Comparative Study of IoT Development Boards in 2021: Choosing right Hardware for IoT Projects

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Abstract: **In today's world our lifestyle has become such, we cannot live without smart devices. These devices are essentially required in our day-to-day routine. They can communicate with themselves as well as with humans by a variety of communication means. With the use of IoT development boards, we can transform these devices into a computerized intelligent system. Various IoT development boards are available with distinct features and costs. It is very hard to find out when to use which development board. This research paper consists of definitions and comparison of various IoT development platforms to make easy for the developer to choose from.**

Keywords: Fog of Things, Cloud Computing, Internet of Things, IoT Boards

I. INTRODUCTION

The IoT i.e. Internet of Things, allows different gadgets to connect and talk to each other and also to us. Today advanced gadgets are in our pockets or our workplaces, however logically more in our homes, structures, and numerous spots and urban communities. These gadgets assume key parts in aiding, gathering, dissecting, and screen information and data about their environmental factors, and are additionally astute to speak with one other through a huge tied organization known as the Internet of Things [1].

The IoT is pacing tremendously, and affecting our lives; ensuing in a world that earlier was only possible in fantasy fiction. The Internet of Things is increasing at a quick pace because there is an outburst in the accessibility of small, inexpensive computing hardware [2]. IoT development boards connect microcontrollers and processors to a pre-built, ready-to-use package with a wireless chip and other features.

IoT hardware is the base of every linked project. Advancement in the Internet of Things leads to more control over the technical skills of these boards[2]. To find the precise IoT improvement hardware for your development, we will contrast the foremost boards/kits in this paper.

These boards have switched to nearly a thousand configurations, from non-Bluetooth-enabled battery-powered chips to Bluetooth-sized credit cards with USB power supply and high-bandwidth Wi-Fi radios. Whatever the requirements of your mission or creation, there is a guarantee that there will be a board that fits exactly your needs.

II. IOT STRUCTURE

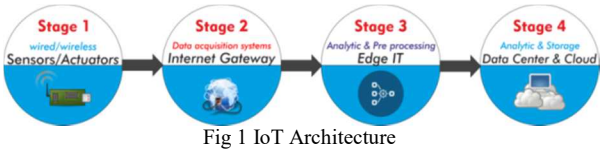

Fig 1 IoT Architecture

A. *Sensors/Actuators*

Environmental data is collected by sensors and then transformed into valuable information. An Actuator is a gadget that changes electric signs over to actual information [11]. It can also change the state of various gadgets. An actuator can, for instance, turn off a water pump after the water gets filled in the overhead tank.

B. *The Internet Gateway*

Information is gathered by the sensor in a simple structure. This information should be collected and transformed into a computerized form for proper handling. In stage 2, The Internet entrance gets the added up to and digitized data and courses it over different gateways like Wi-Fi, wired LANs, or the Internet, to Stage 3 systems for further dealing with [13].

C. *Edge IT*

Digitized and aggregated information in IoT platforms requires extra preparation before it is transferred to the

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Cloud Server platform.[13] This is the place where edge IT works. It is very close to the sensor network so that it gets information directly and efficiently.

D. Data Center and Cloud

Cloud-based database servers are used to the depth analyze, manage and securely store data to get the result. This can be done on-premises or in the cloud server. We can use a hybrid cloud structure which is a combination of public and private clouds. Processing is the same regardless of the platform chosen.

III. UNDERSTANDING THE REQUIREMENT

There are a few variables to remember to choose a development pack reasonable for your IoT project; you need to consider the equipment prerequisites of your undertaking. Complex gadgets and stages are consistently being delivered. You need to perceive the vital attributes in IoT gadgets to analyze and assess new gadgets as they become open. These attributes are for the most part regular in IoT gadgets.

IoT gadgets are outstandingly exact and are intended to work inside extremely distinct structures and conditions, so the equipment prerequisites for IoT projects vary generally with one another [14].

We can arrange the IoT gadget qualities as far as these general capacities:

- Data securing and control
- Data dealing with and putting away
- Connectivity
- Power Management
- Physical plan
- Security
- Ease of improvement
- Cost prerequisites

Working on more, the accessibility of the ideal equipment advancement boards can be of two kinds like [17]

- *Microcontrollers*

  They are planned around System-on-chip (SoC). SoCs are planned with various abilities including information preparing, stockpiling, and systems administration, inside a solitary chip. A microcontroller is an SoC that is utilized to convey information preparing and capacity abilities. It contains a processor center (or centers), memory (RAM), and erasable programmable read-just memory (EPROM) for putting away the projects that sudden spike in demand for the microcontroller.

- *Single board PCs (SBCs)*

  Single-board PCs (SBCs) are a level-up type of microcontrollers, since they permit you to connect fringe gadgets like consoles, mouse, and screens, just as putting away more memory and preparing power.

A. Choosing between microcontroller advancement boards and single-board PCs

Understanding IoT gadget's qualities and application's necessities is a must before beginning any IoT project. Following components are thought-about to get a fitting determination over microcontroller and single-board PC [18]. Make affirm the class and measure of fringe sensors and yield parts that you need, and, if important, any plan circuits for these segments.

- Select a microcontroller or single-board gadget to organize the investigation
- Select the information correspondence conventions that you need to use for intra-gadget correspondence
- To speak with cloud administrations and applications, you should choose to organize equipment and conventions
- Development Boards Comparison and accessibility

There are a ton of highlights for choosing equipment boards for prior IoT projects. Selection of guidelines based, item equipment, for example, microcontrollers or single-load up PCs can save time and cost at the beginning phase of advancement, without losing adaptability [19].

IV. COMPARISON

These boards are compared in a variety of parameters like memory, internet handling, I/O interfaces, audio/video card availability, etc.

A. Particle.io

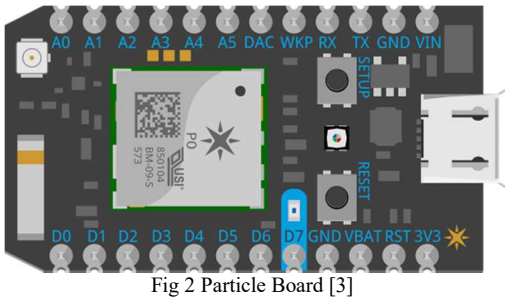

Fig 2 Particle Board [3]

Particle.io is perhaps the most far-reaching IoT board. It provides various features over its other rivals [3].

Particle consolidates an incredible ARM Cortex M3 miniature regulator with a Broad-Wi-Fi chip into a little thumbnail-sized module called Pø (P-Zero). The particle has a 3.3VDC SMPS power supply, RF, and UI parts to the Pø on a little single-sided PCB called the Photon. This is open-source, so one can easily accommodate particles in its project whenever required [3]. This microcontroller is constrained by a specific OS that empowers the programmer to effectively incorporate gadgets with Particle's environment. Particle guarantees you to get online support consistently.

B. Espressif ESP8266

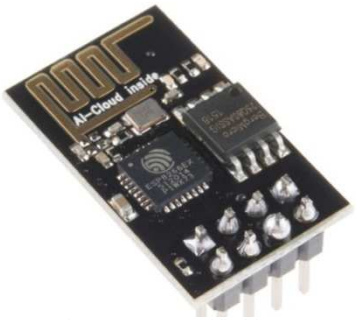

Fig 3 ESP8266 Wifi chip [4]

After particle next best IoT gadgets accessible in the market are created by Espressif Systems, China. Since the arrival of the ESP8266-01 WiFi chip a few years back, ESP8266 based chips and boards are being the most profitable chipset for WiFi-based IoT gadgets. Its modules are very simple to use.

GPIO

The ESP8266 upholds APSD for VoIP applications and Bluetooth conjunction interfaces; it has a self-adjusted RF that permits it to work beneath every working condition and any external RF.

C. Adafruit Range of Development boards

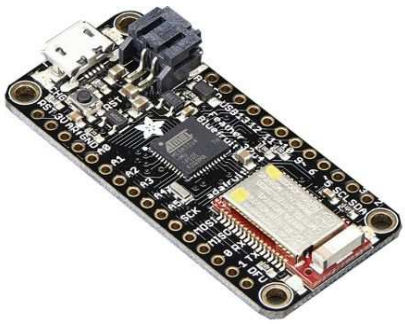

Fig 4 Adafruit Feather Board [5]

The Adafruit Feather 32u4 Bluefruit LE is a 2.4GHz remote convention upheld low-power Bluetooth Low Energy (BTLE) board. It is a mainstream convention among advanced mobile phones. The ATmega32u4 BTLE chip has 32K of FLASH memory and 2K of RAM. It additionally offers USB-to-Serial programming and troubleshooting. The Feather 32u4 Bluefruit LE additionally includes a Bluefruit BTLE module, in addition to two status pointer LEDs. The Bluefruit LE module is the nRF51822 chipset from Nordic which has been modified to give various capacities [5]. The Bluefruit can be utilized as a standard UART RX/TX association profile or it can't go about as an informal association between gadgets. The Bluefruit App for iOS or Android is intended to help you model your undertakings, constrained by your telephone or tablet.

D. Arduino IoT Product Line

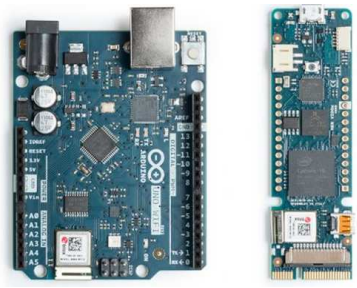

Fig 5 Arduino Board [6]

Arduino offers a range of open-source development kits, microcontrollers, and software tools for building connected products. The main advantage of Arduino over other providers is being a well-developed name in the electronic development room. They also have software tools, third-party library support, a wide array of sensors, and resources, and community support [25].

Previous boards of Arduino utilizes GSM and Wifi. The Main Arduino board dependent on an FPGA Chip are 101(developed with Intel), MKR1000, Arduino WiFi Rev 2, and the MKR Vidor 4000 [6].

Every one of these boards is suited for one or the other applications. For instance, Drone base application is well made from WiFi Rev 2 IMU [6]

E. Raspberry Pi

Fig 6 Raspberry Pi Board

Raspberry Pi is innately a universally useful device, it is unfair to disregard Raspberry's commitment to the advancement of a portion of IoT's items and undertakings in

the current design. They are for the most part excessively strong and modern to be utilized in the advancement of straightforward associated sensors or actuators, yet they discover applications filling in as information aggregators, center points, and gadget doors in IoT projects [24]. The most recent of the raspberry pi boards; the Raspberry pi 4 highlights a Broadcom BCM2711, Quad center Cortex-A72 (ARM v8) 64-bit SoC @ 1.5GHz, 1GB, 2GB or 4GB LPDDR4-3200 SDRAM (contingent upon model), 2.4 GHz and 5.0 GHz IEEE 802.11ac remote, Bluetooth 5.0, BLE, 2 USB 3.0 ports; 2 USB 2.0 ports, 2 × miniature HDMI ports (up to 4kp60 upheld). Asides from a few different highlights like Stereo Audio yield, OpenGL ES 3.0 illustrations to refer to a couple [19]. Raspberry is reasonable for use as passages and in projects high handling pace necessities.

Following is the comparison chart of various development boards discussed above-

Table 1 Comparison chart of IoT development boards

Parameters	Particle.io (ARGON)	ESP8266-01 WiFi	Adafruit Feather 32u4 Bluefruit LE	Arduino 101	Raspberry Pi 4
Processor	ARM Cortex-M4F 32-bit processor @ 64MHz	L106 32-bit RISC microprocessor core based on the Tensilica Xtensa Diamond Standard 106Micro running at 80 MHz	ATmega32u4 @ 8MHz with 3.3V logic/power	Intel Curie x86 (Quark) and a 32-bit ARC architecture core	Broadcom BCM2711, Quad core Cortex-A72 (ARM v8) 64-bit SoC @ 1.5GHz
Operating Voltage	3.6VDC to 5.5VDC	3.0 to 3.6 V	3.7V	3.3V (5V tolerant I/O)	5V
Clock Speed	120 MHz	26 MHz – 52 MHz	8MHz	32MHz	1.5 GHz
RAM	256 KB	-	2KB	24 KB	1GB, 2GB, 4GB
Flash Memory	4MB	512 KB to 128 MB	32KB	196 KB	-
EEPROM	4096 bytes	-	-	1024 bytes	4MBits/512KB
Communication	IEEE 802 11b/g/n	IEEE 802.11 b/g/n Wi-Fi	BTLE	Bluetooth LE	2.4 GHz and 5.0 GHz IEEE 802.11ac wireless, Bluetooth 5.0, BLE
Programming Language support	C/C++, ARM assembly	Micro Python, Circuit Python	Python	Python, C/C++	Python, Java, C/C++, Node.JS
I/O Connectivity	20 mixed signal GPIO (6 x Analog, 8 x PWM), UART, I2C, SPI	SDIO 2.0, (H) SPI, UART, I2C, I2S, IRDA, PWM, 16 GPIO PINS	7 x PWM pins, 10 x analog inputs 20 GPIO pins	14 (of which 4 provide PWM output)	Raspberry Pi standard 40 pin, USB – 2 USB 3.0 ports; 2 USB 2.0 ports
Price	$27	$6	$29.95	$39.95	$35 - $55

V. CONCLUSION

We have given a far-reaching audit of the 5 diverse IoT improvement boards in this paper. The various highlights that accompany each IoT gadget stage make it ideal for specific applications, however not for all. In this manner, for choosing a specific gadget one needs to remember the above gadget highlights with their task need.

The Raspberry Pi is ideal for a worker-based IoT application since it has high extra room and RAM and an amazing processor. Besides, it upholds many programming dialects that can make worker-side applications, like Node.js. The Raspberry Pi can connect to both LAN and Wi-Fi organizations. Then again, Arduino comes in supportive as a customer. It can record and recover information on and from an online worker. It is ideal for logging sensor information

and controlling actuators through orders posted on the worker by another customer. The ESP8266 has exceptionally basic equipment foundational layout and is most superb utilized in customer applications, for example, information logging and control of actuators from online worker applications. The Particle Argon is a valuable IoT prototyping stage considering removed programming, simple code relocation, and quick advancement of ventures. It has Low Power Consumption, Low-Cost Hardware, High Network Reliability, and Local Communications to guarantee brisk and solid conveyance of messages. One can pick Adafruit Feather 32u4 Bluefruit LE when attempting to make a gadget associate with a cell phone. The 32u4 has different benefits, in that it can appear on your framework as a USB chronic connector yet besides numerous other USB gadgets like HID or MIDI.

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