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NodeMCU in Patient's Data Transfer to IoT Platform

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ABSTRACT

Telemedicine is the use of advanced telecommunication tools, within the framework of clinical health, to diagnose diseases or deliver care remotely. In the field of telecommunication, many progress have been made specially with the expanding paradigm of Internet of Things. Our goal in this paper is make use of those low cost and open source tools to accurately transmit patient's parameter to IoT platforms in order to apply a further processing techniques for remote disease diagnostic. To tackle this issue, we made use of ECG samples, sensor for temperature and humidity, connected to the NodeMCU which is one of the fast expanding and effective tools to easily establish communication with large scale data storage servers. The NodeMCU is used to push medical parameters to the ThingSpeak which is one of the most advanced IoT platform embedding MatLab. We made use of two main Application Program Interface (API): Message Queuing Telemetry Transport (MQTT) to push data to server, and the REpresentational State Transfer (REST), web services provide interoperability between computer systems on the Internet. As result of that experimentation we succefully transmited the three parameters, necessary on heart disease diagnosis. This tiny setup could be of a great help for remote medical data processing, also the IoT platform selected gives room to MatLab thereby could allow any type of further and powerful processing.

Keywords: Internet of Things (IoT); NodeMCU; API; REST; MQTT; ECG.

1 Introduction

Telemedicine is the use of telecommunication and information technology to provide clinical health care from a distance. It has been used to overcome distance barriers and to improve access to medical services that would often not be consistently available in distant rural communities. Telemedicine can be beneficial to patients in isolated communities and remote regions, who can receive care from doctors or specialists far away without the patient having to move to visit them [1]. Recent developments in Information Communication Technology can allow healthcare professionals in multiple locations to share information and discuss patient's issues as if they were in the same place. These technologies permit communications between patient and medical staff with both convenience and fidelity, as well as the transmission of medical, imaging and health informatics data from one site to another. Various specialties are contributing to telemedicine, in varying degrees. Just to name some few, in

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Telecardiology electrocardiographs, can be transmitted using telephone, mail and wireless Specialist care delivery. Telepsychiatry, Teleradiology, Telepathology, Teledermatology, Teledentistry, Teleaudiology, Teleophthalmology [2]. According to Grigsby [1], there are four suggested types of telemedicine applications: (a) management of specific diseases, (b) use within specific, specialties, (c) classification according to technology, and (d) types of clinical problems. Whitten et al [3] provides a literature review and overviews three proposed evolutionary stages for telemedicine to date, namely synchronous versus asynchronous modalities, data transfer and storage, and automating decision making and robotics.

As More than three-quarters of cardiovascular diseases deaths occur in low- and middle-income countries, the main causes being the lack of cardiologists and equipment in medical centres. A Holter monitor is a battery-operated portable device that measures and records the heart's activity (ECG) continuously for 24 or longer depending on the type of monitoring required. Some devices to acquire ECG signal and enables monitoring patient remotely rather than keeping them in emergency care due to the lacking of expensive ECG devices for developing countries have been developed but using e-mail as transmission mean [4]. Many existing systems have attempted to simplify ECG data acquisition and analysis. These systems utilize other wireless standards such as Wi-Fi [5], Ethernet [6], [7], Bluetooth [7], ZigBee [8], parallel port [9], USB [10] and even GSM [11], [12], [13]. Mbiadoun et al [14] developed a Universal Module of Acquisition and Transmission of Electrophysiological Signal, he focused on phonocardiogram data acquisition and noise cancellation. Although many wireless standards can be used, there are important considerations such as range, throughput, security, ease of implementation and cost. From his research, Hangsik Shin [15] found that the ambient temperature could induce a difference between HRV(heart rate variability) and PRV (Pulse rate variability). The differences were found in the short-term variables that reflect the parasympathetic activity, for this experiment he has to monitor the ECG and photoplethysmography (PPG) under temperature-controlled, constant humidity conditions.

The Internet of Things (IoT) is an abstraction where by each identifiable object can exchange data among each another, with the traditional wired and wireless technologies, and evolving interoperable information and communication technologies, Machine-to-Machine communications (M2M), right up to IoE (Internet of Everything) [16] [17]. Moreover, IoT is a promising paradigm to integrate several technologies and communication solutions. As defined by European Commission Information Society, the Internet of Things is a manageable set of convergent developments in sensing, identification, communication, networking, and informatics devices and systems [18], [19]. Applications of IoT is now extended to several domains like lightning systems [20], Home automation [21], robotics [22] , health domain [23], environmental science [24] and so on… Some authors have successfully coupled IoT with PWM especially in telecoms [17] and also applied in IOC (Internet on a chip) in robots [22]. Tchamda et al [25] developed a Medical systems for telemonitoring of Heart's mechanical activity and Goelocalization of the Patient Based on the MQTT API. A website uses a URL address to make a call to a server and pull up a webpage in a browser. APIs also facilitate calls to a server, but they execute it more simply. They connect the web, allowing developers, applications, and sites to tap into databases and services much like open-source software. APIs do this by acting like a universal converter plug offering a standard set of instructions

There are many types of APIs. One of the most common types of APIs are Web APIs; these APIs, otherwise known as Web Services, provide an interface for web applications, or applications that need to connect to each other via the Internet to communicate. There are tens of thousands of public APIs that can be used to do everything from checking traffic and weather, to updating your social media status, or even to make payments. There are hundreds of thousands more private Web APIs. These APIs are not available to be consumed by the general public; rather, they are used by companies to extend their services and capabilities across a broad range of use cases.

This work is divided in two main parts. The first one is all about Material and method employed, where we invocated two subparts of our embedded system, namely the hardware section and the software section. The second section is dedicated the implementation of the first part. Thereafter, we will conclude and announce perspectives.

2 Material and Methods

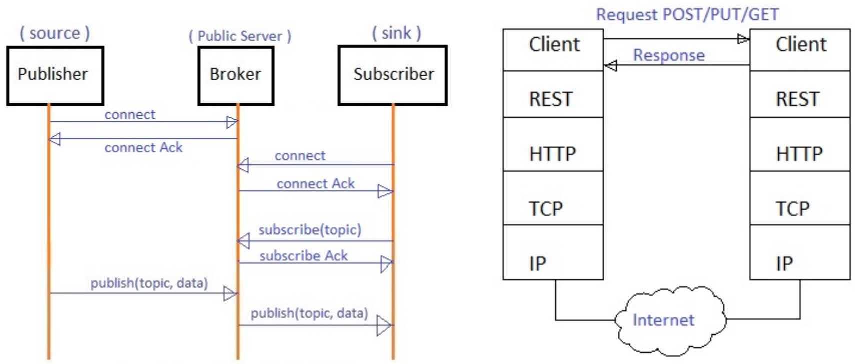
Under the paradigm of IoT and eHealth (eHealth is the use of information and communication technologies (ICT) for health), we will develop in this section a solution to ease ECG data transfer for further processing, by allowing a more powerfull processing tool like matLab to display some ECG data sampled real time. To do so we take advantage of ThingSpeak which is an open IoT platform with MATLAB analytics. Moreover, IoT is a promising paradigm to integrate several technologies and communication solutions. The Internet of Things is a manageable set of convergent developments in sensing, identification, communication [16] [17], networking, and informatics devices and systems [18], [19]. The brain behind the set is the NodeMCU ESP8266. This device will take advantage of a Wi-Fi network. We are going to display via a given network, some ECG strips, through an embedded server, inward a single tiny device. This approach free us from the use of urge systems like dedicated server, router, wires, connectors etc…

Figure 1 Main Modules for IoT Biomedical system

MQTT is a publish/subscribe architecture that is developed primarily to connect bandwidth and power-constrained devices over wireless networks. It is a simple and lightweight protocol that runs over TCP/IP sockets or WebSockets. MQTT over WebSockets can be secured with SSL. The publish/subscribe architecture enables messages to be pushed to the client devices without the device needing to continuously poll the server.

REST is the short form of Representational State Transfer. As shown it is built on HTTP/TCP layers. The REST protocol uses bus based architecture, where in no broker component is needed and end devices can communicate directly. In this request and response messages are used between end devices to exchange the information

ThingSpeak is an IoT platform that uses channels to store data sent from apps (Android, IOs…) or devices. With the settings described in Channel Configurations, we can create a channel, then send data to a channel, and retrieve data from a given channel. For this paper, we made our channels public to be able to share data, with some other medical doctors or hospital around the world. Using the REST API calls such as GET, POST, PUT, and DELETE, helped us create a channel and update its feed, update an existing channel, clear a channel feed, and delete a channel. we made use of the MQTT Publish method to update a channel feed.



(a) (b)

Figure 2: a) Broker based MQTT Protocol, b) REST Protocol

MATLAB® analysis and visualization apps enabled us to explore and view our channel data. ThingSpeak enables is able to interact with social media, web services, and devices through APIs: REST and MQTT. REST API uses calls to create and update ThingSpeak channels and charts. MQTT API is used to update ThingSpeak channels

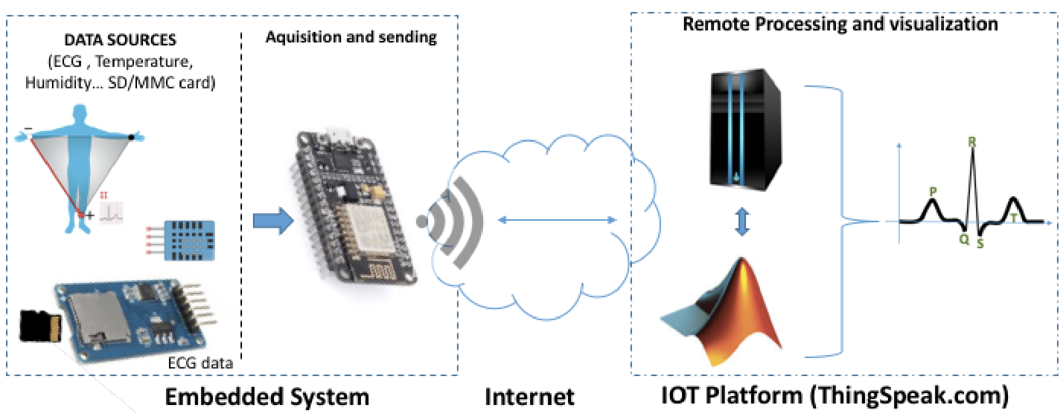


Figure 3: Main Elements for the IoT Biomedical system's architecture

The architecture proposed in **Error! Reference source not found.**, is a benchmark to illustrate our methodology. ECG data collected initially and stored in flash memory, could be inserted into a MMC shield, connected to NodeMCU. This small embedded system converted to Client for Internet can therefore be connected to the thingspeak platform via the wifi layer and transfer those records to the platform. The MatLab machine embedded into thingSpeaktm is then used to carry out further processing

This section is actually divided in two mains sub-sections the first part is all about putting all the hardware together with few adjustments, the second part is all about programming the ESP8622 in Lua language, and Android programing.

2.1 Hardware Design

The new ESP8266 has captured the attention of professional designers, and it has the potential to be an asset in the internet of things. It is highly integrated circuit consists of a 32-bit RISC processor. The ESP8266 also includes a built-in 802.11 b/g/n Wi-Fi circuit that is ready to be directly connected to an antenna engraved on its board. Engineered for mobile devices, wearable electronics and IoT applications, ESP8266EX achieves low power consumption with a combination of several proprietary technologies .

We have two versions of the DHT sensor, they look a bit similar and have the same pinout, but have different characteristics. Here are the specifications of the DHT: Ultra low cost, 3 to 5V power and I/O, 2.5mA max current use during conversion (while requesting data), Good for 20-80% humidity readings with 5% accuracy Good for 0-50°C temperature readings ±2°C accuracy, No more than 1 Hz sampling rate (once every second). Especially DHT22 is Good for 0-100% humidity readings with 2-5% accuracy, Good for -40 to 80°C temperature readings ±0.5°C accuracy, No more than 0.5 Hz sampling rate (once every 2 seconds). The DHT sensor includes a resistive-type humidity measurement component and a NTC temperature measurement component, and connects to a high performance 8-bit microcontroller, Measurement Range for humidity [20%;90%] RH, Humidity Accuracy ± 5% RH, Temperature Accuracy ± 2°C.

The DS18S20 digital thermometer provides 9-bit Celsius temperature measurements. It communicates over a 1-Wire bus that by definition requires only one data line (and ground) for communication with a central microprocessor. Each DS18S20 has a unique 64-bit serial code, which allows multiple DS18S20s to function on the same 1-Wire bus. Thus, it is simple to use one microprocessor to control many DS18S20s distributed over a large area. Measures Temperatures from -55°C to +125°C, ±0.5°C Accuracy from -10°C to +85°C.

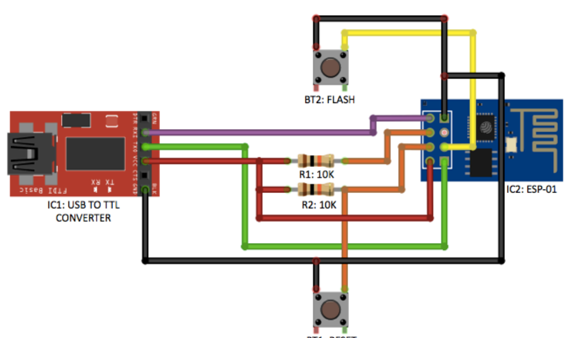


Figure 4:Programming environment

2.2 Software Design

REST is a representational state transfer architectural style designed as a request/response model that communicates over HTTP. MQTT is a publish/subscribe model that runs over TCP/IP sockets or WebSockets. MQTT over WebSockets can be secured with SSL. It is possible to update data to a ThingSpeak™ channel either using a REST GET or POST request or using MQTT PUBLISH method. You retrieve channel data using a REST GET request or MQTT SUBSCRIBE [26]. It is useful to use REST calls to update or retrieve data from a ThingSpeak channel. It is useful to use MQTT to update data to a

ThingSpeak channel, when the device is power-constrained, and requires lower battery consumption to send data to ThingSpeak. Also, an MQTT PUBLISH operation is typically faster in this scenario, when the device connectivity is intermittent, and has limited bandwidth usage, when the immediate updates of data posted to a channel.

The flow chart in **Error! Reference source not found.** summarizes the global functioning, of the system. As the embedded system connects to IoT platform's server, it gets identified, then upload data to the correct channel, then disconnect later after a while, then restarts the cycle.

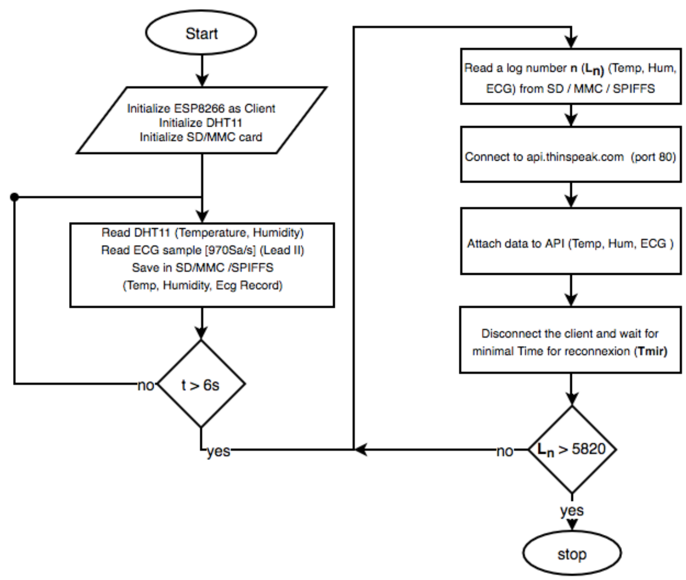


Figure 5: Flow chart illustrating software implementation

The flow chart developed in **Error! Reference source not found.** shows that when the system is started, the NodeMCU is initialised and set as client, as well as the DHT11, for temperature and humidity, the storage device considered for this architecture is an external Multimedia Card, in case that large data initially kept in such a device is to be transferred. Thereafter, in case of direct acquisition, for a device able to acquire at 970 Samples per second, we can keep those record, either in the MMC card previously initialised or in the internal memory of the NodeMCU. A common length of an ECG printout is 6 seconds, known as a "six second strip". Later the system loops through the data acquired to push them to the IoT platform. Read the next sample, connect to the API via port 80, gather temperature, humidity, and the corresponding ECG sample, and forward it to the platform. Six seconds record at 970Sa/s corresponding to 5820, the system shuts down automatically.

The MQTT broker is the central point of communication, and it is in charge of dispatching all messages between the senders and the rightful receivers. A client is any device that connects to the broker and can publish or subscribe to topics to access the information. A topic contains the routing information for the broker. Each client that wants to send messages publishes them to a certain topic, and each client that wants to receive messages subscribes to a certain topic. The broker delivers all messages with the matching topic to the appropriate clients

3 User Query Intent and Storage of Tags

This section is actually divided in two main sub-sections the first part is all about putting all the hardware together with few adjustments, the second part is all about programming the ESP8622 in Lua language, and Android programing.

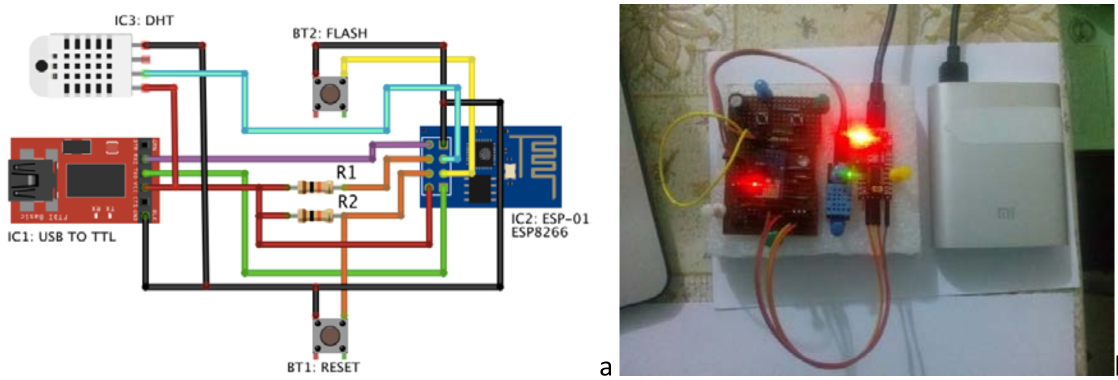


Figure 6: a) System Implementation b)Components setup for Data transmission using ESP8266-01

The system takes advantage of the HTTP (HyperText Transfer Protocol) protocol, to send a web page to any client requesting that page, from any web browser, or any request converted from android applications to http request, providing that his device is attached to the distributor's network, as shown in **Error! Reference source not found.**. This architecture can easily run an HTTP server, accessible through its station mode, and connected to an access point. The core component is a Microcontroller unit based NodeMcu: ESP8266-12E WIFI module,

Figure 7: Chart visualisation for Temperature, Humidity, ECG, dataset plot through MatLab

4 Discussion

From the Figure 7 Field 3 the relative Humidity, associated with the patient's room ambient Temperature, in Field2. These parameters were obtained with a DHT11 coupled to the NodeMCU, then pushed to the IoT platform ThingSpeak between 08h and 11h. The associated ECG is presented on the Field 4 where we can distinguish PQRS waves sent in alongside with temperature and the humidity. The plot 6 presents a set of data transferred from 07h55 to 10h30, and displayed through IoT with the use of MatLab for further processing. This could also be joined Tchamda et al [25] developed to obtain a mini health station. With regards with the work done by Hangsik Shin [15], this work could be considered as implement supplemented with IoT. As compare to [4] our contribution stands as a hardware add-on, for that architecture.

5 Conclusion

The advent of IoT coupled to telemedicine has enhanced use telecommunication tools, within the framework of clinical health, to carefully diagnose diseases remotely. We made use of low cost and open source tools to accurately transmit patient's parameters to an IoT platform. Our contribution carried on transmitting ECG samples, concatenated with temperature and humidity as additional parameters. The transmission was made possible by connecting to the NodeMCU to ThingSpeaktm which is one of the most advanced IoT platform embedding MatLab. We made use the MQTT and REST Application Program Interface. As result of that experimentation we succefully pushed those three parameters, necessary on heart disease diagnosis. The main limitation of such architecture is the authorize time between two data push which is ten seconds, making it slow when acquiring parameters. This setup will be of a great help for remote medical data processing, because the IoT platform selected gave room to MatLab for further processing. The next phase for this work is a dedicated IoT platform to enhance, to overcome those limitations.

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