Smart Organization

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***Abstract*—Rapid changes in application and internet technology have been seen the evolution of the internet. Internet of things (IoT) describes a global network of nomadic devices. It integrates ubiquitous and pervasive computing with digital intelligence. The fundamental concept of IoT is interconnecting the physical "things" using wired or wireless digital communication media like Ethernet, Wi-Fi, Bluetooth and let these things exchange information with each other so that they take a smart decision themselves. In this paper, we discussed the major requirements for incorporating the IoT paradigm in such organization where a large number of people act on shared electrical devices. We propose cost effective IoT framework for an organization to manage and monitor the electrical power consumption of an organization. This prevents wastage of electrical energy.**

Keywords- IoT; Future Internet; Home Automation; Embedded System; Raspberry Pi;

I. INTRODUCTION

From last few years, a novel paradigm called Internet of Things rapidly gaining focus of industries in the field of wireless telecommunication.

Kevin Ashton in 1999 was conceived Internet of things (IoT) during his research at the Auto-ID Lab[1], [2]. We grow up interacting with physical objects around us. There are an enormous number of objects we everyday use like Toaster, Refrigerator, Smart Phones, Water taps, Fan, Air-conditioners, etc. In a general context, we referred to these objects as "Things". The fundamental concept of IoT is interconnecting these physical "things" using wired or wireless digital communication media like Ethernet, Wi-Fi, Bluetooth and let these things exchange information with each other so that they takes smart decision themselves. For example, Thermostat and Air-conditioner are two things; IoT makes them communicate with each other in such a way that thermostat exchanges current temperature sensed with Air-conditioner so that Air- conditioner will regulate room temperature accordingly. The concept of IoT summarized as the pervasive presence of surrounding to us with a variety of "things," which, through unique addressing schemes, can interact with each other to operate smartly.

As stated by Atzori et al. [3], Internet of Things can be categorized in three sub-paradigms, internet-oriented (middleware), things oriented (sensors) and semantic-oriented (knowledge). This type of categorization required because of the interdisciplinary nature of the IoT subject,

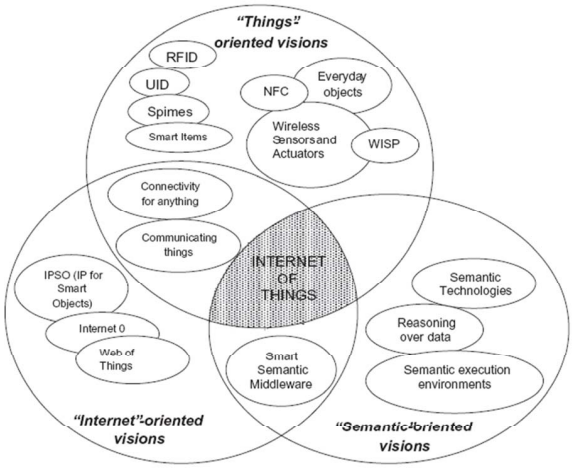

Figure 1. "Internet of Things" paradigm as a result of the convergence of different visions [3].

The Effectiveness and usefulness of IoT only are untethered in application domains where the three sub-paradigms intersect each other. Some of the well-known applications lie in the areas of heath care, home automation, logistics and the electrical grid.

In the era of IoT, middleware constitutes various networking protocol stacks along with core device functionalities. Another sub-paradigm of IoT is the sensor nodes; these are electromechanical devices that sense the surrounding environment. These nodes, then interconnected to each other with efficient networking techniques. Third sub paradigm of IoT is knowledge; Data generated by the sensor nodes must be transformed to information and from this information knowledge get extracted. This knowledge is then used to solve particular problems.

In this paper, we proposed an IoT framework to manage and monitor resources of such organization where a significant number of people operate on shared organizational things like Fans, Water Taps, and Tube Lights, etc. This paper organized as follows. Section III describes the generic architecture of IoT; Section IV depicts the work done so far in this application context. In Section V we describe the proposed framework in detail. We conclude the paper in Section VI.

978-1-5090-1560-3/17 $31.00 © 2017 IEEE
DOI 10.1109/IACC.2017.161

II. MOTIVATION

Organizational resources constitute electrical power, water resource, IT infrastructure, human resource, parking space, etc. Among these resources electrical energy is a most crucial resource of an organization. We took out our Institute as a case study and analyzed that nearly 45KW of electrical power wasted per day due reckless behavior of peoples. We found its frequent case where Fan, Air conditioner, and tube lights were switched ON though no one was present in the room. In another case, we found irrelevant Fan and tube lights were switched ON. So it's necessary to manage and monitor usage of electrical energy to control its wastage. In this regards, we make an attempt to manage electrical resource efficiently by designing IoT framework for the "things" as electrical devices like fan and tube light.

III. IOT ARCHITECTURE

One of the hurdles with IoT is that it is such broad concept that there is no standard uniform reference architecture for it. The IoT system consists of the variety of heterogeneous sensors and actuators, communication methodologies and processing technologies, but integrating these different types of technologies gives rise to the problem of interoperability. To address the issue of interpretability, there must be standardized IoT architecture. One of which is the services-oriented architecture (SOA) deployed in business software systems [4]–[6]. Although there is no such standard uniform Architecture for IoT, in general, IoT architecture can be view as multilayer system.

The first layer is "Things Layer." This layer contains

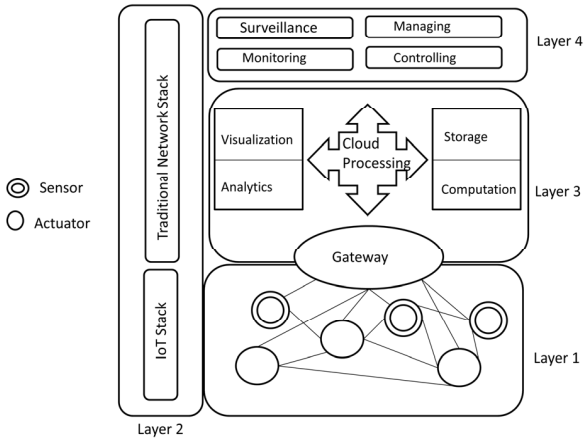

Figure 2. Generic Architecture of IoT [4].

different types of devices or "things." Things can be sensors type or actuator type. These things then interconnected to each other using wired or wireless networking techniques like Ethernet, Wi-Fi, Bluetooth, NFC, etc. The second layer is "Communication Layer," which consist of IoT gateway or edge router which maintains device communication in the first layer and packet routing from the external world to device. The third layer is "Data Processing Layer," it is responsible for handling an enormous amount of data generated by Things in the first layer. The fourth layer is "Service layer" also known as "application layer," It contains different types of services about a context of stuff in the first layer using web application. Sometimes the services can be as simple as just switching off an electrical switch or sometimes may be as complex as the critical infrastructure monitoring.

IV. RELATED WORK

Literature study in IoT implies that various applications of IoT have been developing rapidly from last few years. IoT service framework has proposed for Home and Building Automation [5] [12]. The concept of IoT also used to monitor the industrial environment [6]. Different types of IoT architectures have proposed for Smart City [7]. From IoT, development point of view researcher proposed lightweight networking algorithms and security framework [8] [9]. Current research efforts have been focusing on areas like protocols [10], data privacy identity management, trust and governance, power efficient routing algorithms, embedded operating system [11]. Considering all these available IoT technologies, their limitations, and efficiency, we propose a novel IoT framework to manage and monitor electrical resource of the organization, aiming to prevent wastage of electrical energy of an organization.

V. PROPOSED FRAMEWORK

In this Section, we propose a framework that efficiently utilizes the concept of IoT to manage and monitor electrical resource of the organization, aiming to prevent wastage of electrical energy.

A. Design Objectives and Requirments

The primary objectives and requirements identified for our framework are:

- Designing an architecture and describe device identification.
- Designing device discovery strategy.
- Designing an efficient packet routing strategy.

Key requirements for IoT system are:

1) *Deployable in existing Infrastructure:* Organization has its infrastructure; So IoT framework must be deployable in the existing framework.
2) *Scalable:* Organization can have the varying number of things. So IoT framework must be scalable.
3) *Low Power Consumption:* As the purpose of the framework is to efficiently manage the electrical resource of an organization, total power consumption of the framework should be very less.
4) *Cost Effective:* It is an ultimate requirement of a framework that it is cost effective so that middle scale organizations bear a cost of a framework.

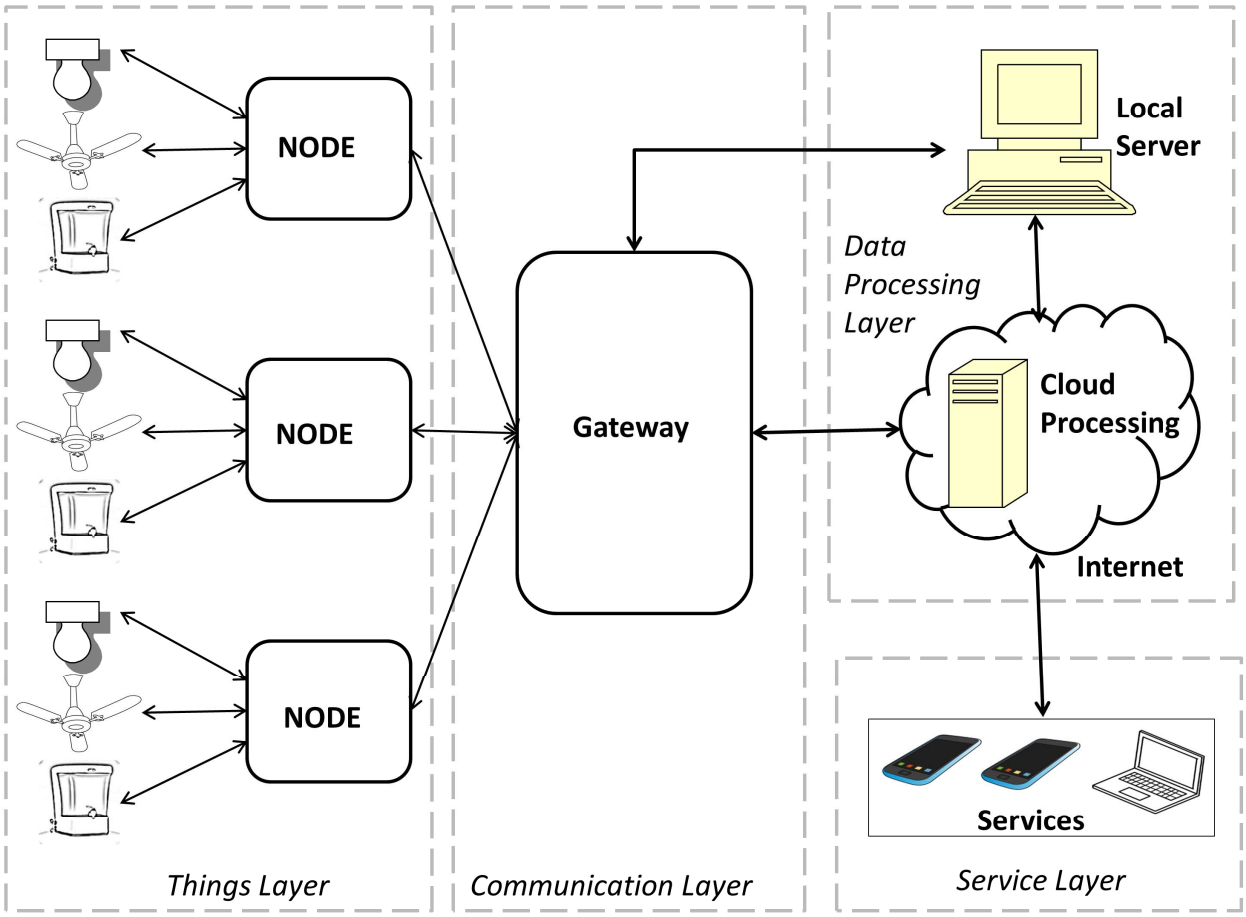

Figure 3. The Architecture of proposed IoT Framework.

B. System Architecture

Concerning generic IoT, the architecture outlined in Section III. The architecture of proposed IoT Framework is illustrated in fig 3. It contains four layers:

a) *Things Layer:* Things layer constitutes internetwork of various devices since we concern about the electrical power of an organization, we consider shared electrical devices in an organization as "Things," which are Fans, Tube Lights and Water Coolers. Total count of these devices is about 4200. To identify these devices uniquely on network one simplest way is assigning IP address to each device to do this we need IP enable network hardware like Ethernet, Wi-Fi radio or Bluetooth Low Energy (BLE) radio per device, but this will increase not only the cost of proposed framework but also power consumption by the framework. One cost effective solution is the forming group of several devices and assigning a common IP address to it this reduces the cost and electric power consumption, but to do this, we required a computing system with networking capability. This group of "Things." with embedded computing system having networking capabilities referred as "IoT Node." and interconnection of nodes known as "Device Network." There is one "Edge Router" or “IoT Gateway" in device network who is responsible for managing nodes and packet routing.

b) *Communication Layer:* There are choices for communication technique for IoT Node. Some common methods are Ethernet and Wi-Fi. IoT gateway has that all communication media which node haves. Communication layer provides embedded software stack that will handle networking packet routing and processing in device network.

c) *Data Processing Layer:* IoT node generates the huge amount of data; to deal with that data we require efficient data processing system. Data processing system can exist either at a Local server

or on cloud depending on size and rate of data generation by IoT node. For our case, we consider data processing at Local server.

d) Service Layer: This layer provides services that can act on device network. As stated above we are dealing electrical devices service layer provides services like controlling devices via smartphones and a centralized server. Monitoring device usage. Scheduling a day to day device activity. The service layer is an interface between an end user and IoT framework.

C. Implementation

As the primary purpose of proposed IoT framework is to prevent wastage of electrical energy of an organization. We designed a prototype and deployed in our organization. This section described design of the prototype.

- *IoT Node Design:* IoT node is embedded system that acts as an interface between Things and Services. Node provides bare functionalities relative to the things. For example, we have Fan and tubes light are things then node provides functionality like Switching ON and OFF the fan or light digitally. A software stack is embedded in the node for managing networking activities. We use Arduino Mega board as the computing device for the node with Ethernet and shield for enabling networking. With some supporting hardware, Node can handle 256 things. Block diagram of the node is illustrated in fig 4. Actual prototype of node is shown in fig 5.

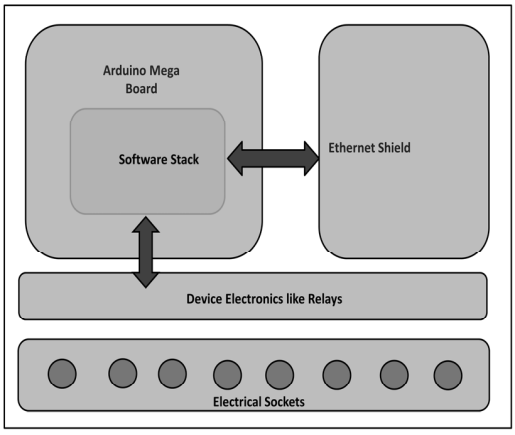

Figure 6. Block diagram of IoT Node.

- *IoT Gateway design:* Gateway is responsible for managing nodes and routing packets in device network. We use Raspberry Pi computing board as gateway hardware. We designed software stack and ported to Raspberry Pi. Ideally, it should handle 64000 IoT Node, but practically due to the resource, constraints it handles 6000 nodes. And Node can handle 256 devices, so total device handling capacity of a framework is 1535000 devices.
- *Data Processing and Services:* We use local data processing approach for managing data. We develop monitoring and managing services using web applications and Android application.

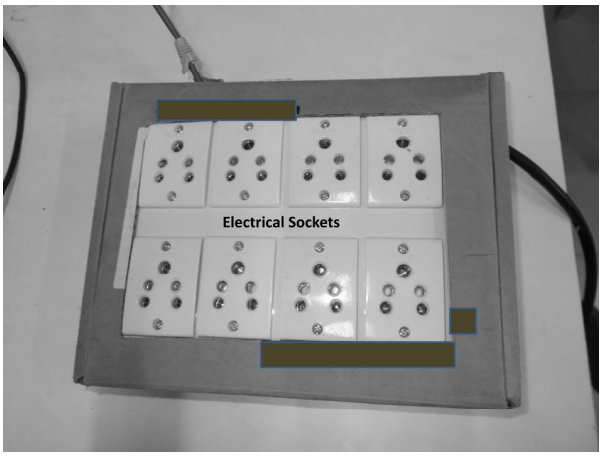

Figure 4. Prototype of IoT Node.

D. Performance Analysis

This section describes the performance of proposed framework. We design testbed for the analyzing framework. Testbed contains virtual IoT nodes; Gateway performance is described by graphs. We analyze CPU usage, cup temperature, and memory by a number of nodes. We inferred that a maximum number of node supported by proposed IoT framework depends on memory that IoT gateway haves. No effect on CPU usage and CPU temperature is seen while an increase in IoT nodes.

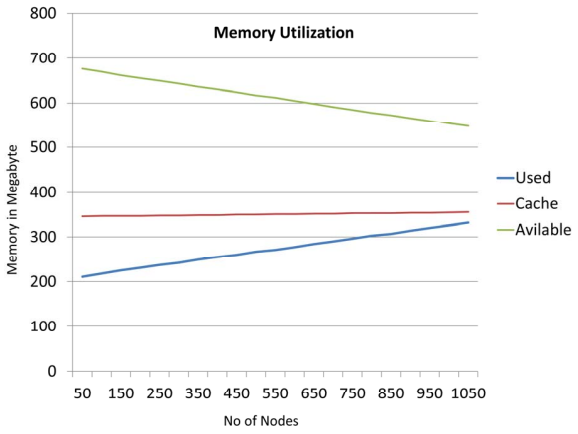

Figure 5. Node vs Gateway memory utilization.

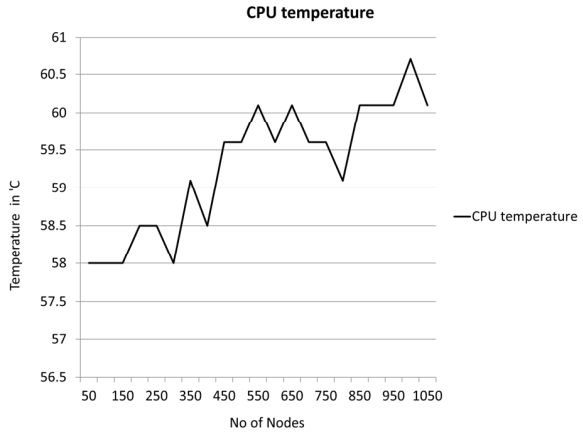

Figure 6. Node vs CPU temprature of gateway.

VI. CONCLUSION

Rapid development in the field of information and communication technology puts the concept of IoT up to great extent. In this IoT paradigm, every device in our surrounding gets connected to each other to form a giant network of things. IoT facilitates the use of devices anytime, anywhere by anyone. In this paper, we discussed the major requirements for incorporating the IoT paradigm in an organization. We propose cost effective IoT framework for an organization for the optimal utilization electrical power.

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