Introduction of IOT and Architecture *Raspberry Pi*

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Abstract. With low cost data storage, processing and communication between gadgets, it is imperative that all our day-to-day activities have to be automated and connected at the same time. Internet of Things (IoT) has made this procedure possible at low cost, ease of access and flexibility of use. IoT provides features like monitoring, analysis, prediction and control.But as it is known, IoT is a concept that can only be put in application when it is connected to suitable and viable devices called Things and Internet Gateway (IG). Raspberry Pi with sensors connected to it, does provide the Things with the IG. In this article, brief introduction to IoT and Raspberry Pi is provided and then it is explained on how to connect the two as a singular unit. The schematic connection between Raspberry Pi and Cloud to establish IoT is discussed pictorially for comprehension.

1. Introduction. 247 connectivity between devices and data processing is the future generation technological demand that will provide human civilization with a smoother, faster and more comfortable life style. And in this pursuit, technologies like IoT have already taken the centre stage. With the advent of Internet of Things concept, the operational and information technologies have not only come closer but apparently have become synonyms. And in this venture, mini system on chip boards are taking the front seat in order to provide the access and freedom to both professionals and amateurs to contribute in the next -gen world. Hence one must keep pace with time and upgrade oneself to acclimatize and accommodate in this paradigm shift

1.1. INTRODUCTION TO IOT. The term Internet of Things (IoT) became truly prominent in 2005 when the International Telecommunication Union published a report on this subject [12]. The IoT concept encompasses devices, sensors, and services existing within an interconnected infrastructure with an efficient access to ample computational facilities. This paradigm enables tangible objects to gather and transmit information about the physical world, thus creating usable services and interfaces allowing these objects to intelligently interact with their users and other systems [28]. The IoT systems have been successfully implemented in many areas, including home automation, surveillance, transportation, and healthcare. An IHS report from March 2016 indicates that the number of installed IoT devices will grow from 15.4 billion in 2015 to 30.7 billion devices in 2020 and to 75.4 billion in 2025 [11]. Consequently, the number of IoT devices is expected to exceed the number of mobile phones by 2018 becoming the largest category of connected devices [4]. A McKinsey report estimates that IoT has a potential economic impact between $3.9 trillion to 11.1$ trillion a year by 2025 [19]. It is unsurprising that many major industry players, including IBM, Samsung, Intel, and ARM, to name just a few, are showing a very significant interest in the IoT market showcasing their relevant products at many recent technology exhibitions. Unlike a new technology or a framework du jour, the IoT represents a new paradigm of computing, much like mobile computing did a decade ago. Given such a tremendous growth

* Both acknowledgments and author affiliation information go in an initial footnote like this, referenced by an asterisk on the end of the last author's name on the author-name line at the top. You can say who you would like to thank here and then end the footnote as follows. Authors: Author One, University of the Atlantic (author1@atlantic.edu) & Other Author, Pacific University (author2@gmail.com).

in the number of deployed devices and services, the IoT is positioned to make a significant impact on the skillset of professionals working in the software and hardware industries. Computer Science educators began to respond to these demands by adding IoT-centric courses in the curriculum and including relevant content into a broad range of existing courses. This paper reviews a number of such initiatives and describes the authors experiences of incorporating IoT projects into an existing Systems Programming course. We examine several hardware platforms suitable for student projects, provide a brief sampling of the projects completed by the students, and conclude by discussing a number of our experiences and lessons that could benefit other educators planning to incorporate the IoT material into their coursework.

1.2. IOT ARCHITECTURE. The architecture of IoT can be broadly categorized and classified in to four stages as Stage I: Sensor/Actuators, Stage II: Internet Gateway, Stage III: Edge IT and Stage 4 : Data Centre and Cloud[9]. Figure 1 represents the five layer architecture of an IoT system and also illustrates the how three different techniques come together to constitute IoT. As illustrated by TechBeacon, Figure 2 demonstrates the four stages of IoT architecture. Sensors and actuators form the limbs of the IoT as sensors first collect data, then process it and upload it for analysis and synthesis and decision making. Once these are down, data is sent back to the actuators for implementation. Now with the advancement of power over ethernet, these devices do not require ac power sources that bring down the hardware part of the configuration. Internet Gateway sits in close proximity with the sensors and converts the sensors analog signal into its digital counterpart through ADCs in the Data Acquisition Systems (DAS) and aggregates output before handing it over to the internet over WiFi, wired/wireless Lan, Hotspots, Digital Subscriber Line (DSL) or Integrated Services Digital Network (ISDN). In stage III, the processed digitized data in realms of internet. The edge IT can be remotely located or closely placed where the data go through further refining and processing and analysis. From here, the data requiring in-depth processing is sent to the Computer Engineering Division Board 44Annual Technical Volumephysical data centre or cloud based systems. And then from here, they are sent out for the actuators. Here servers like Advanced Message Queueing Protocol (AMQP) and Message Queue Telemetry Transport Protocol (MQTT) play a vital role in providing lightweight methods for carrying out message using a publish/subscribe message queueing model[10]. With these four stages working in unison, soon the Information Techn olo gy will merge with o per ational technology to reshape the scientific, engineering and industrial endeavours and will have a strong

2. RASPBERRY PI. Raspberry Pi (/pał/) is a series of small single-board computers (SBCs) developed in the United Kingdom by the Raspberry Pi Foundation in association with Broadcom. The Raspberry Pi project originally leaned towards the promotion of teaching basic computer science in schools and in developing countries. The original model became more popular than anticipated, selling outside its target market for uses such as robotics. It is widely used in many areas, such as for weather monitoring, because of its low cost, modularity, and open design. It is typically used by computer and electronic hobbyists, due to its adoption of the HDMI and USB standards.

After the release of the second board type, the Raspberry Pi Foundation set up a new entity, named Raspberry Pi Trading, and installed Eben Upton as CEO, with the responsibility of developing technology.[20] The Foundation was rededicated as an educational charity for promoting the teaching of basic computer science in schools and developing countries. Most Pis are made in a Sony factory in Pencoed, Wales,[21] while others are made in China and Japan.

2.1. ARCHITECTURE. The architecture of a RPI is based on a Broadcom SOC BCM2835 which belongs to ARM Cortex family with ARMv6 architecture. It is a 32 bit RISC with a clock speed of 700 MHz and has eight pipelines. This architecture is different from Arduino processor which is X86 based and work on CISC which is a better option it provides the pipelining facilities. BCM2835 also provides the branch prediction improving the flow in the instruction pipeline. The advantages that are obtained because of having a RISC architecture are low transistor count, low power consumption and therefore less heat gener ation. This architecture also features three pipelines, viz, ALU, MAC and load /store

2.2. HARDWARE. The Raspberry Pi hardware has evolved through several versions that feature variations in the type of the central processing unit, amount of memory capacity, networking support, and peripheral-device support.

The Pi Zero models are similar, but lack the Ethernet and USB hub components. The Ethernet adapter is internally connected to an additional USB port. In Model A, A+, and the Pi Zero, the USB port is connected directly to the system on a chip (SoC). On the Pi 1 Model B+ and later models the USB/Ethernet chip contains a five-port USB hub, of which four ports are available, while the Pi 1 Model B only provides two. On the Pi Zero, the USB port is also connected directly to the SoC, but it uses a micro USB (OTG) port. Unlike all other Pi models, the 40 pin GPIO connector is omitted on the Pi Zero, with solderable through-holes only in the pin locations. The Pi Zero WH remedies this.

Processor speed ranges from 700 MHz to 1.4 GHz for the Pi 3 Model B+ or 1.5 GHz for the Pi 4; on-board memory ranges from 256 MB to 8 GB random-access memory (RAM), with only the Raspberry Pi 4 having more than 1 GB. Secure Digital (SD) cards in MicroSDHC form factor (SDHC on early models) are used to store the operating system and program memory, however some models also come with onboard eMMC storage[50] and the Raspberry Pi 4 can also make use of USB-attached SSD storage for its operating system.[51] The boards have one to five USB ports. For video output, HDMI and composite video are supported, with a standard 3.5 mm tip-ring-sleeve jack carrying mono audio together with composite video. Lower-level output is provided by a number of GPIO pins, which support common protocols like IC. The B-models have an 8P8C Ethernet port and the Pi 3, Pi 4 and Pi Zero W have on-board Wi-Fi 802.11n and Bluetooth.

2.3. PERFORMANCE. While operating at 700 MHz by default, the first generation Raspberry Pi provided a real-world performance roughly equivalent to 0.041 GFLOPS.[65][66] On the CPU level the performance is similar to a 300 MHz Pentium II of 199799. The GPU provides 1 Gpixel/s or 1.5 Gtexel/s of graphics processing or 24 GFLOPS of general purpose computing performance. The graphical capabilities of the Raspberry Pi are roughly equivalent to the performance of the Xbox of 2001.

Raspberry Pi 2 V1.1 included a quad-core Cortex-A7 CPU running at 900 MHz and 1 GB RAM. It was described as 46 times more powerful than its predecessor. The GPU was identical to the original. In parallelised benchmarks, the Raspberry Pi 2 V1.1 could be up to 14 times faster than a Raspberry Pi 1 Model B+.

The Raspberry Pi 3, with a quad-core Cortex-A53 processor, is described as having ten times the performance of a Raspberry Pi 1.[68] Benchmarks showed the Raspberry Pi 3 to be approximately 80

The Raspberry Pi 4, with a quad-core Cortex-A72 processor, is described as having three times the performance of a Raspberry Pi 3.

2.4. OVERLOCKING. Most Raspberry Pi systems-on-chip could be overclocked to 800 MHz, and some to 1000 MHz. There are reports the Raspberry Pi 2 can be similarly overclocked, in extreme cases, even to 1500 MHz (discarding all safety features and over-voltage limitations). In Raspberry Pi OS the overclocking options on boot can be made by a software command running ”sudo raspi-config” without voiding the warranty.[70] In those cases the Pi automatically shuts the overclocking down if the chip temperature reaches 85 C (185 F), but it is possible to override automatic over-voltage and overclocking settings (voiding the warranty); an appropriately sized heat sink is needed to protect the chip from serious overheating.

Newer versions of the firmware contain the option to choose between five overclock (”turbo”) presets that, when used, attempt to maximise the performance of the SoC without impairing the lifetime of the board. This is done by monitoring the core temperature of the chip and the CPU load, and dynamically adjusting clock speeds and the core voltage. When the demand is low on the CPU or it is running too hot, the performance is throttled, but if the CPU has much to do and the chip's temperature is acceptable, performance is temporarily increased with clock speeds of up to 1 GHz, depending on the board version and on which of the turbo settings is used.

The overclocking modes are:

	..	..	..	..	..
a.	none	700MHz ARM	250MHz core	400 MHz SDRAM	0 overvolting
b.	modest	800 MHz ARM	250MHz core	400 MHz SDRAM	0 overvolting
c.	high	900 MHzARM	250MHz core	450 MHz SDRAM	2 overvolting
d.	Pi 2	1000 MHzARM	5000MHz core	600 MHz SDRAM	6 overvolting

2.5. RAM. The early designs of the Raspberry Pi Model A and B boards included only 256 MB of random access memory (RAM). Of this, the early beta Model B boards allocated 128 MB to the GPU by default, leaving only 128 MB for the CPU. On the early 256 MB releases of models A and B, three different splits were possible. The default split was 192 MB for the CPU, which should be sufficient for standalone 1080p video decoding, or for simple 3D processing. 224 MB was for Linux processing only, with only a 1080p framebuffer, and was likely to fail for any video or 3D. 128 MB was for heavy 3D processing, possibly also with video decoding. In comparison, the Nokia 701 uses 128 MB for the Broadcom VideoCore IV.

The later Model B with 512 MB RAM, was released on 15 October 2012 and was initially released with new standard memory split files with 256 MB, 384 MB, and 496 MB CPU RAM, and with 256 MB, 128 MB, and 16 MB video RAM, respectively. But about one week later, the foundation released a new version of start.elf that could read a new entry in config.txt and could dynamically assign an amount of RAM (from 16 to 256 MB in 8 MB steps) to the GPU, obsoleting the older method of splitting memory, and a single start.elf worked the same for 256 MB and 512 MB Raspberry Pis.

2.6. SOFTWARE. The Raspberry Pi Foundation provides Raspberry Pi OS (formerly called Raspbian), a Debian-based Linux distribution for download, as well as third-party Ubuntu, Windows 10 IoT Core, RISC OS, LibreELEC (specialised media centre distribution)[155] and specialised distributions for the Kodi media centre and classroom management.[156] It promotes Python and Scratch as the main programming languages, with support for many other languages.[157]

The default firmware is closed source, while unofficial open source is available.[158][159][160] Many other operating systems can also run on the Raspberry Pi. The formally verified microkernel seL4 is also supported.[161] There are several ways of installing multiple operating systems on one SD card

2.7. VULNERABILITY TO FLASHES OF LIGHT. In February 2015, a switched-mode power supply chip, designated U16, of the Raspberry Pi 2 Model B version 1.1 (the initially released version) was found to be vulnerable to flashes of light,[231] particularly the light from xenon camera flashes and green[232] and red laser pointers. The U16 chip has WL-CSP packaging, which exposes the bare silicon die. The Raspberry Pi Foundation blog recommended covering U16 with opaque material (such as Sugru or Blu-Tak) or putting the Raspberry Pi 2 in a case.[233][232] This issue was not discovered before the release of the Raspberry Pi 2 because it is not standard or common practice to test susceptibility to optical interference,[231] while commercial electronic devices are routinely subjected to tests of susceptibility to radio interference.

2.8. SPECIFICATIONS. Provided in this section is a brief specification of a Raspberry Pi 3 Model B in a tabular form to have an easy grasp on its feasibility and range of operation.

	..	..
a.	Chip	Broadcom BCM2837 SoC
b.	Core Architecture	Quad - Core ARM Cortex A53
c.	CPU	1.2 GHz (1200 MHz)
d.	GPU	Dual Core VideoCore IV. Provides OpenGL ES 2.0, 1080p 30H.264 high profile
e.		decode,OpenVGCapable of 1.5 giga pixel/s, 24 GFLOPS withtexture filtering
f.	Memory	I GB LPDDR2 (900 MHz)
g.	Networking	10/100 Ethernet, 2.4 Ghz 802.11 n wireless
h.	Bluetooth	Bluetooth 4.1 Classis, Bluetooth low energy
i.	Storage	Micro
j.	OS	Boots with microSD card, Linux operatingsystem.
k.	Power	Micro USB socket 5 V, 2.5 AEthernet: 10/100 baseT Ethernet SocketVideo
l.		Output: HDMI 3.5 mm analog audio/video jack
m.	Connectors	USB: 4 X USB 2.0GPIO: 40 Pin, +3.3 V, 5 V and GNDsupply lines.
n.		Serial camera interface(DSI)15-way flat cable connector.

3. References.

- https://www.researchgate.net/publication/330200556_Raspberry_Pi_and_its_
- https://en.wikipedia.org/wiki/Raspberry_Pi#