Develop an Embedded IoT System and It’s Applications

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Abstract—The Internet of Things may be a hot topic in the society but it’s not a new concept especially in industry. In this paper, we introduce the fundamental concepts of the Internet of Things (IoT) and critical points about how we can build IoT devices. We will also explain about our newly designed IoT hub, “A-Sight” and its hardware design. In particular, we also introduce projects concerning IoT, Vegetable Production and Distribution System and Public Transportation Monitoring System.

Index Terms—internet of things, monitoring system, vegetable production and distribution system

I. INTRODUCTION

IoT shares a common agreement regarding its definition, as we could express it as the seamless integration of internet-based sensors and devices in a wide area network that interacts with a much more advanced Personal Area Network, allowing us to recognize in a much more detail manner the surrounding environment and interchange information with it, in an automatic manner. The future applications and research based on IoT will aver a profound impact on the user side, since most of its application will be in areas like domotics, health, agriculture, intelligent services, etc.

Although IoT research is in its early stage in terms of development, it represents a challenge from the ethical and technological point of view. Standardization is a major issue in IoT, different companies as well as independent organizations, have tried to solve this problem with no success so far, or with no general agreement about a single methodology [1-5].

Embedded systems are usually relatively small/medium computing platforms that are self-sufficient. Such systems consist of all the software and hardware components which are “embedded” inside the system so that complete applications can be implemented and run without the aid of other external components or resources. Usually, embedded systems are found in portable computing products such as PDAs, mobile, and smartphones as well as GPS receivers. Nevertheless, larger systems such as microwave ovens and vehicle electronics contain embedded systems. Nevertheless, here embedded systems are considered that can communicate with each other by means of a wired or wireless communication protocol, such as Zigbee, IEEE.802.11 standard, or any of its derivatives. Therefore, special attention is paid here to embedded Internet-of-Things (IoT) hardware, its design methodology, and implementation requirements. An embedded platform with such communication features can be thought of as a system that contains one or more general-purpose microprocessor or microprocessor core, a number of standard peripherals, along with a number of customized, special function co-processors, accelerators or special function engines on the same electronic board or integrated inside the same system-on-chip (SoC). Already a number of IoT manufacturers include hardware encryption and cryptography blocks in order to increase the security capability of their devices. Normally, specific blocks such as encryption/decryption and video processing engines can be attached on the embedded system’s bus and offer hardware accelerated functionality to the IoT module. An embedded and portable system that includes all of the above hardware/software modules can be thought of as a complete, standalone IoT node.

Currently, such embedded systems are implemented using advanced field programmable gate arrays (FPGAs) or other types of programmable logic devices (PLDs). Alternatively, an embedded IoT node can be implemented with ASIC/SOC logic plus a microcontroller core, but this is financially viable only for large sale volumes. For smaller volumes, or at least for designing the prototype, FPGA logic is the best solution in terms of price/functionality yield. Nowadays, FPGAs offer a very large integrated area, circuit performance, and low power capability. FPGA implementations can be seamlessly and rapidly prototyped, and the FPGA can be easily reconfigured when design updates or bug fixes are released.
II. ESPECIALLY DESIGNED IoT HARDWARE

We designed a special hardware to collect the various information of the bus in the real-time through Machine to Machine (M2M) interface automatically. M2M interface is a microcomputer with various I/O to transmit the measured data to cloud system through the 4G/LTE network. Some related technologies in order to provide the better solutions in this field are described in following.

A. Sensor Networks

The use of different specific-application designed sensors in a network array connected to a high-speed network allows information exchange among different business partners. This sensor network is the core of multiple application layers that will be built over the information provided.

B. Cloud Computing

Many current applications, from storage to Software as a Service (ASA) are using this common affordable platform in order to reduce their hardware expenses. The information retrieved from the sensor networks could be processed or stored in the cloud for future purposes.

C. Control Area Network (CAN)

The data generated by the different agriculture machines, e.g. yield of pesticides, production, etc., can be stored in the cloud as well.

The structure of the M2M interface for proposed transportation monitoring system is illustrated as shown in figure 1. The information from connecting sensors are collected in main board and transfer through the specially designed 4G/LTE shield to the cloud database.

![Fig. 1. System construction of proposed system.](image1)

We also designed and developed new IoT hardware especially for bus monitoring system [figure 2].

The specification of specially designed M2M interface is shown in Table I. The analog or digital signals can be transformed by M2M interface. And these signals will be transformed into the cloud database by 4G/LTE network.

![Fig. 2. Especially designed IoT hardware.](image2)

### TABLE I
SPECIFICATION OF SPECIALLY DESIGNED M2M INTERFACE

<table>
<thead>
<tr>
<th>Item</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microcontroller</td>
<td>ATmega2560</td>
</tr>
<tr>
<td>Operating Voltage</td>
<td>5V</td>
</tr>
<tr>
<td>Input voltage</td>
<td>24V</td>
</tr>
<tr>
<td>Digital I/O</td>
<td>54</td>
</tr>
<tr>
<td>Analog I/O</td>
<td>16</td>
</tr>
<tr>
<td>Flash Memory</td>
<td>256 KB</td>
</tr>
<tr>
<td>Network</td>
<td>4G/LTE</td>
</tr>
<tr>
<td>Size</td>
<td>112mm × 145mm</td>
</tr>
</tbody>
</table>

III. APPLICATION I: VEGETABLE PRODUCTION AND DISTRIBUTION SYSTEM

One of the biggest problems for farmers and for Japan, in general, is the fast pace growing age society. Specifically, farmers are used to pass their knowledge from generations, but the current scenario is leaving farmers with few or no generations since their kids decide to migrate to the city in order to find a working position in manufacturing companies.

This phenomenon is reducing at an alarming pace the number of young farmers putting in risk the continuity of the business. Farmers have been facing different challenges related to their business due to different reasons. In order to solve part of their problems and to create a new business platform the project “Novel nutrition-based vegetable production and distribution system” was created. The initiative of the project was to help farmers with their produce commercialization through the use of technology [7-10].

The creation of this innovative business model required the execution of different steps shown in this section. Members and their functions and interconnections are defined as a first step. A project perspective is shown in figure 3.

1) **Farmers:** In addition to representing the main project’s benefits users, farmers represent the most important information provider. The information provided is vital in order to make the project work.
2) **End users:** Although farmers are the ones that will benefit from the project, end users will be the ones taking most of the total benefits. Since the project is based on the use of the platform by end users.

3) **Restaurants:** The “Ready meal” represented here by the restaurants uses the vegetables provided by local farmers.

4) **Knowledge-based database creators:** Two (2) databases were created during the project development.

   **Nutritional requirement information:** User’s nutritional information, e.g.: user’s physical information, status information, physical condition, nutritional requirement, etc.

   **Food information:** Food/vegetable information, like: nutritional calories, traceability, seasonal information, etc.

5) **Project Integrator:** SOJO University represents the Project Integrator, meaning it will receive the different information presented previously and generate two additional databases:

   **Platform information:** User’s device details e.g.: mobile, tablet, Web, downloaded an application, etc.

   **Attribute information:** Information used in the registration procedure, e.g.: gender, age, family structure, etc.

   **Recommendation generation algorithm:** A recommendation algorithm is designed in order to correlate the different created databases previously mentioned. Its objective is to generate a recommendation to relieve the user’s symptoms based on the information provided by the user.

Because of the limited screen size on the Smartphone edition of the user interface, priority was given to the user’s information input. A high visibility and easy to navigate interface were designed with all navigation features like search from symptoms list and nutrients. Extensive use of JavaScript from the second navigation layer. For the PC version, it was designed in order to allow making an easy icon selection with a reduced directory structure. For display purposes, e.g.: food, nutrients, symptomology, etc that contains large contents a matching program was built in order to provide specific information to the user’s needs [15], [16].

**IV. APPLICATION II: IOT PUBLIC TRANSPORTATION MONITORING SYSTEM**

The current applications for environmental monitoring in urban settings, in general, rely on a small number of measurement stations placed at fixed places. Although the accuracy of the measurement equipment in these units is high, their cost effectively excludes large-scale deployment to get measurements at finer granularity [10].

For this reason, a system using a hardware capable of acting as an intermediary between the operating system and the cloud becomes more economical and faster to install, providing many advantages in the additional collection of data.

Another advantage is to improve the passenger’s experience by refining the current infrastructure in place, aiming at better scheduling and increasing bus ridership through better planning. By getting such data (e.g., waiting times, inside temperature), the performance of the bus system can be further analyzed and suggested changes to a route in order to achieve a more efficient, comfortable and sustainable urban transportation system [9].

It is believed that the use of travel planners to estimate people’s travel behavior can increase the accuracy of the travel...
behavior model in simulation systems. In terms of planning, we say that the use of online services has the potential to influence all aspects of sustainability on a number of aspects, such as collection of traveler data, collection of vehicle data, a collection of traffic data, a collection of air quality data and collection of transfer point data [11].

The system proposed in this work uses IoT (Internet of Things), making the interface of existing equipment and providing new applications. Among the functions, such as the monitoring of the timetable of the bus by the passenger and the company providing the service, one can also monitor characteristics such as: internal temperature of the bus, possible route deviations caused by unforeseen events, driver identification of the bus and insert automatically the route by means of a RFID card. An overview of the proposed system is illustrated in figure 6.

We also develop a users interface for a passenger to search bus location information. This interface allows to user search easily by inserting the bus stop information where they will ride and destination bus stop. A sample of the user interface for the smartphone is shown in figure 7.

The proposed system is also able to provide futures service such as, check the loading and unloading points, the number of passengers, the concentration of people per hour, and sex and age range of passengers, and finding the most used bus stops based on passengers selected routes information. This information also can be useful to public managers, in the case of urban planning and improvement of the quality of life in the city, as well as informing proven managers for commercial ventures and market research.

In addition to the above-mentioned features, the cost of deployment is considerably low due to the application of IoT technology compared to traditional systems in use.

V. CONCLUSION

In this paper, we explain about the development of an IoT system, which is simple to implement, and can easily connect to current hardware inside the bus, without the need of offering an upgrade, and that can be economically interesting for the bus company.

We also proposed a new IoT based public transportation monitoring system and offering new solutions, not only to monitor the vehicle on its route but also to collect additional data, which will be used to improve transportation comfort, as well as information for public and private managers for their projects.

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REFERENCES


