Software Proposal
for
Enhancing Indoor IOT Network Design to support energy Saving

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Abstract

Internet of Things (IOT), is defined as group of devices that are embedded with electronics, sensors and software allowing them to be connected to the internet and receives or sends data. It is widely considered as the future of technology and electronics. There is an increase in power consumption regardless of the carbon footprint resulting from generating electricity. We should be more socially conscious of our choices, with every device we should do our best to minimize our consumption. In this project we aim to find the best indoor placement for several IOT devices by measuring power consumption depending on many features such as the average power consumption of each device, network hops per node and battery voltage of each device and using the measurements to train the system to recommend the best model with the lowest power consumption.

1 Introduction

1.1 Background

The rate of power consumption allover the globe has been increasing lately .According to statistics done by the IEA (international energy agency) the power consumption in the world has increased from 2000 to 2015 from 2,384,207 Kwph to 3,127,361 Kwph.Therefore saving power is something the whole world cares about nowadays and one of the aspects causing higher power consumption in the huge increase of the number of IOT devices as it's stated on Statistica that the number of IOT devices has increased since 2015 from 15.41 billion to 23.14 billion and it's expected for their number to reach 75.44 billion by 2025. Basically one of the aspects leading to high power consumption of IOT devices is their misplacement as they are not always positioned in the optimum way.

In this paper we propose a system that takes the historical data of the the IOT devices such as: their range and power consumption, etc. Using Random Forest, which produces a trained model. An image of the floormap of a room will be processed then enter this model. The output should be a number of possible placement of the devices along with the percentage of their power consumption, the one with the least percentage will be chosen.

1.2 Motivation

The main market motivation behind our idea is the continuous increase of deployment of IOT devices worldwide.In Figure 1, we can see that in 2017 the number of IOT devices was 20.35 Billions. by 2025 and it's expected to reach 75.44 Billion Connected devices. In some of these devices, changing the batteries is not easy and can't be done frequently so we need to be able to extend the battery life of the devices. Moreover still to this day a lot of countries face many problems with providing electrical power to growing populations. So saving Power is highly demanded.

Figure 1: Number of IOT devices over the years

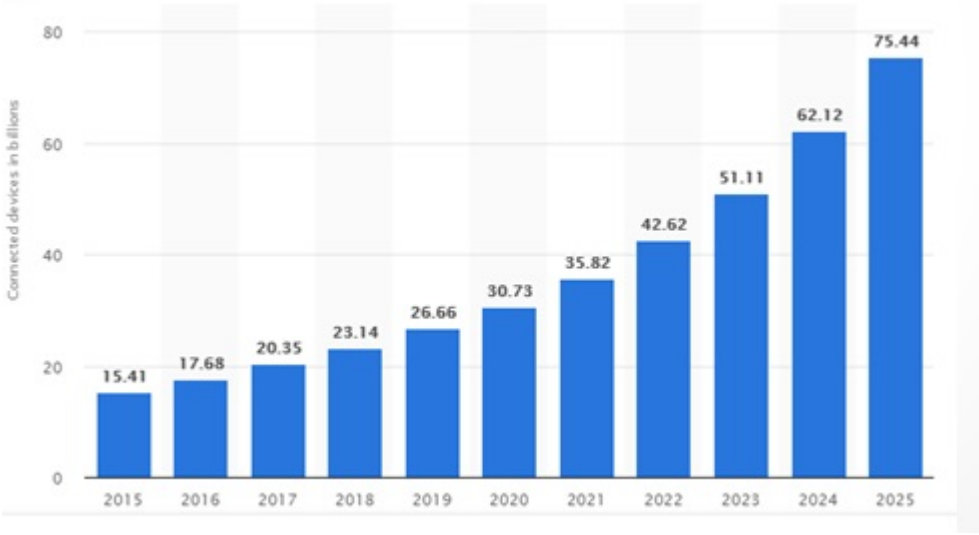


Figure 2: Total World Power Consumption 1970-2014

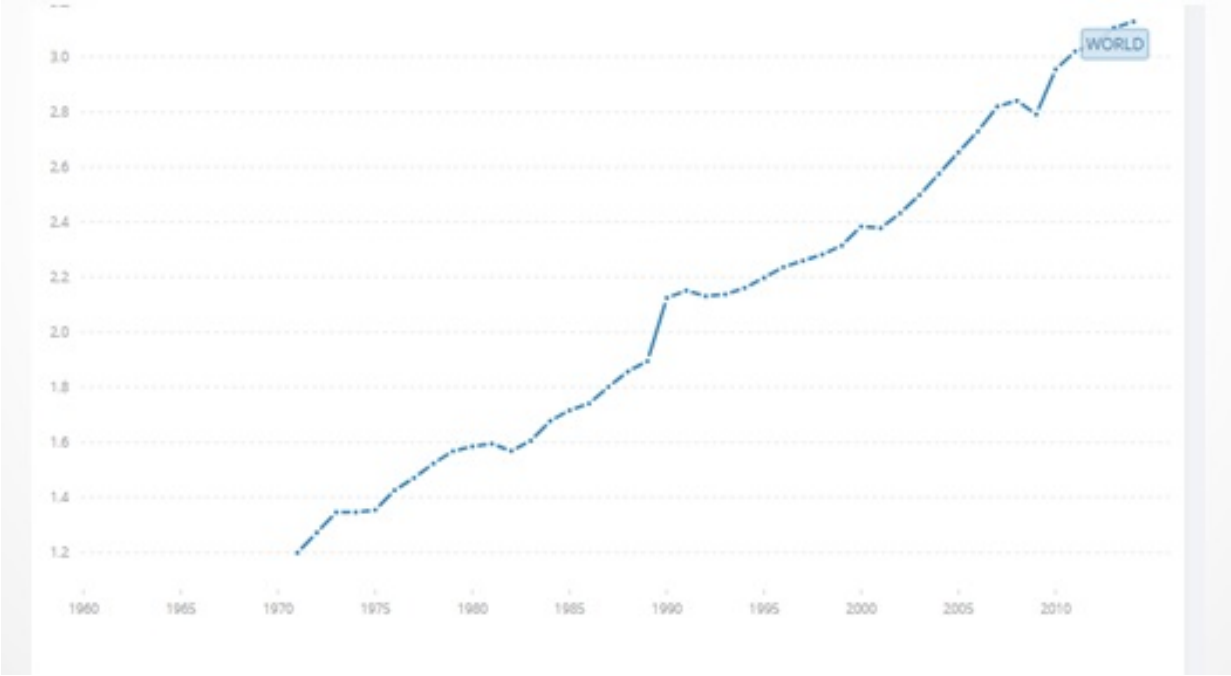
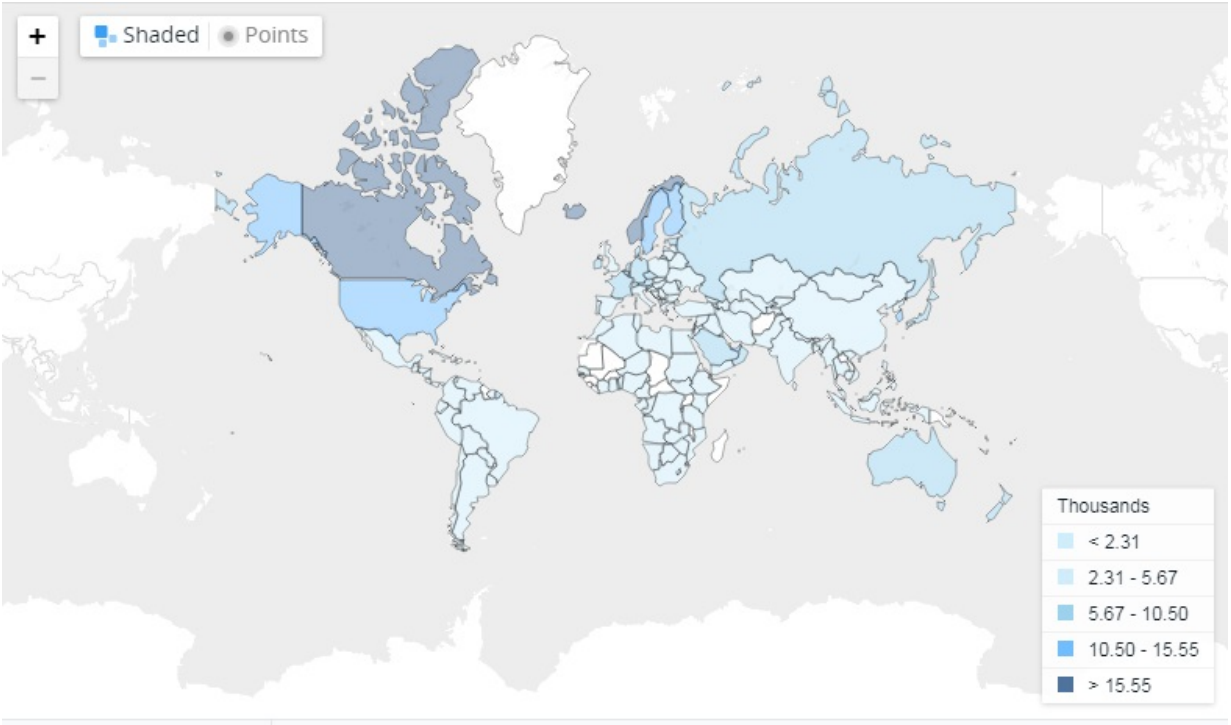


Figure 3: Map of Power Consuming Countries 1970-2014



We also conducted a survey on the importance of IOT devices and their power consumption. The majority of the applicants agreed on their growing importance. While they were almost unanimous on the importance of becoming more energy aware.

1.3 Problem Definition

the problem we discuss in this paper in the misplacement of indoor IOT devices could cause different issues such as: overlapping of their ranges, unnecessary long distance between devices causing the data to travel more, poor coverage, etc. These issues cause the devices to put on more work to overcome these challenges, which may lead to a higher power consumption. Moreover, as the number of IOT devices increase this will this issue will become more prominent and it's effect will be more visible.

2 Project Description

2.1 Objective

Indoor usage of IOT devices is increasing rapidly. Despite it's importance, there is not much care for their placement. Even though, improper positioning could lead to an overlapping of their transmission ranges and cause some devices to have almost no effect.or a huge waste on energy by trying to work more to overcome this overlapping. The main purpose of this system is to ensure that the indoor, corner, installed connected IOT devices are working within their maximum capacity while conserving energy and being eco-friendly at the same time. and to ensure that all regions are covered with minimum interference.

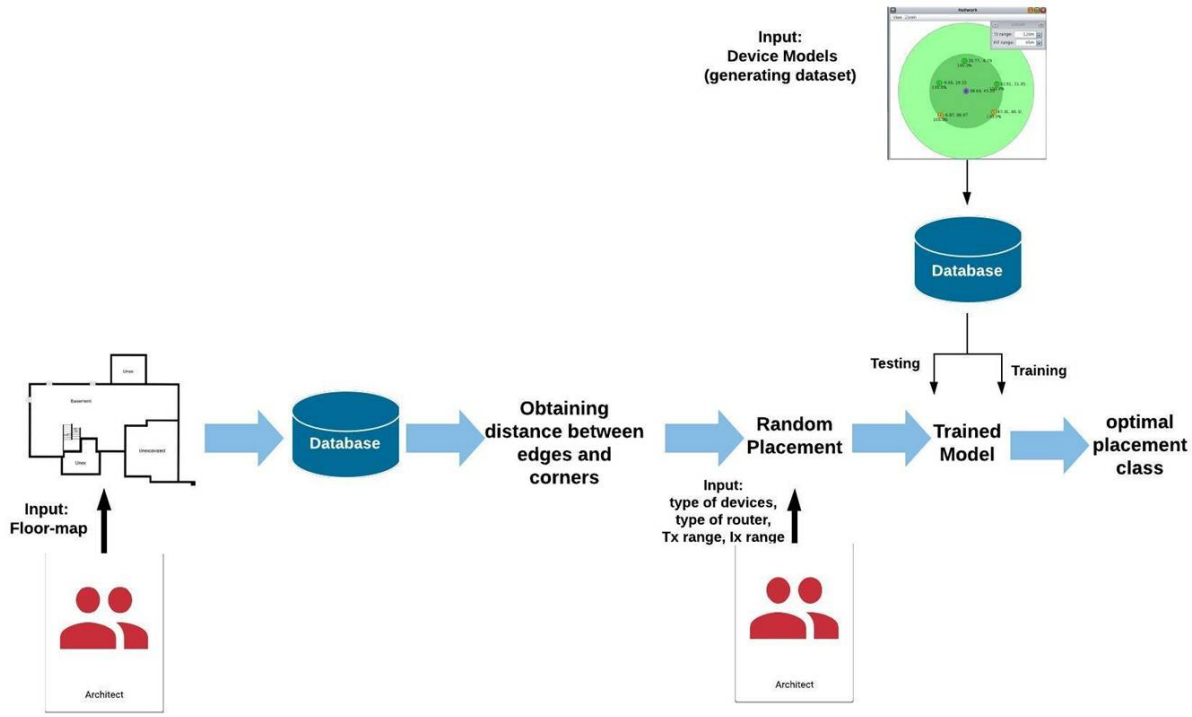
2.2 Scope

1. the system will give the optimal corner placement of the given IOT devices with the least power consumption.

2. extended battery life of IOT devices.

2.3 Project Overview

System Overview



First, the historical data of the devices such as:(Distance, Transmission range, Interference range, etc.) will be obtained from the simulator. the data will then enter the classifier to produce a trained model.
An image of the floormap of the building will be processed through multiple algorithm to get the edges and corners and eventually obtain placement locations .
The image will then enter the trained model and the output will be the different possible placements of the IOT devices and the percentage of power consumed by each placement.

3 Similar System Information

1. Wi-Fi Based Indoor Location Positioning Employing Random Forest Classifier
   (a) Researchers had written this paper to accurately estimate the position of people and track them to be used in Location Based services.
   (b) The main problem was the inaccuracy of indoor positioning systems.
   (c) They proposed implement an indoor localization system based on radio frequency.
   (d) Their system used Random Forest classifier and resulted in an accuracy of 91% .
   (e) this paper is important because discusses the idea of indoor positioning and localization using Random Forest.
2. Modified Random Forest algorithm for Wi-Fi Indoor Localization System
   (a) Researchers had written this paper to accurately estimate the position of people and track them to be used in Location Based services.
   (b) The main problem was the inaccuracy of indoor positioning systems.
   (c) They proposed implement an indoor localization system based on radio frequency.
   (d) Their system used Random Forest classifier and resulted in an accuracy of 91% .
   (e) this paper is important because discusses the idea of indoor positioning and localization using Random Forest.
3. SpinLight: A High Accuracy and Robust Light Positioning System for Indoor Applications
   (a) Researchers had written this paper to tackle The problem of building an effective Indoor Positioning System.

(b) The main problem with indoor localization is that there is no GPS signal accessible inside the buildings. And that,a greater accuracy is usually required indoor than outdoor where even a small localization error may lead to a completely different localization results.

(c) They describe a solution that is based on the existing Wi-Fi infrastructure of a building. This solution will relay on the fingerprint approach..

(d) They were able to improve the localization accuracy over the accuracy of our reference model LRF that was build by straightforward application of Random Forest technique. The horizontal accuracy gains are about 5% to 9% when looking at the mean horizontal error.

(e) this paper is important because it uses random forest in indoor localization.

4. Justification of the Choice of Neural Networks Learning Algorithms for Indoor Mobile Positioning

(a) Researchers have written this paper to examine the main issues related to the creation of complex programs for indoor mobile navigation using neural networks.

(b) The main problem was that the GPS either doesn't work indoors or provide location data with a very high error of about 100-150 meters.

(c) They proposed a system may work on the mobile devices as well as on desktop computers.

(d) The result was a navigation software package that uses the model ANN

(e) This paper is important because it discusses the idea of indoor navigation using ANN (Artificial Neural Network).

5. Poster Abstract: Recommendation-based Smart Indoor Navigation

(a) Researchers have written this paper to help design an accurate user specific indoor behaviour model.

(b) The main problem is that In outdoor spaces, we only have GPS signal,Most of the times, mobile user localization is achieved by WiFi routers. Merchandise, equipment, and packages are tracked by RFID tags.

(c) They proposed a system that could give the user recommendations for indoor navigation based on Recurrent neural network.

(d) The result was a recommendation for best indoor navigation for each user.

(e) This paper is important because it works on the idea of giving recommendations using neural network.

6. Characterizing and Modeling the Impact of Wireless Signal Strength on Smart-phone Battery Drain

   (a) Researchers have written this paper to recognize and improve the services of cellular network and their battery life and help to construct more accurate online power models for smart phones.

   (b) The main problem is how the many cell phone users experience frequent poor signal strength, and how negatively it could impact the battery.

   (c) They have performed the first measurement study of 3G and WiFi signal strength experienced by a large number (3785) of smart phone users over 1 to 19 months of daily usage.

   (d) The result that smart phone users are routinely experiencing significant 3G and WiFi signal variations during daily active phone usage. The 3785 users on which the study was conducted, had 43% and 21% of their data sent in the time of poor 3G and WiFi signal strength, respectively.

   (e) This paper is important because it investigates how the strength of the signal affect the battery life of mobile phones.

7. Poster: Twirl: On the Benefits of Adapting Orientation of a WiFi Access-Point

   (a) Researchers have written this paper due to the impact that The position of a wireless access point (AP) in wireless networks has on the execution of the network especially indoor wise.

   (b) The main problem is how poorly the network performs as a consequence of poor placement of wifi's access point.

   (c) They have performed experiments on the performance of the network, in different places with different antenna angles.

   (d) This paper is important because it shows how adjusting the right placement of the antenna could positively affect the indoor performance of the network.

8. Measuring Sensor to Cloud Energy Consumption

   (a) Researchers have written this paper to measure energy consumption of two iot sensor nodes sending on cloud.

   (b) The main problem is that connecting iot sensor nodes wired or wireless could affect the power consumption as the wireless connection consumes more power than powered.

   (c) The paper tends to measure the energy consumption on both wired network and wireless network on an actual IoT implementation before proposes an energy saving solution

(d) The experiment in this paper proved that connecting iot devices sensor nodes a wireless connection consumes more power than wired connection.

(e) This paper is important because it investigates how the strength of the signal affect the battery life of mobile phones.

9. On the Maximum Movement of Random Sensors for Coverage and Interference on a Line

   (a) Researchers have written this paper to discuss the reallocation of nodes in a network an making it more time efficient.

   (b) The main problem is that every device has a range. If the distance between two adjacent devices is less than the range of one of them, this causes interference.

   (c) Researchers focused on the issue of making the displacement of the sensors more time-efficient.

   (d) The paper drives equations that gives the minimal maximum allocation of the nodes, without causing interference.

   (e) This paper is important because it considers the importance of not letting the sensors ranges overlap.

10. Positioning sensor nodes and smart devices for multimedia data transmission in wireless sensor and mobile P2P networks

    (a) Researchers have written this paper to propose a new positioning scheme for sensor nodes considering holes in wireless sensor and mobile P2P network environments.

    (b) The main problem is that existing positioning schemes do not consider network holes that can occur in real application areas, thereby causing many errors during positioning.

    (c) Researchers focused on hole detection by propagation for hole boundary node detection then estimating the distance by searching neighbours then correcting distance to reduce errors.

    (d) The paper proposed a positioning scheme for WSN and mobile P2P network environments. In the proposed scheme, holes were detected based on neighboring node density when holes were present in a network.

    (e) This paper is important to us because it helps reducing errors during sensor node positioning.

11. Low-Power, Long-Range,High-Data Transmission Using Wi-Fi and LoRa

    (a) Researchers have written this paper to offer a communication between low-power and long-range IOT devices and to reduce power consumption of this kind of transmission focusing small amount of data.

(b) The problem is high power transmission between IOT devices and lack of communication between IOT devices

(c) Researchers worked on creating an environment for IOT devices, designed and supported WI-FI and lora technology to reduce power and to setup a good communication.

(d) The result was LORA was able to communicate Low-Power and long-range with high extensibility and efficiency transmission.

(e) This paper is important to us because of fast transmission and available communication between IOT devices will reduce power consumption and time.

12. Positioning in Resource-Constrained Ultra Low-Power Wireless Sensor Network

(a) Researchers have written this paper to show how network signaling frames of synchronized communication protocols for low power wireless sensor network supporting mobile nodes can be used for positioning.

(b) The main problem is a large number of nodes, frequent battery replacements and manual network configuration are inconvenient or even impossible. Thus the networks must be self configuring and self healing and the nodes must operate with small batteries for a life time of months to years.

(c) Researchers contributed to solve the problem by making the protocols used in wireless sensor network must be highly energy efficient, also low cost of hardware is essential for the feasible usage of these network including large number of devices.

(d) The main results researchers reached is a method for positioning data gathering using synchronized MAC and ENDP signaling frames.

(e) This paper is important to us because it works on positioning in synchronized low power wireless sensor network using network signaling

13. M2M Power Saving based on Analysis of Network Call Data Records

(a) Researchers have written this paper to provide a methodology to reduce the power consumed by M2M devices is proposed via instructing some M2M devices to sleep.

(b) The main problem is the integration complexity of M2M platforms. The Internet of Things (IoT) is expected to include billions of connected devices communication which leads to hugely high power consumption.

(c) Researchers worked on the selection of which M2M devices to go to standby mode and which will continue running to reduce the power consumption, and reduce the network traffic and the Call Detail

Records (CDRs) generated on the telecom operator side from the data service nodes.

(d) The results showed the effectiveness of the model as there is a relation between the signal strength and the QoS shown in the CDRs and hence the effectiveness of the standby model based of QoS to ensure better power utilization.

(e) This paper is important to us because it works on a simulation environment and offers a technique that help in reducing power consumption.

3.1 Similar System Description

While there isn't a system with a similar scope, on of the closest is SpinLight. the system is proposed by authors: Bo Xie, Guang Tan, Tian He. Their system suggests light localization using an infra red light, targeting object tracking applications and smart-phone users. while not being prone to interference and noises. Another paper is "Poster: Twirl: On the Benefits of Adapting Orientation of a WiFi Access-Point". by the authors: Yubing Jian, Shruti Lall, and Raghupathy Sivakumar. their aim is how poorly the network functions when the access point is poorly placed or positioned.

3.2 Comparison

Paper	Author	Problem Statement	Contribution	Algorithm	Results	Pros	Cons
Justification of the Choice of Neural Networks Learning Algorithms for Indoor Mobile Positioning	Pavel A. Novikov, Anatoly D. Khomonenko, Evgeny L. Yakovlev	GPS either doesn't work indoors or provide location data with a very high error of about 100-150 meters.	system may work on the mobile devices as well as on desktop computers.	RProp	A Navigation software package that uses the model ANN	the software package can run on the existing infrastructure of Wi-Fi networks that are deployed in a variety of areas.	must manually map the radio fingerprint.
SpinLight: A High Accuracy and Robust Light Positioning System for Indoor Applications	Bo Xie, Guang Tan, Tian He	Recent studies have a limited	1)Robustness against noise and ambient interference. 2) in-sensitivity to receiver orientation. 3) low energy consumption of	—	-Lower power consumption. -More accurate. Strong against many affecting factors.	location accuracy with a pure digital design, reducing the median error to within 0.04 m	-the need for dense deployment of transmitters. -low speed of lamp shade.
Poster: Twirl: On the Benefits of Adapting Orientation of a WiFi Access-Point	Yubing Jian, Shruti Lall, and Raghupathy Sivakumar	The main problem is how poorly the network performs as a consequence of poor placement of wifi's access point.	experiments on the performance of the network, in different places with different antenna angles.	—	improve the network performance up to 1:5x. Using Antenna, and by 1.8x using twirl.	Simple method of increasing performance.	—
Characterizing and Modeling the Impact of Wireless SignalStrength on Smartphone Battery Drain	Ning Ding, Daniel Wagner, Xiaomeng Chen, Abhinav Pathak, Y. Charlie Hu, Andrew Rice.	many cell phone users experience frequent poor signal strength, and how negatively it could impact the battery.	the first measurement study of 3G and WiFi signal strength experienced by (3785) smart phone users over 1 to 19 months of daily usage.	—	The 3785 users on which the study was conducted, had 43\% and 21\% of their data sent in the time of poor 3G and WiFi signal strength, respectively.	The new model prediction error stays within 5.4%. Similarly, for 3G the new model has an error rate of less than 7.2%, in	—

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Measuring Sensor to Cloud Energy Consumption	A H Azni, Abdul Fuad Abdul Rahman, Najwa Hayaati Mohd Alwi.	IoT devices must provide seamless connectivity while obeying strict power and size constraints.	series of simple experiments which measure the energy consumption of two IoT Sensor Nodes transmitting data to the cloud. They will be used to view the best one between wire and wireless for IoT Sensor Nodes implementation.	—	the differences between wire and wireless is only 100 Minutes of battery life.	Wired consumed less power than the wireless	uses only 2.4GHz wireless protocol
Enhancing Indoor Positioning of IOT Devices	Abdelrahman Samir, Fady Khaled, Rana Muhammed, Samar Saeid.	Misplacement of indoor IOT devices causes different issues which may cause higher power consumption.	System that suggests the best placement of IOT devices .	-ANN to train the model -Harris corner for image processing.	Placement recommendation of IOT devices, based on the historical data of each device. Saving power and increasing battery life	—	—

3.3 Screen shots

Figure 4: Images of SpinLight System installed

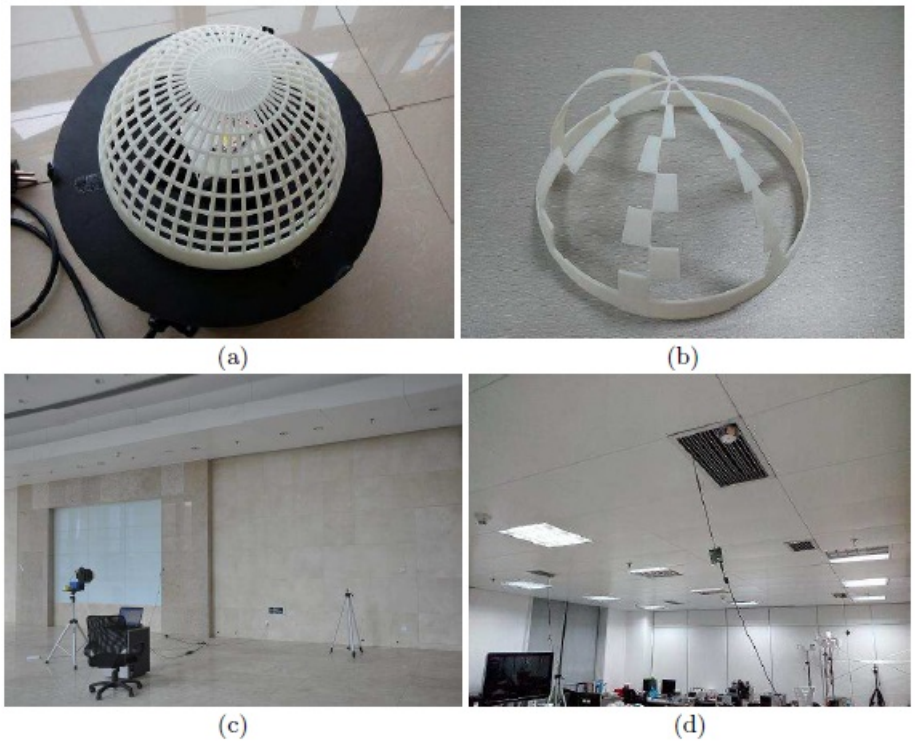
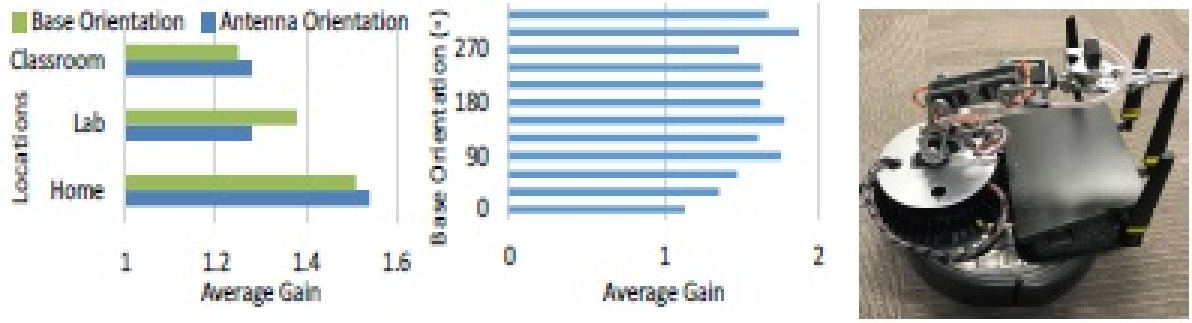


Figure 5: Screen-shots of the difference in readings generated in Twirl Method, and image of the equipment used



4 Project Management and Deliverables

4.1 Tasks and Time Plan

Figure 6: Time plan

Project Phase	Starting	Ending
Receiving proposal and ideas from Dr's and student	2-Jul-18	15-Jul-18
ANNOUNCE PROPOSALS FOR STUDENTS	16-Jul-18	22-Jul-18
REGISTER STUDENTS TO PROJECTS	26-Jul-18	27-Jul-18
1 PROPOSAL EVALUATION	26-Sep-18	27-Sep-18
SUBMITTING SURVEY PAPER	20-Oct	
2 SRS EVALUATION	3 Days after Mid term	
- EXTERNAL EXAMINER	3-Dec-18	11-Dec-18
SDD EVALUATION	2 week of Feb	
EVALUATION IMPLEMENTATION	After spring break	
DELIVERYING 8 PAGES PAPER	days after Spring Vacation	
TECHNICAL EVALUATION	1st week of may	
FINAL THESIS	25-Jun-19	
FINAL PERSENTATION	26-Jun-19	

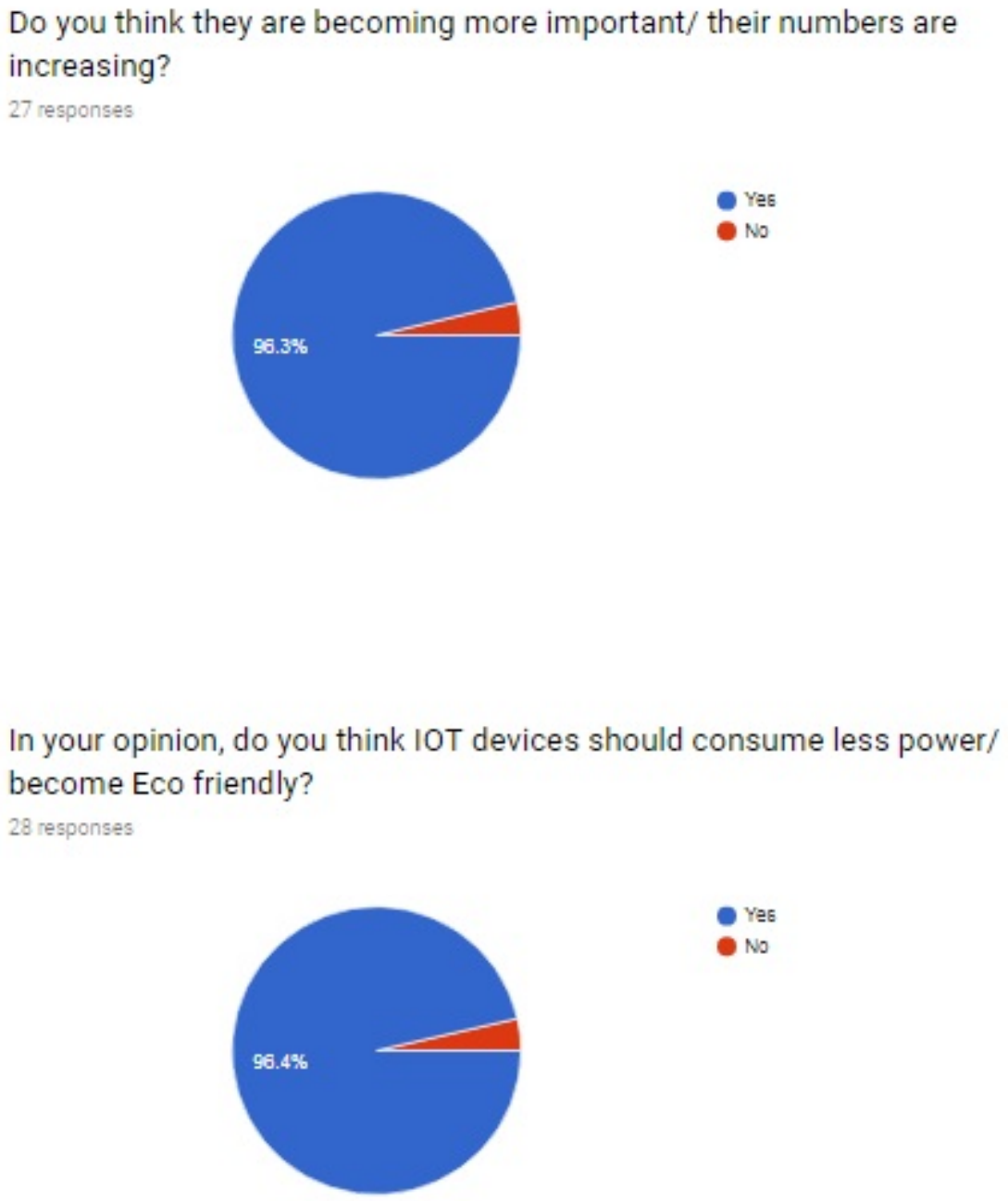
4.2 Budget and Resource Costs

The project will be made on the team members laptops. also instead of acquiring actual IOT devices we are using Contiki simulator. In conclusion, other than the laptops used no additional budget required.

4.3 Supportive Documents

We conducted a survey on the importance of IOT devices and their power consumption. The majority of the applicants agreed on their growing importance. While they were almost unanimous on the importance of becoming more energy aware.

Figure 7: Community Answered Survey



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(1) (2) (3) (4) (5) (6) (6) (7) (8) (9) (10) (11) (12) (13)