Development of Internet of Things Applications with Low Cost Devices

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***Abstract*— The Internet of Things promises to be a silent revolution in consumer relations, productive activities and people's daily lives. In Brazil it begins to be seen as an alternative to face the obstacles of increasing the productivity of the economy or to reduce the inefficiencies of the health system. The Group of Studies and Research in Internet of Things has as a proposal to unite the experiences and abilities of researchers in electronics, telecommunications, computer science and sensor networks to develop innovative solutions and application of promising technologies. In this work, we will demonstrate the ability of the group to carry out research, with results from three specific projects: control of falls for the elderly, medication management and presence control in the school environment. We hope that with the proposition of academic projects such as these, a growing number of students and technicians can benefit from Internet of Things and further advance its adoption in Brazil.**

Keywords — Internet of Things; accessibility; sensor networks; NodeMCU

I. Introduction

The Internet of Things (IoT) promises to be a silent revolution in consumer relations, productive activities and people's daily lives. The technological development in electronics, sensors and communication networks allied to open and intelligent software environments will allow the decision making by the objects and machines or the automation of tasks without the interaction of human operators. Data will be collected all the time by numerous sources and shared between different databases, which requires efficient protocols to accommodate the large flow of information, and insurance to ensure privacy and control of sensitive information and even automated financial transactions.

One of the pillars of IoT's operation is the establishment of connectivity between equipment and sensors of different types. With the fall in communication equipment costs and the increase in the communicability of hardware devices and software services, sensor networks present themselves as an innovative solution, looking for ease and efficiency in data acquisition and subsequent analysis.

Sensor networks have been adopted in the industry for a long time in order to assist the actuation of automation systems. These sensors vary from the tactile reading to using visual verification by means of barcode readers. Many sensors now use radiofrequency, for short, medium (e.g., Xbee and Bluetooth) and long distance between active devices, or locating passive assets. The main challenge for adopting these technologies in an integrated and shared way is to provide an adequate infrastructure for the different devices to communicate, using adequate protocols and properly managing the information systems. Also, for a network of sensors to interact with the data network or automation, it requires great reliability to the receivers.

An important field of action of IoT is in the development of solutions for health and accessibility, that is, to allow the integration of people with disabilities into everyday activities in a transparent and low cost way. Solutions vary from the use of sensors to gauge health and detect emergency situations to complete home automation systems. As stated in [1], the health industry is the one that most presents promises for the use of IoT, revolutionizing treatments and streamlining diagnoses of patients in the 21st century.

A. The IoT scenario in Brazil

IoT quickly moves from laboratories to everyday life in countries such as the United States, Germany, Japan and the United Kingdom and is already palpable in Brazil, where it begins to be seen as an alternative to face the obstacles of increasing the productivity of the economy or to reduce the inefficiencies of the health system. [2] According to [3], the Information Technology (IT) market in Brazil grew by 9.2% in 2015, while the average global growth was 5.6%. The software alone segment grew 30% between 2014 and 2015, while the country faced an economic recession with GDP falling by more than 3%. In 2016, the Brazilian IT market, including hardware, software, services and exports, summed US $39.6 billion, representing 2.1% of Brazil's GDP and 1.9% of total IT investment in the world.

The Brazilian government intends to launch the National Plan for Internet of Things, considering a study conducted by BNDES and MCTIC. [4] This is a set of strategies and public policies that seek to involve companies, government and research institutions in the dissemination of the use of internet connected equipment in industry and services in the country. As a business platform, IT has a more inclusive agenda than previous technology trends. [2]

B. *Group of Studies and Research in Internet of Thing*

The Group of Studies and Research in Internet of Things (GEPIC) in Hortolandia proposes to unite the experiences and abilities of researchers in electronics, telecommunications, computer science and sensor networks to develop innovative solutions and application of promising technologies. Some features are mandatory for the projects, such as using an open environment (free software), efficient use of energy and other resources, strong integration between hardware and software, minimal interference with users and accessible interfaces.

In this work, we will demonstrate the ability of the group to carry out research, with results from three specific projects: control of falls for the elderly, medication management and presence control in the school environment.

II. Low Cost Devices for IoT

To work with IoT, specific devices have been developed, focusing on the best cost-benefit ratio, while offering connectivity, satisfactory environment for development and openness for expansions. The following are the most popular devices.

A. *Arduino*

Arduino is a common term for a type of open-source hardware and software, an Integrated Development Environment (IDE), and a community focused on the development of digital devices and interactive objects that can sense and control physical devices. The project is based on microcontroller board designs, produced by different companies. These systems provide digital and analog I/O pins that can interface to multiple expansion boards (called shields) and other circuits. The boards have serial communication interface (UART and USB in some models), to load programs from personal computers.

For programming, the Arduino project provides an integrated development environment (IDE) based on the Processing language, which also supports C and C ++ languages.

The UNO version of Arduino is the most used and the starting point to development, being the base of comparison for the other versions. The DUE version features ARM architecture instead of the AVR, which allows 32-bit processing, 84 MHz clock, and native USB support. In addition, it contains two Digital-to-Analog Converters (DAC) and Direct Memory Access (DMA) converters, very important for IoT development.

B. *Ensuring onboard WiFi connectivity*

In the same spirit, the ESP8266 development module cost produced by Shanghai-based Chinese manufacturer, Espressif Systems, is compatible with Arduino platforms and allows integrated wireless communication (WiFi) to the board, while maintaining the low. It has GPIO connectors, I2C buses, SPI, UART, Analog-to-Digital Converter input, Pulse Width Modulation (PWM) output and internal temperature sensor. The CPU operates at 80MHz, with the possibility of operating at 160MHz, in a 32-bit RISC architecture. In addition, it has 32KBytes of RAM for instructions, 96KB of RAM for data, 64KB of ROM for booting and a 512Kbytes Winbond W25Q40BVNIG SPI flash memory. The core is based on Tensilica's Diamand Standard LX3 IP. [5]

A more advanced module with WiFi is the NodeMCU [6], which in addition to being compatible with the Arduino IDE and the functions of the ESP8266 library, has more memory and development environment in Lua language integrated with the board. Figure 1 shows a map of all NodeMCU pins and their compatibility with the Arduino standard.

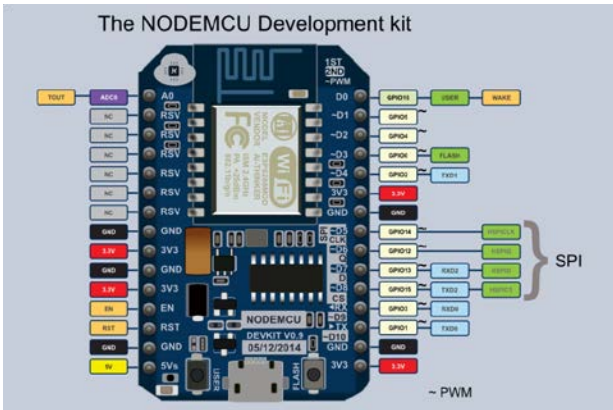

Figure 1 –NodeMcu Pinout [6]

III. IoT Applications

In this section will be described some solutions already implemented involving the mentioned devices and the IoT paradigm. Although these applications are not on a commercial status yet, we hope that these examples will illustrate the power of IoT.

A. *Home health care system: mechanism for detection of falls in the elderly*

Statistics of the Brazilian Institute of Geography and Statistics (IBGE) indicate that Brazil is becoming an old country, that is, with many elderly people. According to a study [9], in 2030 the group of people with 60 years or more will become bigger than the group of up to 14 years. Thus, there is an increased concern about the care of the elderly, since their participation in society increases and consequently the eminent risks in their daily lives.

Providing help as fast as possible to people who already demand special care is a decisive factor in avoiding death and bone fractures. In addition, it is known that detecting the fall can be a solution of high cost in Brazil, since most equipment that detects the fall comes from other countries and the service provided is very specialized. [10]

The objective of this project is to detect the fall of a person using equipment of low cost and sending a remote signal to alert previously registered telephones. The idea came up after analyzing similar products in the market [7] [8] and realize that the costs are very high.

B. *Electronic Wristlet for Medical Management*

The majority of the elderly need to use medications at certain times of the day, but suffers from the forgetfulness

caused by old age. To solve this problem, this project aims to develop an electronic drug management wristlet (similar in design to commercially available smartwatches, such as the ones in Figure 2) that will be used by the elderly throughout the day. Together, an application for mobile devices managed by a third party will control schedules and medicines. As in the other case, ease of use and low cost will be mandatory, as they are critical for the public considered. It also seeks to provide an open and customizable development environment that facilitates future research within the theme.

Figure 2 - Smartwatches: the Pebble Watch (from Pebble Technology Corporation), the Basis Watch, the Contour Watch from Wimm Labs, and the Sony SmartWatch. [8]

For this project, the NodeMCU was used in conjunction with a Real Time Clock (RTC) module to store the time, an OLED display for time display and a buzzer to emit a sound alert.

C. in the School Environment Using Radiofrequency Identification

In this project, a sensor network of Radio Frequency Identification (RFID) is used to control the presence of students in the classroom. This technology, in addition to being low cost and easy to use, it also guarantees greater durability than other identification technologies, such as biometrics. [11] The process is not done fully automatically, but adopting an active use paradigm by the teacher, ensuring the reliability of the results.

The RFID readers used in the project are based on the MFRC522 chip operating at the frequency of 13.56MHz (High Frequency - HF). The reader will be placed at the entrance to each classroom, where the students will record their entry and exit, passing the card in the reader. Figure 3 shows the prototype built.

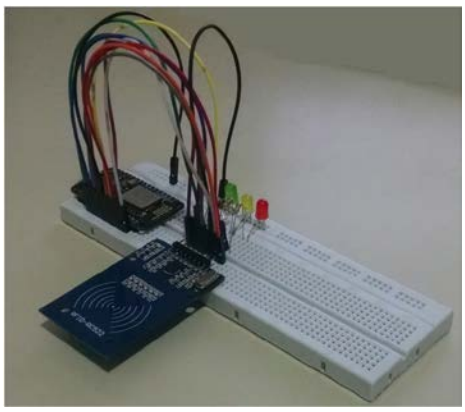

Figure 3 – Prototype of the Presence Control System

In the school environment, companies like Aghora and Haco already offer solutions that integrate the RFID tags into the school uniform and that read at great distances. These solutions aim to guarantee the reliability and total automation of the students' entrance in the school, in order to accurately inform the presence or absence of the students to the respective parents and responsible ones. These objectives, although of recognized social concern, are very difficult to achieve from a technical point of view. RFID readers with passive tags are generally unable to read at great distances, which distance is also dependent on the frequency used. Ultra-High Frequency (UHF) sensors promise distances of 1 to 12 meters [12], but use more expensive equipment. In addition to the distance involved, the angle for reading the signal, as well as the characteristics of the medium (thermal noise, architectural structures in the path of the signal causing multipath, interference of other equipment) impact on the design of the antenna installation and can impede more restrictive objectives.

IV. Conclusions

The adoption of IoT will benefit many areas of industry as well as people's daily lives. Innovation and adoption will only be possible if the devices are accessible, with an open development model and with trained professionals for this technology. As pointed out in [2], it is also necessary to worry about the impact of the IoT on the workforce with low qualification, since it can lead to the extinction of jobs, due to automation of industrial posts and of services, while the number of jobs that are generated is lower than the number of jobs that are extinct.

We hope that with the proposition of academic projects such as these, a growing number of students and technicians can benefit from IoT and further advance its adoption in Brazil.

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References

[1] N. Learner, “How the Internet of Things is Revolutionizing Healthcare”, Health IT Outcomes, 2015.

[2] F. Marques, “The Brazil of Internet of Things”, *O Brasil da Internet das Coisas*, Revista FAPESP, 2017.

[3] “Brazilian Software and Services Market 2017”, *Mercado Brasileiro de Software e Serviços 2017*, Associação Brasileira das Empresas de Software and International Data Corporation.

[4] “Internet of Things: an action plan for Brazil”, *Internet das Coisas: um plano de ação para o Brasil*, Banco Nacional de Desenvolvimento Econômico e Social, Ministério da Ciência, Tecnologia, Inovações e Comunicações, Futurecom 2017 , 2017

[5] “ESP8266 Overview”, Espressif Systems, 2017.

[6] “NodeMCU – Connect Things Easy”, NodeMcu Team, 2014.

[7] T. N. Gia et al., "IoT-based fall detection system with energy efficient sensor nodes," IEEE Nordic Circuits and Systems Conference (NORCAS), 2016.

[8] M. Swan, “Sensor Mania! The Internet of Things, Wearable Computing, Objective Metrics, and the Quantified Self 2.0”, Journal of Sensor and Actuator Networks, 2012.

[9] “Projection of the population of Brazil and of the Federation Units”, *Projeção da população do Brasil e das Unidades da Federação,*

Instituto Brasileiro de Geografia e Estatística, 2017, ww2.ibge.gov.br/apps/populacao/projecao/.

[10] M. Rodrigues, “lderly monitor at distance, with wristband and fall sensor, turn business”, *Monitorar idosos a distância, com pulseira e sensor de queda, vira negócio*, UOL Economia, 2017.

[11] X. Jia, Q. Feng, T. Fan and Q. Lei, "RFID technology and its applications in Internet of Things (IoT)", 2nd International Conference on Consumer Electronics, Communications and Networks (CECNet), 2012.

[12] R.S.G.Villar, F. Hessel, R.R.F.Dias and S.P.Baladei, “Implementing RFID in the business chain: technology at the service of excellence”, *Implementando RFID na cadeia de negócios: tecnologia a serviço da excelência*, Edipucrs, 2011.