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Green Smart World (Internet of things)

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Abstract: *Smart world is intended as objects like watches, mobile phones, computers, cars, buses, and trains can automatically and intelligently serve people in a collaborative manner. Internet of Things (IoT) connects everything in the smart world. This paper discusses various technologies and issues regarding green IoT, which further reduces the energy consumption of IoT. The hot green information and communications technologies like green radio frequency identification, green wireless sensor network, green cloud computing, green machine to machine, and green data center enabling green IoT are studied, and general green ICT principles are summarized. The latest developments and future vision about sensor cloud, which is a novel paradigm in green IoT, are reviewed and introduced. Our work targets to be an enlightening and latest guidance for research with respect to green IoT and smartworld*
Keywords: *Cloud Computing, Green, Radio Frequency Identification, Sensor Cloud, Wireless Sensor Network.*

I. Introduction

1.1 Smart World:

Rapid development of science and technology, the world is becoming ‘‘Smart’’. Living in a smart world[1], people will be automatically and collaboratively served by the smart devices, smart transportation, smart environments, etc. For example, using a global positioning system (GPS), a person’s location can be continuously uploadedto a server that instantly returns the best route to the person’s travel destination, keeping the person from getting stuck in traffic

In addition, the audio sensor inside a person’s mobile phone can automatically detect and send any abnormality in a person’s voice to a server that compares the abnormality with a series of voiceprints to determine whether the person has some illness.

1.2 Research Motivation:

Internet of things (IoT)[2][3][4] targets to connectvarious objects like mobile phones, computers, cars, applianceswith unique addresses, to enable them interacting with each other and with the world. Further, green IoT targets at a sustainable smart world, by reducing the energy consumption of IoT.

II. Overview OF IoT & Green IoT

2.1 IoT:

In a broad perspective, the IoT can beperceived as a vision with technological and societal implications. From the perspective of technical standardization, IoT can be viewed as a global infrastructure for the information society, enabling advanced services by inter- connecting (physical and virtual) things based on, existing and evolving, interoperable information and communication technologies. Through the exploitation of identification, data capture, processing and communication capabilities, the IoT makes full use of things to offer services to all kinds of applications, while maintaining the required privacy.

A dynamic global network infrastructure withself-configuring capabilities based on standard and interoperable communication protocols where physical and virtual ‘‘things’’ have identities, physical attributes, and virtual personalities and use intelligent interfaces, and are seamlessly integrated into the information network.

2.2 Green IoT:

Enabling the smart world, IoT is included by the NIC (National Intelligence Council) of U.S. among six ‘‘Innovative Civil Technologies’’ that will impact U.S. power grids. It is foreseen by NIC that ‘‘by 2025, internet nodes may reside in everyday things, i.e., food packages, furniture, paper documents, and more.’’ However, to enable a sustainable smart world, the IoT should be characterized by energy efficiency. Particularly, since all devices in the smart world are supposed to be equipped with additional sensory and communication add-ons so that they can sense the world and communicate with each other, they will require more energy.

All these make green IoT which focuses on reducing the energy consumption of IoT a necessity, in terms of fulfilling the smart world with sustainability. Considering the energy efficiency as the key during the design and developmentof IoT, green IoT[4].

The energy efficient procedures (hardware or software) adopted by IoT either to facilitate reducing the greenhouse effect of existing applications and services or to reduce the impact of greenhouse effect of IoT itself.

In the earlier case, the use of IoT will help reduce the greenhouse effect, whereas in the further optimization of IoT greenhouse footprint will be taken care. The entire life cycle of green IoT should focus on green design, green production, green utilization and finally green disposal/recycling to have no or very small impact on the environment.

2.3 Application:

Smart Home:

Personal life-style at home is enhanced, by making it more convenient and easier to monitor and operate home appliances and systems (e.g., microwave, oven, air conditioner, heating systems, etc.) remotely. For instance, based on the weather forecast information, a smart home can automatically lower the blinds of windows and close the windows.

Industrial Automation:

With a minimal human involvement, robotic devices are computerized to finish manufacturing tasks. The machines' operations, functionalities, and productivity rates are automatically controlled and monitored. For example, if there is a sudden issue about a machine, the system will immediately deliver a maintenance request to the maintenance department for handling the problem.

In addition, the productivity is improved, by analyzing production data, timing and causes of production issues.

Smart Healthcare:

Performance of healthcare applications is improved, by embedding sensors and actuators in patients and their medicine for monitoring and tracking patients. For instance, by gathering and analyzing patients body data with sensors and further delivering analyzed data to a processing center, the clinical care could monitor physiological statuses of patients in real-time and make suitable actions when necessary.

Smart Grid:

Power suppliers are assisted to control and manage resources so that power can be offered proportionally to the population growth. Therefore, the energy consumption of houses and buildings could be enhanced. For example, the meters of buildings could be connected to the network of energy providers. Then the energy providers could enhance their services, by collecting, analyzing, controlling, monitoring and managing energy consumption. Meanwhile, the potential failures could be reduced.

Smart City:

Quality of life in the city is ameliorated, by making it more convenient and easier for the residents to obtain information of interest. For instance, according to people's needs, various interconnected systems intelligently offer the desirable services (e.g., transportation, utilities, health, etc.) to people

III. ICT Enabling Green IoT

3.1 ICT:

ICT is a term that relates to any facility, technology, application (e.g., radio, television, cellular phones, computers, machines, networks, hardware, software, middleware, storage, satellite systems, videoconferencing, distance learning) regarding information and communication enabling users to access, store, transmit, and manipulate a variety of information. The following Table shows the characteristics between ICT and Green IoT.

Table 1:

ICT	GREEN IoT
RFID (Radio-Frequency Identification): A small electronic device that consists of a small chip and an antenna, automatically identifying and tracking tags attached to objects.	**GREEN RFID:** For green RFID[4] reducing the sizes of RFID tags should be considered to decrease the amount of non-degradable material used in their manufacturing (e.g., biodegradable RFID tags, printable RFID tags, paper-based RFID tags), because the tags themselves are difficult to recycle generally. Energy efficient algorithms and protocols should be used to optimize tag estimation, adjust transmission power level dynamically, avoid tag collision, avoid overhearing, etc.
WSN (Wireless Sensor Network): A network consisting of spatially distributed autonomous sensors that cooperatively monitor the physical or environmental conditions (e.g., temperature, sound, vibration, pressure, motion, etc.).	**GREEN WSN:** Regarding green WSN, the following techniques should be adopted[4] Make sensor nodes only work when necessary, while spending the rest of their lifetime in a sleep mode to save energy consumption Energy depletion (e.g., wireless charging, utilizing energy harvesting mechanisms which generate power from the environment (e.g., sun, kinetic energy, vibration, temperature differentials, etc.)) Radio optimization techniques (e.g., transmission power control, modulation optimization, cooperative communication, directional antennas, energy efficient cognitive radio (CR)) Data reduction mechanisms (e.g., aggregation, adaptive sampling, compression, network coding) Energy efficient routing techniques (e.g., cluster architectures, energy as a routing metric, multipath routing, relay node placement, node mobility).
CC (Cloud Computing): A novel computing model for enabling convenient, on-demand network access to a shared pool of configurable resources (e.g., networks, servers, storage, applications, services). Integrating CC into a mobile environment, mobile cloud computing (MCC) can further offload much of the data processing and storage tasks from mobile devices (e.g., smart phones, tablets, etc.) to the cloud.	**GREEN CC:** With respect to green CC, potential solutions are shown as follows[4] Adoption of hardware and software that decrease energy consumption. In this regard, hardware solutions should target at designing and manufacturing devices which consume less energy. Software solutions should try to offer efficient software designs consuming less energy with minimum resource utilization Power-saving virtual machine (VM) techniques (e.g., VM consolidation, VM migration, VM placement, VM allocation) Various energy efficient resource allocation mechanisms (e.g., auction-based resource allocation, gossip-based resource allocation) and related task scheduling mechanisms Effective and accurate models and evaluation approaches regarding energy-saving policies Green CC schemes based on cloud supporting technologies (e.g., networks, communications, etc.).

IV. Sensorcloud

Sensorcloud is ‘‘an infrastructure that allows truly pervasive computation using sensors asan interface between physical and cyber worlds, the data-compute clusters as the cyber backbone and the internetas the communication medium’’[5].According to MicroStrains, sensor-cloud is ‘‘a unique sensor data storage, visualization and remote management platform that leveragespowerful cloud computing technologies to provide excellent data scalability, rapid visualization, and user programmable analysis’’[5].

About the energy efficiency of sensor-cloud, two novel collaborative location-based sleep scheduling (CLSS) mechanisms for WSNs integrated with MCC.

Specifically, the focus of CLSS is enhancing the WSN lifetime, while still catering mobile users’ data requests in sensor-cloud. For decreasing the integrated WSN’s energy consumption, the detailed technique is dynamically changing the awake or asleep state of every sensor node, based on the mobile user’s locations.

CLSS1 targets at maximizing the integrated WSN’s energy consumption saving, while CLSS2 also takes into account the integrated WSN’s scalability and robustness. Theoretical and simulation results are both performed to demonstrate the effectiveness of the proposed CLSS mechanisms.

Concerning the sensory data transmission in sensor-cloud, a scheme named TPSS, aiming at reliably offering more useful data to mobile cloud from WSN. Particularly, the key issues that affect sensory data’s usefulness and WSN’s reliability are identified first. Then TPSS which consists of two main parts is introduced. Considering the time and priority features regarding mobile user’s data requests, first part is time and priority-based selective data transmission (TPSDT), for WSN gateway to selectively deliver more useful sensory data to the cloud. Second Part is priority-based sleep scheduling (PSS) algorithm, for WSN to save energy consumption so that sensory data can be collected and delivered more reliably.

Analytical and experimental results show the effectiveness of TPSS about enhancing sensory data’s usefulness and WSN’s reliability for sensor-cloud.

4.1 Future Sensor Cloud:
Future sensor cloud will evolve into social sensor cloud (SSC), in which social networks (SNs),

WSN and cloud connect and complement each other. In social-cloud, integrating SNs and CC, there is already much research.

In SSC, leveraging SNs, not only will the sensor-cloud resources and services be shared, but also the SNs could be used to achieve better energy efficiency for sensor-cloud in the following ways.

- Sharing the sensor-cloud resources and services to other users with SNs, will substantially reduce the resources and services requested by the sensor-cloud users. As a result, the energy consumption of sensor-cloud can be decreased dramatically.
- The massive user behavior information in SNs could be collected and analyzed as well as further utilized to enhance the energy usage in sensor-cloud. In return, users will also be better satisfied.
- Based on the amount of resource consumption and service usages created by a variety of users in SNs, the deployment of resources could be optimized and the waste of resources could be reduced in sensor-cloud.

V. Conclusion

As an inspiring and latest guidance for research concerning smart world, this paper has discussed various technologies and issues with respect to green IoT, which plays a significant role in achieving a sustainable smart world. Specifically, the technologies related to green IoT including hot green ICT (e.g., green RFID, green WSN, and green CC) have been introduced, with the summary of general green ICT principles. In addition, bestowing particular attention to sensor-cloud which is a novel paradigm in green IoT, The latest developments about sensor-cloud have been shown and the future sensor-cloud has been envisioned. Finally, future research directions and open problems regarding green IoT have been presented.

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