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Beagle Bone Black (BBB) Powered Data Concentrator for Smart Health Monitoring System

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Abstract: Healthcare is the maintenance or improvement of health via the diagnosis, treatment, and prevention of disease, illness, injury, and other physical and mental impairments in human. It is one of the most promising applications of information technology. The Telemedical systems focus on the measurement and evaluation of vital parameters, e.g. ECG, heart rate, heart rate variability, EEG, pulse oximetry, plethysmography and fall detection. The system described in this paper presents a personal healthcare system that is both flexible and scalable. Employing embedded wearable low-power sensors, the system measures health parameters dynamically. For wireless transmission, these sensors are connected to the data concentrator through ESP8266 Wi-Fi module .Beagle bone black (BBB) is used as a data concentrator or sensor node. The main task of Data Concentrators is to collect data which is originated from any devices in the network that is connected via wired or wireless interfaces and protocols. In this work, a system is designed to continuously monitor the physical health of an individual, the Electrocardiogram (EEG) and other vital parameters. This data is stored in a database and can be displayed in a website that can be accessed only by authorized personnel. This idea is familiar however; this paper presents a substantive and inexpensive method using BBB. The primary task of this system is to update the data to the database and alert the doctors for any aberrancy.
Keywords: Data Concentrators, Beaglebone Black (BBB) board, Internet of Things, ESP8266 Wi-Fi module, Healthcare, ECG, Health monitoring, Sensors system, ThingSpeak webserver

I. INTRODUCTION

The advancement in the new innovative technology and Internet of Things (loT) has had it substantial influence in the healthcare system. Moreover, the fusion of novel advances in technology with the healthcare systems provide us with a wide window for improvements in the areas of patient care and communications, support for decision making and reducing the inaccuracies [2]. But the fragmented nature of the healthcare system, which is further worsened by the lack of tools for communication between the specialists, stimulates the need of functional interoperability to ameliorate this coordination. Currently, information technology is considered a necessity rather than a supporting tool.

Information and communications technologies are transforming our social interactions, our lifestyle and our workplaces [5]. One of the most promising applications of information technology is healthcare monitoring and wellness management. In the last one decade the healthcare has drawn considerable amount of attention. Healthcare is moving from reactive responses to acute conditions to a proactive approach characterized by early detection, prevention and long-term healthcare management. In this framework, health condition monitoring and wellness management are seen as significant contributors to individual healthcare and wellbeing. This is particularly important in developed countries with a significant aging population, where information technology can be employed to significantly improve the management of chronic conditions and, thereby, overall quality of life.

The prime goal was to develop a reliable patient health monitoring system so that the healthcare professionals can monitor the patients, who are either hospitalized or executing their normal daily life activities. A major aspect in the healthcare system is the monitoring of the patient's vital signs such as temperature, blood pressure and heart rate. Many monitoring devices that display the patient's vital signs are commonly present in the critical care units in operating rooms. But there could be instances where the doctor couldn't be alerted in time when there is an emergency, despite of 24 hours of monitoring. Also the data couldn't be shared remotely with the other doctors who are specialists in that field and the family members. Technology that enables all these

activities are available but aren't accessible and affordable by many people in developing nations. Hence the problem can be overcome by just a simple add-on to the current devices lacking these capabilities. A simple pragmatic solution to this problem can be made using Beagle bone board. In our system we are measuring patient's health parameters (ECG, temperature, heart rate, pulse, etc) different available sensors. This sensor collected data i.e. biometric information is given to Beagle bone board and then it is transferred to server. Biometric information gathered can be wirelessly sent using ESP8266 Wi-Fi module. The data stored in a database and can be displayed in a website that can be accessed only by authorized personnel. The doctors, RMOs, patient or his family members can be given authorization. The system even facilitates the doctor to view the patient's previous history from the data in memory.

II. LITERATURE SURVEY

Continuous or even occasional recording of biomedical signals is particularly critical for the diagnosis and treatment of cardiovascular diseases. For example, continuous recording of an electrocardiogram (ECG) or photoplethysmogram (PPG) by a wearable sensor provides a realistic view of a patient's heart condition by tracking such factors as high blood pressure, stress, anxiety, diabetes and depression, during normal daily routines. Further, automated analysis of such recorded biomedical signals supports doctors in their daily work and allows the development of warning systems. This brings several benefits, such as decreased healthcare costs, by increasing health observability, collaboration among doctors and doctor-to-patient efficiency. Moreover, continuous monitoring serves to increase early detection of abnormal health conditions and diseases, offering a way of improving patient's quality of life.

Such integration enables resource sharing within networks, maximizing the utilization of available resources. In addition, communication with the individual nodes in a network requires an efficient addressing mechanism. In addition, new generation mobile phones have an important impact on the development of such healthcare systems, as they seamlessly integrate a wide variety of networks (3G, Bluetooth, wireless LAN and GSM) through access points (APs), thereby providing an opportunity to transmit recorded biomedical signals to a central server in a hospital. As a result, continuous monitoring of biomedical signals will no longer be restricted to the home environment.

Recently, the patient health monitoring systems is one of the major advancements because of its improved technology. Currently, there is need for a modernized approach. In the traditional approach the healthcare professionals play the major role. They need to visit the patient's ward for necessary diagnosis and advising. There are two basic problems associated with this approach. Firstly, the healthcare professionals must be present on site of the patient all the time and secondly, the patient remains admitted in a hospital, bedside biomedical instruments, for a period of time. In order to solve these two problems, the patients are given knowledge and information about disease diagnosis and prevention. Secondly, a reliable and readily available patient health monitoring system is required.

In order to improve the healthcare of patient, we can make use of technology in a smarter way. Nowadays, more attention is focused on the prevention and early detection of diseases as well as on optimal management of chronic conditions. These functions are often augmented by new location-independent technologies. In order to fully realize a pervasive or ubiquitous environment, personal area networks (PAN) must be connected to internet protocol (IP)-based networks. In recent years, health care sensors along with Beagle bone board play a vital role. Wearable sensors are in contact with the human body and monitor his or her physiological parameters. We can buy variety of sensors in the market today such as ECG sensors, temperature sensors, pulse monitors etc. The cost of the sensors varies according to their size, flexibility and accuracy. The Beagle bone board which is a cheap, flexible, fully customizable and programmable small computer board brings the advantages of a PC to the domain of sensor network.

III. DATA CONCENTRATOR

Data concentrators in substations provide a vital interface with intelligent electronic devices (IEDs). Retrieving operational and non-operational IED data and communicating it to the corporate network, they provide users with the data required for faster, more informed business decisions. A data concentrator is the core of data and energy management in an advanced metering infrastructure (AMI). It provides the technology to measure and collect energy usage data. The concentrator can also be programmed to analyze and communicate this information to the central utility database. Not only can the utility providers could use this information for

billing services, but can improve customer relationships through enhanced consumer services such as real-time energy analysis and communication of usage information [11]. Additional benefits of fault detection and initial diagnosis can also be achieved, further optimizing the operational cost. Data concentrators also called data aggregators provide the core functionality required to measure analyze and collect the data. They then communicate that data to a central database for troubleshooting and analyzing. Figure 1 is showing the typical data concentrator network.

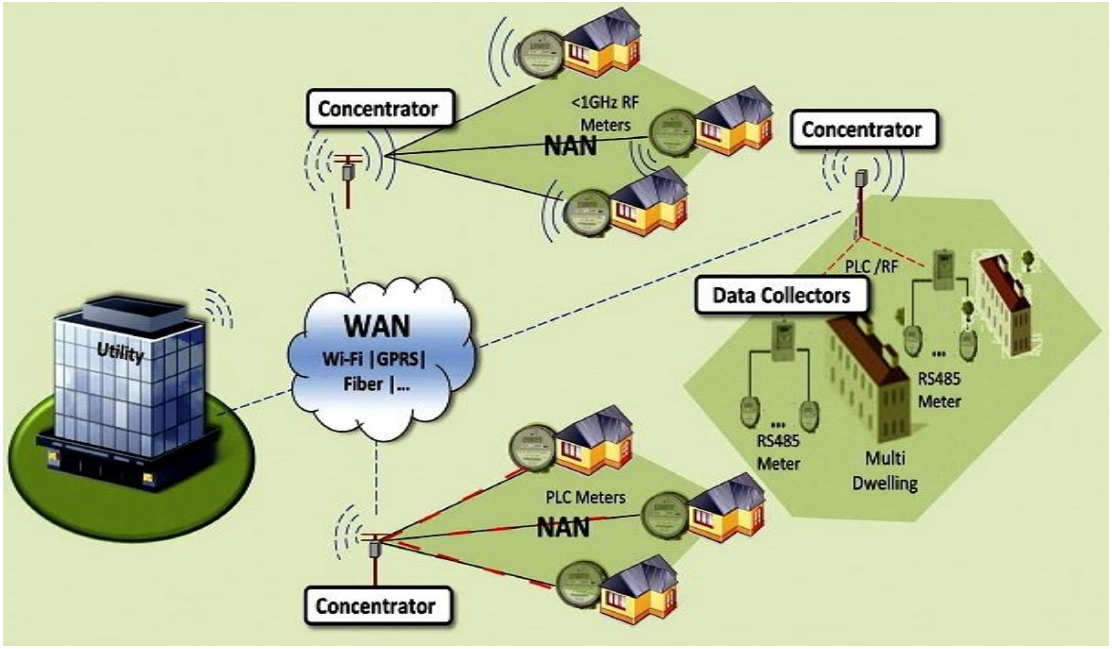

Figure 1: Typical Data Concentrator Network

A. Main Functions of a Data Concentrator

Data concentrators push intelligence to the edge of the grid by integrating, organizing and aggregating information from e-meters or other end equipment on the grid. Typically located at the transformer or a secondary substation level, data concentrators need to have the following basic functionS:

- Provide reliable communication with meters and head ends
- Secure consumers' data and information
- Monitor regional grid status
- Support various data management applications.

IV. METHODOLOGY

In our system we are measuring patient's health parameters (ECG, temperature, heart rate etc) by using different available sensors. This sensor collected data i.e. biometric information is given to the ESP8266 Wi-Fi module through Arduino board. The Arduino processed the data and sent the data to Beagle bone board by wireless medium (Wi-Fi) and then it is transferred to server. The Beagle bone board which is a cheap, flexible, fully customizable and programmable small computer board brings the advantages of a PC to the domain of sensor network. Biometric information gathered can be wired or wirelessly sent using ESP8266 Wi-Fi module. The data stored in a database and can be displayed in a website that can be accessed only by authorized personnel. The doctors, RMOs, patient or his family members can be given authorization. All the values are stored on the server are the most recent value is displayed on webpage. The doctor along with their login credentials can login and see the patient data. Doctors can see all previous records of a patient and suggest medicines and changes in prescription. Also patients are given unique user id and password to view their records. The system even facilitates the doctor to view the patient's previous history from the data in memory.

V. BLOCK DIAGRAM OF THE SYSTEM

In our system Beaglebone black Board is used as data concentrator for smart health monitoring system. The block diagram of the system is depicted in fig2.

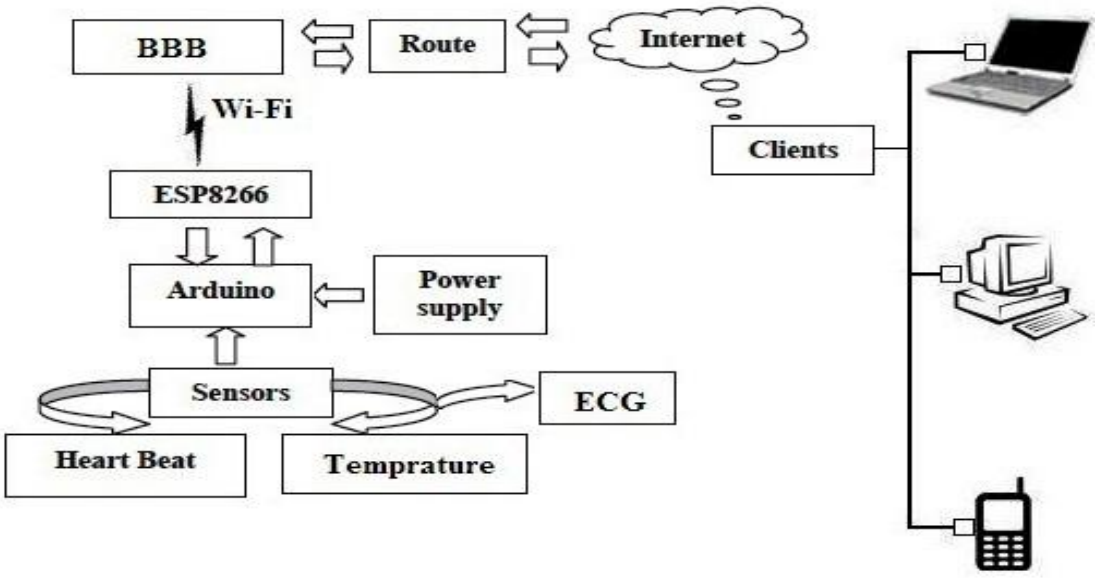

Figure 2: Block diagram of Beaglebone board based smart healthcare system

A. Block Diagram Description

1. Beaglebone Black Board

BBB is the main block of the system. It is used as a data concentrator. BBB is the newest product in the Beagle family. This board features a powerful TI Sitara™ ARM Cortex™-A8 processor which runs at 1 GHz. And a 2 GB on-board flash memory acts as the "hard drive" for the board to host a Linux operating system and other software development tools. With a user-friendly, browser-based Bone script programming environment called Cloud9, a learner can easily program the BBB board to rapidly prototype electronic systems that interface with real-world applications. As the knowledge of users develops, the board provides more complicated interfaces including C/C++ functions to access digital and analog pins aboard the ARM Cortex A8 microprocessor. The full power and capability of the BBB board can be programmed in the underlying onboard Linux operating system, such as Angstrom or Ubuntu. Beaglebone Black is currently most widely sold board worldwide because of its low-cost. Beaglebone black is regarded as most utilized Beaglebone board amongst all boards available till date for various applications and hardware based projects and has support of developers and hobbyists communities worldwide. It is powered by AM335x 1GHz ARM Cortex A8 processor and supports 3D graphics acceleration. Because of its configuration this board can boot Linux in less than 10 seconds.
Applications: Robotics, Solar Technology, Full-Fledged Portable PC, Spider Bot, Camera Drones.
Table 1 is showing the technical specification s of BBB.

Table -1Technical Specification of Beaglebone Black

SoC	CPU	GPU	DSP	RAM	Connectivity Options(Audio/ Video)	Storage/Network Option	Internal Modules	Software	Price
AM3358/9	ARM-Cortex A8	Power VRSGX 530	N/A	512	1 USB, Micro-HDMI, cape add-ons	Ethernet	UART,PWM, GPMC,MMC,SPI, I2C,ADC, CAN bus, Timers, JTAG	Ubuntu, Android, Debian, Cloud 9, IDE onNode.js w/Bone script Library	$55

a. Beaglebone Black Board-Components

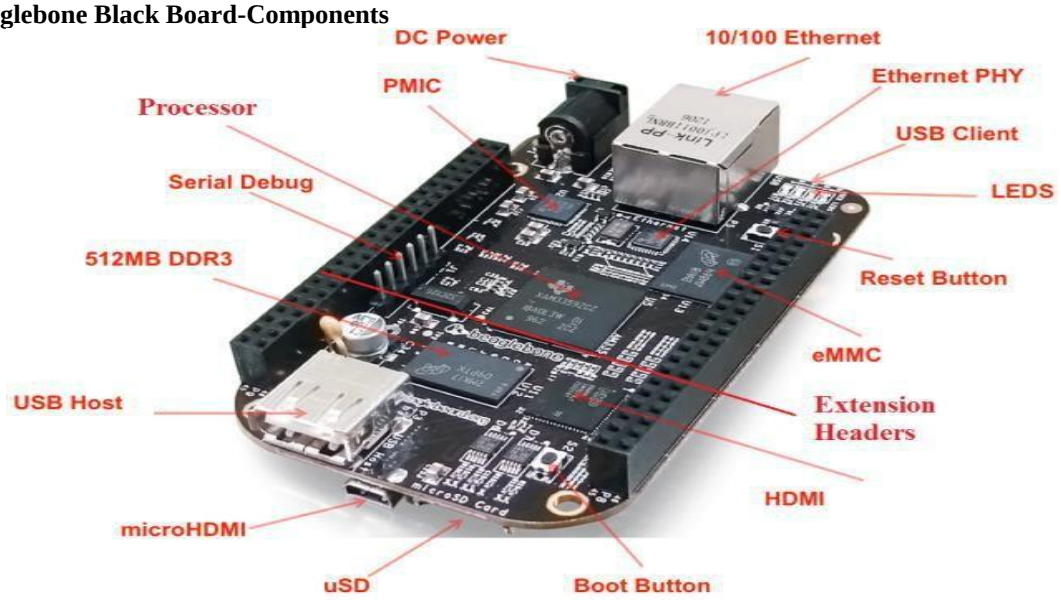

Figure 3: Beaglebone Black Board-Components [Image Source: www.beagleboard.org]

The following are the components of Beaglebone Board:

- **Processor:** Processor being the heart of Beaglebone board manages all sorts of controls and operations. Beaglebone processor is based on ARM Cortex A8/A15 Processor technology running at various clock speeds like 720 MHz, 1GHz, and 1.5GHz.

- **RAM:** Depending on various generation models, Beaglebone boards are equipped with 128/256/512/2048 MB RAM.

- **DC Power Jack**: Beaglebone requires 5V and 500 mA of DC power to operate. Along with DC power jack, 2.1 mm barrel jack connector will be required to power the board. Beaglebone facilitates over voltage protection chip upto 12V.

- **Ethernet Port:** Beaglebone has on-board 10/100 standard RJ45 Ethernet Port supporting all sorts of networking protocols along with Wi-Fi connection sharing.

- **Reset Button**: Reset Button reboots the board. It provides logic 1 or 0 to trigger the processor. Functioning similarly like Reset Button on computer/smart phones, it reboots the entire operating system and also provides backup from failure if lock up situation occurs.

- **USB Host:** USB Host provides same features like USB port on normal computers/laptops. Beaglebone USB host ports enables users to connect various 3rd party peripherals like Keyboard, Mouse, Web Camera, Wi-Fi adopters and external storage devices like pen drives, USB card readers and hard disk drives.

- **LEDs:** Beaglebone board has LED located aside power connector to indicate power ON signal when power applied to board. Most of the boards are equipped with 4 LED's with following functionalities: LED0 will be ON when Board is up and running. LED 1 will indicate microSD card operations. LED 2 indicates Active CPU active situation. LED 3 indicates flash memory access.

- **Extension Headers:** Beaglebone has 2 extension headers on left and right side which facilitates integration of various electronic components like LED's, Switch's, Sensors, and Modules *etc*. for developing various projects.

- **USB Client:** USB Client port is basically used for connecting Beaglebone to computer and power would be provided via USB. When connected to computer, it appears like storage device.

- **MicroSD Card Slot/uSD:** MicroSD card slot facilitates integration of microSD cards to store operating systems, applications and data. Taking Beaglebone black into consideration, where operating system is stored on onboard flash memory by default, any updates can be done via sd card slot only. Operating systems can be downloaded on Beaglebone website which can be written on SD card via Win32Disk Imager software.

- **HDMI:** HDMI port does the work of connecting Beaglebone board to HDMI enabled Monitor/TV. It supports maximum resolution of 1280x1024 pixels.

- **Serial Debug:** Serial Debug is used for serial communications to connect an FTDI TTL-232 cable or breakout board and enable text based terminal via USB.

- **eMMC/Onboard Flash Memory**: Beaglebone (Black version) has operating system stored on eMMC/onboard flash memory to boot up the board without any SD card requirement.

- **Boot Button:** Available only in Beaglebone black. Continuous hold of Boot Button instructs Beaglebone to boot from SD card attached on SD card slot rather than onboard flash memory.

- **PMIC (Power Management Integrated Circuit):** PMIC module provides power backup solution to Beaglebone via connecting li-po batteries. These batteries will act as UPS for Beagle bone for providing backup to users over electricity failure to shut down the board or does necessary important work till batteries last long.

2. ESP8266 Wi-Fi Module

ESP8266 offers a complete and self-contained Wi-Fi networking solution, allowing it to either host the application or to offload all Wi-Fi networking functions from another application processor. ESP8266 on-board processing and storage capabilities allow it to be integrated with the sensors and other application specific devices through its GPIOs with minimal development up-front and minimal loading during runtime. With its high degree of on-chip integration, which includes the antenna switch balun, power management converters, it requires minimal external circuitry, and the entire solution, including front-end module, is designed to occupy minimal PCB area. Figure 4 is showing the ESP8266 module.

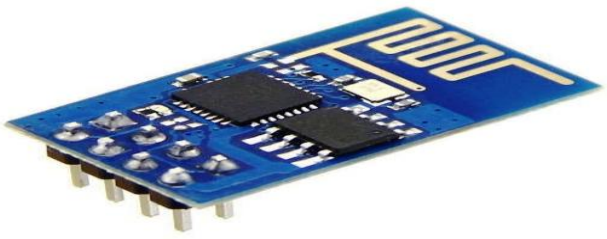

Figure 4: ESP8266 Module

Comparison on the three comprehensive sensor temperature systems has been done and benefits and similarities have been taken as guideline to model the web based architecture system implementations. Therefore these systems benefits the future development and designing of the web based temperature monitoring system either in contributing on the hardware, software or the systems itself.

This chip embeds an ultra low power Micro 32-bit CPU, with 16-bit thumb mode. This CPU can be interfaced using: code RAM/ROM interface (iBus) that goes to the memory controller, that can also be used to access external flash memory, data RAM interface (dBus), that also goes to the memory controller AHB interface, for register access, and JTAG interface for debugging . The memory controller contains ROM, and SRAM. It is accessed by the CPU using the iBus, dBus and AHB interface.

a. Programming of ESP8266

The ESP8266 is a 3.3 volt device only. It can draw over 300 milliamps at some peak operations. To give it a safe margin, the LD1117-3.3 regulator is safe, able to supply 800 milliamps when it needs to, cool at 500 milliamps. So you can connect a3.7 V battery,5V battery. If you have noisy power, like a poor quality cell charger, etc. place a capacitor between power and ground on the input and output. 0.1 microfarad would be typical, 10 microfarad electrolytic capacitor (which have + and - leads) for a more noisy supply.ESP8266 being connected via generic FTDI USB to Serial device. 5 volt signal levels can harm the ESP8266. This may be mitigated via level shifting or a voltage divider on the ESP8266 receive (RXI) pin for such devices. The FTDI Friend is safe as the default transmit and receive signal level is 3.3 volts if left on the default on the back. Download and install FTDI drivers from http://www.ftdichip.com/Drivers.html. Fig 5 is presenting the connection of ESP8266 with FTDI cable.

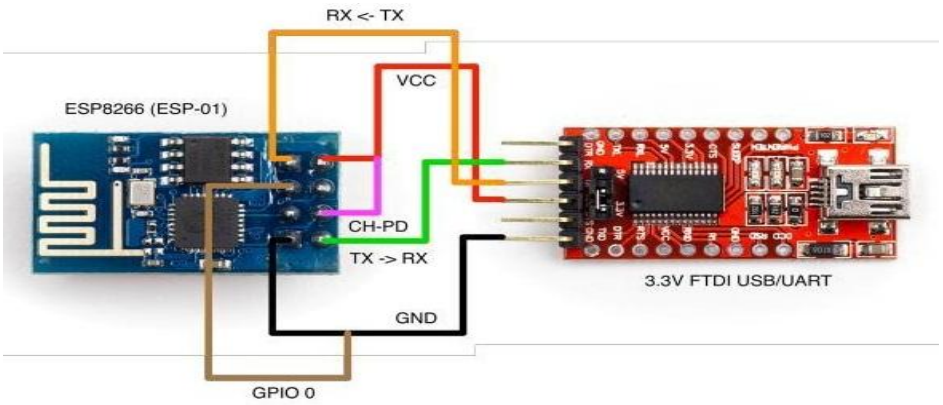

Figure 5: Connection of ESP8266 with FTDI cable

3. Arduino Board

Arduino consist of both physical programmable circuit board and piece of software. Integrated Development Environment (IDE) that runs on computer used to write and update computer code to the physical board. Arduino allows installation of third-party platform packages using Boards Manager.

- Install Arduino 1.8.1 from the Arduino website.
- Start Arduino and open preferences Windows then Enter
- http://arduino.esp8266.com/stable/package_esp8266com_in dex.json into *Additional Board Manager URLs*

Field. You can add multiple URLs, separating them with commas.

- Open Boards Manager from Tools > Board menu and install esp8266 platform (and don't forget to select your ESP8266 board from Tools > Board menu after installation).
- Select the board (Tools->Board->Generic ESP8266 board).
- Select the COM port to which ESP8266 is connected via FTDI cable.
- Install libraries for esp8266. Now we can load program to ESP8266 using Arduino IDE 1.8.1
- We can also View the Status on serial window of Arduino.

4. ECG sensor:

ECG electrode sticks to chest to pickup ECG signals. Then wires are connected to AD8232. This sensor is a cost-effective board used to measure the electrical activity of the heart. ECGs can be extremely noisy, the AD8232 Single Lead Heart Rate Monitor acts as an op amp to help obtain a clear signal from the PR and QT

Intervals easily. This sensor is a cost-effective board used to measure the electrical activity of the heart. This electrical activity can be charted as an ECG or Electrocardiogram and output as an analog reading. ECGs can be extremely noisy, the AD8232 Single Lead Heart Rate Monitor acts as an op amp to help obtain a clear signal from the PR and QT Intervals easily.

The AD8232 is an integrated signal conditioning block for ECG and other biopotential measurement applications. It is designed to extract, amplify, and filter small biopotential signals in the presence of noisy conditions, such as those created by motion or remote electrode placement.

The AD8232 module breaks out nine connections from the IC that you can solder pins, wires, or other connectors to. SDN, LO+, LO-, OUTPUT, 3.3V, GND provide essential pins for operating this monitor with an Arduino or other development board. Also provided on this board are RA (Right Arm), LA (Left Arm), and RL (Right Leg) pins to attach and use your own custom sensors. Additionally, there is an LED indicator light that will pulsate to the rhythm of a heart beat. Fig 6 is showing the ECG sensor

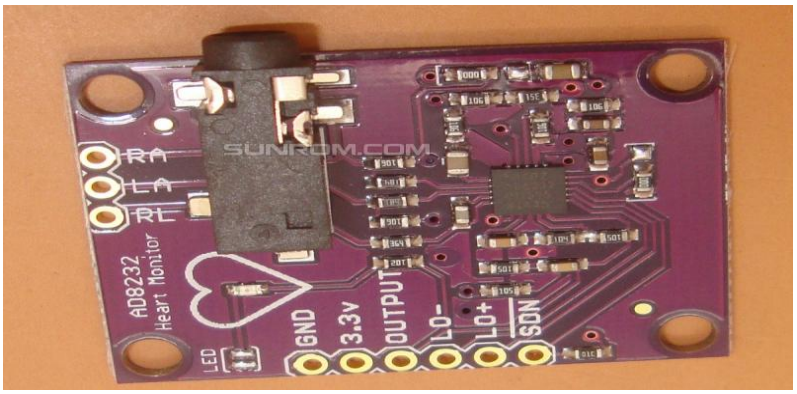

Figure 6: ECG Sensor

5. Heart Rate sensor

The sensor gives the digital output of heat beat when a finger is placed on it. When the sensor is started then the LED flashes with beat sound. The output generated is in Beats per Minute (BPM) rate. Fig 7 is showing the Heart rate sensor.

Figure 7: Heart rate sensor

6. Temperature sensor (LM35):

It is a sensor used to measure temperature. The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. It measures temperature more accurately than thermistors. It is sealed and does not undergo oxidation. It does not require output voltage to be amplified. Fig 8 is showing the temperature sensor LM35.

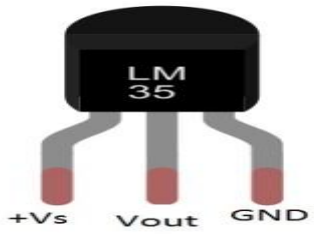

Figure 8: Temperature sensor [LM35]

7. Server

The data send by BBB is stored on a server. The detailed information of patients and doctor is registered through website on stored on server. The website can be accessible from anywhere. We are using ThingSpeak as a web server. It is an open source "Internet of Things" application and API to store and retrieve data from things using HTTP over the Internet or via a Local Area Network. With ThingSpeak, you can create sensor logging applications, location tracking applications, and a social network of things with status updates.

In addition to storing and retrieving numeric and alphanumeric data, the ThingSpeak API allows for numeric data processing such as time scaling, averaging, median, summing, and rounding. Each ThingSpeak Channel supports data entries of up to 8 data fields, latitude, longitude, elevation, and status. The channel feeds support JSON, XML, and CSV formats for integration into applications. The primary element of ThingSpeak activity is the channel, which contains data fields, location fields, and a status field.

We have to follow following steps:

a) Sign In to ThingSpeak™ using either your Math Works® Account or ThingSpeak account, or create a new ThingSpeak account.
b) Click Channels > My Channels.
c) On the Channels page, click New Channel.
d) Check the boxes next to Fields 1–3. Enter these channel setting values:
Name: Smart Healthcare System, Measurement Field 1: Temperature (F), Field 2: Heart Beat,
Field 3: ECG
e) Click Save Channel at the bottom of the settings.

You now see these tabs:

- Private View: This tab displays information about your channel that only you can see.
- Public View: If you choose to make your channel publicly available, use this tab to display selected fields and channel visualizations.
- Channel Settings: This tab shows all the channel options you set at creation. You can edit, clear, or delete the channel from this tab.
- API Keys: This tab displays your channel API keys. Use the keys to read from and write to your channel.

Data Import/Export: This tab enables you to import and export channel data.

VI. WORKING OF THE SYSTEM

The BBB is act as a wireless access point. The board sends the data to the server. In the web server first login and then the health parameter of the person is displayed on the screen. Sensors send the data which are send it to the BBB through ESP8266 Wi-Fi module. The aim of our system is basically monitoring patient's health parameter and gets the accurate result. It is useful for doctors. The doctors are continuously monitor the health parameter of any of their patients from any location and virtually connected to the patient through website. Also through this system real time parameter values can be measured so this system is beneficial for hospitals as well as in clinic also.

The working of the system is following the steps:-

ESP8266 module first check the IP address of BBB when its IP is available it request the arduino to get data from sensors.

f) The system collects the health parameters data of the person/patient.

g) Collected data may be analog. So, convert the data into digital form using Arduino.
h) These sensed data are transmitted to the Beagle bone board through ESP8266.
i) At the server end the doctors can see the current health status using login Id and password. Through this system, the doctor can able to see the health parameters like temperature, ECG, heart rate values efficiently and store data on web server.
j) The values are in form of - Temperature we are getting Celsius, heart rate in pulses, ECG in percentage shown on display as well as on website.
k) The any threshold value will be fluctuating from specified value then the alarm will be triggered which is connected through raspberry pi and RMO's get the alert.

The work flow of the system is describing by the fig 9.

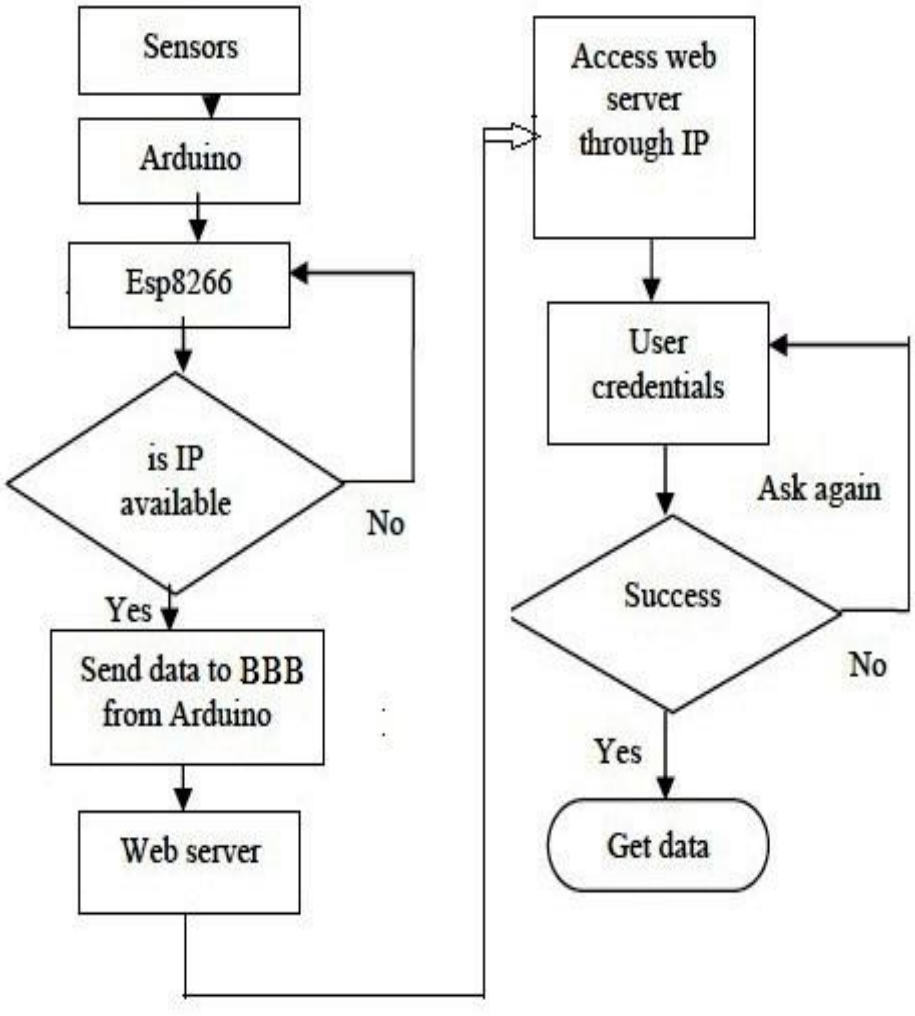

Figure 9: Work Flow of the System

VII. RESULTS

Smart Health monitoring system is practically implemented and the results are obtained. Just go to Thingspeak.com and open the channel Created. Results of Health care system are as follows:

The health platform is show in fig 10 &11. It is the webserver which can only accessed by the authorized person and the online the patient health parameters is displayed after successful login only.

Fig 12 show the terminal diagram that finding the heart beat from the input sample files and updating the database of website. It shows the screenshot of terminal using putty software.

Figure 10: Temperature output on the webserver

Figure 11: Heart rate output on the webserver

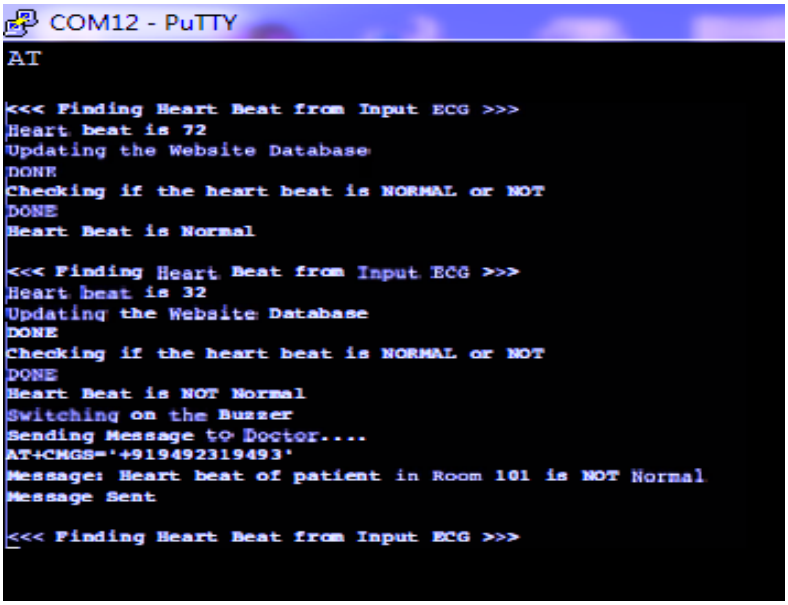

Figure 12: Screenshot of terminal process on PuTTY software.

VIII. CONCLUSION

In this study, a new approach is presented and proved, that works in an automatic way, guaranteeing a seamless monitoring of ECG signals and other health parameters. Realized system can be a prototype for health care system to monitor patient's vital signals. Beaglebone Board (BBB) is used for this application because of its multi-tasking capability and low power consumption. Also this system can be installed easily in all the hospitals and huge data obtained can be stored in the database. Moreover this data is much valuable. Beaglebone Board, with its broad variety of features can be used for several purposes and have much scope in future. Even the results can be made to be accessed from mobile through an application. Any intelligent system can be added and can be further improvised to facilitate the clinicians and the patients. We can also conclude that with the evolution of network integration and the management of embedded devices operating multimodal tasks, a more precise and universal healthcare service scheme can be realized.

A large amount of data can be collected using this system. This colossal amount of data, consisting medical history of many patients' parameters and corresponding results, can be explored using signal processing techniques and data mining, in search of consistent patterns and systematic relationships in the disease. This could a point of paramount significance for the medical research. Simply, the researchers provided with actual results which make their study easier. Additionally, they can also predict the nature of disease and take some preventive measures in advance. For instance, if a patient's health parameters are changing in the same pattern as those of a previous patient in the database, the consequences can also be estimated. If the same patterns are repeatedly confirmed, it would be easier for the medical personnel to find a remedy.

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REFERENCES

[1]. Sang-Joong Jung, RistoMyllylä, and Wan-Young Chung, *"Wireless Machine-to-Machine Healthcare Solution Using Android Mobile Devices in Global Networks",Member, IEEE,*IEEE SENSORS JOURNAL, VOL. 13, NO. 5, MAY 2013.

[2]. J. G. Ko, C. Y. Lu, M. B. Srivastava, J. A. Stankovic, A. Terzis, and M. Welsh, "*Wireless sensor networks for healthcare*", *Proc. IEEE*, vol. 98, no. 11, pp. 1947–1960, Nov. 2010.

[3]. Suhas Kale, C. S. Khandelwal, *"Design and Implementation of Real Time Embedded Tele-Health Monitoring System",* 2013 International Conference on Circuits, Power and Computing Technologies [ICCPCT-2013].

[4]. Matthias Wagner, Benjamin Kuch, Carlos Cabrera, Peter Enoksson, Arne Sieber, "*Android Based Body Area Network for the Evaluation of Medical Parameters",* 10th International Workshop on Intelligent Solutions in Embedded Systems, 2012.

[5]. K. Navya, Dr. M. B. R. Murthy, "*A Zigbee Based Patient Health Monitoring System",* Int. Journal of Engineering Research and Applications Vol. 3, Issue 5, Sep-Oct 2013, pp.483-486.

[6]. Gareth Mitchell, The Raspbeny Pi single-board computer will revolutionize computer science teaching [For & against], Vol.7, NO.3, pp. 26, 2012.

[7]. Edwards, C., "Not-so-humble raspbeny pi gets big ideas," in Engineering & Technology, vol.8, no.3, pp.30-33, April 2013

[8]. Vamsikrishna, Patchava; Sonti Dinesh Kumar; Shaik Riyaz Hussain; Rama Naidu, K., "Raspberry PI controlled SMS-Update-Notification (Sun) system," in Electrical. Computer and Communication Technologies (ICECCT), 2015 IEEE International Conference on , vol., no., pp.I-4, 5-7 March 2015

[9]. S.L.Y. Youling, X. Weisheng, "Design of Remote Real-Time Temperature Monitoring System". The Eighth International Conference on Electronic Measurement and Instruments ICEMI Proceeding 2007.

[10].Awwad Y and Chia Feng Lin, Hsien Tang Lin, Shyan Ming Yuan, "The construction of information gathering with SMS messages", WSEAS Transactions on Communications, Vol.5, pp 1208-1213, Jun.2006.

[11].Texas Instruments, *Smart Data Concentrator EVM (TMDSDC3359) Hardware Manual*, TMDSDC3359 Wiki (http://processors.wiki.ti.com/index.php/Smart_Data_Concentrator_EVM_(TMDSDC3359)_Hardware_ Manual)
[12].Anand Nayyar and Vikram Puri, " A Comprehensive Review of BeagleBone Technology: Smart Board Powered by ARM", International Journal of Smart Home,Vol. 10, No. 4 (2016), pp. 95-108
[13].S.Cleva, A. I. Boganiand and L. Pivetta, "A low-cost high-performance embedded platform for accelerator controls", proc. PCaPAC2012, Kolkata, India, **(2012)**.
[14].Global Smart Grid Cyber Security Market 2012-2016: Worldwide Industry Share, Investment Trends, Growth, Size, Strategy And Forecast Research Report 2016 – BWWGeeksWorld by www.broadwayworld.com
[15].M. Nassar, J. Lin, Y. Mortazavi, A. Dabak, I. H. Kim, and B. L. Evans, "Local utility powerline communications in the 3-500kHz band: channel impairments, noise, and standards," IEEE Signal Proc. Mag., to appear
[16].http://eecatalog.com/smart-energy/2014/04/09/data-concentrators-are-key-to-engineering-a-smarter-grid/
[17].Publitek marketing communications, "BeagleBone Black Brings Arduino-Style Connectivity Simplicity to Embedded Linux", Digi-key Article Library.
[18].Beagle class ECE497 in Rose-Hulman: http://elinux.org/Embedded_Beagle_Class
[19].Course website: http://mavweb.mnsu.edu/hen/EET310_fall13.html
[20].https://www.arm.com/, Accessed on, (2015) October 27.
[21].H Yau, "Learning BeagleBone", Packt Publishing Ltd, (2014).
[22].http://www.digikey.com,Accessed on (2015) October 27.
[23].http://www.ti.com ,Accessed on (2015) October 27.
[24].Python Softwares, https:l/pypi.python.org/pypi
[25].Heart Rate, http://www.practicalclinicalskills.com
[26].Health, www.heartlandmedical.com
[27].www.github.com/ESP8266/Arduino.html