

A CLOUD SOLUTION FOR MONITORING ENVIRONMENTAL CONDITIONS IN A SMART UNIVERSITY

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Abstract: Certainly, in the coming years, the Internet of Things will have a great involvement in many fields, including education. Gradually, every university will need to transform its entire campus in a smart environment, which will lead to a safer and more attractive space for carrying out all specific activities. The aim of the hereby paper is to describe a simple solution for cloud storage of data that can then be processed automatically and presented to decision makers from university.

Keywords: *Internet of Things, Big Data, Arduino, Cloud, Google Drive, Google Docs*

INTRODUCTION

A smart university, in the context of Internet of Things (IoT), can be identified as an ensemble of smart subsystems, such as smart lighting, smart parking, smart tracking, smart inventory and so on, that are acting individually or together, in order to improve all activities in the campus.

With the help of hardware that runs a software program that can have a few lines of code, we can turn an object such as a classroom into a smart object. This object can automatically report the presence of students in the courses, can monitor environmental conditions and can communicate with other neighboring classrooms.

All these actions typically involve a continuous process of transitive and interpretation of data received from various sensors. Due to the large volume of data should use the cloud services, whose main purpose is to provide an Internet-based interface for the control center so that the user can access it remotely [1].

A platform can be identified as a software framework that can be used to build multiple remote service applications [2]. An IoT service developer, by using a service platform, can maximize their time and energy on the development of the specific application [3].

IOT PLATFORMS

To manage the sensor data, there are a lot of IoT platforms each with specific features. Some are free, others cost, each with various storage facilities, processing and presenting data in graphical or text form. Among them it can be mentioned the following [4], [5]:

- Azure - Microsoft Azure is a growing collection of integrated cloud services for achieving more, moving faster and saving money [6];
- IBM Bluemix - is a cloud platform as a service (PaaS) developed by IBM that supports many programming languages (including Java, Node.js, Go, PHP, Python, Ruby Sinatra, Ruby on Rails, Scala) and services (like integrated DevOps) to build, run, deploy and manage applications on the cloud [7], [8];
- Xively - formerly known as Cosm and Pachube, it offers an Internet of Things (IoT) platform as a service, business services, and partners that

enable businesses to quickly connect devices to the Internet [9], [10];

- Nimbits - is a Data Logging Service and Rule Engine Platform for connecting sensors, people and software to the cloud [11];
- ThingSpeak - offers features like real-time data collection and storage and MATLAB analytics and visualizations [12];
- Digi (formerly known as iDigi) - Combining the iDigi Device Cloud with The Social Machine enable almost any machine, anywhere in the world, to connect rapidly and easily to the Service Cloud [13];
- Sen.Se - is an open platform for Internet of Everything, not only for Internet of Things. In this platform Nature, Environments, Machines, Humans, Objects, Information, Physical and Virtual spaces all mix up, talk, interact, enrich and empower each other in all sorts of ways [14];
- SensorCloud - is a product of LORD MicroStrain Sensing Systems and allow devices to directly store their data in the cloud, and enabling a fast viewing and analyzing of data [15];
- Exosite - contains one platform and portals for cloud-based data and device management [16];
- EVERYTHING - is an IoT cloud platform that manages real-time data to drive applications using all connected products [17];
- Paraimpu - is a social platform for the Internet of Things. It is a social tool with the aim to allow people to connect, compose and share Things, Services and Devices to create personalized applications [18];
- Manybots - is a user-centric personal data hub where anyone can backup and explore his digital trace from different apps and devices [19];
- Kaa - is a 100% open-source and free to use middleware platform for rapid creation of IoT solutions [20];
- ThingWorx - is one of the most widely-adopted IoT platforms. It helps companies deliver new value via a comprehensive technology stack, groundbreaking design and runtime environment [21], [2];
- Cumulocity - is a solution based on cloud technology for the IoT / M2M (Machine to Machine) market. Cumulocity is a compound

word of 'Cumulus Cloud' ("Cloud") and 'Velocity' [22];

- GroveStreams - is one the most powerful platforms in the cloud providing near real-time decision making capabilities to millions of devices and users [23].

GOOGLE DOCS SOLUTION

Besides the aforementioned platforms, there is also the possibility to store the data in the cloud as an Excel file, so simple and much used worldwide. If the data are into a file on Google Drive, it can be draw graphics, download data on the PC and share this data with other people.

Google Drive offers the possibility of creating a Spreadsheet using Google Sheets that is a spreadsheet program that let people organize information in a tabular format. There is full support for charting, sorting, cell formatting, formulas, multiple worksheets and pivot tables [24].

In order to monitor the environmental conditions from a classroom or a particular room like a server's room, one of the simplest examples is the transmission of values temperature and humidity. To achieve this purpose it can be used an Arduino Uno board and a sensor DHT11 [25].

The data received from the sensors are transmitted by Arduino board using a Form in the appropriate Spreadsheet created earlier. Following the introduction of compulsory HTTPS connection to Google Drive, this cannot be done directly, but needed an intermediary to do the post, namely PushingBox.

The steps used are as follows [26], [27]:

1. Firstly it has made logging into a Gmail account
2. Secondly it must create of a Form
 - from Google Drive page: Select "New" -> "More" -> "Google Forms"

- create the form with TEXT type box. It can be inserted as much boxes it is needed. Then, it is named the Form and the Questions. The Questions names will be the columns names in the final Spreadsheet.

- click "Done" and the Form was created.

The form created for IT Center server room of our University is shown in Figure 1.

3. To see the Spreadsheet in that it will be published the data, it can be choose *View Responses* button

4. Finding the form's ID and those of fields where it will be sent the information

- in the URL it can be identified the formkey that it will be used in the Arduino sketch.

- normally the TEXT boxes are named entry.0.single, entry.1.single etc. The best way is to explore the HTML code to check these names.

5. Connecting to PushingBox.

- here anyone can be logged using the same Google account

- configure a service, a method, a scenario and an action

6. Writing code for Arduino board

Figure 1 Google Form for IT Center server room

Now it must upload data from sensor to the Spreadsheet with Arduino board. It can be used both the POST and the GET method to send data to the Form.

Into the sketch file that runs on Arduino board must be a code that contains something like:

```
byte server[]={213, 186, 33, 19};
char serverName[] = "api.pushingbox.com";
...
if(client.connect(serverName, 80)) {
  Serial.println("Connected");
  client.print("GET
/pushingbox?devic=v40E1BAXXD&temp=");
  client.print(temp);
  client.print("&humi=");
  client.print(humi);
  client.println(" HTTP/1.1");
  client.print("Host: ");
  client.println(serverName);
  client.println();
  client.println("User-Agent: Arduino\r\n\r\n");
  ...
}
```

After the sketch file running, the sensor values are transmitted in Spreadsheet, which will have the following form:

	A	B	C
1	Timestamp	Temperature	Humidity
357	10/4/2015 10:23:19	23	46
358	10/4/2015 10:23:32	23	47
359	10/4/2015 10:23:45	23	46
360	10/4/2015 10:23:58	22	45
361	10/4/2015 10:24:09	22	44
362	10/4/2015 10:24:23	22	43
363	10/4/2015 10:24:36	22	42
364	10/4/2015 10:24:51	22	41
365	10/4/2015 10:25:14	22	40
366	10/4/2015 10:34:55	22	38
367	10/4/2015 10:35:14	22	39
368	10/4/2015 11:13:33	22	39
369	10/4/2015 11:19:55	22	41
370	10/4/2015 11:20:27	22	39
371	10/4/2015 23:30:37	22	37

Figure 2 Data stored in the Spreadsheet

Next, in other Sheets of the Spreadsheet, it can be generated graphs that will help to analyze data.

By introducing some filters, it can be created and displayed charts for last month, last week or any period of time. For example, the following filter displays values for the last week:

=filter('Form Responses 1'!A:C, 'Form Responses 1'!A:A>now()-7)

All data and graphs generated based on them are stored in the cloud, in Google Drive, but all of them must be presented to decision makers of smart university. To achieve this, it can be created a dedicated web site with a simple interface, allowing to the authorized persons the possibility to view data and graphs, generally without the right to change data (see Figure 4).

Like the above example, the values can be processed both in the form of text and especially graphical form. Moreover, when it can be achieved a previously set breakpoints, the messages can be sent in various forms, such as classical messages or notifications by e-mail directly on the smartphone. It is also possible to operate various actuators, devices responsible for the operation of another mechanism or system.

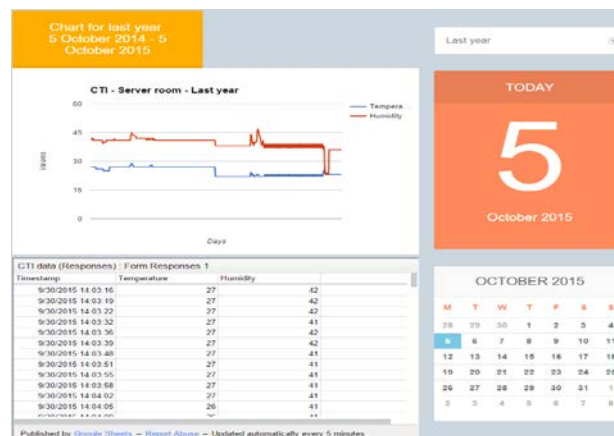


Figure 3 The web site for monitoring environmental conditions from the server room

CONCLUSIONS

Although Google Drive is not a platform dedicated to the Internet of Things, in this article I wanted to show the possibility of using it for both data storage and especially for specific charting, just by using Excel functions. Obviously the IoT platforms are much more dedicated facilities, but there may be situations in which data must be shared various users, maybe even to be modified and then the best solution is the one offered by Google Drive.

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