Bluetooth LE
- ✓ Power: 5V, supplied via micro USB connector
- ✓ Video & Audio: 1080P HD video & stereo audio via mini-HDMI connector
- ✓ Storage: MicroSD card
- ✓ Output: Micro USB
- ✓ GPIO: 40-pin GPIO, unpopulated
- ✓ Pins: Run mode, unpopulated; RCA composite, unpopulated
- ✓ Camera Serial Interface (CSI)

In order to use a Pi Zero W, you'll need to add a power supply (your phone charger and a micro USB cable will do), and to use the 40-pin GPIO connector you'll need to buy the header pins. Plus, the OS will require a microSD card, which slots into the connector on the left-hand side of the board in the picture above.

The official case costs £6 comes with three lids. One is plain with no holes. A second has a hole for the camera module and comes with the necessary ribbon cable to connect the module to the Pi Zero W. The third has a cutout for the GPIO connector.

1.4. Raspberry Pi 3

Raspberry Pi launched the first microcomputer on Feb. 29, 2012. Four years after the original Raspberry Pi rolled out the company takes another swing at the microcomputer market and showcases the Raspberry Pi 3. The device comes at the same price as the Pi 2 variant, at $35.

Released in early 2016, the Raspberry Pi 3 is the latest, most powerful Raspberry Pi on offer. In features a 1.2 Ghz quad core ARM Cortex-A53, offering a 300 Mhz increase in CPU speed over the Raspberry Pi 2. However the most exciting new features are in its connectivity options. The Raspberry Pi 3 comes loaded 802.11n WiFi and Bluetooth 4.1, which is a huge asset for projects in our increasingly wireless world. It features all of the same peripheral connection as the Raspberry Pi 2, and has an identical GPIO layout and form factor. The Raspberry Pi 3 is a big upgrade from the Raspberry Pi 2 and the best product for getting started with Raspberry Pi, or upgrading current projects.

Under its hood, we find:

- ✓ Processing power from a 1.2 GHz 64-bit quad-core ARM Cortex-A53 CPU. This has approximately the power of 10 Raspberry Pi 1s.
- ✓ Bluetooth 4.1 and 802.11n wireless LAN, both of which are integrated.
- ✓ Total compatibility with Raspberry Pi 1 and 2.

As a reminder, the Raspberry 2 came with four USB ports, a full HDMI port, 40 GPIO pins, an ethernet port, camera interface, display interface, microSD card slot, VideoCore IV 3D graphics core and a 3.5 mm audio jack with composite video.

Key Features

- ✓ 1GB RAM
- ✓ Bluetooth 4.1
- ✓ 1.2GHz 64-bit quad-core processor
- ✓ Inbuilt 802.11n Wireless LAN Network
- ✓ The other common features include:
  - ✓ 4 pole Stereo output and Composite video port
  - ✓ Full-size HDMI
  - ✓ Camera port for connecting the Raspberry Pi camera
  - ✓ Very low cost.
- ✓ It's an open computer that can be given to kids of make experiments and learn
- ✓ new technology.

- ✓ Can connect with TV, USB keyboard-mouse.
- ✓ OS is Linux so it is easy to use and learn.
- ✓ Inbuilt GPIO that can be used for projects and Robotics.

CPU Comparison

The Raspberry Pi 3's new Broadcom SoC, dubbed BCM2837, has the identical basic architecture as its previous models, BCM2835 and BCM2836. This means that tutorials and projects that need the exact details of the Raspberry Pi hardware will keep working.

Raspberry Pi 2 Model B sported a 32-bit quad-core ARM Cortex-A7 CPU complex clocked at 900MHz. With its 33 percent upgrade in clock speed and architectural improvements, the Raspberry Pi 3 is 50 to 60 percent more powerful in 32-bit mode when compared to its predecessor.

Form Factor, Design And Connectivity

More than half a year was spent to help the new BCM2837 SoC play well with the BCM43438 wireless "combo" chip. The Raspberry 3 maintains almost the same form-factor as the Raspberry Pi 1 Model B+ and the Raspberry Pi 2 Model B. The single noticeable modification is the location of the LEDs, which were repositioned in the opposite side of the SD card socket so that the antenna could fit.

The built-in Bluetooth and wireless LAN will offer the customers of Raspberry Pi 3 with access to more USB ports.

Power

Every connector kept its place and functionality from the Raspberry Pi 2 Model B. What is more, the board still supports a 5V micro-USB power adapter. The company recommends using a 2.5A adapter, should you plan to connect your Raspberry Pi 3 to power-hungry USB gadgets.

Software

For Raspberry Pi 3 to work properly, a recent NOOBS or Raspbian image from its download page is required. An improved version of 32-bit Raspbian will be delivered soon, and the company says that it looks into delivering a 64-bit variant, as well.

GPIO

The Raspberry Pi comes with a set of 26 exposed vertical pins on the board. These pins are a General Purpose Input/Output interface that is purposely not linked to any specific native function on the Raspberry Pi board.

Instead, the GPIO pins are there explicitly for the end user to have low-level hardware access directly to the board for the purposes of attaching other hardware boards, peripherals, LCD display screens, and other hardware devices to the Pi. For example, if you wanted to take an old arcade controller and wire it directly to your Raspberry Pi to give your arcade a more authentic feel, you could do so using the GPIO interface.