Internet of Things(IOT) Based Smart Grid

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***Abstract*—*Smart grid is one of the features of smart city model. It is energy consumption monitoring and management system. Smart grids are based on communication between the provider and consumer. One of the main issues with today's outdated grid deal with efficiency. The grid become overloaded during peak times or seasons. It is also possible to hack the system, and basically, take free electricity. By using smart grid consumer and owner get daily electricity consumption reading and owner can cut electricity supply remotely through internet if bill is not paid. One more thing, the data collected from the smart meters should not be accessed by any unauthorised entities. In case meter tempering is happened then owner and consumer get message and then owner take the action accordingly. Fitting the circuit on customer's energy meter, from that energy consumption data can be acquired. After acquiring of data, that data can be updated on cloud service, so that consumer and provider can access that data through internet. The main part of project is smart grid meter. When LED in smart meter gives 3200 blinks this means one unit is consumed. Second feature of this project is one micro switch is fitted in meter. This is to prevent meter tempering. There is one hidden switching circuit in that, whenever any person try to open the meter switch will get popup and controller send the message to owner and consumer. Third feature of project is control meter, if bill is not paid by customer then owner can cut the meter. Acquiring of data needs human resources, we can save this critical resource by using smart grid application.*

Keywords*—*Internet of Things; sensors; smart grid; smart meter.

I. INTRODUCTION

Internet of Things (IOT) is a concept and a paradigm that considers pervasive presence in the environment of a variety of things/objects that through wireless and wired connections and unique addressing schemes are able to interact with each other and cooperate with other things/objects to create new applications/services and reach common goals. The goal of the Internet of Things is to enable things to be connected anytime, anyplace, with anything and anyone ideally using any path/network and any service. Internet of Things is a new revolution of the Internet. Objects make themselves recognizable and they obtain intelligence by making or enabling context related decisions thanks to the fact that they can communicate information about themselves. They can access information that has been aggregated by other things, or they can be components of complex services. Smart cities are complex environments where several areas of innovation meet in order to substantially improve socioeconomic development and quality of life.

The Smart Grid (SG), the intelligent power grid, could be seen as the largest instantiation of the IOT network in the next future. The whole power grid chain, from the energy power plant generation to the final electricity consumers (houses, building, factories, public lightning, electric vehicles, smart appliances, etc.), including transmission and distribution power networks, will be filled with intelligence and two-way communication capabilities to monitor and control the power grid anywhere, at a fine granularity and a high accuracy. For instance, smart houses, will be equipped with smart meters and smart appliances, whereas power generators and electric transmission and distribution networks will be equipped with various sensors and actuators. The aim of the SG is to keep a real-time balance between energy generation and consumption, by allowing a fine-grained monitoring and control over the power chain, thanks to the huge number of the two-way communicating smart objects (smart meters, smart appliances, sensors, actuators, etc.). The Internet Of Things (IOT) will deliver a smarter grid to enable more information and connectivity throughtout the infrastructure and to homes. Through the IOT, consumers, manufacturers and utility providers will uncover new ways to manage devices and ultimately conserve resources and save money by using smart meters, home gateways, smart plugs and connected appliances.

Why Do We Need a Smart Grid?

- Good seldom insinuates that you cant be better, and in this case, a smart grid can be much better.
- Notwithstanding the naysayers, there are limitations on most of the energy resources on Earth, and we are beginning to better understand that. As such, we are learning to appreciate the value of better and more efficiently consume our energy resources and incorporate sustainable forms of energy into our lives. Smart grids can better accommodate these needs.

- We all want to live in a more comfortable fashion, but not without going broke along the way. Smart grids hold the promise of enabling greater comfort without requiring greater expense; at least long term.

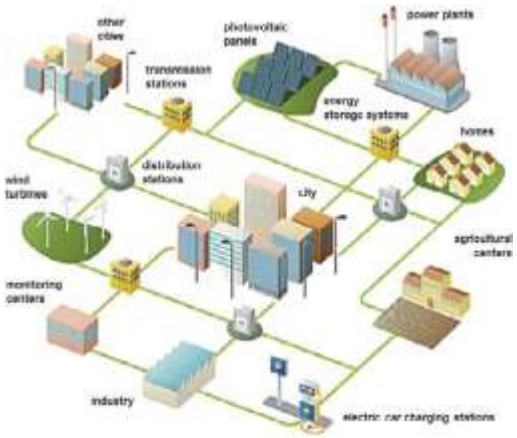

Fig 1: Smart grid representation.

There is increasing public awareness about the changing paradigm of our policy in energy supply, consumption and infrastructure. For several reasons future energy supply should no longer be based on fossil resources. Neither is nuclear energy a future proof option. Inconsequence future energy supply needs to be based largely on various renewable

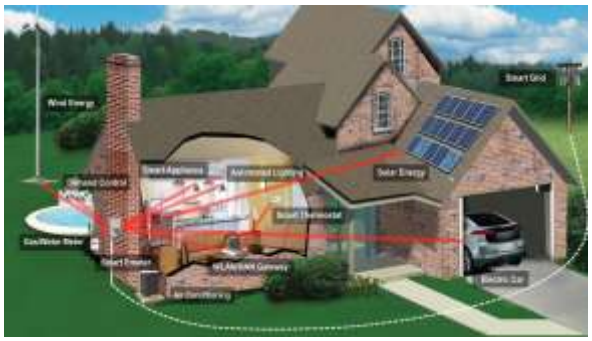

Fig 2: Smart grid connectivity enabling smart home services

resources. Increasingly focus must be directed to our energy consumption behaviour. Because of its volatile nature such supply demands an intelligent and flexible electrical grid which is able to react to power fluctuations by controlling electrical energy sources (generation, storage) and sinks (load, storage) and by suitable reconfiguration. Such functions will be based on networked intelligent devices (appliances, micro-generation equipment, infrastructure, consumer products) and grid infrastructure elements, largely based on IOT concepts.

A smart grid is an energy delivery system that moves from a centrally controlled system, like we have today, to a more consumer driven, iterative system relying on bi-directional communication to constantly adapt and tune the delivery of energy.

II. PROBLEM DEFINITION

1. Avoid the possibility of hacking the system, and basically, taking free electricity.
2. To prevent meter tempering.
3. Real-time Models and design methods describing reliable interworking of heterogeneous systems (e.g. technical/economical/ social/environmental systems).
4. To reduce the human efforts, and to cut the power automatically if the bill is not paid.

III. LITERATURE SURVEY

One year after the past edition of the Clusterbook 2012 it can be clearly stated that the Internet of Things (IOT) has reached many different players and gained further recognition. Out of the potential Internet of Things application areas, Smart Cities (and regions), Smart Car and mobility, Smart Home and assisted living, Smart Industries, Public safety, Energy environmental protection, Agriculture and Tourism as part of a future IoT Ecosystem have acquired high attention. In line with this development, the majority of the governments in Europe, in Asia, and in the Americas consider now the Internet of Things as an area of innovation and growth. Although larger players in some application areas still do not recognised the potential, many of them pay high attention or even accelerate the pace by coining new terms for the IoT and adding additional components to it. Moreover, end-users in the private and business domain have nowadays acquired a significant competence in dealing with smart devices and networked applications. As the Internet of Things continues to develop, further potential is estimated by a combination with related technology approaches and concepts such as Cloud computing, Future Internet, Big Data, robotics and Semantic technologies. The idea is of course not new as such but becomes now evident as those related concepts have started to reveal synergies by combining them.

However, the Internet of Things is still maturing, in particular due to a number of factors, which limit the full exploitation of the IOT. Among those factors the following appear to be most relevant:

- No clear approach for the utilisation of unique identifiers and numbering spaces for various kinds of persistent and volatile objects at a global scale.
- No accelerated use and further development of IOT reference architectures.
- Less rapid advance in semantic interoperability for exchanging sensor information in heterogeneous environments.
- Difficulties in developing a clear approach for enabling innovation, trust and ownership of data

in the IOT while at the same time respecting security and privacy in a complex environment.

- Difficulties in developing business which embraces the full potential of the Internet of Things.
- Missing large-scale testing and learning environments, which both facilitate the experimentation with complex sensor networks and stimulate innovation through reflection and experience.

Overcoming those hurdles would result in a better exploitation of the Internet of Things potential by a stronger cross-domain interactivity, increased real-world awareness and utilisation of an infinite problem-solving space.

These forward-looking considerations do certainly convey a slight touch of science fiction, but are thought to stimulate the exploration of future living worlds. The overall scope is to create and foster ecosystems of platforms for connected smart objects, integrating the future generation of devices, network technologies, software technologies, interfaces and other evolving ICT innovations, both for the society and for people to become pervasive at home, at work and while on the move.

- Fostering of a consistent, interoperable and accessible Internet of Things across sectors, including standardisation.
- Directing effort and attention to important societal application areas such as health and environment, including focus on low energy consumption.
- Offering orientation on security, privacy, trust and ethical aspects in the scope of current legislation and development of robust and future-proof general data protection rules.
- Providing resources like spectrum allowing pan-European service provision and removal of barriers such as roaming.
- Maintaining the Internet of Things as an important subject for international cooperation both for sharing best practises and developing coherent strategies.

The Internet of Things continues to arm its important position in the context of Information and Communication Technologies and the development of society. Whereas concepts and basic foundations have been elaborated and reached maturity, further efforts are necessary for unleashing the full potential and federating systems and actors.

IV. HARDWARE ARCHITECTURE

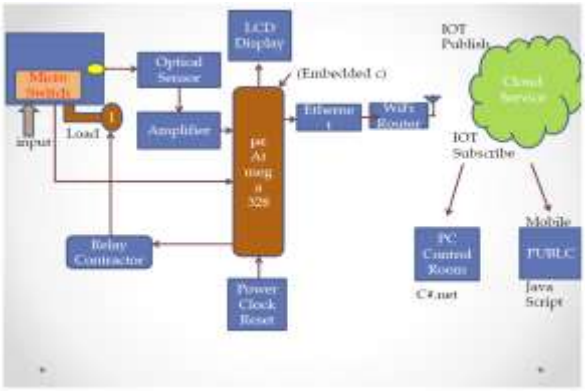

Fig 3: Block Diagram of IOT based smart city

Smart grid is energy consumption monitoring and management system. The three basics features of smart grid are:

1. Consumer and owner get clarity of electricity consumption readings.
2. Owner can cut electricity supply remotely through internet if dues/bills are not paid.
3. The data collected form smart meters cannot be access by unauthorized entities. In case energy theft is happened the owner and consumer get message to take necessary action.

Block daigram Description:

Basically a circuit will be fitted i.e smart meter in consumers home so from that we will acquire data and after acquiring we will upload/update the data on cloud service so that owner of smart grid (for E.g. MSEB or Reliance) and customer can access that data. The smart meter circuit consists of LED which usually blinks 3200 times so to calculate that impulse we fix LED which will indicate 1 Unit electricity consumption for 3200blinks i.e. 3200 impulse = 1KW. To pick the pulses in the circuit we connect photo detector on meter. The output of this photo detector will be connected to transistor so that it amplifies the signal which we obtained from photo detector. When LED blinks light of LED fall on photo detector so that amplifier junction will break ,because of light junction breaking will leads to flow of Leakage current which results into enabling of Transistor. When transistor is on, the supply goes to ground which means we get low(0) in output. When LED is off photo diode off as no light falls on photo detector then transistor becomes o so supply we get high(1) in output. Means when LED blinks we get Logic zero pulse. We use ATMega328 microcontroller in circuit. It is advance AT 1 series controller and 328 is number of controller. Microcontroller counts how many pulses we get that is our unit consumption. Second thing micro-switch is fixed on meter. One point of micro-switch is connected to the ground and other point is connected to microcontroller at pin. This all circuit is

to prevent meter tampering means to detect power theft. Basically, there is a hidden switch in meter, whenever any person try to open the meter, the switch will get pop up and we get logic high in controller pin and after that controller sends the message to owner and consumer that meter has been tampered. Both daily consumption units micro switch data we take it as input in controller and both these readings are displayed on LCD display. So because of that we can check the status of meter. If bill is not paid by the customer then owners can remotely cut the power supply PubNub site which is owners site. So relay contractor is connected in circuit. When theft is detected we get logic one then relay contractor will get Open and electricity supply of meter will get cut.

Hardware description:

In circuit, we give 230v supply as AC input to meter. Input part and output part of meter each have one phase and one neutral port this output phase wire connected to load (bulb)
through relay. Relay by default is in close condition. Circuit starts working when relay is in close condition. But if relay triggered then relay will get open and immediately circuit stops working. In meter circuit, LED gives pulse according to value of load. On meter Cal means calibration is written. When LED gives 3200 impulse, means 1 kw-hour unit is get consumed. Means when LED blinks for 3200 times 1 unit will get consumed. For now to save time we take 1 pulse equal to 1 unit. To catch LED pulse there is one photodiode is connected next to LED. Signal of photodiode is very week so transistor (BC549NPN) is connected near to photodiode to amplify the signal. Output of collector connected to A0 pin of microcontroller. So microcontroller count the pulses from optical sensor which is connected to A0 pin. Inside the meter there are seals on both sides of meter, so for meter tempering people give heat to that seal, so seal will get loose and meter will get open. By opening the meter screws anyone can temper the meter and change the meter readings or by adding one more coil on meter anyone can slowdown the meter. In our case, inside the meter there is one switch which is by default in close condition. If someone trying to open meter, switch will get open and send the message to owner and user. By this way user and owner can control meter tampering.

In this circuit switch is connected outside the meter for better understanding. So in this project this switch is in normally open condition. When someone press that switch, switch will get triggered and message will get sent. So this is a theft switch.
To give power supply to circuit we take same 230volt supply which flows from meter. By using step down transformer this 230v supply step down to 12 volt 1 amp. This 12 volt supply is AC supply so we rectify that supply by using 4 diodes and then filters it using capacitor then it became 12v DC supply. This diode, filter, voltage regulator7805, filter of 1f, spike suppressor of 0.1f , power supply indication LED and current limiting register make whole power supply section complete.

Microcontroller ATmega328 want clock, so crystal oscillator of 16MHZ and 2 capacitor of 22pf are connected. Using this clock program inside the microcontroller is executed. Further RESET pin on board is active low. 1 register is connected to pull up that pin. Because that pull up it could not by default get RESET. When supply is get on then by using software program automatically it will get RESET. But if anyone want to RESET the circuit, then by cutting the power supply and again restarting it, circuit will get RESET. So each time after restarting, the circuit it will get RESET.

In microcontroller, from A0 to A5 6 analog pins and 0 to 13 total 14 digital pins are there. In this project there is no analog sensor so 6 analog pins also use as digital pins. On A0 pin of microcontroller optical sensor is connected and on A1 pin theft switch is connected. A2, A3, A4, A5 pins are used to generate meter number. Meter number is in form of decimal power number. If 1st switch is on then meter value is 1, if 2nd switch is on then meter value is 2. If both 1st and 2nd switch are on then value of meter is 3. If all 4 switches are on then meter value is 15. So by making combinations of these 4 switches meter number will get created which is between 1 to 15.

On A0 and A1 pin built in UART is there. By using UART we can make serial communication. Output from these A0 and A1 pin (optical sensor and theft sensor output) goes to arduino board. On the arduino board there is one arduino shield. That arduino shield receive serial data from microcontroller. Inside the arduino board one more ATmega328 microcontroller is there. So in this project there are 2 ATmega328 microcontrollers. 1st microcontroller handle the project circuit and 2nd microcontroller communicate with PubNub which is online server. Communication from microcontroller to arduino board is serial communication which is in form of Tx and Rx. So microcontroller send optical sensor data to arduino shield through Tx wire and arduino shield send data from PubNub to microcontroller through Rx. On arduino module Ethernet is connected. This Ethernet is connected to any nearby router or WiFi module by configuration process. So microcontroller data goes on internet through Ethernet and data is updated on cloud service.

Pin number 3, 4, 5, 6, 7, 8 of microcontroller connected to LCD display. This LCD display is of 16/2 dimension means 16 column and 2 rows. Preset is of 10 K is connected to microcontroller to adjust the brightness of LCD screen. Further output from 9th and 10th pins of microcontroller goes to transistor. This is BC549 NPN transistor. This transistor amplify

the signal and magnetized the coil of relay. Relay is of 12v which is SPDT means Single Pole Double Throw relay. If 1st relay is get triggered then load will cut off. If 2nd relay is triggered then we get buzzer. Means if any problem is occurred control unit give the trigger, so because of triggering both relay get activated and power will cut off.

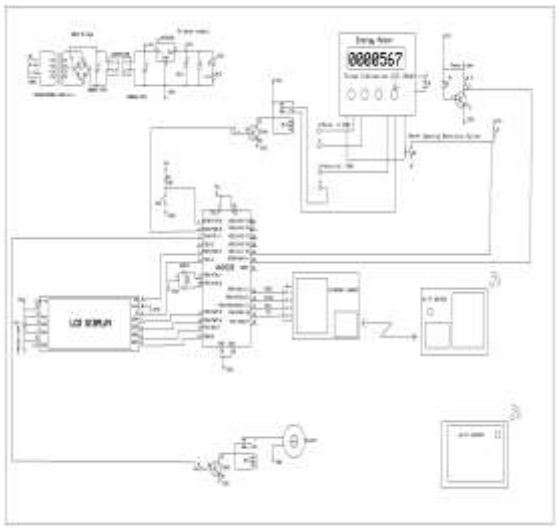

Fig 4: Circuit Diagram of IOT based smart grid

V. SOFTWARE IMPLEMENTATION

Software Applications used are:

1. **PubNub:** In our project PubNub is owners (MSEB, Reliance, TATA) site. Basically PubNub is a global Data Stream Network (DSN) that makes it easy to develop and deploy realtime mobile and web apps, using just two functions (Publish and Subscribe) to pass data back and forth in under 1/4 second. PubNub utilizes a Publish/Subscribe model for realtime data streaming and device signaling and supports all of the capabilities of WebSockets, Socket.IO, Data Channel and other streaming protocols. PubNub provides SDKs for over 70 different programming languages and environments including JavaScript, iOS, and Android, as well as JavaScript frameworks such as AngularJS, Ember.js, and Backbone.js. PubNub also provides client libraries for board platforms including Raspberry Pi, Arduino, Texas Instruments, and Microchip.
2. **Freeboard.io:** In our project Freeboard is client/customers site. Freeboard is a turn-key HTML-based "engine" for dashboards. Besides a nice looking layout engine, it provides a plugin architecture for creating data sources (which fetch data) and widgets (which display data) freeboard then does all the work to connect the two together. Another feature of freeboard is its ability to run entirely in the browser as a single-page static web app without the need for a server. The feature makes it extremely attractive as a front-end for embedded devices which may have limited ability to serve complex and dynamic web pages.

The overview of these websites are as follows:

Fig 5: PubNub Website.

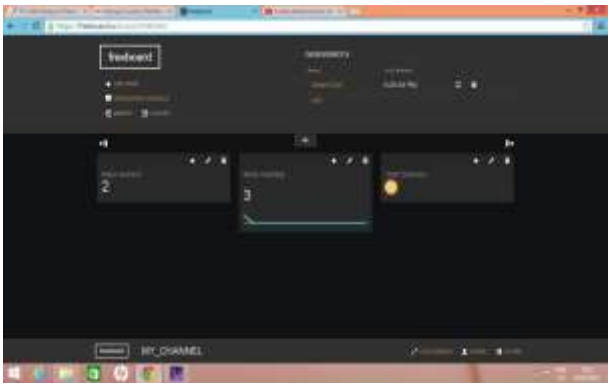

Fig 6: Freeboard.io Website.

VI. ADVANTAGES AND DISADVANTAGES

Advantages:

- More efficient transmission of electricity.
- Quicker restoration of electricity after power disturbances.
- Reduced operations and management costs for utilities, and ultimately lower power costs for consumers.
- Time saving technology.
- Tamper detection to reduce electricity theft.
- Energy saving robust and reliable smart sensors/actuators.
- Absolutely safe and secure communication with elements at the network edge.

Disadvantages:

- Exposure of sensitive customer data.
- Connectivity to untrustworthy partners that cannot be selected.
- Exposure of critical infrastructure due to connectivity reasons.

- Introducing malicious software, compromised hardware could result in denial of service or security threats.
- Biggest concern: Privacy and Security.
- Some types of meters can be hacked.

VII. CONCLUSION

A revolution in energy domain is underway, namely the Smart Grid. Smart Grid is owner as well as user friendly technology. User can check daily consumption from any location using internet. Owner can control customer meter from control unit. Smart grid represents one of the most promising and prominent internet of things applications. More efficient transmission of electricity. Quicker restoration of electricity after power disturbances. Reduced operations and management costs for utilities, and ultimately lower power costs for consumers. Time saving technology. Control on Meter tempering.

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