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SMART BUILDING AUTOMATION USING INTERNET OF THINGS

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Abstract - *In modern years, the field of Information and Communication Technology has mainly focused on the Internet of Things (IoT). IoT based services improve the environment in many applications. Home automation based IoT one such versatile and popular application. The application domain of Urban IoT systems like Smart City's whose objective is to take benefit of the current communication technologies in order to provide the best services. One important element of Smart Cities is the Smart Buildings. This, Smart Building, a new concept where the building gains from the improvement of communication and automation technologies, creating an environment with more efficiently use the available resources. For commercial structures such as factories or shopping centers, the transition to smart buildings is essential for growth. This will help the organizations to save a large amount of money because of better efficiency as well as improved overall building operation. The IoT has created an entry to assist in the management of such buildings. Sensible Buildings and sensible cities region unit ceaselessly remodeling activities meted out by folks on each day. Smart cities will soon emerge with services such as temperature management, water management, disaster management, machine failure management, lighting facilities which in turn is connected to the internet/cloud facilities. In today's comparison, some cities have started enforcing this kind of smart management approach by conjuncting everything about the community to the internet. Along with energy conservation, smart buildings aids to save money. Here are some of the largest IoT smart building modules likely to be introduced in this paper.*

1.Predictive maintenance
2.Disaster Management
3.Temperature adjusting wrt Environment
4.Smart Water Management (Plumbing).

Index Terms— Smart City, Internet of Things, Arduino UNO, Smart Building, Cloud Computing, Cox Model, Dobrovolsky, EPANET, Hysteresis, PID.

1. INTRODUCTION

ADVANCES in mobile computing and the growth in Internet applications will ground to the development of internet services for future generations, that is ubiquitous and pervasive. With considerable progress in pervasive computing fields, networking technologies, and the boost in applications related to the Internet and their services have led to the development of the Internet & its services for future generations. Internet in the coming generations, like IoT, will connect not only computers devices but also interconnect cities,homes, gas, buildings, electrical grids and water networks making them smart and accessible. This IoT services will be an excellent development for smart Building revolutionizing the way it works, maintain the living standards, education development like smart - classes, and better ways to secure and protect data.

We can provide efficient services in ways where the Cyber-physical systems are used in environments i.e integrated part of the IoT system. Such systems read sensor data from the physical environment, processes the information, and sends the appropriate instructions to a wide range of actuators or effectors to change the physical environment. According to the given definition, a Smart Building can be seen as a diverse interconnection of Cyber-physical systems.

Automation of buildings and adaptive control functionality are considered as the future of upcoming buildings that must be allocated in Smart Cities. Smart Buildings(also called SB) links automation, information technology, security, industrial controllers and communications to achieve a feasible level of comfort and energy consumption. Presence of different range of users and varying environmental factors, the computational power needed to operate an SB is equivalent to the power that is consumed in large data centers. In order to avoid the construction of data or operation centers, different entities in the Smart Buildings can be used.

Cloud Computing (also called Internet Computing) is a set of resources and services available to use through the internet. The goal of Cloud Computing is the sharing of operating systems, applications, storage, data, and processing capacity among different users. PLX-DAQ is a Parallax microcontroller data acquisition add-on tool for Microsoft Excel. Any of our microcontrollers connected to any sensor and the serial port of a PC can now send data directly into Excel. PLX-DAQ has the following features: Plot or graph data as it arrives in real-time using Microsoft Excel. The framework evaluated using the Arduino integrated development environment as a local controller for all the managed/monitored elements and Local Cloud Services to provide the whole system with computational power.

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2. BACKGROUND

A. INTERNET Of THINGS

The development of IoT has efficiently interconnected devices to other such available platforms and also the integration of the physical world with information space. Increasingly researchers pay attention to applications of global service in different industries combined with web service (such as Cloud Computing), and other such related techniques. Although IoT has no such of a clear definition or correct flow architecture, it has served in application backgrounds: smart homes, Could abed Virtual intelligent assistant, smart cities, smart business, medical-care faculties, environmental observing, and security and surveillance just to mention few of them [8].In this scope, our Smart Buildings require architectures that can deal with large amounts of different kinds of information, big data, etc. and perform computation by making use of advanced data processing techniques, all of this sustained by communication standards and Internet Protocols

B. SMART CITY

Urban IoT aimed at the concept of Smart Cities, with its main objective being to bring out the maximum goodness and advantages of communication technologies and advanced control so as to serve high-quality purposes. One such important goal in our concept is to set up a well-integrated environment for every available physical resource that is used in the city's development and also management applications. The deployment of smart city technologies leads to the improved utilization of resources and rapid advancement in global information services, of both human and nature, and also effective management of those resources when a crisis situation arises regardless of nature of trigger. This trigger can be nature such as earthquakes, tsunami, etc, terrorism or war-zones, failures or human errors.

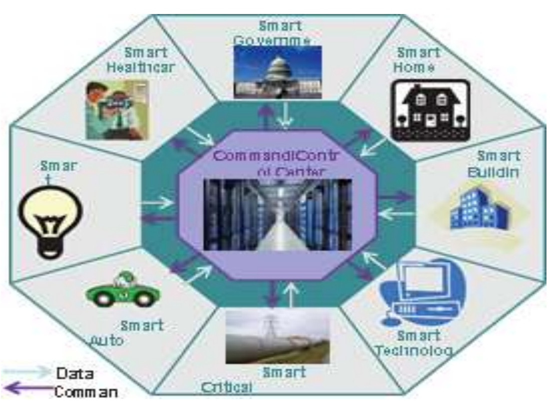


Fig. 1.The generic structure of Smart city.

The above figure shows a general smart city generic architecture where all resources, services, and organizations are interconnected to create a citywide, closed-loop control system. Cities occupy 2% of the total Earth's region and yet, they bring forth around 70% of greenhouse gas emissions [10]. More than 70% of these emissions come from buildings. Most of the current buildings ingest energy without any feedback with the outside world. This leads to a waste of energy if we consider that as much as 20% of the total power issued to the grid is used for only 1/20th of the time [10]. Waste in electric energy (many other Cities' resources) could be prevented by enabling automatic and efficient communication between buildings and services providers. Apparently, the current structure must be upgraded to Smart Buildings that can exchange feedback and status with the Smart City in order to optimize the use of available resources, especially energy.

C. SMART BUILDING

A Smart Building is a facility whose characteristics modify with time. SB can react to the internal and/or external environment changes without human interaction in order to provide comfort to the residents and while taking into consideration financial and energetic perspectives [11].SB combines real-time observing with event management and data analytics to help managers to optimize the available resources, and enhance reliability.[12]. Some of the main characteristics of Smart Buildings are [12]:

- They improve reliability and performance to reduce energy consumption.
- Lower maintenance and management are needed, as a consequence, operating costs are reduced.
- Captured data can be used to perform energy analytics.
- All the metrics can be collected in a repository for future analysis.
- Real-time events can be centralized for consolidation, correlation or to initiate certain action when a service is requested.
- Anomalies can be detected by applying analytical rules.
- Analyze historical data to identify trends and perform corrective actions.
- Create scenarios to perform context awareness.

In order to handle all the described characteristics, Smart Buildings need to have high computational power. This computational power can prevail from a data center in the same facility but, if the SB is intended to be part of the IoT, its information must be accessible from everywhere. Hence a higher level of computing services is needed. The best option seems to be Cloud Computing since it is reliable and available from anywhere.

WORKING PRINCIPLE

To attain our proposed system need to use Arduino Uno controller to monitor the environment of the building. In this temperature sensor is used to monitor the inside and outside building of the temperature and automatically turns on the load depends on the two temperature sensors. Water sensor used to find the water leakage in the pipeline. The vibration sensor is used to find the earthquake level. IR sensor is used to find the fan rotating speed level. This sensors data will update into the cloud using IoT module. GSM is used to send the emergency message.

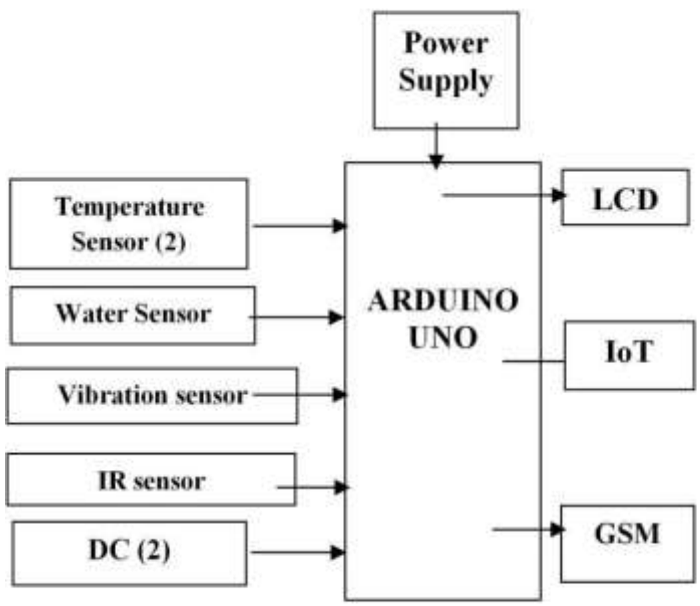


FIG.2. Block Diagram of the Smart Building Automation.

3. DOMAINS

The application domain of Internet of Things systems has the current technologies to provide the best services. One important element of Smart Cities is the Smart Building. Smart Building (also called SB) is a new concept where the building gains from the evolution of automation technologies to make over smart environments that are more efficient in of the available resources and much more secure. Such smart systems are complex, dynamic and heterogeneous.

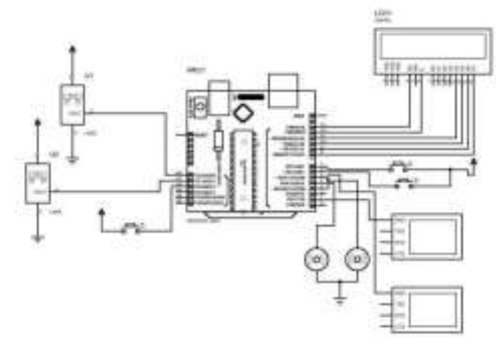


Fig.3.Architectural Diagram of the modules of SB

The above figure shows the architectural diagram of the model that has been projected. Thus, Smart Building(also called SB) needs more and can be obtained by using cloud computing. We also have evaluated and validated our approach by applying our framework which is intended to be a Smart Building integrated to the Internet of Things. We also introduced modules that enhance the automation of the building to a new level. For Predictive maintenance a DC motor and an IR sensor is used, Disaster Management(Earthquake Early Warning System) vibration sensor is used but piezo sensor can be installed in the shafts of the buildings to detect seismic wave vibration, Water Management uses a water sensor to find leakage in the pipelines and a water distribution network stimulation is done through EPANET, Temperature w.r.t Environment uses two temperature sensor (one to detect the internal temperature and the other to detect the external temperature).

A. PREDICTIVE MAINTENANCE

Predictive maintenance is nothing but analyzing machine failure before the actual failure with the help of IoT. It uses hardware and sensors devices to account on the state of the building using IoT. The time for the maintenance to be performed is provided. Unexpected problems that usually crop up with preventive maintenance can also be overcome using predictive maintenance. Predictive maintenance makes it challenging for commercial and industrial activities since it is performed to keep the environment running.

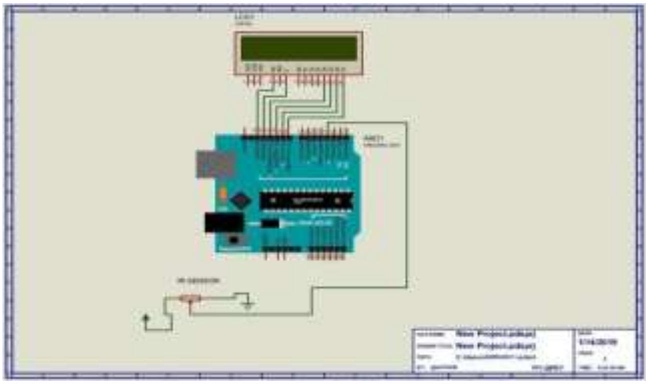


Fig.4. Architecture Diag. for Predict. maintenance

The above diagram is the architecture for predictive maintenance. In this paper, we have designed a model circuit that consists of an IR sensor and a DC motor(like that of a Fan). When the power supply is been provided then the DC motor which is actually a fan starts to rotate, the rotation per minute can be recorded with the IR sensor. When there is no disturbance in the IR sensor the sensor shows an output of 0. But if a disturbance is been noted then an analog output of 1 is recorded. This output of 1 is initialized as a counter that suggests the no. of times the edges of the fan cuts the IR sensor. If the fan is under normal working condition then the counts have been recorded to be above 12,000, and the fan is damaged due to wear and tear or it needs any maintenance then the count is below 10,000. We also did the experiment with a couple of fans, with keeping the voltage constant of 12V. The recordings have been created in a dataset using PLX-DAQ and COX- regression model has been used to find the lifespan of the fan since it is a lifespan analysis model. The Lifespan Analysis model determines, device's remaining lifespan when functioning. Depending on the circuit/device, lifespan can also be calculated in miles, hours, stress cycles, or any other metric unit. In many cases where the time to an event (such as a failure) is to be predicted, the Cox Regression technique is suited. Cox Regression can also take potential influence factors into account and fine-tune its failure estimates accordingly. The plot of Cox regression is done using Kaplan Meier and Cox proportional hazards model. The shape of the survival function and the regression coefficients for the predictors are estimated from observed subjects; the model can then be applied to new cases that have measurements for the predictor variables. For Cox Regression analysis we can use R package named survival analysis. Using linear regression the accuracy of the dataset turns out to be about 77%. Software such as Weka tool and programs such as RapidMine permits one to simply got wind of processes to accomplish all 3 steps in an exceedingly sturdy manner. But we used R programming to predict the accuracy of the algorithm proposed.

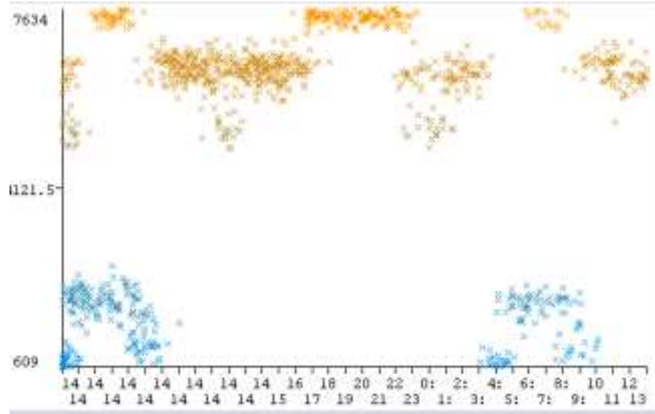
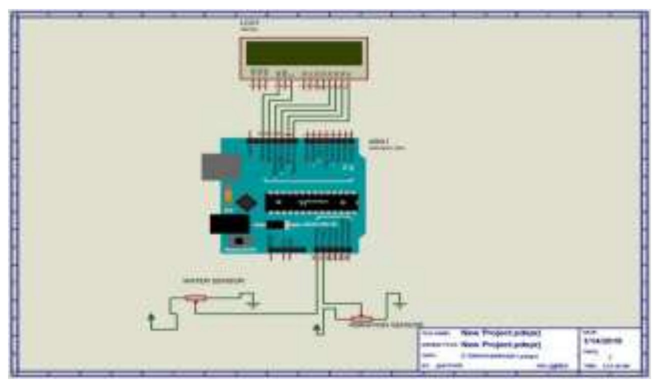


Fig.5. Linear Regression model for predictive maintenance

B. DISASTER MANAGEMENT

Disaster Management is one of the major concern in today's world. In this paper, we propose a system that can be used to predict an earthquake beforehand.



Figz.5.ArchitecturalzDiag.zforzDisasterManagemet

Thezabovezfigurezshowszthezarchitecturalzdiagramzofzd isasterzmanagement. In this circuit, a vibration sensor is been used to sense the disturbance in the surrounding. If no vibration is sensed then the circuit given an output of 0 and if there is a vibration that is been sensed then the circuit gives an output of 1.This is helpful in determining high-frequency vibration which will trigger when the s waves is detected by the earthquake sensor placed at the foundation of the building i.e near a steel shaft. When a p wave has been detected by the earthquake sensor, then the circuit sends an alarm message to the public of that locality like that of the Early Earthquake Warning System and waits for the next s waves to be detected by the earthquake sensor. According to analysis, it has been said that w.r.t the epicenter of the earthquake the periodic timing for the p wave to occur will take utmost 10 seconds to reach the earthquake preparation zone. Electrical damping is one of the major limitations and is limited by a shunt resistor.

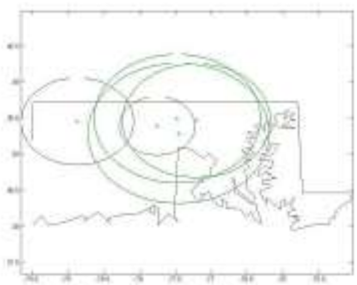


Fig.6.Determining sensing of epicenter region

The earthquake preparation zone is calculated with the help of the vibration circuit. Earthquake parameter can be predicted with the precursor anomaly, one of such is the emission of radon in the atmosphere which ultimately results into changes in the electron and ion density in the atmosphere even the atmosphere magnetism gets affected. Using the vibration sensor the area of the earthquake distribution is recorded and the epicenter distance from a particular point is calculated. This can be also done with the help of seismograph when the p waves and s waves are recorded in the working station after the earthquake has occurred. The lag time between the waves with giving the epicenter but in this proposed model, we sense the area prone the earthquake and the radius of the earthquake w.r.t epicenter is calculated. According to Dobrovolsky formula, the relation between the radius of the affected region will give us the estimated magnitude of the earthquake in that region: $R=10^{0.414M-1.696}$, where R is the radius of the earthquake preparation zone and M is the magnitude of the earthquake. Earthquake anomaly can range from regular one to an abnormal one such as electron and ion density, electron temperature, total electron content, electric and magnetic field and land surface temperature several days before the actual earthquake. The suitable behavior for considering the earthquake can be about 45 days. So the date for impending the earthquake is calculated based on M + IQR, where M is the median and IQR is the inter-quartile range of the predicted value of the earthquake date of the precursors.

C. WATER MANAGEMENT SYSTEM

The rise in technology has counted software developments and consumer electronics engineering goods to have initiated the Internet of Things (IoT). IoT may be an assortment of objects that put a job together so as to serve tasks during a united manner. This binds process power to convey knowledge concerning encircling environments. The devices are in the type of tailored sensors, appliances and knowledge analysis microchips.

In our project, the configuration of water sensors determines the leakage of water in the pipeline. The detector sends out the water and transfers the data into the screen LCD. A Cloud server is deployed to host the water knowledge analytical internal representation that looks after the whole water observance & inspection system. It collects the observation(water observing) knowledge advancing by the entries and stores this information for analytic, afterward, it can be displayed in the web-based dashboard. Data assortment is organized with the help of PLX-DAQ, for a week in the web dashboard. There are many leak detection methods like steady state method(hydrostatic leak detection method), pressure flow deviation method, Acoustics, and vibration technique. Each water sensor is provided with an ID so that it becomes easier for the end user to identify the exact pipeline in the water distribution system, where the leakage has occurred and maintenance needed. Sometimes the water leakage is tiny that it becomes unpredictable using water sensor, then the variation in the water flow and pressure difference is added as a parameter to analyze the leakage.

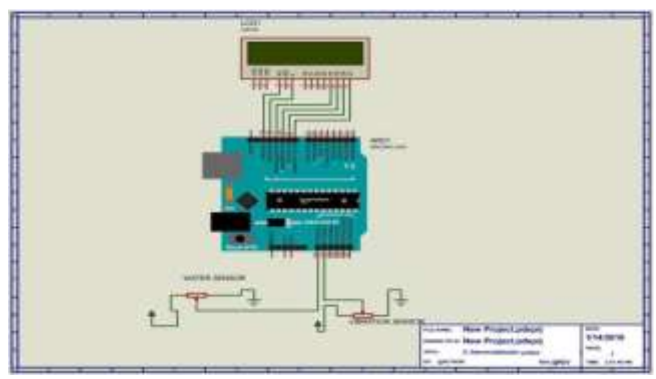


Fig.7.Architecture Diag. for Smart Water System

The above figure shows the architectural diagram of Smart Water management with a water sensor. With the dataset been created and a web-based dashboard updated the values, it is necessary to predict the leakage in the building where the leakage has exactly occurred. EPANAET is the water distribution software that is used to build the water distribution system/network of the building. Network parameter such as a number of nodes, pipe ID and pipes are used to suggest the leakage in the pipeline. The below diagram suggest the water distribution system of SRM Campus with its base demand and flow rate mentioned for every pipeline.When the source of the water distribution system, pipelines with id, tanks, pumps,reservoir are mention in the schematic map then many parameter can be evaluated with this consideration.

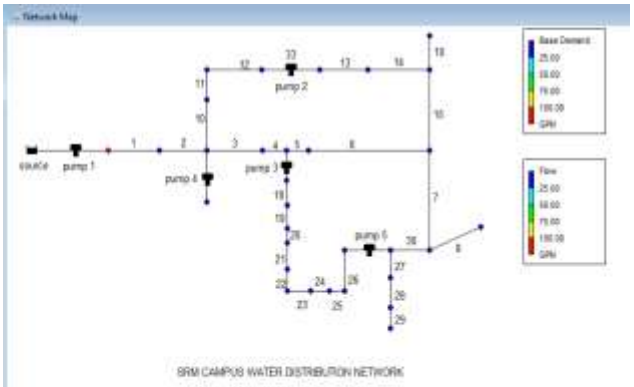


Fig.8. Map of SRM Campus water distribution system

D. TEMPERATURE ADJUSTING W.R.T ENVIRONMENT

For the development of effective management improvement methods to manage residential electricity consumption in an extremely good grid setting, prognostic algorithms are required that are straightforward to execute, minimize custom configuration, and result in sufficient accuracy to modify important management selections. The top two biggest consumers of electricity in an exceedingly typical residence are heating and air-conditioning(A/C). A self-learning algorithmic rule for predicting indoor, i.e, the temperature within any four walls(enclosed like a room) changes springs employing a first-order lumped capacitance technique. The algorithmic rule is developed in much the way that key style details like size and shape of the window, thermal insulation property, and air-tightness that have an effect on heat loss and star heat gain are combined into the parameter, which has good sensitivity or effectiveness, which will be learned from observation. This removes the requirement for custom configuration for every residence. With the use of experimental data, it can be made evident that an effective overall heat transfer coefficient and thermal time constant for the house can be comprehended from a single night-time temperature deterioration test, I.e, temperature decaying test. It was undeniable that an efficient star heat gain constant is learned while not information of the window space and orientation by application of a self-learning, sliding-window algorithmic rule that accounts for variations in the climate or seasons and see-sawing in daily forecasts.

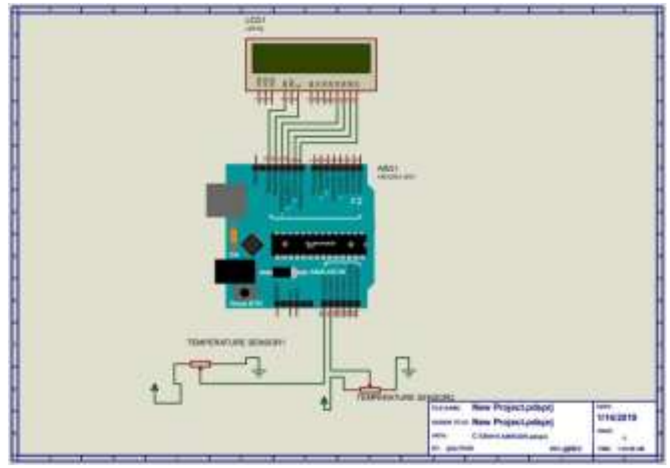


Fig.8.Architecture Diagram for Temperature Adjusting System w.r.t Environment

The above figure is the architectural diagram of the temperature adjusting system. In this system, two temperature sensors have been installed to calculate the difference in the temperature and run or shut down the AC when the threshold temperature is attained. The ensuing algorithmic rule is shown to be ready to predict indoor temperatures for a one-day time horizon employing a star irradiance and out of doors temperature forecast, and management selections for operating a heat pump. Hysteresis algorithm can be used in smart heating. With this algorithmic rule, once the distinction between the set-point and space temperatures is at intervals a given sensitivity threshold, the Thermostat assumes the set-point temperature has been reached. You can modify the physical phenomenon algorithmic rule sensitivity threshold within the Thermostat's advanced settings. If you employ smaller thresholds (0.1 °C), the Thermostat is going to be a lot of awake to space and set-point temperature changes. With larger thresholds, the Thermostat is going to be a lot of tolerant to variations in these temperatures and can switch the heating on and off less usually.

4. CONCLUSIONS

In our very paper, a framework to integrate a Smart Building to the Internet of Things has been introduced. Our framework uses Cloud Computing capabilities to provide with computational power to the same time, save energy. The framework was tested in a real scenario, having good feedback in terms of communication from the cloud and from the building itself. Local rules were applied to test real-time scenarios where the communication is compromised. The local rules were able to handle situations where the integrity of people (and the building itself) is compromised.

Usage of IoT experiences a big challenge to guaranteed and defend such systems, due mainly to the increased footprint of the attack surface, the consequence of large-scale implementations of this kind of systems. It is critically important to focus greater attention on securing infrastructures against cyber- attacks. These challenges are addressed through powerful research in securing and defending infrastructures and their services using Intrusion Detection systems and resilient techniques. It is essential to comment that our current approach and proposed framework, build the basis for future developments that could, using cloud computing, facilitate the implementation of systems for securing and enabling the personalization of spaces inside speakers, using heuristics and intelligent algorithms implemented in distributed environments, as well as allowing doing Big Data analysis. The tendency is to create a smart world where all devices share their resources. Our job is to make our cities much more secure and resilient against threats, and the obvious way to do so is by protecting our infrastructures from the very beginning

REFERENCES

1) Andrea Z., Nicola B., Angelo C., Lorenzo V., and Michele Z., "Internet of Things for Smart Cities", IEEE Internet of Things Journal, vol. 1, no. 1, February 2014.

2) Banerjee, A., Venkatasubramanian, K.K., Mukherjee, T., Gupta, S., "Ensuring Safety, Security, and Sustainability of Mission-Critical Cyber-Physical Systems", Proceedings of the IEEE, Volume: 100, Issue:1, October 2011.

3) Buckman, A., Mayfield S, M. Beck, B. M. "Whatisa Smart Building?", Smart and sustainable built Environment, Vol.3 Iss 2 pp. 92 – 109, 2014.

4) Wang, Z., Wang, L., Dounis, A. I., Yang, R., "Multi-agent control system with information fusion based comfort model for smart buildings" Applied Energy, Volume99, pp. 247-254, 2012.

5) M. Sadiku, S. Musa, O. Momoh, "Cloud Computing: Opportunities and Challenges", Potentials, IEEE (Volume: 33, Issue: 1), February 2014.

6) Tao F., Cheng Y., Xu L., Zhang L., Li B., "CCI-CMfg: Cloud Computing and Internet of Things-Based Cloud Manufacturing Service System", IEEE Transactions on Industrial Informatics, (Volume: 10, Issue: 2), February 2014.

7) Miorandi, S. Sicari, F. De Pellegrini, and I. Chlamtac, "Internet of Things: Vision, applications and research challenges" Ad Hoc Networks vol. 10, no. 7, pp. 1497–1516, 2012.

8) Palattella, M., Accettura, N., Vilajosana, X., Watteyne, T., Grieco, L.A., Boggia, G., Dohler, M., "Standardized Protocol Stack for the Internet of (Important) Things", Communications Surveys & Tutorials, IEEE (Volume:15 , Issue: 3), December 2012.

9) Morvaj, B., Lugaric, L., Kranjcar, S., "Demonstrating smart buildings and smart grid features in a smart energy city", 3rd International Youth Conference on Energetics(IYCE), Proceedings of 2011.

10) Eun-Kyu Lee, Peter Chu, and Rajit Gadh, "Fine-Grained Access to Smart Building Energy Resources", IEEE Internet Computing, 2013.

11) Jiong J., J. Gubbi, Slaven M., and Palaniswami M., "An Information Framework for Creating a Smart City Through Internet of Things", IEEE Internet of Things Journal, VOL. 1, NO. 2, April 2014.

12) Tao F., Zuo Y., Li D. X., and Zhang L., "IoT-Based Intelligent Perception and Access of Manufacturing Resource Toward Cloud Manufacturing", IEEE transactions on industrial informatics, vol. 10, no. 2, February 2014.

13) Abdullahi A., "Privacy-aware IoT Cloud Survivability for Future Connected Home Ecosystem", IEEE/ACS 11th International Conference on Computer Systems and Applications(AICCSA), 2014.

14) Obermeier, S., Wahler, M., Sivanthi, T., Schlegel, R., Monot, A., "Automatic attack surface reduction in next-generation industrial control systems", IEEE Symposium on Computational Intelligence in Cyber Security(CICS), Orlando, Florida, 2014.