

Saving Environment Using Internet of Things: Challenges and the Possibilities

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Abstract

The term Internet of Things (IoT) emerged in the early 2000s but actually gained momentum only in the past few years, however we still do not get to see them in our daily life. It has generally been avoided by the mainstream market due to its “cryptic” nature which requires technical knowledge prior to its use. Lack of strong business model (by companies) and inability to adapt to new rapid changes (by consumers) are the two primary factors contributing to the fact that IoT is well ahead of its times but it need no longer be. In this paper, I’ve created a setup for smart home that allows the users to control their electrical appliances from internet and even makes the appliances smart enough to react to the environmental conditions on their own. Using this setup, I observed the pattern in which electricity consumption and carbon footprints reduced as compared to the conventional setup *i.e.* without IoT. Analyzing this data provided me a solid proof that IoT definitely helps us to save electricity and environment. Since IoT is beneficial for all, I, then focused on the challenges that are hampering the penetration of IoT into the daily lives of consumers and how the consumer is overlooking the benefits that it has to offer, which even includes a primary concern for many, *i.e.* saving money. This paper is overall aimed to change the way a consumer thinks about IoT and to provide a solid ground to how it is beneficial.

Keywords

Arduino Based Projects, Embedded Devices, Internet of Things Home Area Network, Relay, Smart Homes

1. Introduction

Internet of Things (IoT) came into existence with the Dot-Com bubble but it can be evidently said that it failed to make any notable impact on the aspect of making your homes smart, otherwise they would have been incorporated in our homes just like any

other invention. Making your homes “smart” is not just about automation of few mere things but rather it is an equilibrium set between the tangible goods and the computers with the help of Internet. In the term IoT, the “T” stands for “things”, but what things are we actually referring to? Turns out, IoT is not a homogenous discipline, as many would consider, but rather it is a collection of services that bridge the gap between the physical world and the digital world, thereby creating a “smart” environment [1]. We already have internet, the sensors and the devices but IoT acts like a bridge between all of them. It is like giving a power to think to the devices, which means, everything around you, especially those with a Printed Circuit Board (PCB), can be connected to the internet in a way that they all help produce Big Data on analyzing which we can seamlessly translate manual tasks towards automation, thereby making your homes smart, where even the machines can “sense” and respond on their own [2].

The term “smart” is used often in various contexts but is vague in itself as it may mean different for different people, therefore the first priority should be to address what “smart” means. Anything that reduces human efforts and automates the tasks should be termed as “smart”. Hardware like Arduino [3], that’s based on IoT, were built to provide power to users so that they can build “stuff” on their own but this has led to some problems of its own (discussed later in section III) [4]. As of now, we have two ways to get IoT in our homes, either a perfectly laid out plan before a home is even made or we can try to fit IoT into our existing homes which could be a little “dirty”.

Applications of IoT are numerous and possibly every human effort can be effectively translated into a sophisticated piece of code—and this is where the problem lies. Not everyone on earth can write a computer program and this hugely decreases the target audience share for the IoT market and its derivatives. Therefore, the only potential audience left for it are those who can program. This seems to be huge gap for something that was built to provide users with freedom of creating useful things for themselves. To fill this gap, numerous startups and companies emerged [5] that claim to utilize IoT while making your homes smarter in numerous ways such as:

- 1) Turning ON or OFF electric appliances with the help of smartphones and internet.
- 2) Automation of window shades and security cameras with their control over mobile phones.
- 3) Actions based on environment’s behavior, such as notifying user if smoke is detected in the house.

However, these companies have failed to gain huge traction [6], at least in the countries like India which has huge population, signifying existence of audience for IoT too. The challenges are numerous for a seamless integration of IoT in the lives of common people [7]. Unless the users are exposed to how IoT can change their lives with benefits to both their “pockets” and the environment, no consumer would be compelled for a shift [8].

This paper is divided into 3 parts. In the first part I’ve created a setup based on IoT that allows the user to control two electrical appliances over the internet and even make

the appliances react on their own to environmental conditions. This setup shows that how IoT helped to reduce electricity consumption, human efforts and the ways in which it was beneficial for the environment too. The second part discusses the challenges that IoT sector faces, from a perspective of both, companies and consumers—supported with a survey. The third part give ideas on how IoT can also be implemented in such a way that it could possibly save lives of people along with a few plans on how new building can exploit IoT.

2. Experiments and Their Results

Numerous programmable boards are available in the market and for the experiments in this paper, I have used an Arduino Uno [9] which is based on the microcontroller AT-Mega328P. These experiments were carried with proper safety precautions and various equipment to calculate readings like electricity consumption over time. The tasks accomplished with this experiment will help justify that how IoT is helping us save electricity (*indirectly money*) thus leading to reduced carbon footprints.

2.1. The Setup

The schematics are shown in the **Figure 1**, given on the next page. The Arduino is the main component which is connected to a computer with Internet connection and takes the electricity through the USB power supply. Two sensors are connected directly to the Arduino and are used to read environment's condition. The Temperature Sensor (market name: DHT 11) [10], connected with 3.3 V, GND and D7 pin, measures the humidity and temperature while the Motion Sensor (market name: Passive Infrared (PIR) Motion Sensor) [11], connected with 5 V, GND and D10 pin, looks for any changes in the Infrared levels of the area, which it captures as movement, if found. Two relays [12] are connected in “Normally Closed” mode, to turn ON or OFF the load (*i.e.* electrical appliance). Load 1 is taken as a Lighting Source, such as a bulb or a fluorescent lamp while Load 2 is taken as a temperature controlling appliance, such as a fan or a desert cooler which do not provide temperature controlling facility by default and are also used heavily in India [13] [14]. With both the loads, one end of the load goes directly into the Power Socket while the other end goes into the Relay from which it goes into the remaining terminal of the Power Socket.

This setup will allow the user to control the electric appliances over smartphone or any device with Internet. On the software side, the “Processing” Integrated Development Environment (IDE) is programmed in a way that it reads the current state of both the relays (*i.e.* On or Off) from the website, which is specially created for this purpose, and finally sends the relevant command to Arduino. The Arduino also keeps on checking both the sensors for their input and turns ON the load 1 if the PIR Motion Sensors detects any changes in the IR levels, it turns OFF the appliance if no changes in IR level is observed in 2 minutes. Similarly, the Load 2 gets turned OFF if the room temperature goes below 20 Centigrade and turns ON as soon as the temperature gets above 20 Centigrade.

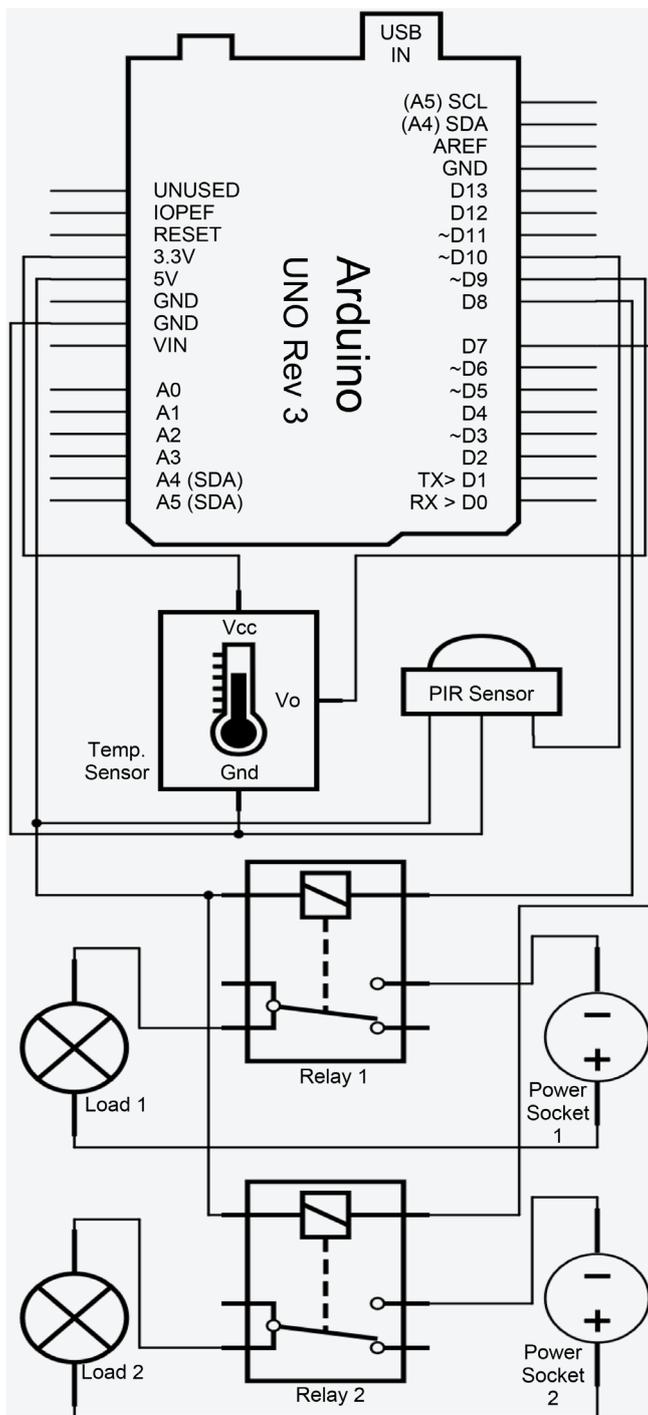


Figure 1. Schematics of the connection that controls an electric appliance (*load*) using a relay and Arduino Uno.

With above setup, we’ve come closer to building our smart homes in which you can control your appliances and they can even “react” to the environment. This setup will help us in understanding the pattern in which electricity is consumed in any average house thereby allowing us to build an argument for how the IoT will be beneficial for

our environment.

2.2. Observations

Readings were taken over a 4 weeks long time-span during summer season in the Indian region. During these 4 weeks, the entire IoT setup was used on alternate weeks, in order to remove any discrepancy. The first and the third weeks were without the IoT set up, however, Arduino was programmed to measure the number of hours the loads were used without any interference in their normal circuit. Week second and the fourth were connected with the IoT circuit as described in the previous section (**Table 1**).

The highlight of the result was that the electricity consumption hugely decreased with the Load 2 *i.e.* Dessert cooler responsible for cooling the room. The decrease in units consumed was almost 40% for load 2 alone. The decrease in unit consumption for Load 1, lighting source, was not huge but it was a considerable 15%, which can still be huge if the electricity bill is already high for someone. Reduction in consumption of electricity directly correlates to the fact that we've decreased our carbon footprint [15]. For generating 1 Kilowatt-hour of energy, we're producing nearly 2 pounds of Carbon dioxide [16]. That sums up to be nearly 58 pounds of Carbon dioxide with just two appliances without the use of IoT setup. However, when using the IoT setup, the carbon footprints drops down to 37 pound, reducing the excess 21 pounds of Carbon dioxide that was being generated uselessly.

Overall, we can conclude that a simple IoT set up on just two appliances can help us reduce our electricity bill and carbon footprints by almost 36% from those two appliances. The reasons to this decrease are as discussed below:

1) People generally tend to leave the lights switched on when they're temporarily going out of the room. Sometimes, this "temporary" period may unexpectedly get longer too. However, with the IoT setup being deployed, the PIR sensor will automatically sense if the IR levels are static for some time or not and if they are, it will automatically switch off the lights, and again switch them ON if someone enters as it changes the infrared levels of the room.

2) At times, the user might have gone out for a vacation or just to the next super-market but unfortunately, forgot to turn OFF the appliances. In such cases, the appliance would be running uselessly and simply wasting all the energy. However, IoT provides you an excellent option to turn OFF any of those appliances from your smart-phone simply by visiting the website that was specially created for this purpose [17]. Therefore, the useless consumption of electricity has been removed.

Table 1. Observation table showing the amount of energy consumed over a time period of 4 weeks.

	Week 1		Week 2		Week 3		Week 4	
	Without IoT Setup		With IoT Setup		Without IoT Setup		With IoT Setup	
Load 1 (Tube Light) Consuming 40 W	<i>Hours Used</i>	127.4	<i>Hours Used</i>	107.8	<i>Hours Used</i>	121.8	<i>Hours Used</i>	105.7
	<i>Units Used</i>	5.1	<i>Units Used</i>	4.3	<i>Units Used</i>	4.9	<i>Units Used</i>	4.2
Load 2 (Dessert Cooler) Consuming 170 W	<i>Hours Used</i>	144.9	<i>Hours Used</i>	86.8	<i>Hours Used</i>	136.5	<i>Hours Used</i>	81.9
	<i>Units Used</i>	24.6	<i>Units Used</i>	14.7	<i>Units Used</i>	23.2	<i>Units Used</i>	13.9
Total Units Consumed from Both the Loads	29.7		19.0		28.1		18.1	

3) Dessert coolers provide a continuous flow of air, however at night, temperature of the environment decreases naturally, minimizing the need of cooler. However, not everyone can get up at night and switch them OFF manually. Therefore, with the IoT setup, whenever the temperature falls below 22 Celsius (*or as required*), it automatically turns the cooler OFF and also turns it ON whenever the temperature gets above 22 Celsius. Moreover, cooling is something that isn't an instant process, making it safe to turn OFF the appliance whenever unnecessary.

With a more complex setup integrated throughout the home and with the help of more data from each individual "thing" [18], we can create a smarter environment with more thinking capabilities of its own. But for now, we've seen that how IoT helps in reducing electricity consumption, significantly.

3. Challenges to the IoT Sector

Products like Arduino and Raspberry Pi made it easier for some part of the society to code their own automated stuff. However, the majority can't code or is not of the "Do-It-Yourself" (DIY) type¹. This gave chance to various companies to build their own version of smart home. Samsung, LG, Intel and many more companies saw this opportunity and launched their product. These products allowed consumer to automate tasks, including tasks that would get executed after a certain behavior of user like stepping into the house or saying something.

All of this made our homes smart but there still lies challenges in front of the IoT sector that are hindering it from deeper integration into the lives of common people and not just those who are somehow related to tech field. Following are the challenges that lie in the path of IoT, supported with statistics from a survey that was conducted online on random citizens of India who are actively using Internet. I was able to get 855 people for the survey out of which, the majority fall into the age group of 24 to 30.

3.1. Unaware about IoT

This may seem to be surprising but 71% of the respondents to the survey didn't know what IoT is about, what it can do and how it can help them and the environment. This is primarily because there have been no advertisement and strong player in the IoT sector. Although companies like Samsung have stepped into this sector, yet, they haven't really expanded their product line to countries like India. As the name IoT suggest, "Internet" is its primary component and because the internet connectivity isn't cheap in India, it probably made IoT a tool of the future. Companies refrain from building up a product that relies on another service, which in itself is poor in a given area [19].

The Indian government took some steps to create "smart cities" and "digital India" [20], however they haven't been deployed yet and would take years to get them in our daily life. Thus, people will have to wait before they can get glimpse of what IoT is. Unless we have boot camps demonstrating the use of IoT in a house, we can't expect to see

¹Spencer, A. (2005). DIY: The rise of lo-fi culture. London: Marion Boyars.

any interest from people in this sector.

3.2. Lack of a Great Business Plan

IoT just adds easiness to your life, it isn't a new product in itself, after all you can still switch off the lights manually. This is the same case that happened when LED tried to take over CFL lighting. Both of them illuminate the place but LED has far more benefits that aren't directly visible. This type of problem actually poses a big hurdle for startups which despite having a great IoT product, can't appeal the normal audience for the price that they're asking for, even though that product might be justified in long term. Nearly 64% of the respondents didn't want to make a comparatively large investment in an IoT based product, despite its huge advantages. Some big players like Intel and Samsung may still think of investing huge capital in order to compel customers for the shift but they haven't done so yet, owing to the fact that there's a lack of demand or maybe, this is not the right time [21].

These challenges can be seen as a vicious circle which will continue to flourish until the customers show interest or either the companies spend money on popularizing IoT based products. It would be years from now until when we would get to see IoT products in every house. It is also evident from past examples that the gap between the date of invention of a technology and the date of daily use for that technology as a product, has always been over multiple decades. And IoT has been there only for one and a half decade, be assured, it is inevitable and will happen soon.

4. Possibilities with IoT

Are we now any closer to smarter homes? We definitely are. We've already seen that how we could control our appliances from anywhere and even made them smart enough to respond to their own surroundings. On a full-scale home, there would be several "things" that can work in harmony with each other to produce relevant data, which can be used for automation. After all, IoT is all about getting more and more data to analyze, in order to produce a better "automation".

All the smartness of any house will go in vain if it cannot help the user in case of emergencies. With reliable sensors, we can actually move ahead from simply controlling our appliances to the health of humans living in that house. It would be like, allowing your choice of doctor to know your body's state at any point of time and in case, when the "levels" go abnormal, an ambulance can be automatically sent to your home or any other relevant action may be taken by the doctor. This might seem to be a little fiction but here is the fact, we have already developed sensors that can monitor our heart rate, breathing pattern, body temperature, current location and all of this, packed into a small wrist-watch lookalike, known as smartwatch—with a little more features [22]. Since we are capable of capturing the data, we can simply use IoT to transmit this data continuously to the choice of doctor. Amount of silent deaths, heart attacks being the largest contributor, can hugely decrease since the doctors will be able to get the user's body activity before any mishap may occurs. All we now need to do is to simply

bridge the gap for contact between the consumer and the doctor, for which IoT seems to be promising.

This may sound to be simple but it isn't actually. We would need a whole network of systems that are interconnected and in an unfortunate event, failure of any one will cause all the service to crash. Internet acts like the backbone for IoT, reliable internet connectivity, especially in countries like India and other eastern countries is still a challenge [23] and needs to be fixed soon before we can even plan of having products based on IoT.

We can implement various aspects of automation in new houses that are yet to be built. In fact, we can totally remove the concept of physical switches. What we'll need to do is to directly connect the lights, fans and other appliances to IoT and sensors. So, PIR sensor can be attached with light, temperature sensor can be attached to fans and so on. Now, these appliances can think on their own that when to start and when to stop. On top of this, a control panel can be provided in form of a mobile application which can override the state of appliance. All that we'll be now left would be simply power sockets, whose control would be in our smartphones; totally removing the need of physical switch. If could implement it, then our life would actually be altered in the following way:

When you'll wake up, the smartwatch will sense it and would power ON your coffee maker, automatic removal of curtains from window some nice music will start to play. You take a sip of coffee and are ready to leave for work. The house will automatically turn OFF every appliance and also lock itself, which would unlock only if it sees that you're around, using the data (*i.e. your coordinates*) from GPS of smartwatch that's in your hand. Before getting back to home, you can turn ON the AC from your office for some pre-cool effect.

These are some of the ways in which IoT can change the way we live our life. With more sensors getting developed each day, we can actually get to see something totally unexpected in our smart home.

5. Conclusion

Environment has been a major concern for past decade and IoT is a way that indirectly protects the environment while also reducing our electricity consumption. These are the two main benefits that IoT can provide to us when deployed in a house. Of course, it also makes our lives easy but that's just an added benefit and also the selling point. As of now, there do lie a lot of hurdles in the path of IoT but as the users are learning more about its benefits, we can expect to see it in our homes soon. This would be the time when challenges to IoT sector would diminish and the ideas discussed in this paper could be implemented in our houses. Thereby allowing us to lead a smarter life with a smart home which is capable of its own to respond to environmental factors and thus saving electricity and reducing carbon footprints for us.

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