

Energy Efficient Computing: A Comparison of Raspberry Pi with Modern Devices

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Abstract—In today’s modern world, Internet has become a basic need of everyone. Apart from the basic features of the Internet, i.e., surfing and web browsing, we need additional features such as entertainment, online video streaming and socializing etc. To utilize different features of the Internet, different devices are available that varies in terms of cost, computing power, display and energy consumption. In this paper, we present how different features of the Internet could be surfed by having a single device Raspberry Pi. We compare different characteristics of Raspberry Pi with modern computing devices like Smartphone, tablet PC, laptop and smart TV. Our results show that essential computing tasks could be achieved in more energy efficient way. We prove that Raspberry Pi consumes less power and can save notable amount of energy in routine computing tasks.

Keywords—Raspberry Pi; comparison; smart devices; energy efficiency

I. INTRODUCTION

The Raspberry Pi is a credit-card size computer that was developed in the Laboratory of University of Cambridge and released by Raspberry Pi Foundation in 2012 [1]. The aim of Raspberry Pi was to stimulate the teaching of computer science at school [2]. The Raspberry Pi has a 700MHZ ARM11 co-processor [3], Broadcom Video Core IV[4] graphics, 512 MB RAM on model B and 256 MB RAM on model A. This microcomputer has 85.6 X 53.98 mm(3.37 X 2.125 in) size and its weight is 45g (1.6 oz.)[4], it has two USB ports in model B and one in model A, 1 Ethernet port on model B. It has GPIO (general purpose I/O) connectors so we can communicate with sensors, motors and other embedded systems [1]. It has open-source Linux (Raspbian) operating system, you can also run Android, Arch Linux ARM, Firefox operating system, Google chromium, Fedora, Plan 9 ,RISC and UNIX[2] . Raspberry Pi has different usages like you can use it for watching movies, playing games etc. Raspberry Pi has a flexible platform for applying utilities and for experimentation [5].

“The Pi Store” is the market to download its applications. Raspberry Pi provides a graphical desktop environment so that it can be used for general purpose reading e.g. reading documents, working with spreadsheets. It can also be used for web browsing as simply as in smartphones, tablets, laptops, desktops and Smart TVs. As these devices can perform many similar tasks but energy consumption of these devices varies for these specific tasks.

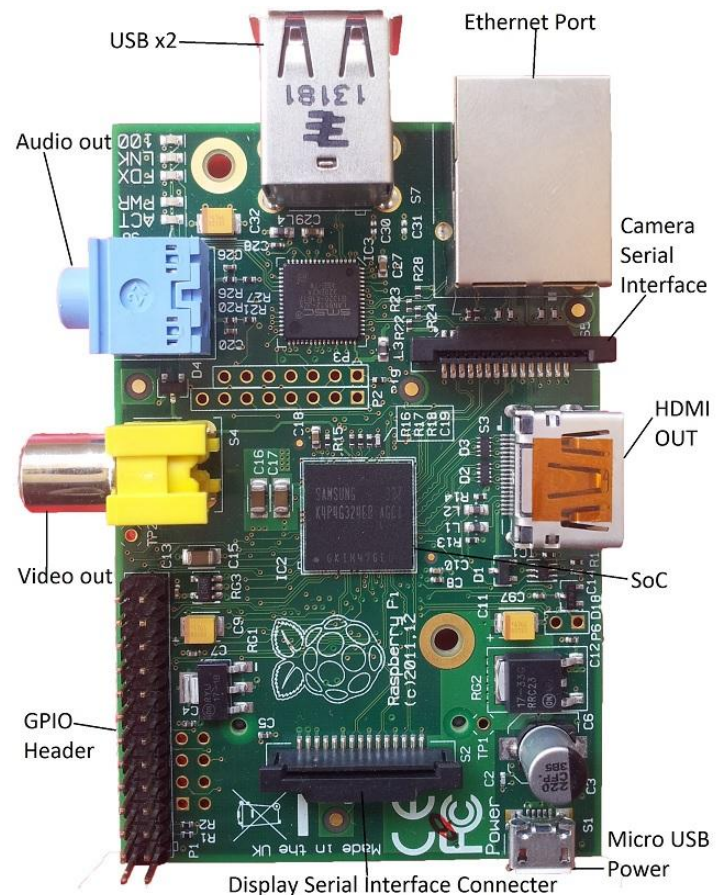


Figure 1: Raspberry Pi Model B

The rest of the paper is organized as follows. Section II overviews the related work, Section III discusses the energy efficient computing of different devices, Section IV provides numerical results before the paper is concluded in Section V.

II. LITERATURE REVIEW

With the advancement of technology, different devices are manufactured which are enriched with different features based on user needs. Many features of these devices are common but all are not similar, even same features are presented differently by different devices. So it is important to discuss these modern devices briefly.

A. Smartphone

Smartphone is handheld device with functionalities of several other devices such as computer, cellular phone, music player, radio, GPS etc.[6]. They also support 2G/3G/4G data. It is pocket or handbag size device and very easily portable and light weight. It can be used for reading, Internet, gaming messaging, mailing and many other purposes. Smartphones are available with different operating systems such as android, windows, blackberry, Symbian and I operating system. Energy consumption of different model varies with respect to screen size, operating system and available hardware. Whereas HTC sensation XL having 4.7 inch screen needs 5 watt power to run and costs 400US\$ [7].

B. Tablet

Tablet is mobile computer with display, circuitry and battery in a single unit. A tablet is easily portable and light weight computing device when compared to a laptop. It has virtual keyboard and have touch screen. Their screen sizes are approximately 7 to 10.1 inch. Tablets are available with android, windows, blackberry and I operating system. Tablet normally gives more than 8 hours battery time. Energy consumption is comparatively less than laptop. It just need power of 25 watt to run[8]. It comes with some pre-installed applications but they can be enhanced by downloading and installing from relevant app store. Price of tablets varies with respect to the performance and screen size, but they are cheaper than laptops.

C. Laptop

It is a portable computer, small enough to fit on lap. It provides opportunity to study, Internet usage and gaming and even can do programming in many different languages. Windows, mac, Linux and other operating systems can run on it. It can be run on battery or AC power. It approximately runs on 50 watt[9]. And its battery time is 2-4 hours. Now a days ultra-books are available in markets which are very light weight and give more than 8 hours battery time. Laptops are available with different performances so their prices also varies with performance.

D. Desktop

A computer designed to fit on the top of the desk. Easily upgradeable, available with window, mac, Linux and few other operating systems. Watching movies, Internet surfing, studying, programming and many other uses. It is most powerful among all these devices. So its energy consumption is also high. It needs 82 watt energy to run without display[10].

E. Smart TV

Smart TV is a TV with built-in Internet capabilities. It provides access to stream videos and music. It comes with different operating systems. It also provides access to social networking apps. It has capabilities to check emails, web

browsing, gaming, watching movies etc. A smart TV with 32 inch display needs approximately 80-110watt to run.

III. ENERGY AND PERFORMANCE EVALUATION COMPARISION

In this section, performance evaluation of different devices is discussed and energy efficient computing is measured. Raspberry Pi can be boot-up with just a power of 5 Volts [11]. For normal usage Raspberry Pi run on just 2.25 watts without display and energy consumption is 8.1 kilojoules per hour (kJ/h), whereas laptop generally runs on 50 watts[9] and consume 180 kJ/h and desktop runs on 82 watts without display[10] and energy consumption per hour is 295.2 kJ. So Raspberry Pi consumes 22% less power than a laptop. It has vast range for display, it can be connected with TV, LCDs and laptop's or mobile screen as well. On the other hand smartphone (HTC sensation XL) runs on 5 watt and consume energy 18 kJ/h, tablet runs 25 watts [8] and consume 90 kJ/h where as smart TV run on 221 watts and energy consumption is 795.6 kJ/h.

Although these devices can be used for web or education but people prefer those devices which yield more satisfaction and fulfill their requirements, like they do not want to use web all the time, they want entertainment too. Even continuously studying is also difficult. While buying the device, cost also plays an important role, people prefer to buy device with maximum qualities and minimum cost. Users having confidential data in these type of devices prefer security instead of user-friendliness. Energy efficiency is also important which affect power savings at national level. Portability also plays important role. Desktop and Smart TV are not portable at all so it will be difficult to carry them from one place to another. Whereas laptops are comparatively more portable but do not give good battery time as compare to tablets, but their performance is better, and also provide environment for programming. On the other hand smartphones are very portable and can easily put into pocket and handbag. The brief comparison is discussed in the Table 1. Table 1 shows the comparison of specific model of different devices. Energy efficiency is calculated in kilojoule per hour. According to the table Raspberry Pi is most energy efficient device with just credit card size. Whereas desktop and Smart TV are highly energy consuming devices with no portability. Laptop although provides almost all the services without any difference from desktop and is also portable and energy efficient but more expensive than desktop. On the other hand only smartphone is available with cellular services.

IV. COMPUTING ENERGY EFFICIENCY

Energy efficient products are now in high demand as they reduce energy cost and thus results in saving money for consumers. Energy efficiency cause reduction in pollution from environment, availability of more energy and improve the economy as well.

The energy consumption of Raspberry Pi and other devices are not same. Smart TV with 32 inch display consumes maximum energy amongst them. Desktop without display consume 295.2 kJ/hour energy, if LCD having 17 inch display that needs 40 watt to run and consumes 144 kJ/hour is attached with it then energy consumption of whole computer will be 439.2kJ/hour[12]. On the other hand 10.1 inch LCD (B101UAN02.2) consumes 13.14 kJ/hour energy[13], Energy consumption of Raspberry Pi with this LCD is 21.24kJ/h. If all these devices are used for web browsing or general purpose usage then there consumption in kilo joule per hour is mentioned in Figure 1.

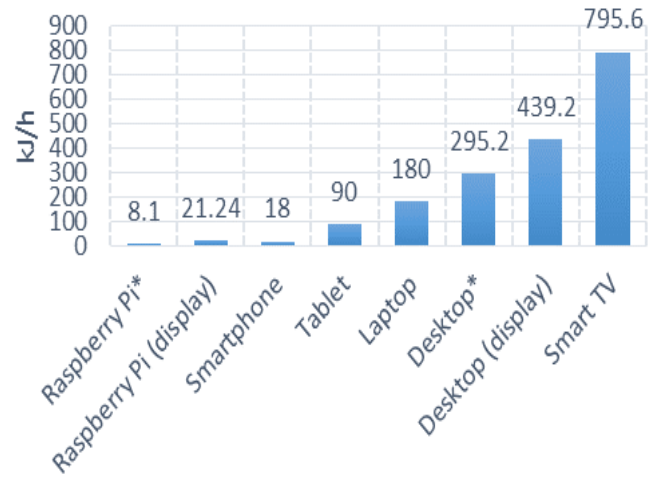






Figure 2: Energy consumption comparison of Raspberry Pi in kilo joules per hour.

Use of energy efficient devices where they are used in bulk are very effective to save energy. For example in university

TABLE 1. PERFORMANCE COMPARISON OF MODERN COMPUTING DEVICES

		Energy Efficiency (kJ/h)	Power (watt)	Cost (US dollar)	Apps	Reading and Web Browsing	Cellular Services	Device for Coding and Programming	Portability	Battery Time
Raspberry Pi (Model B)		8.1	2.25*	35	PI store	Yes	No	Yes	Credit card size	Optional
Smart phone	iPhone	18	5	400	App store	Yes	Yes	No	Pocket size	More than 6 hours
	Android (sensation XL)				Google play store					
Tablet	iPhone	90	2.5	320	App store	Yes	No	No	Book size	More than 8 hours
	Android (Samsung galaxy tab 4)				Google play store					
Laptop (vaio SVF15323CXW)		180	50	728	Window store	Yes	No	Yes	Briefcase size	2-4 hour
Desktop (dell inspire 300)		295.2	82*	599	Window store	Yes	No	Yes	Not portable	No
Smart TV (32LA6210)		795.6	221	408	LG Smart world	Yes	No	No	Not portable	No

having 500 desktops and running 12 hours a day and 5 days in a week, then desktop consume 8856 mega joule (MJ) energy whereas Raspberry Pi consume 243 MJ energy in a week. Table 2 shows the comparison of energy consumption in mega joule with respect to time.

TABLE 2. ENERGY CONSUMPTION COMPARISON IN MEGA JOULE

Devices	Per day	Per month	Per year
Raspberry Pi	48.6	972	11664
Smartphone	108	2160	25920
Tablet	540	10800	129600
Laptop	1080	21600	259200
Desktop	1771.2	35424	425088
Smart TV	4773.6	95472	1145664

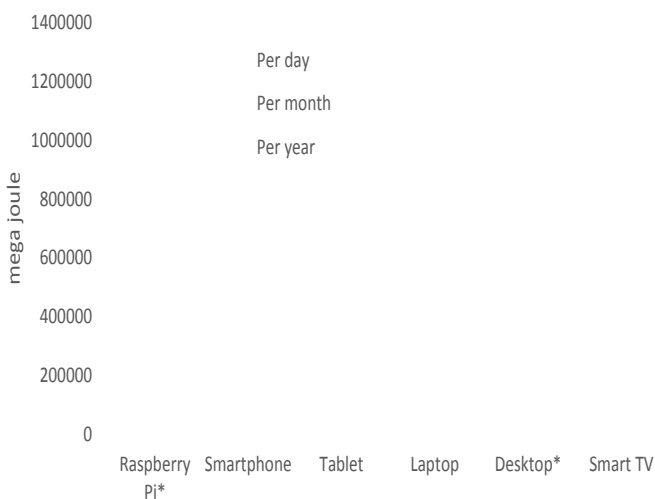


Figure 3: Energy Consumption comparison in mega joule

Table 2 shows numerical values of energy consumption and Figure 3 shows the graph of energy consumption of Raspberry Pi and other devices. By comparing the energy difference of Raspberry Pi and a desktop 425088MJ-11664MJ = 413424 MJ energy can be saved which can be utilized on other resources or web browsing on Raspberry Pi with same amount of energy for another 36 years.

V. CONCLUSION

In this paper, we discuss power consumption, cost, portability and energy efficiency of different devices and we compared with Raspberry Pi. In our performance comparison we have evaluated the power consumption of Raspberry Pi with and without display screen. The results show that Raspberry Pi with 10 inch display consumes almost same amount of energy as a Smartphone with 4.7 inch display. So Raspberry Pi is cost and energy efficient than other devices especially for reading and web browsing and for making hardware and software related projects. We have also

discussed the comparison of other devices which will help the user to opt energy efficient device. We strongly believe that fundamental computing tasks could be easily accomplished by Raspberry Pi in more economic and energy efficient way. In future. We will explore how Raspberry Pi could be used as smartphone and tablet with multiple operating systems.

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