# Energy Consumption and Reliable Communications for Green IoT

Saurabh Singh[1], Seo Yeon Moon[1], Gangman Yi[2], Jong Hyuk Park[1*]
[1]Dept. of Computer Science and Engineering, Seoul National University of Science and Technology (SeoulTech), Seoul, 139-743, REPUBLIC OF KOREA
[2]Department of Multimedia Engineering, Dongguk University, Seoul 100-715, REPUBLIC OF KOREA

E-mail: [1]{singh1989, moon.sy0621, jhpark1}@seoultech.ac.kr, [2]yi.gangman@gmail.com

## Abstract

Green Internet of Things (IoT) is the study and practice of eco-friendly sustainable computing. The basic goal of green computing is to reduce the use of materials and maximize energy efficiency with reliable and secure communications. The paper presents various technologies and issues regarding green IoT. It also studies the green Information and Communication Technology (ICT) such as green M2M, green Cloud Computing (CC), and green Data Center (DC). In addition, this paper mentions about the reliability in IoT Communication and and issues to achieve green IoT communication by applying efficient activity scheduling technique for energy saving. Finally, we propose the green IoT-Home Service (GIHS) model which provides efficient energy management in home automation system.

## 1. Introduction

An IoT is a field in communications where various smart devices are included to share data and make decisions. IoT will be a business sector changing power for a broad range of continuous monitoring and updating applications, for example, E-medicinal services, home automation systems, natural observing and industrial computerization as it is supporting to countless and accomplishing better cost-effectiveness [1]. IoT aims to accomplish better cost-effective communication devices.

For accomplishing the sustainable smart world, this paper talks about the different advances and issues on green IoT which further decreases the vitality utilization of IoT [2]. At that point, the issues about green data advancements such as green data center, green remote sensor system, and green distributed computing, green machine to machine, empowering green IoT are considered.

In this paper, a green IoT-Home Service model based on the energy consumption and reliable communication is proposed. The model offers an exhaustive package that provides energy monitoring system, secure communications, real time price information, optimizing energy usages, and intelligent decision making engine.

## 2. GREEN IoT

To empower the sustainable smart world, the IoT should be characterized by energy efficiency. IoT is a combination of identification of devices, sensing data, communications, computations, and providing services and semantics as shown in Fig.1 [2]. Especially, since all devices in the smart world are consumed more energy due to the additional sensory and communications [3]. In addition, from the growing interest and adoption from various organizations, the energy consumption will be further significantly. Therefore, it is very critical to develop green IoT which focuses on reducing the power consumption of IoT. The Green IoT is defined as follows [4].

The energy efficient procedures adopted by IoT either to reduce the impact of the greenhouse effect of IoT itself or to facilitate reducing the greenhouse effect of existing applications and services. The entire life cycle of green IoT should be focused on green design, green production, green utilization, and finally green

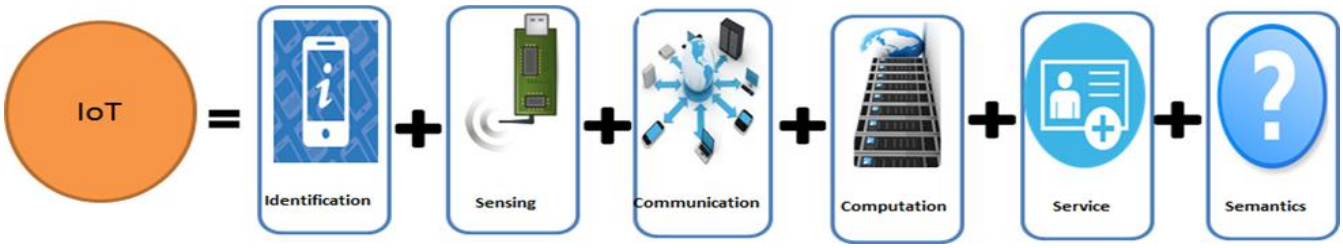


Fig.1. IoT building elements

disposal/recycling to have no or very small impact on the environment

### 2.1 GREEN M2M

Regarding M2M communications, massive M2M nodes that logically gather the monitored data are deployed in M2M domain.

Concerning green M2M, with the massive machines involved in M2M communications, it will consume more energy, particularly in M2M domain [5]. The following methods might be used to increase energy efficiency. The transmission power is intelligently adjusted the minimal necessary level. To design efficient communication protocols like routing protocols with the application of algorithmic and distributed computing techniques. Moreover, joint energy-saving mechanisms such as with overload protection and resources allocation. We can employ energy harvesting and the advantages of spectrum sensing, spectrum management, interference mitigation, and power optimization of CR [6].

### 2.2 GREEN DC

To handle various data and applications, DCs consume significant amounts of energy with high operational costs and emit more CO2. In addition, with the increasing amounts of data generated by many pervasive and ubiquitous things or objects such as sensors, mobile phones etc. even more energy is needed. With the increase adoption of smart technologies, the energy efficiency for DCs becomes more important [7]. In terms of green DC, possible techniques to improve energy efficiency can be achieved from the following;

By using renewable or green sources of energy such as wind, solar power, water, heat pumps, etc. You can utilize efficient dynamic power-management technologies such as Turbo Boost, vSphere. Also design more energy-efficient hardware like exploiting by using the advantages found in Dynamic Voltage and Frequency Scaling (DVFS) techniques and vary-on/vary-off (VOVO) techniques [8]. Furthermore, design novel energy-efficient data center architectures like Nano Data Centers (NDC) to achieve power conservation.

### 2.3 GREEN CC

In CC, the resources are treated as services, which are IaaS PaaS and SaaS. With the growing number of applications moved to the cloud, more resources need to be deployed and more power is to be consumed, resulting in more environmental issues and CO2 emissions.

To handle the issue, hardware solutions should be designed the device which reduces energy consumption. Software solutions also try to offer efficient software designs which are consume less energy with minimum resource utilization. Power-saving virtual machine techniques such as VM consolidation, VM placement, VM migration, VM allocation are power saving technologies [9] that can be applied. There are various energy-efficient resource allocation mechanisms such as gossip-based resource allocation, auction-based resource allocation, and related task scheduling mechanisms [10].

### 2.4 Reliability in IoT communication

To achieve green IoT, since not all sensor nodes are expected to be simultaneously active in the IoT domain, Reliability is a challenging issue nowadays. To improve the reliability of IoT communication, exploiting redundancy technologies including information redundancy, temporal redundancy, and spatial redundancy can be efficient approaches for IoT communications.

In the physical world of IoT communication, reliability in the network has considered during system architecture, during system development, and sensor gateway communication with network device. In the network the information must be able to pass the information in a reliable manner with low latency rate [12].

Ross and Thomas [13] present, that unreliability arises in low power and low load balancing system in wireless sensor networks. They suggest, in time synchronization, channel hopping mesh network, all nodes in multi-hop network are synchronized within microseconds and provides more than 99.99% end-to-end reliability.

### 2.5 Energy efficiency in IoT communication

The energy efficiency turns into a challenging issue, particularly in the sensor domain. The energy consumption in IoT communication is increasing day by day. The energy efficiency is able to be improved and be increased by wisely adjusting transmission power to the minimal required level, and carefully applying distributing computing and algorithms techniques to design efficient communication protocols such as routing protocols, etc.

Further, the activity scheduling has to improve the energy consumption in IoT communications. The aim of doing this is to switch some nodes to the low-power operation or sleeping mode. Therefore only subsets of connected nodes remain active while the functionality of the original network is preserved. In Gallais et al's research [11], an activity scheduling scheme is proposed for sensing coverage that appears to be the best in the literature. This scheme needs time to be slotted, and activity scheduling is then done in rounds. In each cycle, a hub chooses an irregular timeout and listens to messages from neighbors before it lapses. These messages contain the decision of activity that means whether it is to be dynamic or not of their senders.

## 3. GIHS: Green IoT-Home Service Model

Green IoT and smarthome are recently developed phenomenon that has very attracted the focus of academia and industries. In this chapter, the service model is proposed. The proposed method is capable of handling commands between home devices and energy providers to optimize the energy consumption. The GIHS provides power management service by utility such as advance energy metering system.

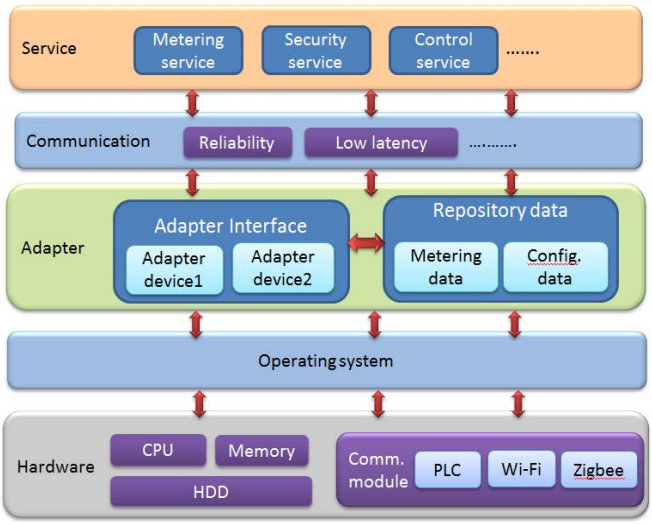


Fig.2. GIHS model

**GISH functionalities**: GISH provides a fine grained energy monitoring system, real time price information, optimizing energy usages, and intelligent decision making engine. GISH functionalities are as follows:

- Advance metering system
- Remote appliance control
- Two-way secure communication
- Interoperability
- Intelligent decision making

**GIHS layers**: The architecture of GISH is shown in Fig. 2. The GIHS consists of hardware, operating system, adapter, communication, and service.

- **Hardware layer**: This layer includes physical devices such as CPU, memory, power line Control (PCL) modem, and connects through serial port and other physical interfaces.

- **Operating system**: It provides a platform to operate and transfer the data between hardware and adapter.

- **Adapter**: To maintain the interoperability, it generates specification communication message of appliances. The generated

message depends on the model of data and protocol of the target and forward the information message through network media such as Zigbee, PLC, Wi-Fi. GIHS has huge data storage capacity. It stores the metering data, configuration data and detailed information of sensors.

- **Communication:** This layer focuses on reliable communications in green IoT sensor network. It is guaranteeing successful message transmission in a mesh network with low latency rate.

- **Service:** This layer is an interface of GISH which has functionality component that offers the service power management to consumer.

## 4.Conclusion

In this paper, we have studied the latest guidance for research concerning in IoT for smart world. This paper has discussed various technologies and challenges for green IoT that plays an important role to build a smart IoT world. The technology related to green IoT including green M2M, green CC, and green DC have been introduced.

The discussed issues are the reliability in IoT communications and the way to achieve green IoT communication by applying efficient activity scheduling techniques for saving energy. The paper presented a service based green IoT-Home model which has much functionality and provides efficient energy consumption services to the consumer. Finally, a green IoT-Home service model based on energy efficiency and reliable communications are proposed.

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