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Green Computing for Internet of Things

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Abstract— Cloud computing services are used to meet the ever-growing demand of IoT. Data centers are becoming one of the largest energy consumers to provide the infrastructure for the IoT paradigm. The demand for energy will increase in the future as more innovation emerges and technology follows new practices that lead to the adoption of green computing. Green computing strategies reduce the energy consumption of IoT devices without compromising performance. This white paper evaluates many aspects of green computing for IoT computing and analyzes key concepts, challenges, and mitigations.

Index Terms – Internet of Things (IoT), Cloud Computing, Edge Computing, Energy Consumption.

1. INTRODUCTION

The Internet of Things (IoT) brings together intelligent objects integrated into heterogeneous networks to monitor processes and make decisions. This is large-scale sensor data that is leveraged using computational resources. Green computing can use resources or do otherwise in an environmentally friendly way. It involves the development and removal of various elements used in computers to reduce the environmental impact. Companies are starting to invest in computing equipment made from recyclable materials. The purpose of green computing is to use computing resources and economically viable ways in an environmentally friendly manner. Figure 1 shows IoT device statistics by year. IoT devices are connected to various networks and their growth continues to accelerate as businesses embark on digital transformation. It also influences the spending and revenue of his IoT market in the world. These added devices also pose network security issues that need to be addressed accordingly.

2. BACKGROUND

Green computing

Green computing is the design and use of resources that are environmentally friendly and sustain computing power without degrading it. Resources used in computers are recycled after use. Companies making these devices should use less energy and be more biodegradable. The majority of IoT devices are energy efficient sensors, which has led to their massive use by industrial players. These sensors also help advance IT to use wireless networks efficiently. Data centers provide data storage and processing capabilities for big data. Cloud computing platforms face the challenge of increasing numbers of IoT devices. These IoT devices require low latency and mobility, which is why they employ edge computing for real-time services. Fog computing is a distributed computing paradigm aimed at connecting network devices at different computing layers. It provides IoT devices with low-latency responses that centralized cloud computing architectures cannot provide. Green computing focuses on preserving computing power while reducing energy consumption and being environmentally friendly. Computer CPU manufacturing technology has advanced, making it more energy efficient with each generation. However, as the number of computing devices in use has increased, it has become imperative to meet the demands of green computing. Green computing has been introduced to cloud computing to reduce energy consumption and reduce the use of harmful substances within devices.

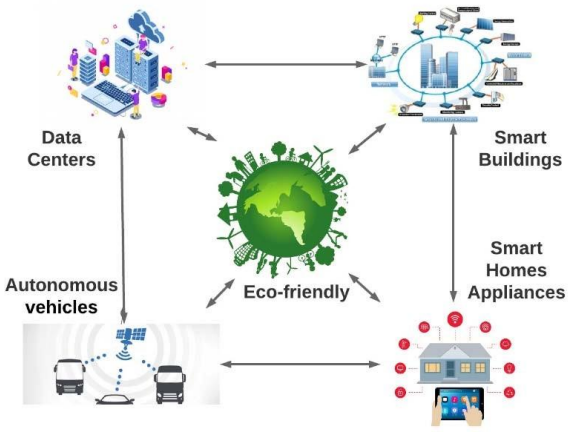

Figure 2: IoT green computing

Internet of things

IoT is the connection of devices to form an intelligent world. This is a paradigm that affects both society and technology. IoT technology involves building an infrastructure for connecting smart objects based on evolving information and network services. The data collected from the device must be processed for analysis and data protection regulations must be guaranteed. IoT is energy efficient when building smart cities. This is because the number of sensor devices and cooperating add-ons makes it easy for them to communicate with each other. Green computing must focus on reducing

energy consumption to meet the sustainability and environmental friendliness of smart cities.

IoT has become a key factor in today's world, connecting devices critical to decision making. Most of these devices are sensors and devices that facilitate data exchange across various networks and enable information exchange between devices. This has led to the emergence of edge computing, enabling low-latency responses and reducing resource congestion in centralized data centers. Send all device data computations to a nearby edge data center. A distributed infrastructure also reduces network congestion that occurs during data transmission.

IoT applications rely on the internet for communication, manufacturing embedded hardware and managing IoT devices, and cloud computing for storage and processing. Finally, there is the presentation layer for interpreting the data that make up the various application layers of IoT, as shown in Figure 3. The architectural layer of IoT includes a perception layer made up of sensors and actuators. The network layer enables interconnection and communication between devices and transfers data. The application layer includes tasks such as displaying processed data and other abstract services. Figure 5 shows the different layers and their components classified according to their energy consumption.

Cloud computing

Cloud computing has resulted in the emission of CO2 due to the energy consumption from the data centers. Various practices have been adopted to lower the energy consumption by data center machines by using hardware virtualization and energy-Conversant strap in software applications. The energy consumption is predicted to rise with the continuous usage of cloud computing services and the data centers which host them. It is for this energy concern that there is a need to rethink how data centers adopt green computing, and the equipment been used [6]. An overview of IoT data been collected from devices, processed, and analyzed.

Edge-IoT

An increase in the rise of mobile devices has resulted in mobile edge computing (MEC) for low latency responses. MEC provides mobile computing, network congestion control, and storage capacity to the edges of the networks. MEC lowers the usage of mobile energy and supports latency-critical applications. The development of the 5G network has been motivated by the gains of MEC, which combines both wireless communications and mobile computing to offload network computation. Wireless sensor networks are responsible for sending data by indoor devices, at the front end of Wireless Mesh Sensor Networks (WMNs), edge devices are deployed to reduce the network congestion helping users to tailor their needs through MEC.

3. APPLICATION OF GREEN COMPUTING IN IOT

There are many government regulations to promote green computing. IoT edge computing has developed and benefited many industries. The various technological domains using green computing are:

Autonomous vehicles

The automobile industry is investing in autonomous vehicles for driverless cars, which will have to analyze and make decisions on data that pertains to their surroundings for movements and directions. These vehicles need to transmit Data to the manufacturers so that they can track their usage and also get the required maintenance alerts. The data will be transmitted through networks resulting in congestion. To achieve low latency when accessing the network, it is necessary for the manufacturers to device new effective computing ways

Edge computing aides the autonomous vehicles in transmitting and sharing the data between them. Edge data centers that are located at nearby geographical proximity helps in making the flow of data seamless. They also enable less usage of energy for sensors used in these autonomous vehicles. Since there is a shift towards the adoption of autonomous vehicles, the risk of carbon emissions is reduced, which will be a step forward towards the eco-friendly approach.

Smart cities

The data collected from sensors, which includes traffic, infrastructure, and home appliances, are used by city leadership to address the challenges witnessed in these cities. The data collected from these sensors are massive and requires extensive computing capabilities to process and analyze them; also, the response back to these devices should be in real-time, resulting in less usage of energy.

Industries

Industries such as oil drilling, can utilize IoT edge computing to gather data on a variety of environmental factors without relying on pre-collected historical data. Thus by adopting edge computing in industries, there will be lesser energy consumption in production .

4. ADVANTAGES OF GREEN COMPUTING

Green computing brings various benefits; some of them are:

Eco-friendly

Green computing reduces the negative impact of the manufacturing and disposal of computing devices in a manner that is eco-friendly and ensures environmental sustainability.

Resource utilization

The data centers use resources such as computers for processing the collected data, the equipment used to make computer components should be biodegradable and also do not degrade on performance.

Low latency and Cost saving

Edge computing enables the allocation of resources in a manner that is efficient in energy consumption and reduces response latency. It also increases the lifetime of the devices saving on cost .

Improving on compliance

Green computing also enhances the compliance and regulation of the companies in meeting the business demands set by their customers and other stakeholders, also improving their image.

5. CHALLENGES FACING GREEN COMPUTING IMPLEMENTATION

Green computing awareness

People lack knowledge about green computing and its implications. According to the survey, he is only 28% aware of CO2 emissions and their impact on the environment.

Equipment cost

Businesses will have to pay to adopt green computing. People believe it in the traditional way. Savings over using modern energy efficient means. But these days, companies are controlling emissions by considering the energy consumption and carbon footprint of hardware devices.

Performance degradation

There are concerns regarding the materials used for making eco-friendly equipment resulting in performance degradation. Hence it is required to educate people regarding the usage of biodegradable devices and their performance.

6. SOLUTIONS TO THE CHALLENGES

Data centers

Data centers are an integral part of today's cloud computing industry. The energy consumption of these data centers should be reviewed regularly and steps taken to use biodegradable hardware components.

Virtualization

Data centers are an integral part of today's cloud computing industry. The energy consumption of these data centers should be reviewed regularly and steps taken to use biodegradable hardware components.

Recycling equipment

People discard unwanted hardware, which should be biodegradable so that it is eco-friendly. A lot of computer parts could cause harm to the environment. Thus, by using recyclable material, we can reduce the impact of these materials on the environment.

7. RESEARCH IMPLICATION

This white paper provided comprehensive insights on green computing for the Internet of Things. Green computing must adopt methods that reduce energy consumption and do not affect device performance. Companies should focus on energy efficient design of IoT devices and raise public awareness. Advancing green practices requires policy change and cooperation between organizations. This white paper presents challenges and possible solutions for green computing. Researchers can provide insight into best practices to follow to integrate green computing into the IoT. Green computing not only benefits the IoT but also promotes a cleaner environment.

8. CONCLUSION

IoT green computing is a top consideration when building a sustainable ecosystem. By adopting green computing practices, we can manufacture recyclable equipment and reduce energy consumption across our computing infrastructure. Green computing is therefore a great solution to support the growth of green IoT.

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