Preeminent Development Boards to Design Sustainable Integrated Model of a Smart Healthcare System under IoT

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Abstract— Conventional healthcare systems were just passive with the approach of smart healthcare services. Smart healthcare has been tended to consequently decrease the death and casualty rates the world over. The gratefulness lies in the court of the Internet and ICTs. IoT (Internet of Things) helps healthcare administrations by providing dynamic, inescapable, and intellectual services. Due to deal with medical issues and various unexpected diseases, a suitable, incorporated, smart, well-groomed, modern, and sustainable healthcare monitoring with wellness service deliverance arrangement is required under the IoT platform. A variety of development-boards have been created and are currently being utilized in the field of healthcare. These IoT based development boards reduce endeavors, cost, and time in a feasible way. Patients care better in IoT based integrated healthcare services system. Several companies have made-up these development-boards and these are being used by several organizations to fulfill the requirement of healthcare services for many purposes. This review paper provides an insight on aspects, dimensions, a prototype of sustainable integrated smart healthcare architecture with explicit clarification of significant development boards to design and implement a sustainable smart healthcare system that empowers strong connectivity among numerous devices and human beings in the recent digital era.

Keywords—Healthcare, ICT, IoT, Development Board, integrated smart healthcare architecture

1. Introduction

With the advancement of innovation in data, the idea of smart healthcare services has continuously gone to the front. With the progress of Information Technology (IT) and logical assumptions, regular medication with biotechnology as its center and has step by step get going to digitize and to information. Apparatuses of Information and correspondence innovation (ICT) have become an indispensable infrastructural resource for use in the maintenance of social healthcare administrations. The possible impact of ICT in-use view of healthcare laborer on ICT in medicinal services conveyance and commitment of ICT to healthcare services and maintenance in an urban, rural, and remote area in strife circumstances. Savvy healthcare services utilize another age of data advances, for example, the IoT, large information, cloud-computing, and man-made consciousness, to transform the customary healthcare system in inside and out manner, building healthcare services increasingly productive, progressively helpful, and more personalized[1][2]. As of now, the total populace is developing quickly and the craving for remote and persistent healthcare services checking is likewise expanding quickly. If we think about India, the main ten explanations behind transience here as cited are heart illnesses, looseness of the bowels, lower respiratory contaminations, neonatal preterm birth, stroke, interminable obstructive pneumonic sicknesses, self-destruction, street mishaps, neonatal diseases, and tuberculosis (TB) [3][4]. Death because of a portion of these reasons can be removed or decreased like illnesses of heart, pre-birth death, stroke, and poor respiratory contaminations [5]. This is conceivable with the rise of IoT, for example, many diseases are unusual and impudent for example, coronary
failure, stroke, and so on. Assume an individual out of nowhere gets a respiratory failure or a stroke, at that point a prompt activity should be clasped to spare the individual's life. With the idea of IoT getting survive, it is conceivable to screen different key boundaries Electrocardiogram (ECG) of a person. At that point gained ECG report can be forward to specialists in remote areas with reasonable use and continuously. At that point as input, the specialists, experts can propose an appropriate life sparing determine. The correspondence among the patients and the doctors should be possible using different IoT based development boards, for example, Intel Galileo, Arduino, Raspberry, and so on. Hence, the sole idea of IoT [6] can associate the clinics, patients, specialists, ambulances, crisis clinical administrations, clinical staff, and so forth together, making the medicinal services stages everywhere throughout the world open and advantageous. The following segment illuminates the few parts of IoT.

2. Perception and Dimension of IoT
The Internet has got in touch with every sector in the recent digital world. It affects everybody’s life in staggering manners. Nonetheless, this is a long way from being done. Presently, we have entered a huge sizzling time of much increasingly necessary network where a wide assortment of machines and instruments can be associated with the web. The name of this time is "Internet of Things" (abbreviated as IoT). IoT has been defined by various authors in many ways such as Vermesan et al. [7] defined the IoT as basically an association among the physical and advanced digital world. The computerized world interfaces utilizing plenty of sensors and actuators. Pena-Lopez et al. [8] defined, IoT as a worldview that registering and organizing abilities are installed in any sort of potential item and this competence utilizes for questioning to adjustment its state if conceivable. It is an idea [9] that mirrors a connected set of anybody, whenever, wherever any assistance and at any system. IoT gives a reconciliation way to deal with all these that enclose inserted innovations to be intelligently associated and empowers them to impart and detect with the real-world[10-12]. It is fundamentally a foundation of different comparable or divergent items with particular identifiers, being utilized alongside sensors, hardware, arrange network, that guides these things/articles to amass and process information and further exchange this information, and so on; making the situation of gadget to-gadget or individuals to machine correspondence, wake up. It empowers the gadgets and individuals to be associated with one another whenever anyplace and everywhere[13][14]. According to the above-portrayed clarification, a suitable IoT-based structure encompassing around three measurements appeared in figure 1.

![Figure 1. Dimensions of IoT](image)

3. Sustainable Integrated Smart Healthcare Architecture
Numerous individuals are losing their carries on with these days because of different sicknesses such as cardiovascular infections, diabetes, circulatory strain, and so on. Likewise, many individuals need
long haul and constant checking of different physiological parameters and afterward, the data concerning imperative boundaries are sent to the specialist/s for sure-fire help. In any case, without a supportable and appropriate incorporated savvy human services system, it is horrendously hard to keep up all these sorts of observing and trading of data. Although numerous patients losing their carries on with due absence of a proper human services system, not because of treatment. The Healthcare system incorporates issues of access, consumption, and assets. The essential reason for medicinal services is to upgrade personal satisfaction by improving wellbeing. Business organizations center on making money-related benefits to help their valuation and stay reasonable. Human services must concentrate on making social benefits to satisfy their guarantee to society[15][16]. IoT devices are tracked with labeled by sensors to locate medical equipment like wheelchairs, defibrillators, nebulizers, oxygen siphons, and other checking hardware. Arrangement of clinical staff in various areas can likewise be investigated on-going. To consistently make our social healthcare administrations powerful massive and secure, the IoT depends on a few empowering advances. The capability of IoT for wellbeing and clinical administrations is handled by brilliant sensors that precisely measure, screens, and dissect an assortment of wellbeing status designators. These incorporate fundamental vital wellbeing signs, for example, beat rate and circulatory strain. With the assistance of IoTs potential, specialists are presently ready to gather continuous crude information from various patients for a consistent timeframe through brilliant gadgets associated with an interconnected system, which guarantee them trustable and dependable outcomes as well as timesaving which will be of most extreme advantages IoT will upset human services by fundamentally bringing down expenses and improving quality[17][18].

This section of the paper is presenting sustainable and easily maintainable integrated smart healthcare services deliverance and monitoring. As appeared in figure 2, it underpins the plan auxiliary pictorially. At first, the parameters of physiological data are gathered by different sensors put on the body of a person. Sensors can be EMG, EOG, ECB, BP, etc. Information gathered by the individual is sent to the development boards (Arduino/Raspberry Pi/IBM Watson/Intel Galileo, etc.)These development boards can build healthcare applications progressively open as intelligent articles. Preparing the information is finished with these boards then the collected data is sent to the doctor, in the case of person is in an emergency and can get the advice from the doctor so in this way person’s life can be saved[19][20].

![Figure 2. Sustainable Integrated Smart Healthcare Design](image)

In this way, this procedure requires IoT arrangements at the healthcare services space, to diminish the death-rates. The remote observing system is like decreases visits of patients as they don't need to visit
the specialist once in a while. Furthermore, a great deal of time is additionally spared as the patient doesn't need to visit the specialist or the emergency clinic to complete the normal tests. What's more, a great deal of patient's and specialist's vitality is recovered also, on the off chance that an individual is in a crisis, at that point some clever choices can be made, and moment help can be given to the individual and thus the individual's life can be spared[21][22]. There are different preferences that a healthcare system integrates with IoT views, as appeared in figure 3. The following stage illuminates the compositional structure of a healthcare system incorporated to IoT with different physiological parameters are detected and then with the assistance of different sorts of development boards data can be sent to any remote area to a specialist/medical clinic or any patient’s relative.

![Figure 3. Key Gains by IoT Based Integrated Smart Healthcare](image)

4. Major IoT based boards for smart healthcare

Today, different kinds of improvement development boards are accessible on board to structure IoT based models and applications. A portion of these development boards is talked about in this piece of the paper. This segment of this paper gives a brief look at two generally useable and productive IoT based advancement development boards. Another chance is that the information can be matches put away on a cloud-based stage so information of the patient can be gotten to whenever and anyplace, for additional investigation.

4.1 Arduino Uno

"Uno"("Italian term") means "one", was pulled out to stamp the original advent of Arduino Software. Uno board is the foremost USB supported Arduino development board. Arduino integrates the development environment (IDE) was indication variants of Arduino that has now superior to the current release[23][24]. Arduino is a gadgets prototyping stage that is utilized, by many, as an approach to find out about computerized hardware. It offers simple access to an entire assortment of information. It is the vast utilized microcontroller-based board with a size of 2.7 inches long and 2.1 inches-widen depends on ATmega328P. Moreover, it has a force of USB Jack and connector. It has four screw-based openings that permit the board to join to the surface. Python language is used for the Arduino Uno board for functioning. It specifies 14 incorporate complexes I/O pins, out of which 6 pins can be used for PWM yields, 16 MHz quartz gem, 6 pins for-simple sources of info, header-ICSP in addition to reset button. It likewise has its processor and storage module a memory [25][26]. Following figure 4 and Table 1 gives the itemized useful depiction of Arduino parts.
Figure 4. Arduino Uno Development Board

Table 1. Functional Component Description of Arduino

| S.No. | Components        | Functions                                                                 |
|-------|-------------------|---------------------------------------------------------------------------|
| 1.    | Reset Button      | This will restart any code that is loaded to the Arduino Board           |
| 2.    | AREF              | Stands for Analog Reference and it used to set an external reference voltage |
| 3.    | Ground Pin        | There are a few ground pins on the Arduino and they all work the same     |
| 4.    | Digital Input/Output | Pins 0-13 can be used for digital input or output                   |
| 5.    | PWM               | The Pins marked with (~) symbol can simulate analog output              |
| 6.    | USB Connection    | Used for Powering up your Arduino and uploading sketch                   |
| 7.    | TX/RX             | Transmit and receive data indication LEDs                                |
| 8.    | Atmega Microcontroller | This is the brain where the program is stored                        |
| 9.    | Power LED indicator | The LED lights up any time of voltage going into the Arduino used.        |
| 10.   | Voltage Regulator | The Control the amount of voltage going into the Arduino Board           |
| 11.   | DC Power Barrel Jack | This is used for powering your Arduino with a power supply            |
| 12.   | 3.3 Pin           | This pin supplies 3.3 volts of power to the projects.                    |
| 13.   | 5V pin            | This pin supplies 5 volts of power to projects.                         |
| 14.   | Ground Pins       | There are a few ground pins on the Arduino and they all work the same   |
| 15.   | Analog Pins       | These pins can read the sign from an analog sensor and convert it to digital |

4.2 Raspberry Pi

Raspberry is a reference to a natural product naming custom in the past times of microcomputers. A ton of PC organizations was named after fruit [27] and was created in the UK by the Raspberry Pi establishment [28]. Raspberry Pi is an undeniable PC. It is fundamentally a Visa measured smaller than usual PC. It executes on its working method that is Raspbian. Likewise, it’s a minimal effort IoT board [29] and a little measured PC utilized Linux working system. It is a smaller than usual size PC utilized for the most part to run bigger and keen projects to accomplish yield rapidly. It is supplied with many info and yield pins in addition to a system correspondence interface. It can interface with various devices and gadgets which interoperable with each other. Raspberry Pi makes them a weakness that is it can't peruse and process simple signs. It doesn't work in Analog To Digital Converter (ADC). At the point when web association is dynamic tools devices, this can go about as a server too. Thus, the server transmits the data to e necessary goals, for example, telephone, tablet, PC, PC, and so on. This minicomputer can achieve a few obligations, for example, doing word preparation, spread development boards, giving remote correspondence, observing the top quality video, and messing around also [30][31]. Raspberry Pi 4B+ (RP4) is the kept going model created by the organization, which has all the necessary most recent wired and remote correspondence systems
utilized in the vast majority of the savvy ventures. A solitary Raspberry Pi 4 goes to a Quad-center Processor yet it has three distinct adaptations that give three unique sizes of RAM. Pi 4 uses a small HDMI and it likewise has two ports for two 4K displays[32].

![Figure 5: Raspberry Pi 4B+ (RP4)](image)

**Table 2. Pi Pin Configuration of Raspberry**

| Function | Pin | Pin |
|----------|-----|-----|
| 3V3      | 1   | 2   |
| GND      | 9   | 10  |
| GPIO7    | 11  | 12  |
| GPIO8    | 13  | 14  |
| GPIO9    | 15  | 16  |
| GPIO10   | 17  | 18  |
| GPIO11   | 19  | 20  |
| GPIO12   | 21  | 22  |
| GPIO13   | 23  | 24  |
| GPIO14   | 25  | 26  |
| GPIO15   | 27  | 28  |
| GPIO16   | 29  | 30  |
| GPIO17   | 31  | 32  |
| GPIO18   | 33  | 34  |
| GPIO19   | 35  | 36  |
| GPIO20   | 37  | 38  |
| GPIO21   | 39  | 40  |

**4.3 Intel Galileo**

It is the foremost line of Arduino-affirmed development boards dependent on Intel x86 engineering and is intended for the creator and training networks. Intel discharged two forms of Galileo, alluded to as Gen 1 and Gen 2. The board was stopped on June 19, 2017. It utilizes 32-piece item collections Intel Premium arrangement of processors. IntelGalileo depends on Chip (Intel Quark)which is a chip away at x86 engineering comprising low down the voltage in addition to it spends force. Pushing ahead to this, the second Generation of Intel-Galileo Gen2 was good with 5V and 3.3V Arduino-Unos. Additionally, it has 20 advanced Input /Output sticks alongside 6-simple data sources, 6-PWMs with 12-piece goals, two UART(Universal Synchronous Asynchronous Receivers Transmitter) out of them one imparted to reassure [33-35]. It takes a shot at a four hundred MHz collect as acquired from the IntelPentium arrangement. Particular of this board incorporates SRAM, 8MB NOR DRAM, L1-512.
KB, CACHE Flash, SD card space to around 32GB in addition to USB.[36][37]. The following figure 6 and Table 3 gives the key subtleties of Intel Galileo components [38].

![Figure 6. Intel Galileo Development Board](image)

**Table 3. Major Component configuration of Intel Galileo**

| Components        | Functions                                                                 |
|-------------------|---------------------------------------------------------------------------|
| Ethernet          | Connects the Galileo up to any 10/100 Mbps LAN.                           |
| RS-232 Port       | In a weird, 3.5 mm ‘stereo’ jack form factor. The sleeve is ground, the tip is TX, and the ring is RX with the proper cable, this can be used to access the Linux terminal. |
| USB Client        | To connect this to the computer to program the Galileo with Arduino.     |
| USB 2.0 Host      | This supports an interface with USB devices like keyboards, mass storage, etc. with a USB hub, up to 128 devices can be connected to this port. |
| Standard Arduino Connector | • 8-Pin Power Header (3.3V, 5V, GND, Reset, etc.)  
  • 6-Pin Analog Unit Header (A0-A6)  
  • 8-Pin Digital I/O Header (D0-D7), which includes UART on pins 01, PWM on pins 3,5 and 6  
  • 10-Pin Digital I/O Header (D8-SCL), Which includes I²C Pins and PWM on Pins 9,10 and 11  
  • 2x3-Pin ICSP Header breaks out SPI pins. |
| Reboot Button     | Pressing this button will reboot the entire Galileo-Linux included, Boot time is about 30 seconds, so don’t press this accidentally. |
| Pin 13 LED        | As with most Arduinos, the Galileo ties a small, on-board LED to Pin 13. Great for the Blink Sketch |
| Arduino Reset Button | This will restart solely the Arduino Sketch running on the Galileo. This Button acts much more like the reset button. |
| SD Card           | The Galileo Supports up to 32 GB SD cards. We will have to use this socket if we hope to boot the Galileo of the biggest Linux image. |
| 5V Power In       | This is a center-positive, 2.1mm barrel jack for a clean, regulated 5V supply. The power supply should be included with Galileo. |
4.4 IBM Watson

IBM Watson is an AI-based model that responds as per queries and questions. IBM Watson model was built by the IBM-DEEPQA venture but was discharged in the year 2011 as the "world's most developed inquiry replying mail"[43][44]. It is a domain that improves the capability of the system so it can offer relevant responses to inquiries ask over in distinctive languages. Essential point was to help medical specialists to take care of patient’s side effects, chance elements, and consequently obtain medical advice. Investigations were made and outcomes indicated an ideal opportunity for analysis diminished. It had the option of furnishing with proper suggestions[45]. It could be evaluated with great information every day. What's more, General-Motor is intending for utilizing IBM-Watson with vehicles in-order to recover area administrations [46][47].

![Figure 7. Original IBM Watson Question-Answer architecture](image)

5. Conclusion

Healthcare monitoring and medical service delivery system has become essential for everyone. Automation and digital transformation of the healthcare system can provide more benefits with sustainable integration of consolidates IoT based development boards to design and implement a healthcare model towards individuals and the medical fraternity. IoT based development board in the healthcare system reduced the expenditure and diminished the time and effort, patient’s monitoring form remote with feasibility. IoT based integrated smart healthcare system systems can convey ideal quality healthcare services offices to the individuals with the goal that different illnesses can be distinguished on schedule and henceforth the death-rate can be diminished. As of now referenced, there are different focal points of IoT based human services systems. Build up a sustainable, cost-effective, less time and strong connectivity between the millions of people and technological devices is the main motto of all these IoT based development boards and their applications for enhancing the healthcare and wellness system. These IoT based development boards are efficient, reasonable and now these smartboards start to integrate with AI which will provide a most high level diagnostic and monitoring system to the patients at anything and everywhere even remote location. Therefore, it will certainly boost the excellence of healthcare services as a smart way towards the entire modern society at a reduced cost.
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