IBM Cloud Solutions for Home Automation

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ABSTRACT
Home automation is one realization of the Internet of things that allows us to control devices and systems at homes from different locations at any time where (Things) are connected to the internet in one way or another. Using Cloud services in HAS is not new , it provides the required platform to create applications and share different resources that help enhancing systems.

IBM has introduced a Platform as a service that have collection of solutions for Storage, Security, Data and Analytics, Mobile …etc , it provides shared resources like the required memory and necessary platforms to help individuals, Developers and organizations to create and develop their applications and run them securely on the cloud which is the core of the design in this paper.

Monitoring appliances and devices in the cloud is beneficial as it can be done from any device at any time, IBM Watson provides its services through Bluemix account where all devices and sensors can be registered and different services like Visual Recognition, Text to Speech and Speech to Text are utilized to be used in designing Home Automation System. The APIs provided by the Bluemix allow the development of applications using these services under different tools like Node-RED, and various languages such as Java , PHP, Swift, Python and others.

The System described in this paper aims to use the services provided by IBM Cloud platform in designing a Cloud-Based Automated Home, It is developed using a Node-RED instance in a Raspberry Pi that acts as the central controller at home , This integration helped in building a cloud-based system with intelligent Specifications in an easy and cost effective method.

Keywords
Cloud computing, IBM Bluemix, Home Automation, Watson Language Services, Visual Recognition, Node-RED, Internet of Things Platform

1. INTRODUCTION
Home automation basically refers to the ability of controlling and monitoring home appliances with the minimum human effort possible where devices at home are connected to the internet using various approaches. Modern advances in electronics and communications technology have led to the miniaturization and improvement of the performance of computers, sensors and networking. These changes have given rise to the development of several home automation technologies and systems [1].

Cloud Computing is an Internet-based computing that provides Computing as services rather than hardware or products where services and shared resources like memories and software are being delivered over the network using different Internet protocols [2], the support that cloud computing has given to Home Automation systems is quite huge as they provide different services such as the required storage, platforms to host the applications and real time access to devices' data.

Cloud Computing layers typically include SaaS (Software as a service) which aims to deliver web based applications to users/customers, PaaS (Platform as a service) which provides platforms for creating applications as a service and IaaS (Infrastructure as a service) and the latter offers Infrastructures and storage resources as a service like the virtual machines [2].

2. RELATED WORK
Home Automation systems like in [1] allow the user to control various appliances and lights within their home from any location in the world through Pachube cloud network using mobile devices, PCs or in-home remote controller. Pachube treats each unit in the house as a data point, These data points are manipulated to control the units inside the home.

The system overviewed in [2] Measures home conditions using sensors, Manages and controls home appliances according to the commands sent via cloud using actuators and stores sensors and cloud data for further analysis. A web application was created (using Google App Engine platform) as a cloud service to allow clients access and control home appliances remotely from their smart phones.

The Design in [6] implemented a hybrid WiHA (wireless home automation) communication architecture that can operate in both Cloud-Based Mode and in Stand- Alone Mode with minimized cost to switch between the two modes, In the Cloud-Based Mode the WSAN (wireless sensor area network) devices of the WiHA system are all connected to a kind of server in the cloud and users can monitor and control the devices through the internet during configuration as well as usage remotely. In the Stand-Alone Mode, the devices are interconnected to each other directly or through a kind of local gateway, and users can monitor and control the devices locally without any involvement of internet or cloud server.

The Design integrated a Raspberry Pi to act as the Home Gateway where all the devices were connected wirelessly to the Pi using the 6LoWPAN Technology, and The Cloud Server program runs on the Amazon AWS EC2 platform. Users (end consumers or installers) can connect to the Cloud Server or the Home Gateway directly from their UIs.

The hybrid architecture took the advantages of both modes as it simplifies the system configuration and maintenance by the Cloud-Based Mode, and reduces the security and privacy issues by the Stand-Alone Mode ,yet the response time of the wireless protocol was too big compared with practical HA system requirements which was a drawback of the design.

3. BLUEMIX

The approach in this paper was to use Bluemix Cloud services from IBM to enhance home automation systems with the integration of Cognitive Computing represented in Watson language services and machine learning algorithms of Visual Recognition service .Bluemix is The platform as a service that provides various services such as the Internet of Things Platform that allow users to register their devices and sensors in the cloud in order to send their data, monitor and control appliances at home from location and at any time, in addition to other services like visual Recognition, Watson text to speech and speech to text which were integrated in this system designed by authors.

IBM Bluemix is an open-standard cloud-based platform for creating and running applications. It supports all types of applications, web, mobile, big data, new smart devices… etc [3], it's a platform as a service (PaaS) that provides not only the environment for creating applications but also have a rich cocktail of services that ranges from services for Storage , Security ,Mobile , Data and Analytics ,Watson and many other.

Bluemix supports APIs and does not need Virtual Machine or middleware setup to run the applications, it supports multiple languages and it's layered are secured, applications can be monitored in real time, besides the user can chose the development tool and focus only on developing Apps as IBM will take care of the rest concerns such as security, it has flexible pricing and user pays for the services he/she consumes only. (Figure 1) shows the Cloud services utilized for our HAS.

IBM Bluemix Internet of Things (IoT) service provides a simple but powerful capability to interconnect different kinds of devices and applications all over the world. The secret behind the Bluemix IoT service is MQTT, the Message Queue Telemetry Transport protocol [4].

MQTT is a machine-to-machine (M2M)/ "Internet of Things" connectivity protocol. It was designed as an extremely lightweight publish/subscribe messaging transport protocol. It is useful for connections with remote locations where a small code footprint is required and/or network bandwidth is at a premium [5].

Bluemix uses MQTT to publish data on the cloud, it is a simple, lightweight, publish/subscribe messaging protocol on top of the TCP/IP protocol, It's the ideal protocol for the emerging IoT world. In general terms, the Bluemix IoT service acts as the MQTT broker, and is thus responsible for distributing messages to connected clients (devices and applications). Devices include machines that publish information they detect, and applications are the programs that consume the information received from those devices. Devices and applications communicate with the MQTT broker using the MQTT protocol, as shown in (Figure 2).

4. SYSTEM DESIGN

Home automation systems are widely adopted nowadays and various designs are being introduced using different technologies every now and then, the approach in this paper concentrates on delivering a cloud-based home automated system under the IBM Watson to benefit from the collection of services provided by its platform.

The Design mainly consists of two parts, the Home side and the Cloud side, the Home side includes the appliances to be controlled and sensors that send their data/readings to the local (main/centralized) controller which is the Raspberry Pi in our design .while the Cloud platform receives these data and delivers the services to the user helping monitoring and controlling appliances from anywhere at any time using different devices such as PCs, Smart Phones, Tablets..etc.

The home side basically has all the appliances connected to the main controller Raspberry pi B+ [7] (a credit-card-sized single-board computer developed in the UK by the Raspberry Pi Foundation it has a Broadcom BCM2835 system on a chip (SoC), which includes an ARM1176JZF-S 700 MHz, Video Core IV GPU, and 512 MB of RAM, Does not include a built-in hard disk or solid-state drive, but uses an SD card for booting and long-term storage.) ,The Pi is connected to the internet via its Ethernet port and devices (Lamp ,Fan and TV) are represented with LEDs here for simplicity in addition to the PIR sensor for motion detection.

The Cloud side is the platform that provides different services like the Internet of Things, Visual Recognition and Watson Text to Speech and Speech to Text, It provides APIs to allow users to interact with the services provided through Bluemix.

4.1 Node-RED

The applications created to monitor and control our devices were developed using Node-RED which is a visual tool for wiring together hardware devices, APIs and online service for wiring the Internet of Things [8]. Node-RED provides a browser-based flow editor that makes it easy to wire together flows using the wide range of nodes in the palette. Flows can be then deployed to the runtime in a single-click, JavaScript functions can be created within the editor using the rich text editor [9].

Node-RED is the main tool used to create the applications to monitor and control devices and PIR sensor in our application for the Internet of Things Platform and to make use of rest of the services, a stand –alone instance of Node-RED was Downloaded and configured in the Pi with various Nodes for wiring Devices and connecting services provided by Bluemix as Node-RED have a rich library to support IBM Watson Services. (Figure 3) shows Node-RED start working on the Pi.

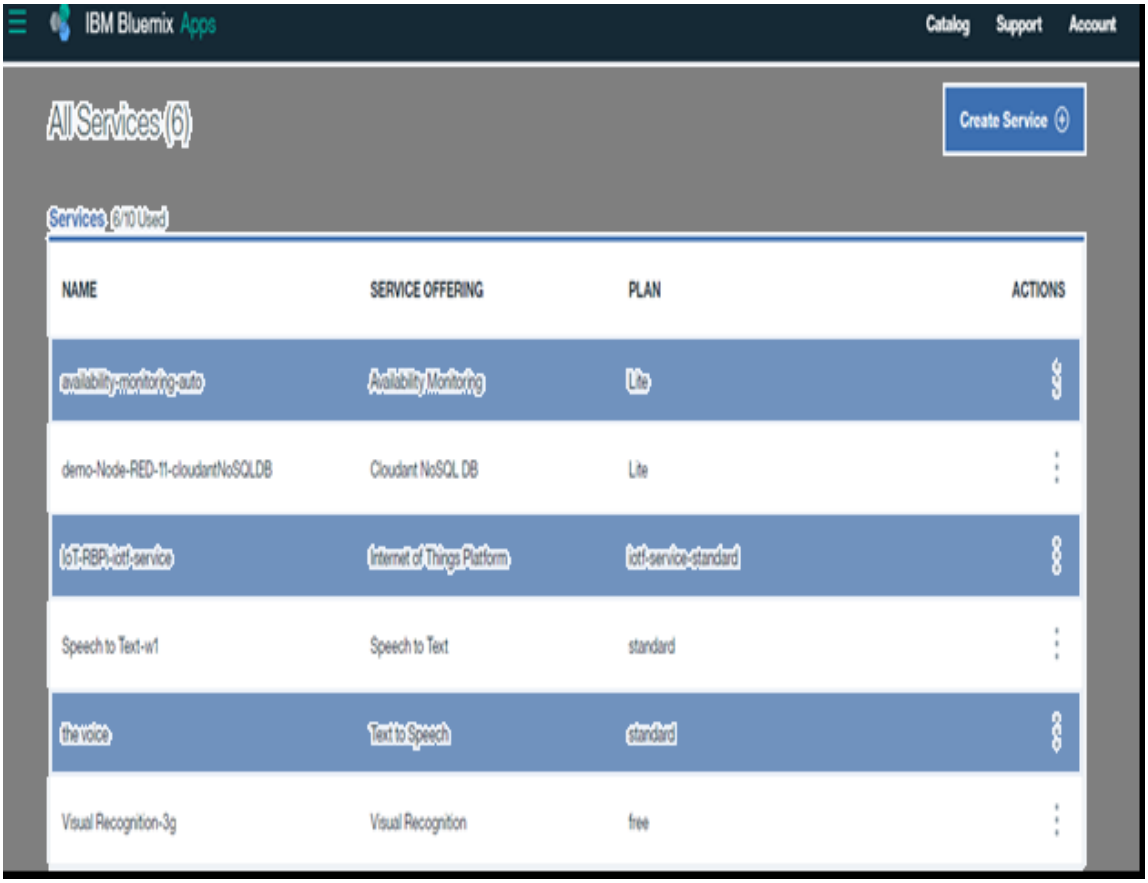


Fig 1: Some of the Cloud Services

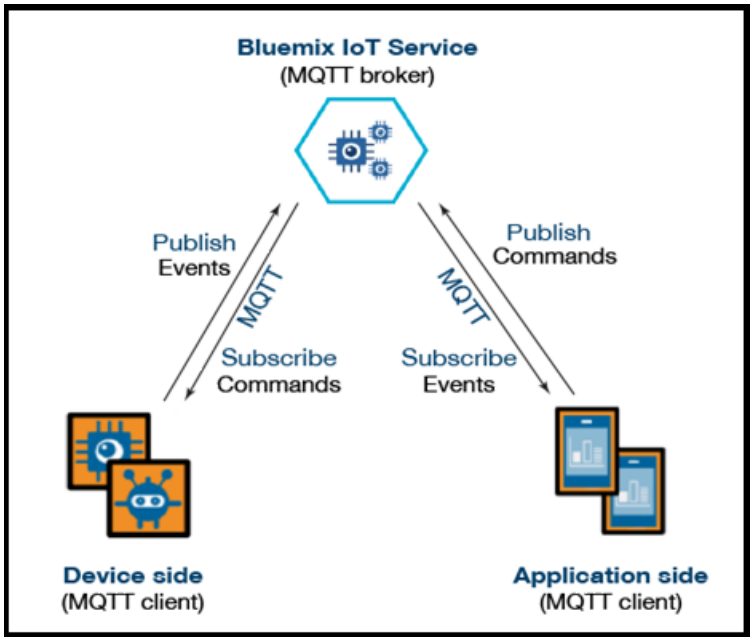


Fig 2: MQTT working principle

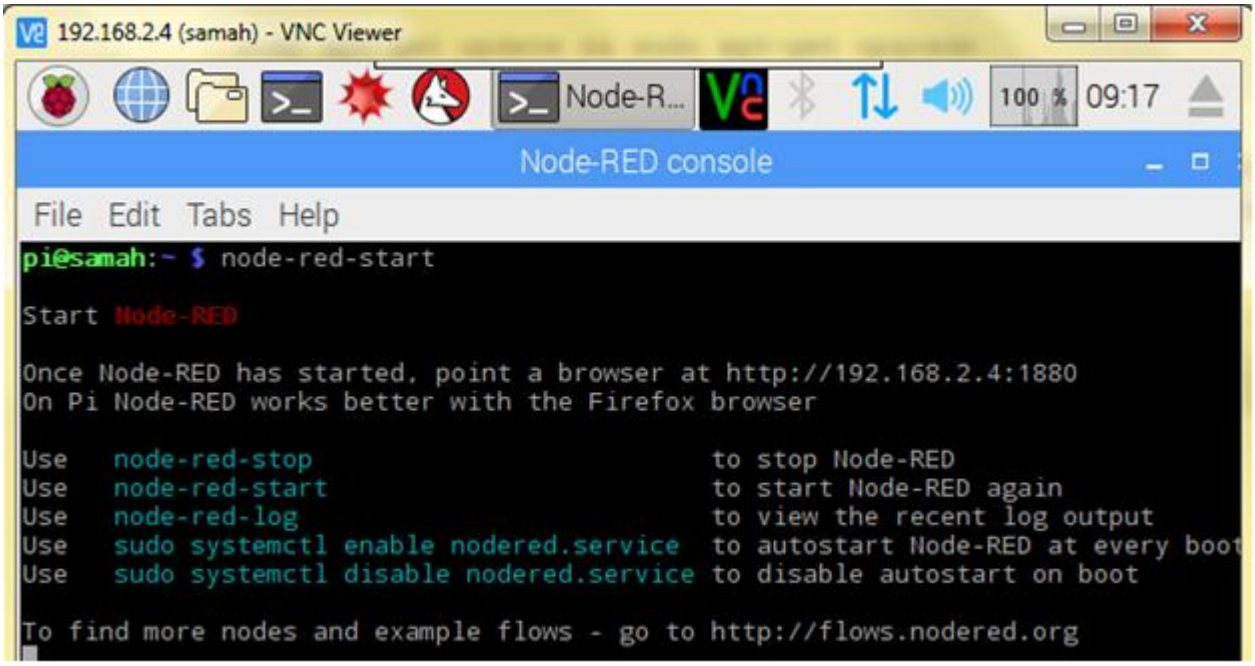


Fig 3: Node-RED starting on Pi

4.2 Internet of Things

Watson Internet of Things Platform is a fully managed, cloud-hosted service that makes it simple to derive value from Internet of Things (IoT) devices. Devices, gateways or sensors can be configured and connected to Watson IoT platform in order to retrieve and analyze the real-time data [10].

In order to send devices and sensors data to the cloud an application using Node-RED was created and connected it to Bluemix account using the credentials and API provided by the platform to allow secure connectivity.

LEDs representing the devices were connected to Raspberry Pi along with the PIR sensor as shown in (Figure 5) and the readings were sent to the cloud in real time. (Figure 6) and (Figure 7) show Pi data, and (Figure 8.a and 8.b) shows PIR sensor data in the IoT cloud platform.

The application was created using Node-RED with a user interface for monitoring and controlling appliances from different devices as Node-RED can work in any browser using the port 1880, The IP address belongs to the Pi, in the design the user interface is found in (192.168.2.4:1880/ui/#/0), (Figure 9) and (Figure 10) shows the user interface in a normal PC and in an IPhone respectively.

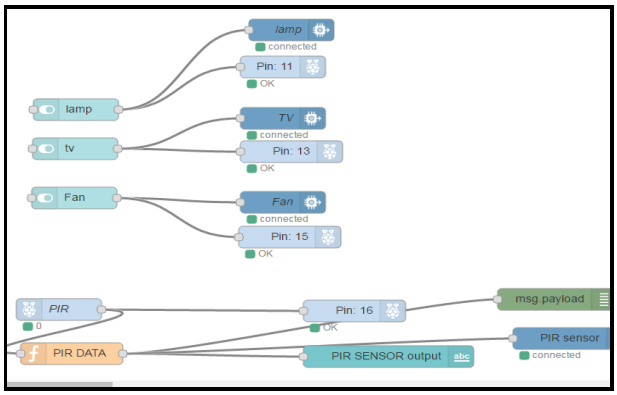


Fig 4: Devices and sensor connected to the Bluemix

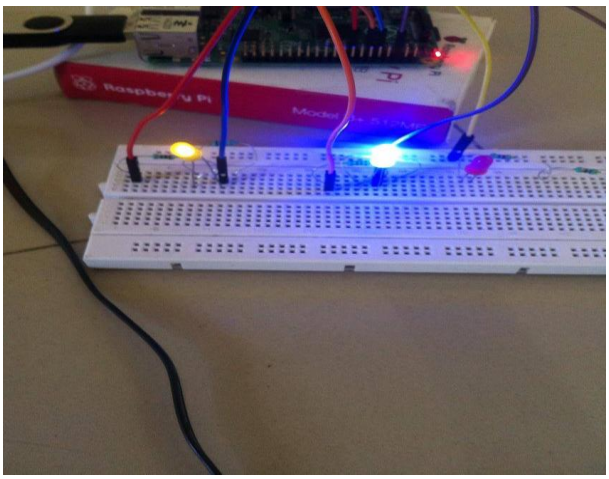
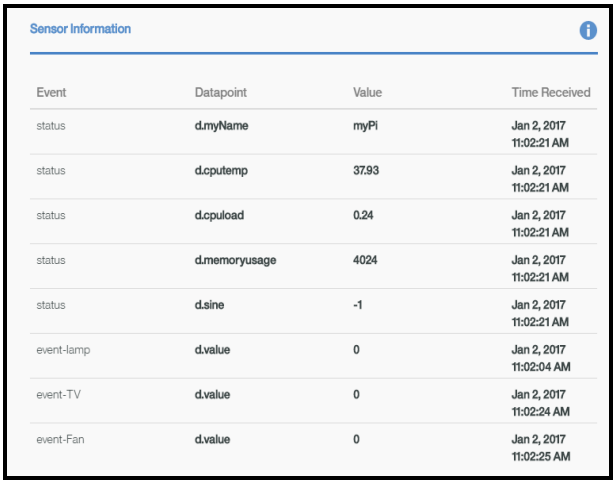


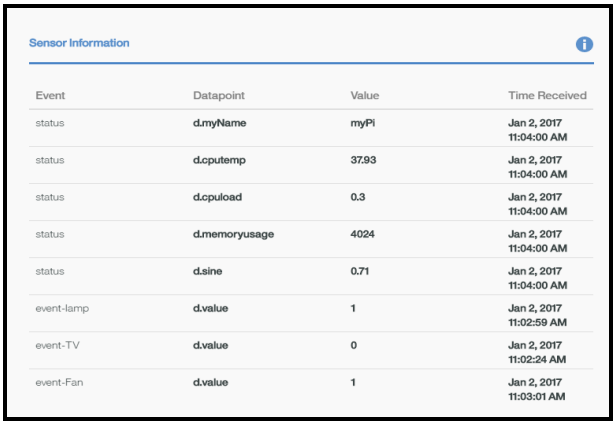
Fig 5: LEDs representing two devices connected to the Pi



Sensor Information

Event	Datapoint	Value	Time Received
status	d.myName	myPi	Jan 2, 2017 11:02:21 AM
status	d.cputemp	37.93	Jan 2, 2017 11:02:21 AM
status	d.cpuload	0.24	Jan 2, 2017 11:02:21 AM
status	d.memoryusage	4024	Jan 2, 2017 11:02:21 AM
status	d.sine	-1	Jan 2, 2017 11:02:21 AM
event-lamp	d.value	0	Jan 2, 2017 11:02:04 AM
event-TV	d.value	0	Jan 2, 2017 11:02:24 AM
event-Fan	d.value	0	Jan 2, 2017 11:02:25 AM

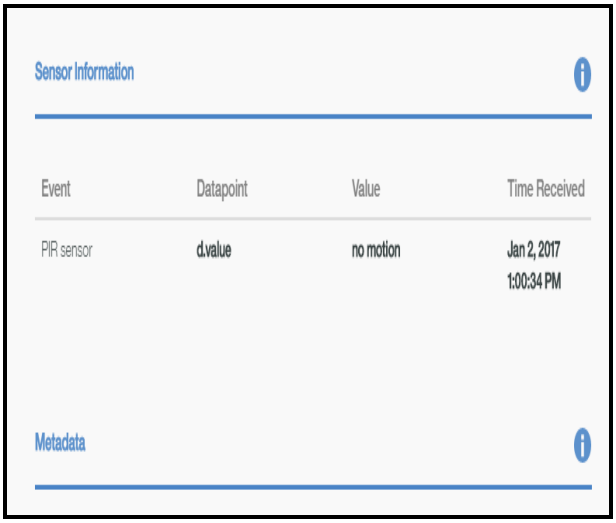
Fig 6: devices Data



Sensor Information

Event	Datapoint	Value	Time Received
status	d.myName	myPi	Jan 2, 2017 11:04:00 AM
status	d.cputemp	37.93	Jan 2, 2017 11:04:00 AM
status	d.cpuload	0.3	Jan 2, 2017 11:04:00 AM
status	d.memoryusage	4024	Jan 2, 2017 11:04:00 AM
status	d.sine	0.71	Jan 2, 2017 11:04:00 AM
event-lamp	d.value	1	Jan 2, 2017 11:02:59 AM
event-TV	d.value	0	Jan 2, 2017 11:02:24 AM
event-Fan	d.value	1	Jan 2, 2017 11:03:01 AM

Fig 7: Devices Data changing

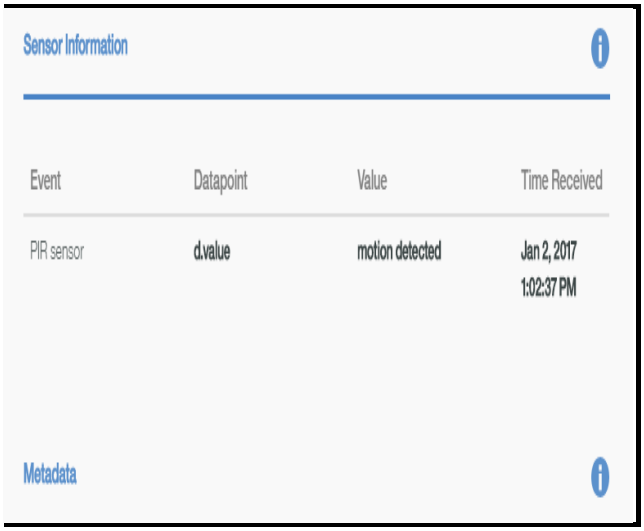


Sensor Information

Event	Datapoint	Value	Time Received
PIR sensor	d.value	no motion	Jan 2, 2017 1:00:34 PM

Metadata

Fig 8.a: PIR Sensor on Cloud



Sensor Information

Event	Datapoint	Value	Time Received
PIR sensor	d.value	motion detected	Jan 2, 2017 1:02:37 PM

Metadata

Fig 8.b: PIR Sensor on Cloud

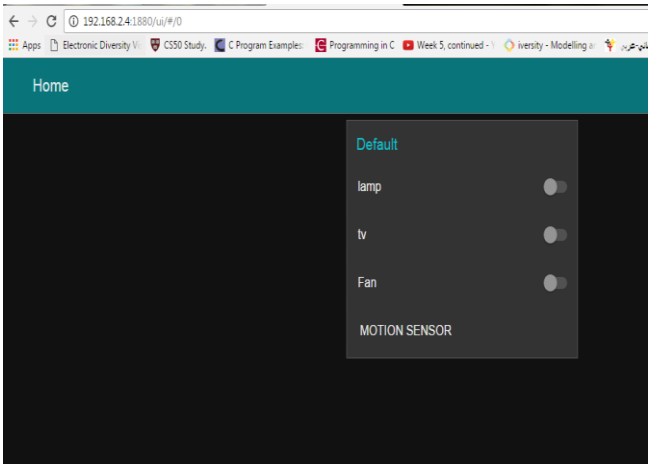


Fig 9: UI in PC

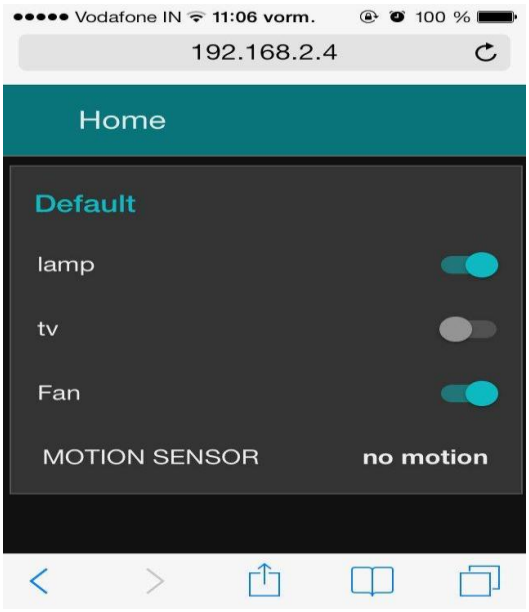


Fig 10: UI from iphone

4.3 Visual Recognition

The IBM Watson Visual Recognition for Bluemix Cloud Service allows Clients to create smart applications that perform content analysis on visual content. Using image recognition and machine learning algorithms, Clients can enrich and extract semantic meta-data from content, such as tag descriptors, faces, text, and other information within visual content [11].

The service provides API endpoints in order to perform content analysis such as the Image classification used in the current design which analyzes complex scenes and understands objects, surroundings, detect faces and predict ages of humans in photos and pictures.

In this approach a camera was connected to the Pi and programmed using Node-RED to take a picture upon the motion detected by the PIR sensor and save it to the Pi memory, the VR (Visual Recognition) Service will classify the image taken and display the result .(Figure 11) shows the Pi camera connected.

The aim is to use the VR result to monitor a child's play area or an elderly at home in order to send a spoken message if needed using Text to speech service provided by Watson IBM. (Figure 12) shows the Node-RED App created to take a picture and sends it to the VR service for classification and (Figure 13) shows classification of an image provided to the application as a test.

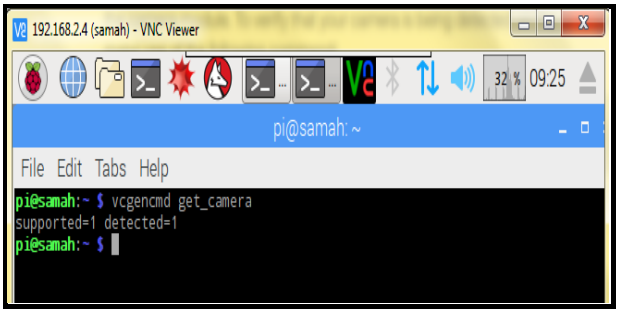


Fig 11: Pi Camera Detected

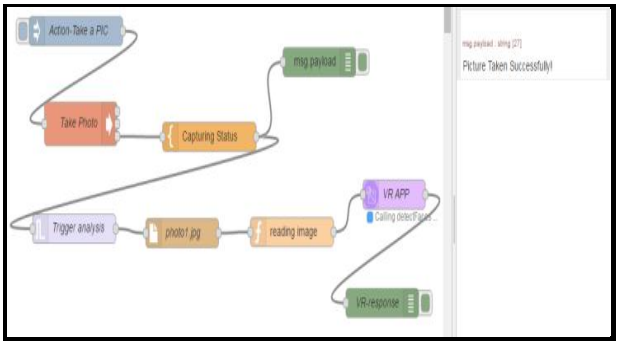


Fig 12: flow created to take picture and request VR service from Bluemix

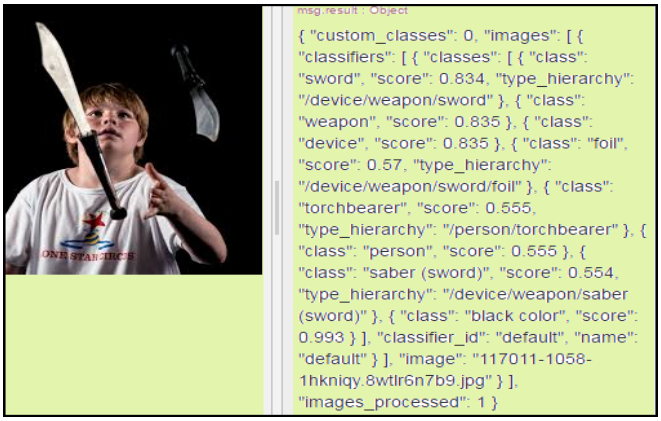


Fig 13: Picture provided for Classification

4.4 Text to Speech

The IBM Text to Speech service (T to S) provides an Application Programming Interface (API) that uses IBM's speech-synthesis capabilities to convert written text to natural-sounding speech. The service streams the results back to the client with minimal delay [12]. It offers the spoken speech in different languages and voices and delivers it in different formats too.

In the Design (T to S) was used to send a voice message to residents at home when it's necessary, relying on the results from (VR) classification and detection as the camera took a picture upon the motion detected by the PIR sensor knowing that the child has finally reached home coming from school and we need to remind him/her to take the medicine. The application created using Node-RED allows user to write the message they want to convey and converts it to a speech format to be played from the pi as it's saved in its memory as a (WAV) file. (Figure 14) shows the Text message sent to (T to S) service to be converted into a spoken speech.

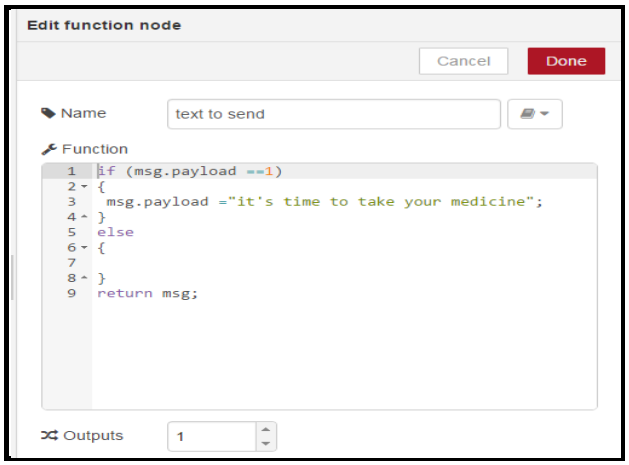


Fig 14: message sent to Text to Speech Service

4.5 Speech to Text

The IBM Speech to Text service (S to T) provides an Application Programming Interface (API) that lets you add speech transcription capabilities to your applications. To transcribe the human voice accurately, the service leverages machine intelligence to combine information about grammar and language structure with knowledge of the composition of the audio signal. The service continuously returns and retroactively updates the transcription as more speech is heard [13].

Integrating the Speech to Text in the HAS to allow residents at home to reply back or send messages to someone who is not at home when it's needed in a form of Text. The recorded voice or a direct speech via a microphone can be passed to the service in order to get the output in a Text format, a recorded file saved in the Pi memory was used in our design. (Figure 15) shows the output from (S to T) service.

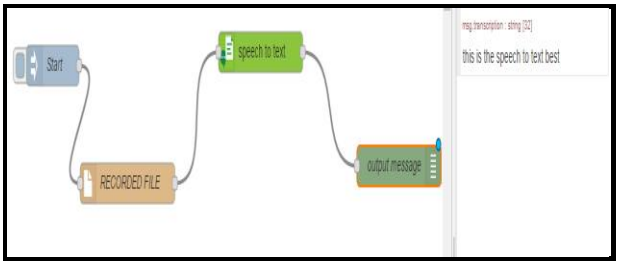


Fig 15: Speech To Text Output

5. DISCUSSION AND CONCLUSION

The System was developed as described in the paper and working properly as the user is able to monitor devices and sensors in Bluemix Cloud platform in real time from any device and at any time. The services provided by the platform are working as expected after registering The Pi as a device in the Cloud giving highly acceptable results.

The Speech to Text service output was slightly inaccurate as it depends on the quality of the recorded Voice, the record was "this is the speech to text test" and service output came as "this is the speech to text best" which is not bad giving that we are not English native speakers).

The Applications developed using Node-RED are very flexible and can be re-arranged to display more various outputs such as the Text to Speech service in which the text can be changed all the time for different speech messages .

The paper described the integration of IBM Cloud platform with Home automation systems and explained the utilization of some of the solutions provided by IBM watson , Compared to normal Home Automation Systems Text to Speech and Speech to Text needs huge effort to be implemented as user have to train the system to recognize Speech and analyze Voices ,But with IBM Watson everything is ready as a service and the machine learning is an on-going process for the system learns from every experience done by every user.

Also the Visual Recognition in Normal systems needs selecting a good Classifier and trains it to recognize Pictures, people and Objects while here all the effort is done by IBM services including the Continuous learning from every experience.

The design in this paper focused on the usage of IoT platform, Text to Speech, Speech to Text and Visual Recognition services in the Home Environment to deliver some of the Basic requirements in a Cloud-Based Automated Home, The same system can be enhanced by integrating more services from Bluemix according to the desire and need.

Bluemix offers large number of Cloud Solutions that can be utilized to fit in different designs, environments and for various requirements and that sounds just perfect as we know that the value of the Internet of Things is not in collecting data from different (Things) ,it's rather what we are going to do with the collected data..

6. ACKNOWLEDGEMENT

Authors are thankful to the Director, Bhaskarcharya Institute for Space Applications and Geo-Informatics (BISAG), Department of Science & Technology, Government of Gujarat, Gandhinagar, Gujarat, India for providing facilities to carry out this research work

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