Understanding Green IoT: Research Applications and Future Directions.

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Abstract: The Internet of Things (IoT) has been envisaged to describe a number of technologies and research disciplines that enable global connectivity over the worldwide physical objects. The Green Internet of Things (G-IoT) is predicted to introduce significant changes in our daily life and would help in realizing the vision of "green ambient intelligence." Within a few years we will be surrounded by a massive amount of sensors, devices, and "things," which will be able to communicate via 5G, act "intelligently," and provide green support for users in managing their tasks. This paper presents research motivation to green IoT , it illustrates basic understanding of green IoT and Its architecture , with few research applications , finally it suggest some of the research optimal and efficient solutions for greening IoT.

Index Terms—Internet of Things (IoT), green IoT, 5G, wireless sensor networks, cloud computing, smart cities, energy efficiency.

1. INTRODUCTION

As science and technology develop rapidly, the world becomes "smart". Living in such a smart world [1], smart devices (such as watches, mobile phones and computers) will serve people, intelligent transportation (such as cars, buses and trains) and smart environments (homes, offices, offices). And factories) and so on. For example, if you are using a GPS (Global Positioning System), the location of a person can be continuously uploaded to a server that immediately returns the best route to the destination of the trip so that the person is not removed. May be caught in traffic. In addition, a person's mobile phone's audio sensor can automatically detect a person's voice mismatch and send them to a server that compares the gap with a series of fingerprints to determine if the person is ill. Finally, all aspects of the cybernetic, physical, social, and spiritual worlds of people in the intelligent world will be interconnected and intelligent. As the next big turning point in human history, the intelligent world gets a lot of attention from universities, corporations, governments and so on.

Research Motivation

Our world consists of different "things". As a smart world leader, the Internet of Things [IoT] [2]-[3] tries to connect different objects (such as cell phones, computers, cars, devices) with unique addresses so they can connect with each other. Communicate with each other and with the world. In addition, the ecological goals of the Internet of Things in a sustainable and intelligent world, reducing energy consumption in the Internet of Things. In this article, to build a sustainable smart world, we are focusing on green IoT and exploring various technologies in the green IoT. We discussed the latest developments in the sensor cloud [4], [5], the new paradigm of green IoT and the review of the future sensor cloud. After all, future research directions and outstanding issues related to green IoT will be presented. According to our knowledge, this work is the first to analyze the realization of the intelligent world from a green IoT perspective. Hopefully this work will serve as an informative and up-to-date guide to green IoT and the smart world.

Research Contribution

The main contributions of this paper are shown as follows.

- Enabling green IoT, this paper analyzes green ICT (eg green RIFD codes, green RSNs, green CCs, green M2Ms and green CCs) and summarizes the general principles of green ICT.
- Towards the green IoT, this document provides an overview of the latest developments in the sensor cloud field and visualizes the future sensor cloud. In addition, this paper outlines future research directions and outstanding issues related to the Green IoT.

2. OVERVIEW OF IoT AND GREEN IoT

2.1 IoT

There are various refusals for IoT [2] - [3]. We give two examples from ITU-T (International Telecommunication Union (ITU) Telecommunication Standardization Sector) and IERC (IoT European Research Cluster). Definition of ITU-T: "From a broad perspective, IoT can be seen as a vision that has both technological and social implications." From a technical standardization point of view, IoT can be seen as a global infrastructure Information Society Connects to each other (physically and virtually) in accordance with existing, advanced and interoperable information and communication technologies. Through identification, data collection, IoT makes full use of all its functions to provide services for all types of applications.

Elements: The IoT elements [6] are shown in Figures 5 and 6. In particular, the IoT includes six elements, namely identification, detection, communication technology, computers, services and semantics. Identification is crucial for identifying and linking services to your issue. electronic product codes (EPC), ubiquitous codes (uCode), etc. are examples of identification methods used by the IoT.

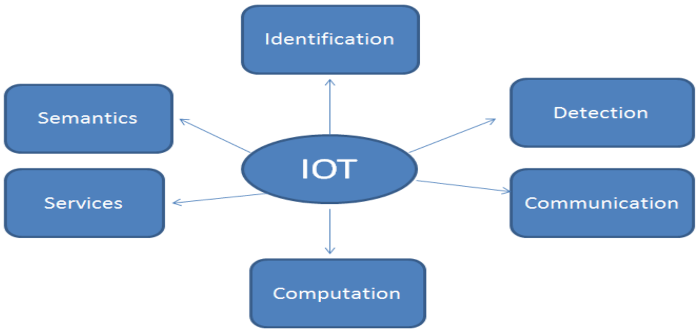

Figure 1. Elements of IoT.

Discovery involves collecting various data from related objects and sending them to a database, data warehouse, data center, etc. The data is analyzed in more detail to perform specific actions based on the required services. Sensors can be moisture sensors, temperature sensors, portable detectors, mobile phones, etc. Communication technologies connect different objects to offer specific services. The available communication protocols for IoT are: Wi-Fi, Bluetooth, IEEE 802.15.4, Z-wave, LTE-Advanced, Near Field Communication (NFC), ultra-wide bandwidth (UWB), etc.

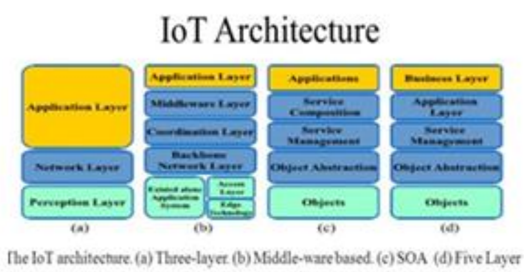

Figure 2. IoT Architecture.

IoT services can be divided into four classes: identity-related services, information-gathering services, collaboration services and ubiquitous services. Identity-related services form the basis for other types of services, as any application that represents real-world objects in the virtual world must first identify the objects. Information gathering services collect and compile raw information that needs to be processed and reported. Cooperation services use collaborative data to make decisions and respond accordingly. Comprehensive services provide collaborative services to anyone who requests them, anytime, anywhere. Semantics means the ability to intelligently acquire knowledge to provide the required services. This process usually includes: discovering resources, utilizing resources, modeling information, recognizing and analyzing data. The commonly used semantic technologies are: resource description frameworks (RDF), web ontology language (OWL), efficient XML interchange (EXI), etc.

2.2 Green IoT

Enabling the intelligent world, IoT is included in the US National Intelligence Council (NIC). UU. Of the six "innovative civil technologies" that affect the US UU. NIC anticipates that "by 2025, Internet nodes can be part of everyday life, namely food packaging, furniture, paper, etc." However, to make a sustainable and intelligent world possible, IoT should describe energy efficiency [6]. Especially because it is assumed that all smart world devices are equipped with additional sensors and communications add-ons so that they can feel the world and communicate with each other, they need more energy. In addition, the demand for energy, driven by increasing interest and acceptance of various organizations, will grow rapidly. All of this means that an environmentally friendly environment that aims to reduce IoT energy consumption needs to face the smart world in terms of sustainable development. If we believe that energy efficiency is important for the development and development of IoT, green IoT can be defined as [3]. "Energy efficient (hardware or software) procedures applied by IoT to reduce the greenhouse effect in existing applications and services or to reduce the impact of IoT greenhouse effect. Eco-design, organic production, ecological use and ecological disposal / recycling, so that they do not have a very low environmental impact.

3. IoT AND GREEN IoT:

RESEARCH APPLICATIONS

For IoT and Green IoT there are many applications [2] - [3]. We offer several application scenarios.

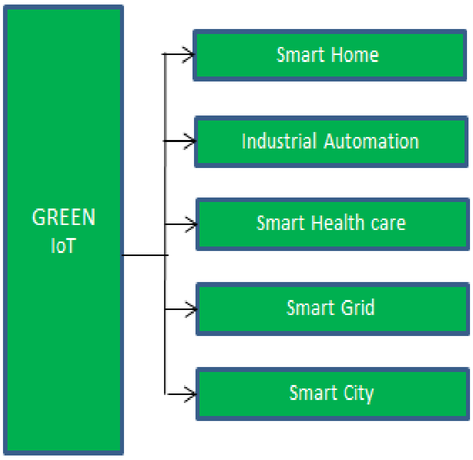

Figure 3.Green IoT Applications

3.1. Smart Home

Improves the personal lifestyle of your home by easing and smoothing the control and use of appliances and devices (microwave, oven, air conditioning, heating systems, etc.) outdoors. . For example, according to the weather forecast, a smart house can automatically cut and close the window shade.

3.2. Industrial Automation

With minimal human involvement, robotic devices are automated to perform production tasks. Machine operations, functions and productivity are automatically checked. For example, if there is a problem with the machine, the system immediately sends a maintenance request to the maintenance department to resolve the problem. In addition, productivity increases by analyzing production data, time and causes of production problems.

The Internet of Things (IoT) can support collaboration and communication between objects automatically. However, with the increasing number of involved devices, IoT systems may consume substantial amounts of energy.

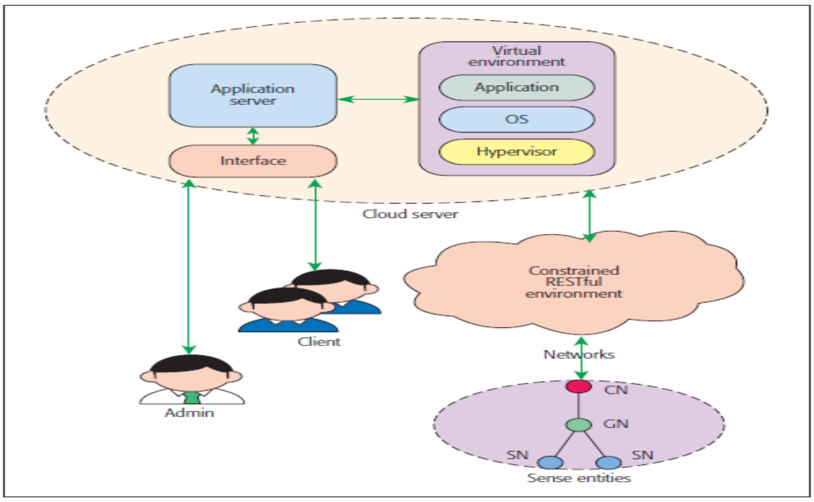

Figure 4. Green Industrial IoT Architecture:
An Energy-Efficient Perspective

The overall architecture toward energy-efficient IoT is illustrated in Fig. 4, which is comprised of a sense entities domain, RESTful service hosted networks, a cloud server, and user applications. Smart devices and nodes are deployed in the sense entities domain. To further optimize energy savings, they are classified into sense nodes (SNs), gateway nodes (GNs), and control nodes (CNs). The network hosts RESTful web services and connects the sense entities with the cloud server. The cloud server virtualizes objects, which then are transferred to the server applications. Processing and computation for the extracted data from the sense entities domain are also made on the cloud server. The application server interface assists the client to communicate with application server without access to the server side codes, while direct access can be made by the administration (admin) node.

Sense Entities: IoT networks involve sensor nodes and smart devices that are Internet Protocol (IP) enabled and RFID attached. Compared with smart devices, sensor nodes have strict energy constraints due to their dependence upon batteries. Although there are differences between their capabilities in terms of

memory and processing, for the convenience of discussion and without loss of generality, we omit these differences. We adopt a novel deployment for these nodes targeting the energy efficiency issue, which will be discussed later. SNs collect the desired information data from their interested area and send them to GNs. Then GNs store the data in buffer and forward them to CNs. Also, GNs run a protocol to calculate the sleep intervals of SNs, which will be discussed in a later section. CNs work as the manager to allocate resources under them and redirect the aggregated data to the networks. Allocation of SNs to specific GNs is also decided by the CNs.

RESTfulService Hosted Networks: Nowadays, REST methodology has been considered [6] in many IIoT proposals, since it makes the integration and accessibility of the heterogeneous devices easier and more convenient. Thus, our network hosts a RESTful service where functionalities and data are regarded as resources that are able to be accessed with uniform resource identifiers. For resource-constrained environments, this RESTful service makes the applications lightweight, simple, and fast [7]. Our proposed RESTful service networks may serve as a bridge between physical sense entities and virtual objects. They receive the specification data from the sense entities side, such as product ID, device IP address, or device features, and notify the cloud sever to create the virtual objects with the semantic description of the sense entities.

Cloud Server: In our energy-efficient IIoT architecture, the cloud server includes the following two components.

Virtual Environment: Physical things, included in the sense entities domain, are virtualized for service lookup in the virtual environment. Then the virtual objects are hosted and composited as applications performed inside the virtual machine.

Application Server and Interface: The application server allows SNs to communicate with the client through the interface or via direct access from the admin. The registry is made by tracking the services and physical entities that are available within the entire IoT.

User Applications: Working as client side applications, the user applications can be classified into the following two categories according to the authentication mechanisms.

Client Applications: To use virtual objects hosted as applications in the virtual environment, the client uses application interface to send requests to the server. Direct access is not allowed within this authentication.

Admin Applications: Unlike the client application, an admin application has the right to access the server directly. Then the admin can promptly make necessary modifications to the system and monitor the performance of the whole system.

3.3. Smart Healthcare

Improves the performance of healthcare applications by integrating sensors and actuators for patients and their medications to track and monitor patients. For example, collecting and analyzing body conditions of patients with sensors and sending analyzed data to a treatment center, clinical care can monitor the physiological state of patients in real time and take the necessary measures.

3.4. Smart Grid

Energy suppliers receive support for resource management and management so that energy can be provided in proportion to population growth. Therefore, the energy consumption of houses and buildings can be improved. For example, building meters can be connected to a network of energy suppliers. Energy suppliers could improve their services by collecting, analyzing, controlling, monitoring and managing energy consumption. Meanwhile, possible failures can be reduced.

3.5 Smart City

Improving the quality of life in the city, making it easier for people to find useful information. For example, depending on the needs of the population, different interrelated systems intelligently offer attractive services (such as transport, utilities, health, etc.) to people.

4. GREEN CLOUD COMPUTING TECHNOLOGY

Cloud computing (CC) is the new virtualization technology used on the Internet. It offers unlimited computing, unlimited storage and Internet services as it saves a lot of energy (energy consumption) and is more efficient than traditional data centers. CC technology is ubiquitous, while IoT is widespread. The combination of CC and IoT as a whole is a broad field of research. The primary goal of the GCC is to promote the use of environmentally friendly products that can be easily recycled and reused. The primary goal of the GCC is to reduce the use of hazardous materials, increase energy consumption and improve the recycling of old products and waste. In addition, this goal can be achieved by allocating resources.

Figure 5.Green Cloud Computing

5. FUTURE OF GREEN IOT

The bright future of the Green Internet will change our future environment to become healthier and greener, the quality of services is very high, socially and environmentally friendly, and economically. Today's most interesting areas are more environmentally friendly, such as communication and ecological networks, green design and implementation, environmentally friendly internet services and applications, energy saving strategies, RFID and networks. Integrated sensors, mobility and network management, networking of homogeneous and heterogeneous networks. , smart objects and green location.

The following research fields have needed to be researched to develop optimal and efficient solutions for greening IoT:

1. UAVs need to replace a large number of IoT devices, in particular agriculture, traffic and surveillance, thus reducing energy consumption and pollution. UAV is a promising technology that will bring green internet at low cost and high efficiency.

2. Sensor transmission data for mobile cloud is more useful. The sensor cloud integrates the wireless sensor network and the mobile cloud. It is a very promising technology to make eco-friendly. A green social network as a service (SNaaS) can study system energy efficiency, service, network storage networks, and cloud management.

3. M2M communication plays an important role in reducing energy consumption and hazardous emissions. Smart machines need to be smarter to activate automated systems. The machine's automation time should be kept to a minimum in the case of traffic and take the necessary and immediate measures.

4. Green IoT design can be implemented from perspectives that offer excellent performance and high quality of service. Searching for appropriate techniques to improve service quality parameters (such as bandwidth, time, and performance) will effectively and efficiently promote eco-friendly IoT.

5. As IoT grows, it requires less energy, looks for new sources, reduces the negative impact of IoT on people's health and changes the environment. Then green IoT can make a significant contribution to a sustainable and smart environment.

6. In order to achieve energy balance, radio frequency energy collection should be taken into account in supporting communication between IoT devices.

7. Further research is needed to design IoT devices that help reduce CO2 emissions and energy consumption. The most important task for a smart and environmentally friendly environment is to save energy and reduce CO2 emissions.

6. CONCLUSION

It is evident that this study has shown research motivations towards enabling green IoT, further reviews the recent developments about sensor-cloud and envisions the future sensor-cloud. This paper has been demonstrated several applications of Green IoT with optimal and efficient solutions for greening IoT.

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