A novel approach to design Smart Home Architecture in Energy Efficient way based on IOT-A Survey.

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Abstract — **Internet of things represents a new milestone in computing in which devices are connected to the Internet and use internet to communicate with each other. The connection between "Things" of internet needs huge amount of data transfer and analysis for successful results and justify their role by reducing human effort. The amount of information used in IOT plays an important role in the quality of system. Huge amount of information leads to better results but requires a lot of energy and less amount of information does not allow system to be up to the mark .There has to be a tradeoff between the amount of information and energy consumption along with no compromise in area covered. In this paper, we survey solutions for the very well known and understood problem of energy management in Internet of Things. First we provide briefing about the various techniques used for componential energy efficiency. Then we propose our architecture for energy efficiency encapsulating the whole system. Then we dive deeper into the architecture covering important features of the same.**

Key words : Internet of Things (IOT), Energy Efficiency, Energy efficient index (EGF) tree, ECH, OGM, cloud computing sleep interval, sensors, Layers.

I. INTRODUCTION

Due to the change in the scope of applications of internet shifting towards making "Physical World Smarter", there is no doubt that people will witness a shift in the number of connected devices soon. It is estimated that in the next five years fifty billion devices will be online. Wireless networks are the most important for the success of the IoT infrastructure. Sensors should be able to communicate without constraint of physical wiring thus making them more independent. The things of internet should exhibit power efficiency apart from excellence.

The sensors are expected to be active only when necessary that is to read, send data or to make a decision and be lying dormant for the remaining time thus implementing power efficiency. Atmel, Texas Instruments, Freescale, STMicroelectronics are offering such microcontrollers that make application building very fast. An important factor that affects IOT infrastructure is the architecture While 32bit cores, low cost microcontrollers have the advantage of being more compatible to large number of open-source software still they have high power consumption. Many companies are working towards the manufacturing of microcontrollers exhibiting inherent energy efficiency which will help in the overall architecture of IOT in the bigger picture.

The fulfilling of the following requirements is necessary for any IOT system:

A. Interoperability

A prime concern is consumers must have easy to connect and easy to use devices that simply work together. In a smart home, network devices and systems come from different vendors with different network interfaces, but still need to interoperate to achieve join executions of tasks. Interoperability is defined as the ability of systems, applications, and services to work together reliably in predictable fashion. It is the ability of two or more systems to exchange information and use the information that has been exchanged.

B. Self-Management

To operate and collaborate with other devices, to adapt to failures, changes in the environment, it is the main requirement of the sensor nodes to be self-managed, which mean complete independence of human intervention.

C. Maintainability

Maintainability is an essential requirement in a network that reflects how reliable and durable the smart home network is. Changes that happen everywhere including the home environment due to failing nodes tires batteries. The smart home network must be designed with the goal of easy maintenance that repairs the various devices and communication components quickly and cost effectively.

D. Power Consumption

An efficient IOT network needs minimal battery drain and low power consumption for communication. The devices connected in IOT smart home can determine the best time to operate which in turn provide higher efficiency in power consumption. The power consumption should be very less.

Many communication technologies are well known such as Wi-Fi, Bluetooth and ZigBee. The energy consumed by these protocols also plays a vital role in overall energy utilization. Following are the important protocols associated Internet of Things:

ZigBee: A low power consuming IEEE 802.15.4(2003) makes use of mesh networking which makes utilization of communication resources much more efficient. ZigBee has some significant advantages in complex systems offering low-power operation, high security and robustness

Bluetooth Low Energy (BLE): This protocol provides the same range coverage with much reduced power consumption as the original Low power latency and lower complexity makes BLE more suitable to incorporate into low cost microcontrollers

Wi-Fi: Wi-Fi is predominant communication technology chosen for IOT applications. Existing protocols like WPS make the adjustment of internet of things devices more comfortable with the existing network. Wi-Fi offers the best power-per-bit efficiency. Power consumption when devices are idle is much higher with conventional Wi-Fi designs.

Apart from protocols, techniques are available for reducing energy consumption in IOT infrastructure itself which have been proposed earlier by various authors. The paper aims to study the architecture which utilizes the fact that IoT resources use negligible energy in sleep mode and therefore the architectural design allows the sensors to switch to sleep mode [1] under three cases: 1) When it is not necessary to sense the target environment in a given period of time; second2) When the coverage area can be compromised for battery life 3) When the battery level is critically low. When the sensors go in sleep mode, this arrangement gives two options: 1) Switch to sleep mode 2) Get released and reprovisioned later for energy efficiency. The main objectives of the architecture are providing a mechanism for the efficient energy utilization hardware as well as middleware elements of IoT systems and reprovisioning of the allocated cloud resources when corresponding sensors are in sleep mode As well as predicting and controlling the sleep interval of sensors which depends upon the previous usage history and remaining battery level. The architecture consists of three layers, the Sensing and Control Layer (SCL), the Information Processing Layer (IPL), the Application Layer (AL) and the issues handled by each layer. The SCL collects data from the target environment in an energy-efficient way and transmits it to the IPL, which, in turn, extracts useful information from it.

The rest of this paper is organized as follows. Section II contains Energy Efficiency Techniques (literature review). Architecture is drawn in Section III. Section IV contains Theoretical Analysis. Section V is Conclusion

II. LITERATURE REVIEW

A. An Energy Efficient Index Tree: This technique is to address the challenge of spatial index trees mostly not being efficient for query data collection and aggregation, Energy-efficiency index tree[2] (EGF-tree) has been proposed for efficient data collection and aggregation, especially for the situation when sensor nodes are distributed unevenly. The region of the sensor network is divided evenly into grid cells (mostly). An EGF tree is constructed through merging grid cells nearby. A multiregional query aggregation method is proposed for facilitating the collection and aggregation of simultaneous queries. First, the whole region of the sensor network is divided into grid cells with the same geographic size. Then, any two grid cells are merged into one sub-region, when the message forwarding distance between them is the smallest. The smaller the distance between two grid cells is, the less the energy consumption is needed when forwarding the same size of message between these two grid cells. Upper level sub-regions are merged pair-wisely in the similar manner, and this procedure iterates until a tree hierarchy viz an EGF tree, is formed. A multiregional query aggregation method is proposed. This approach includes the following three steps: 1) Aggregation query plan generation.2) Query command routing and result returning 3) Query result decomposition. Based on this EGF-tree hierarchy, multi-region queries are aggregated in-network and queries are executed efficiently.

B. An energy efficient hierarchical clustering index tree: The whole region of the sensor network is divided evenly into grid cells. Then multiple grid cells are clustered into one subregion, ensuring that the energy consumption for forwarding messages between them is the smallest. Upper level sub-regions are clustered in a similar manner. This procedure iterates until a tree hierarchy, an ECH-tree [3], is formed. ECH-tree has less dead space in high-level sub-regions. Time-correlated region query method is there for answering continuous queries while mitigating the energy consumption regarding these queries. Generally, all sensor nodes are required to report their values to the base station at the beginning. They report the last values continuously, only when these last values of certain sensors are significantly different from the values reported to the base station previously. Queries are answered through assembling the values of interested sensors saved in the base station. The technique is energy efficient, especially when the region is mostly interested by end-users, and queries are to be answered continually.

Energy-efficiency index tree called EGF-tree. First, the whole region of the sensor network is divided into grid cells with the same geographic size. Then, any two grid cells are merged into one sub-region, when the message forwarding distance between them is the smallest. The smaller the distance between two grid cells is, the less the energy consumption is needed when forwarding the same size of message between these two grid cells. Upper level sub-regions are merged pair-wisely in the similar manner, and this procedure iterates until a tree hierarchy: an EGF tree, is formed. Leveraging the EGF-tree hierarchy, a multiregional query aggregation method is proposed. Theoretical analysis and experimental results show that the energy consumption of forwarding query requests and their results depending on our EGF-tree hierarchy is reduced in comparison with the related techniques. There are two algorithms used in this paper. The first algorithm shows the ECH-tree construction procedure when sensor nodes are distributed unevenly. First of all, the entire region is divided uniformly into grid cells, each grid cell is a square and the side-length of each grid cell 2pr. r is the communication radius of sensors. The communication radius of sensors is assumed the same in this research. We choose the side-length a 2pr, the optimal cluster size is 1 hop in dense regions, and the size should be larger in sparse regions. The gird cells are grouped into several clusters. The new formed cluster sub-regions are clustered recursively, until the root cluster is formed. Algorithm 2 details the grid-cell clustering procedure. Usually, the cluster heads are selected according to the probability of optimal cluster heads decided by the network. Being a cluster head node is much more energy consuming than being an average head node, it is necessary that each node takes its turn as cluster head in rotation. LEACH incorporates the randomized rotation of the high-energy cluster head position among sensors to avoid depleting the energy of any sensor. Therefore, the energy load of being a cluster head is evenly distributed among the nodes in a sub-region. ECH-tree is constructed through clustering the adjacent grid cells having minimum transmission energy for the same size of message. For the sensor nodes, they are the First ones to be divided into the grid cells with the side-length 2p r. The grid cells are then clustered into a larger region based on the energy minimum principle. The larger region becomes the parent node region of the clustered grid cells. This procedure iterates until the root node is formed. Time-correlated region queries depend on ECH-tree. Energy consumption is reduced for avoiding redundant data forwarding when considering the sensor data change degree in continual time intervals. Continual reporting can make the base station assemble the query results directly from the grid cell tables.

C. Object Group Localization Connectivity: Object Group Mobility (OGM)[4] is a phenomenon that naturally emerges as usually IoT objects are carried by a human or a vehicle together with several other objects. Consider the case in which nodes of the same group are equipped with different network interfaces, that is, the group is heterogeneous. In this way, it can be shown that it is possible to increase location accuracy. Dynamic membership of objects within a heterogeneous group can be effectively managed (dynamically vary, increase in size, reduce, split, join, etc.) . The usage of a collective agent, allows to further reduce the signalling overhead while keeping updated the information relevant to the group members. Considering object group mobility (OGM) it is shown how OGM can be exploited to reduce signalling traffic and to improve the accuracy of object localization along with it by means of a collective agent representing a group of objects as a whole, it is possible to reduce signalling traffic and improve accuracy in object localization and analytical framework to assess the advantages of the proposed approach nodes, usually move in groups. That is, objects typically aggregate around a carrier (a person, a truck, a car, a bag, a box, etc.). This occurrence can be shown through the concept of object group mobility (OGM) and the carrier around which objects aggregate is denoted as group master (GM). Master as well as moving nodes denoted by the Slaves are the IoT items. The group master is specifically assumed to be equipped with multiple wireless interfaces. Emergence of group mobility has been observed in various wireless cases and utilised to reduce energy consumption and to preserve privacy in mobility management. In an Internet of Things scenario, group mobility can be fruitfully used for reducing mobility management over head. For this, the GM assigns addresses available in its “home network” to the slaves, so registering them as nodes of its network. Accordingly, slaves set the address of the GM home network as their care-of-address at their home agents. This results slaves in a group moving and thus the foreign address changing, no binding messages will be exchanged among slaves and their home agents: only the

GM will inform its home agent about the care-of-addresses of the slaves in the group.

III. ARCHITECTURE

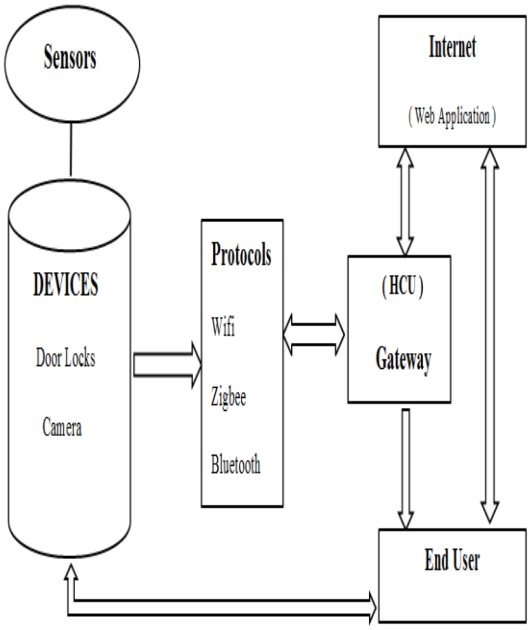

Fig 1:System Architecture

1. Energy conservation is a major aspect in our everyday life. Human activity is the major cause of energy wastage. Using the principle of IOT, we can meet our power utilization requirements. This paper proposes Architecture for IOT, which ensures an energy efficient utilization of the resources. Even the ability to control these devices under different environment scenarios will assist in making the smart home more energy efficient.
2. The system monitors the energy usage and security of the house in a user friendly, energy efficient way and a mobile way even when user is not at home itself.
3. Various types of sensors will be used to monitor the place under observation. The use of many cameras can be reduced to very few because of sensors.
4. The instruments that will be using sensors are doors, cameras. The focus is surveillance hence cameras will be undergoing change in a major way. The camera which now consumes energy by remaining switched on 24*7 will be able to operate as per requirement by the end of the project.
5. One camera does not affect much but many cameras in places like banks, malls add up to a lot of power consumption.
6. Protocols like Zigbee and Wi-Fi will be used. The use of Wi-Fi is energy consuming though. But it will be used only for application level where faster communication is required.
7. Zigbee is energy as well cost efficient protocol but a bit slow. Hence, use of Wi-Fi is mandatory.
8. Use of Gateway makes it possible that all configurations are done on a single device. More flexible.
9. The web application is the connection of the system with the user. The system will communicate with the user with the help of application.
10. The application will give alerts about the intruder to the user thus making assistance to the user easy.
11. The intruder tries to make illegal entry, the sensors detect it.
12. The sensors switch on the camera, which was off all this time.
13. The camera records as well as captures a picture of the intruder.
14. The picture of the intruder is checked on the cloud before involving the app. If the picture is not already stored, quick action is taken.
15. The application is communicated about the intrusion.
16. The user is notified by using the application.
17. Though we talk about surveillance, this system can work for other areas like health monitoring.

IV. THEORETICAL ANALYSIS

Earlier there were many methods which could introduce energy efficiency in the IOT components. But this system will do so in the whole architecture. The techniques described in Literature Survey [II] are a few of them. But they do not bring energy efficiency in the entire architecture of IOT. So this method is a path breaking one as it considers the entire system under use instead of concentrating on one component

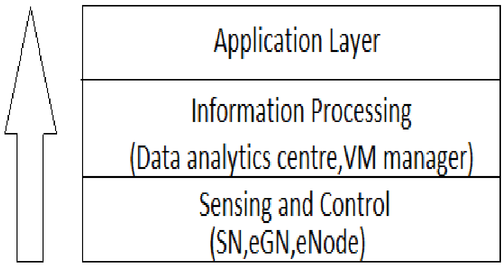

Fig 2: Architectural layers

Sleep interval in sensors: The architectural design allows the sensors to switch to sleep mode under three scenarios:

1) When it is not necessary to sense the target environment in a given period of time
2) When the coverage area can be compromised for battery life
3) When the battery level is critically low.

When the sensors are in sleep mode, the architecture allows the allocated middleware resources to either switch to sleep mode or get released and reprovisioned later for energy efficiency .Thus, the resources of hardware and middleware elements of IoT have been “tuned” together in the architecture for better performance and energy saving.

A) SCL- SCL consists of the hardware elements of an IoT system. It collects raw data in large volumes and sends them for data analysis.
The three main components of this layer are sensor nodes (SNs), energy-saving gateway nodes (eGN), and an energy-efficient base station (also called the evolved node or eNode). Each of these components is explained in short below:
a) SN- The SNs are responsible for data collection. They sense the target environment and send the sensor measurements to a gateway node (eGN). Based upon the frequency of data collection and transmission, SNs are classified as either trigger based or periodic. The trigger-based SNs wait for a particular event (trigger) to occur and transmit data only when trigger is fired. On the other hand, periodic sensors collect and transmit data on regular intervals or on arrival of a query. Both types of SNs collect the data in their respective buffers, and their communication hardware sends the collected data to eGN.
b) eGN- The eGN is a major contributor for saving energy in the SCL. It not only provides storage media for sensed data but also acts as a controller of SNs connected to it. It calculates the sleep interval of each SN connected to it in two steps. In the First step, it predicts the length of the next sleep interval of an SN on the basis of its previous usage history. Then in the next step it uses this predicted value to calculate the actual sleep interval based
c) eNode- The SCL contains a base station or an eNode that controls all the eGN. It fetches any required information such as quality of information from the cloud data analytical center and passes it to eGN. It also transmits all the data harvested by SNs to the IPL and, hence, sets up a communication path between sensors and cloud resources. In addition, the eNode allocates SNs to each eGN depending upon the battery level of the eGN and the distance of the SN from the eGN.
B) IPL: The data collected by the SNs are in raw form and in large volumes. The data need to be stored, processed, and analyzed to extract interpretable information from it. This task is accomplished by the IPL, which uses storage and data analytical tools provided by the cloud computing platform. This layer consists of a data analytics center, storage media, and different physical and virtual machines. The data analytical center further consists of an energy-efficient resource allocator (eRA), an information analyzer (IA), and an application-dependent information convertor (ADIC).
a) eRA- The eRA is the energy-saving component of the IPL. It allocates the hardware resources for data processing according to the requirements of the SCL. The resources of the SCL and the IPL are “tuned” together for better performance and energy saving. This mechanism allows for the energy-efficient use of the cloud resources
b) IA- IA calculates the level of information extracted from data collected by the SCL. It classifies the level of information into L levels ranging from very low (level 1) to very high (level L). The factor (quality of information) is calculated by the IA and is conveyed to the eNode whenever the level shifts from a higher to a lower level or on reception of a query from the eNode.
c) ADIC- The information extracted by the IPL can be used by any application in the AL. The same information can be used by various applications but in different forms. ADIC converts the information into the required form for different applications. This mechanism provides application developers a platform (PaaS) for easy application development

D) AL- AL provides services to the end users. It provides an interface to users for applications such as health monitoring, smart city, smart transportation, environment monitoring, surveillance, business intelligence, smart grid, and remote monitoring. The information derived from raw data collected by the sensors can be used by any application. In addition, this layer also provides the visualization tools to show the processed data

All of these help to introduce Sleep interval in sensors and efficient working of the system.

V. CONCLUSION

In this paper, architecture for IoT has been proposed, which ensures an energy-efficient utilization of the resource. The energy is effectively and efficiently saved by switching the hardware resources of the SCL and the IPL to sleep mode. The key feature of the proposed model is the exchange of energy-related information between the two layers. The sensors switch to sleep mode based upon their available battery power and other factors, such as quality of extracted information, conflict factor, and CoV. This mechanism enables cloud environment to predict the maximum amount of data that can be received during the next time interval, and hence, resources can be provisioned accordingly. Hence, the PA effectively increases resource utilization of hardware resources of both the SCL and the IPL. In a nutshell, the PA is energy efficient. Moreover, due to flexible nature of the PA, it can be applied in a large number of IoT networks. Various resources are integrated in smart home application system and allowing the existing smart home system to be executed. Here, for the connectivity we choose networking and routing protocols that offers scalable, versatile and management solution

The various techniques shown in the paper viz Index tree, Object group mobility are all used for energy efficiency of components of IOT. Introducing sleep interval in the architecture makes an energy efficient architecture and not just components.

To lower the power consumption by an IoT node only hardware changes is not the way. Smart communication protocols help in making exchange of data between devices less power consuming.

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