B. TECH. PROJECT REPORT

On

Web of Things

Standardization of the sensor data across web platform using RESTful web APIs

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DISCIPLINE OF COMPUTER SCIENCE AND ENGINEERING

INDIAN INSTITUTE OF TECHNOLOGY INDORE

November 2016

Standardization of the sensor data across web platform using RESTful web APIs

A PROJECT REPORT

Submitted in partial fulfillment of the
requirements for the award of the degrees

of
BACHELOR OF TECHNOLOGY
in

COMPUTER SCIENCE & ENGINEERING

Submitted by:
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Guided by:
Dr. Abhishek Srivastava

INDIAN INSTITUTE OF TECHNOLOGY INDORE
November 2016

CANDIDATE'S DECLARATION

We hereby declare that the project entitled **"Standardization of the sensor signals across web platform using RESTful web APIs"** submitted in partial fulfillment for the award of the degree of Bachelor of Technology in 'Computer Science & Engineering' completed under the supervision of Dr. Abhishek Srivastava, Assistant Professor, Computer Science & Engineering**,** IIT Indore is an authentic work.

Further, I/we declare that I/we have not submitted this work for the award of any other degree elsewhere.

Ajay Kumar Saini **Husain Haidery**

CERTIFICATE by BTP Guide(s)

It is certified that the above statement made by the students is correct to the best of my/our knowledge.

Dr. Abhishek Srivastava

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Preface

This report on "**Standardization of the sensor signals across web platform using RESTful web APIs**" is prepared under the guidance of Dr. Abhishek Srivastava.

Through this report we have given detailed data flow in sensor network, web services and tried to explain every technology used.

We have tried to the best of our abilities and knowledge to explain the content in a lucid manner. We have also added data flow diagrams and circuits to make it more illustrative.

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Acknowledgements

We wish to thank Dr. Abhishek Srivastava for his/her/their kind support and valuable guidance.

It is his help and support, due to which we became able to complete the design and technical report.

Without his support this report would not have been possible.

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Abstract

Currently Internet Of Things is a hot topic in Computer Science Field. In this project we have tried to solve biggest issue faced by IOT application developers i.e standardizing the data provided by 'things' in IOT, this issue has been resolved by the approach of Web Of Things. To achieve this goal we have created whole fully functional sensor network based on master slave model. In this project one of WOT technologies i.e. REST has been used for providing data collected from sensor network over internet and JSON has been used to standardize collected data. With the help of REST, python Flask and MySQL technologies a proper database & linked to it a web service, have been created for analysis purposes. An application also has been developed to illustrate the importance of this collected information in an Online Virtual World(Second Life).

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Introduction :

In the larger part of the project, aim is to develop a complete data flow from sensors to Second life; an online virtual world, where data collected by sensors from real environment could be reflected in the second life. In this way, we would be able to create a replica of the real world environment into the second life. This project is one of the initiatives towards Smart-city development. By developing a proper replica of real world into virtual world, N number of experiments could be first performed inside the virtual world before actually implementing them on real projects. With the use of large amount of data from many sensors, we get a better insight of real environment behaviour making it easy for analysis. Another aspect of the project is better monitoring of places. A sensor network can provide a lot better information than a camera and monitor an area more effectively.

Our part in the project is to establish a sensor network using few sensor nodes like temperature, humidity, infrared etc. and collect data from these sensors through microcontrollers and send it to the server via BLE modules. On receiving data from sensors, APIs running on server would convert the data into standard format and make it available for the world through URLs. The second life environment would be able to access the data through the URLs to create replica of the real world environment. Further, a database and service have been developed to pull and store large amount of sensor data.

In the other part of the project, on collecting enough data on real environment behaviour, a machine learning program uses this data to build a virtual world that behaves exactly like it's real world counterpart, thus creating a proper replica of real world in second life.

Inside Second life, certain events have been created that uses data from the sensors and reflect them. As an example, a door opens and closes on detecting obstacle from actual sensor.

Study:

- Internet of Things: Internet of Things also popularly known as IOT is **integration of physical world into computer based systems.**It's a technique to provide collected information from electronic devices or 'things' across the internet which in turn can be used by different type of applications like smart homes, smart cities, smart industries etc.

- Web of Things: It is an approach to implement communication among 'things' of internet of things.It forms the base of creation of internet of things using existing web technologies like **REST**, SOAP, HTTP etc. and standard data interchange formats like JSON and XML.

- Sensor Network: A sensor network comprises a group of tiny, typically battery-powered devices and wireless infrastructure that monitor and record conditions in any number of environments. The sensor network connects to the Internet, an enterprise WAN or LAN, or a specialized industrial network so that collected data can be transmitted to back-end systems for analysis and used in applications.

  In this case a type of LAN have been created using BLE modules which are available at each sensor nodes and Server Node. Server Node comprises of Raspberry Pi 3 and a power source. Server Node communicates with each of sensor nodes via BLE.

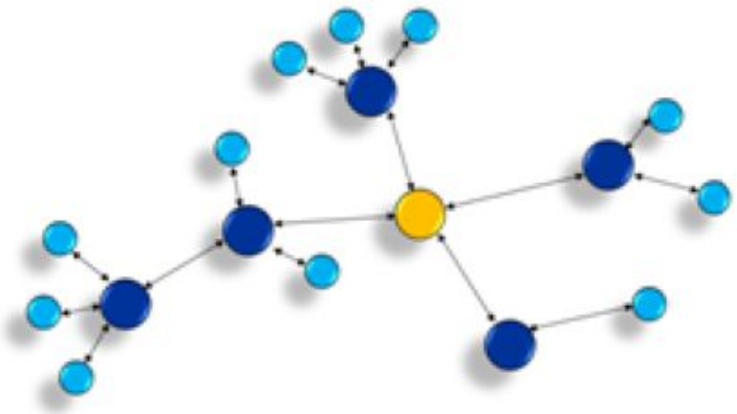

Figure 1: Sensor Network

- Sensor Node: A sensor node is a node in a sensor network that is capable of performing some processing, gathering sensory information and communicating with other connected nodes in the network.

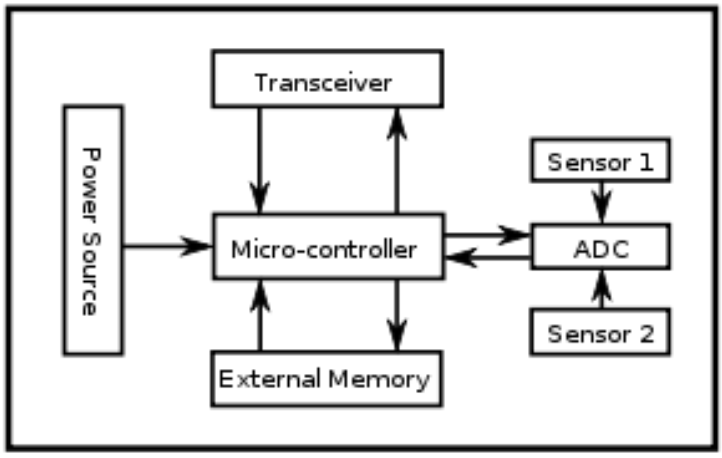

Figure 2: Sensor Node

In this case it consists of a microcontroller(Arduino), a BLE module as transceiver, power source and sensor/s(Temperature and humidity, infrared, flame).Microcontroller is used to fetch the data from sensor/s and write it on the BLE module. In turn, BLE module broadcasts the data and any device with mac address of this BLE can read the data.

Following sensor nodes have been developed:

- Temperature and Humidity Sensor node.
- Infrared Sensor Node.
- Flame Sensor Node.

- Web Service: A Web service is a service offered by an electronic device to another electronic device, communicating with each other via the World Wide Web.In this particular case we have used REST.

A web service is a program located on a web server. To communicate with it, a RESTful web service provides a URL, and uses standard formats like JSON and XML to transfer data. Using URLs data can be transferred between clients and web services. A web service is also

attached to database, thus, by hitting URLs data can be fetched from or put into a database using web service.

Figure 3: Web service flow

- Second Life: Second Life is an online virtual world. In many ways, Second Life is similar to MMORPGs (Massively Multiplayer Online Role Playing Games). Second Life users (also called Residents) create virtual representations of themselves, called avatars and are able to interact with other avatars, places or objects.

  Any resident in Second life is able to buy land and construct arbitrary objects which can be further modified and coded to perform actions similar to that of real life. To write code in Second life, Linden scripting language(LSL) is used. Every code in second life needs to be attached to some object.

  Second life provides many APIs which can be used to create objects that are able to behave just like they would in second life. Also Second life lets user pull data from outside and use in the virtual world. In this way, a proper replica of real environment can be developed in Second life.

- Communication protocol : A communication protocol plays the key role in the concept of Internet of Things. It is because of communication protocols that wireless transmission of data among sensors and servers in possible. Various protocols are being used today, some of which are Bluetooth low energy(BLE), Zigbee, Wifi etc. As part of this project BLE will be used for serving the purpose.

- Bluetooth Low Energy 4.1 : Bluetooth low energy (Bluetooth LE, BLE) is a wireless personal area network technology. Compared to Classic Bluetooth, Bluetooth Smart is intended to provide considerably reduced power consumption and cost while maintaining a similar communication range.

Concept Design:

Elements:

1. Server on Raspberry Pi that receives data over BLE.
2. Sensor nodes with Arduino and following sensors separately:
    - Temperature + Humidity
    - Infrared
    - Flame

   connected via BLE to the server.
3. APIs running on server to convert data.
4. URLs to fetch standardized sensor data.
5. Service on Client's computer to fetch & store data into database.
6. Database on Client's computer.
7. Web service for second life to receive data from client.
8. Adaptation of sensors' output into virtual world-Second life.

Design :

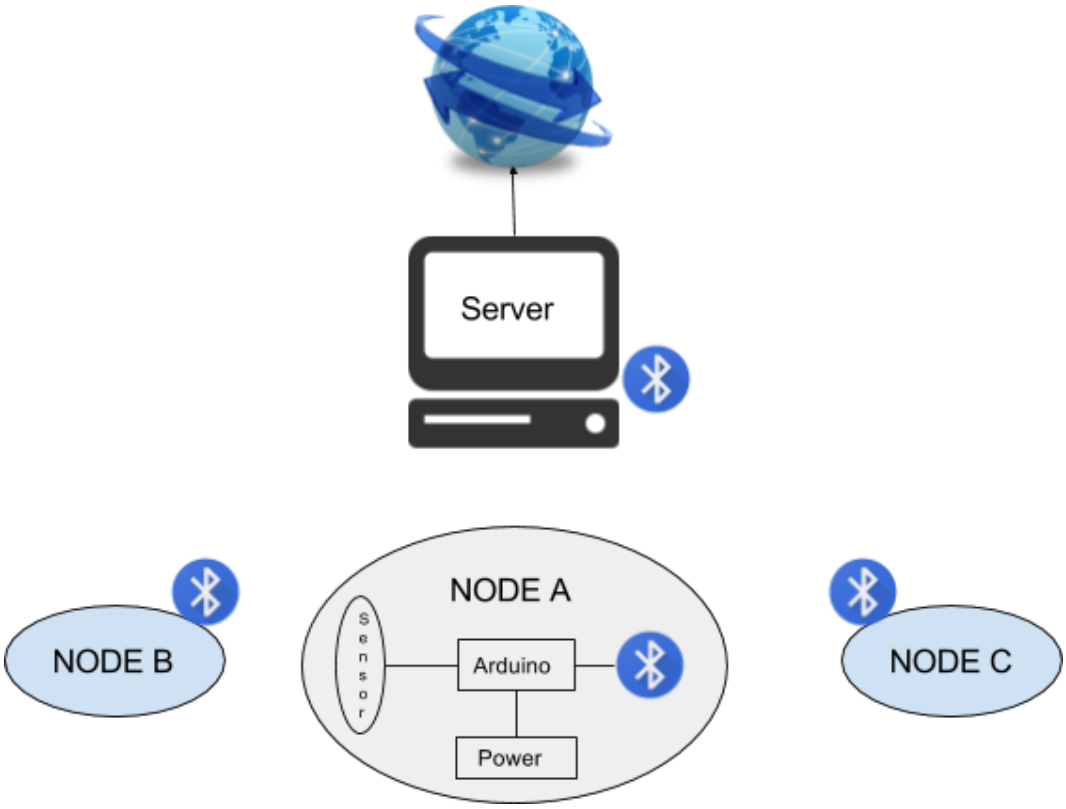

Figure 4: Sensor Network architecture

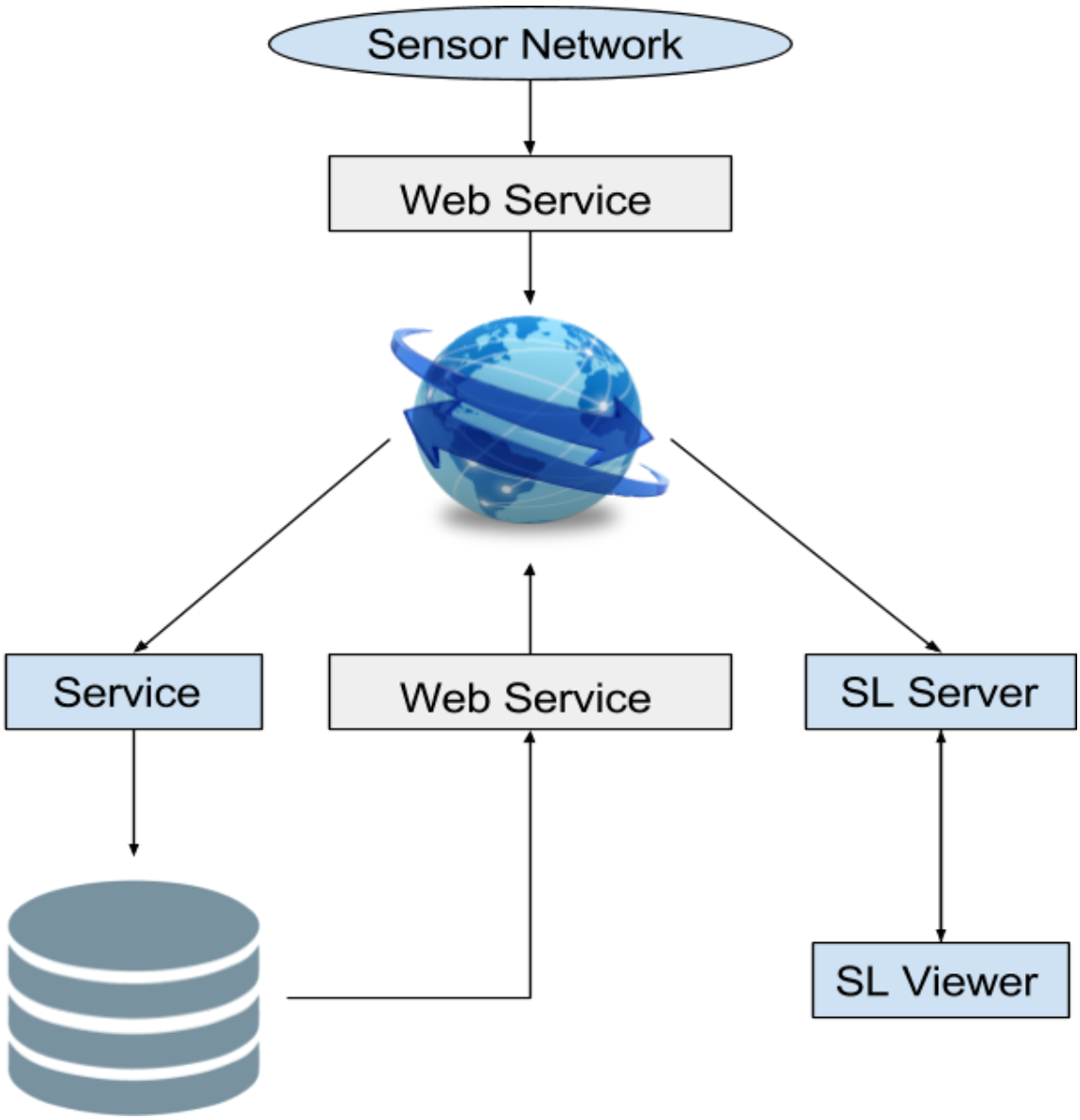

Figure 5: **Complete flow of the project**

Implementation:

- **Sensor Network:**

Complete sensor Network is consisted of one sensor master node and three slave sensor nodes. Each slave sensor node consist of 8-Atmega 8 **microcontroller**, BLE 4.1 **transceiver, sensor** (humidity and temperature/ infrared/flame) and a **power source** (of power 3.3V or 5.5V).Following is the circuit diagram of slave sensor node.

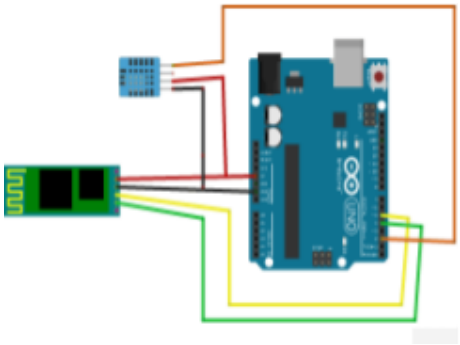

Figure 6 : Circuit design of a Sensor node

Master Node consists of **Raspberry Pi 3.0** and a **power source**.Raspberry Pi 3.0 have inbuilt BLE 4.1 **transceiver** and **wifi adapter**.

Raspberry Pi works on **Raspbian** operating system which is linux based operating system.

Slave sensor node's microcontroller is programmed in such a way that it reads from the sensors and write the data after some manipulations on the BLE buffer every two seconds, In turn BLE broadcasts buffer data to every device it is connected to.Following is an example of data sent by these sensors:

Master Sensor node's Raspberry Pi have a web service (see next section) running in python environment which receive the data broadcasted by slave sensor nodes using inbuilt BLE.

- **Web Service on Pi :**

A RESTful web service has been developed on Raspberry Pi which acts as a middleman between sensor network and outside world. If sensor nodes were directly exposed to data-seeking devices there would be high chances of chaos and issues of

standardization. Say, for ‘m’ sensor nodes and ‘n’ number of clients, we would need m*n connections to provide all the sensor data to clients. Secondly, sensor data format may not be compatible with all the clients.

Thus, putting a web service in the middle simplifies communication of sensor network with the outside world. In our implementation, we use Python web framework - Flask to develop our web service. The Flask web service runs on Raspberry Pi.

The web service comprises of multiple functions which return sensor data on demand by the client. Each of the functions are bound with a unique route(URL), by calling these URLs clients can receive sensor data in a standardized form, here we use JSON format to return data. JSON is a simple data interchange format widely used. As a client calls a URL, the code bound with it is run. Consequently, connection request is made to all the concerned sensor nodes, all the available nodes provide their data to the server via BLE, and the resultant data is returned to clients in JSON format

One example of client-server communication :

Target URL - 110.224.206.190:5000/all_data

JSON Response from service -

{ “H” : “30”,
“T” : “27”,
“Flame” : “1”,
“Infrared” : “0” }

Following URL extensions have been created to access sensor data -

- /all_data
- /temp_humidity
- /infrared
- /flame

- **Database & service**

The future of project lies in automation of the virtual environment which will be achieved through machine learning techniques.These techniques require huge data set of

real environment sensor data for testing purposes.Keeping this in mind a database has been designed and a service is used to interact to the database.

MySQL database server has been used which runs on localhost at port no 3306.Snippet of database schema of **sensor_data** table :

sensor_data	
id	Integer
time	Timestamp
humidity	Double
temperature	Double
flame	Boolean
infrared	Boolean

Service pull the sensor data from webservice hosted at Raspberry PI in sensor Network every five seconds in json format by creating a GET requests to target URL "110.224.206.190:5000/all_data".After getting sensor data it divides data in corresponding sensor local variables, accesses the database and insert the sensor data to corresponding database column of **sensor_data** table.

- **Web service for second life:**

  Second life is a virtual online world hosted by Linden Labs.Linden Labs provide second life viewer to clients to explore this virtual world.To create any changes in second life world we have to write the code in second life viewer provided code editor and send

this code to Second life server, In turn second life server compile this code and send the response back to second life viewer.

For initial phase of this project we need latest sensor data to adopt real world environment in second life(see next section).Since Second Life server is hosted at Linden

Labs (San Francisco) it needs to access latest sensor data which is in database(hosted at client side).

To resolve this problem we have hosted a web service at client side which takes latest sensor data (only temperature and humidity for now) from database and provides it online in string response to any web client which accesses this target URL : "client_side_public_ip:5001/temp_humid".

Temperature : 26.0 Humidity : 31.0

- **Adaptation of Sensor data inside Second Life:**

  Second life, to pull data from outside world, uses URLs, and URLs in response return data to second life. This data is then used to associate with objects in second life. Each object in second life can be independently linked to a dataset from outside world. To show how data is pulled and adapted inside second life, we have used data from Infrared sensor and created a simple door in second life that opens when infrared sensor senses obstacle and closes when removed. A URL is specifically associated with the door which pulls data from the sensor, which returns '1' when it detects obstacle or '0' otherwise. The URL is called at fixed intervals automatically to get the latest data. Also, a display has been developed in virtual world to show the current temperature and humidity of real environment.

Conclusions:

- A sensor network has been developed to monitor environment.
- The information collected from sensors has been completely standardized into lightweight data-interchange JSON format and web services have been deployed to provide URLs to access this information.
- The information has been stored in database at client's computer for futuristic analytic purposes.
- The information collected from sensors has been adopted/reflected in virtual online world (second life) to provide a glimpse of future work.

Scope for future work:

- The RESTful APIs developed during the project would create the base for the larger project of development of an intelligent virtual environment inside Second life & Smart-home/Smart-city projects.
- By adding more sensors to the existing sensor network, better insight can be drawn on the behaviour of an area/real environment.

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