REVIEW ON SUSTAINABLE GREEN INTERNET OF THINGS AND ITS APPLICATION

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Abstract: The world is striving to become smart with the latest findings evolved in the communication and the information technology. The emerging of the things that could automatically and intelligently render service to the people in cooperative way acts as a part of this smart world and the internet of things take the significant role in the development of the smart world as it is capable of connecting every tangible things of the world. Though this technological advancement paves way for a seamless and an efficient way of communication, the excess energy consumed by the various add-ons used along with the devices that make the world smart cause environmental pollution and unknown destructions. Multitude of strides researched in improving the energy efficiency in the devices to make the internet of things sustainable and green is reviewed in the paper along with its applications hoping that this would create awareness in the development of the future smart applications.

Keywords: Internet of Things, Sustainability, Green IOT, Smart Objects,

1. INTRODUCTION

To start with let us go in to the description that explains in detail the internet of things and its essentialities. The major key that paved way for the internet of things is the development in the communication and information technologies and the entailment in the need for the seamless communication and service. The internet of things connecting all the tangible things around us is made possible by many add-ons that help in the, detecting and monitoring the scenario, making the conveyance and the computation possible and following with the service that are to be provided and all these are enabled using the set of protocols and coding to regulate the flow properly. The fig.1 provided below shows the add-ons or the element that serve as the back bone of the internet of things.
The element in the process of the providing a seamless communication and services consumes more power triggering the sustainability concerns [1]. The energy consumption of the internet of things also introduces toxic pollution and E-waste that affects the surroundings and the ecosystem.

The findings and the proposals to reduce the harmful effects of the internet things, and develop a green internet of things that are sustainable is reviewed in the paper along with the applications of green internet of things. The review is comprised of the methods followed in reducing the harmful effects of the internet of things and the applications that are enriched with the green internet of things. The Review proceeds by gathering of research papers related to the green internet of things using the internet database available and categorizes the paper with section 2 providing the over view of the green internet of things, and its sustainability, section 3 with the applications that employ the green internet of things followed by challenges in deploying Green-IOT in section 4 followed by Conclusion in section .5
2. OVERVIEW OF SUSTAINABLE GREEN INTERNET OF THINGS

The section proceeds with the overview of the sustainable green internet of things based on the survey conducted from the literature gathered. The researchers provide the details of the key components in the internet of things and the different layers that cause the major power consumption creating harmful effects in the environment. The fig.2 is the detailed picture of the power requirements of the internet of things.

Fig. 2 IOT Layers and the Components

The fig.2 presenting the frame work of the IOT delivers a clear picture of the layers in the IOT and the components involved in the internet of things and the description of their power consumption. The energy optimization techniques in the IOT have is insisted in all its layers to make it green, eliminating its harmful effects on the
ecosystem. The author Bol, David et al in the year 2013 suggests the green system on chip for internet of things that includes the complete set of components required for the conveyance and the service provisioning. The chip was designed battery less with a high computing performance at a lower die area and decreased power demands. Then Maksimovic et al in his paper in 2018 presents the “principals and the role of the green internet of things along with the analysis of the significance of the green technologies”, as the green technologies potentially enhances our ecosystem and heightens the quality of living, decreasing the negative impact on the health of the human beings as well as the surroundings more researchers concentrate applying the principles of the green technologies to the internet of things the author Maksimovic provides the goals of the green technology and its employment in the IOT to bring down the harms and heighten the benefits. The table.1 below shows the aims of the green technology and the task to be accomplished for satisfying the principles of the green-IOT.

<table>
<thead>
<tr>
<th>Aims of Green Technology</th>
<th>Strides to Achieve Green Technology in IOT</th>
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<tbody>
<tr>
<td></td>
<td>• Eco-friendly Design</td>
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<tr>
<td>• Reduce- energy consumption</td>
<td>• Facilities to bring down energy consumption</td>
</tr>
<tr>
<td>• Recycle- batteries</td>
<td>• Utilization renewable energy</td>
</tr>
<tr>
<td>• Refuse- energy consumption , E-waste</td>
<td>• Moving the decentralized, the intelligent processing and the storage to the edge of the network</td>
</tr>
<tr>
<td>• Renew- energy harvesting</td>
<td>• Rendering conveyance only when required.</td>
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<tr>
<td>• Responsibility – reduces power wastage</td>
<td>• Reducing the data length</td>
</tr>
<tr>
<td></td>
<td>• Establishing tradeoff processing for Communications.</td>
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</table>

Table.1 Aims and the Strides to Achieve Green technology

Shaikh et al 2015 presents the details of the technology enabling the green internet of things, the details of the technologies such as the green tags that involve the context awareness, active tags, and passive tags, near field...
communication, the green sensors that include nano technologies, embedded systems, wireless sensors and actuators and finally the green internet services that include cloud computing, information sharing, smart web services, knowledge aggregation etc. Mirjana, et al 2017 describes the” Green internet of things and green nanotechnology role in realizing smart and sustainable agriculture." The author Cathryn, et al elaborates the "Performance evaluation of green data centre management supporting sustainable growth of the internet of things.” The author describes the development of the green network management employing the optimization techniques to provide a green approach for managing the network. The table.2 presents the summary of the elements involved in the IOT, the reason behind the power consumption and the optimization methods followed and the parametrics that are optimized to develop the green-IOT based on the literature review.

<table>
<thead>
<tr>
<th>Elements</th>
<th>Reason for Energy Demands</th>
<th>Energy Optimization Methods</th>
<th>Merits</th>
</tr>
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<tbody>
<tr>
<td>Sensors</td>
<td>Continuous Monitoring</td>
<td>Compressed sensing, sleep scheduling, selective sensing</td>
<td>Enhancement in localization of sensors, mobility management, delay management</td>
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<tr>
<td>Radio frequency</td>
<td>Identifying the monitored data</td>
<td>Employing passives sensors</td>
<td>Improved performance</td>
</tr>
<tr>
<td>Identification</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Destination Nodes</td>
<td>Examining and storing of data</td>
<td>Optimization of computations in the tasks to core mapping</td>
<td>Improvement in the quality of service</td>
</tr>
<tr>
<td>Data Center</td>
<td>Processing of information, performing high computation task</td>
<td>Proper distribution of load Reducing the data path</td>
<td>Heightened Throughput</td>
</tr>
<tr>
<td>Gateways</td>
<td>Establishing link between sensor nodes</td>
<td>Managing storage space, scheduling of the events</td>
<td>Better coverage</td>
</tr>
<tr>
<td>Resource Allocators</td>
<td>Allocation of data to resources from gateway</td>
<td>Proper allocation of the processing components</td>
<td>Proper scheduling</td>
</tr>
<tr>
<td>WSN</td>
<td>Conveying and networking</td>
<td>Energy efficient routing</td>
<td>Reduced battery usage</td>
</tr>
<tr>
<td>Base Station</td>
<td>Moving the sensed data to the processing layer and fetching the information from cloud to gateway</td>
<td>Load balancing</td>
<td>Improvement in interoperability and interaction</td>
</tr>
<tr>
<td>Process Control</td>
<td>Performing computations and allocation of servers</td>
<td>Algorithms for Dynamic allocation of Tasks</td>
<td>Improvement in quality of service and minimization of Cost</td>
</tr>
<tr>
<td>Actuators</td>
<td>Performing action in response to stimulus</td>
<td>Proper monitoring and predicting of energy consumption</td>
<td>Privacy, security and usage pattern</td>
</tr>
</tbody>
</table>

Table.2 Summary of the Green IOT Development
3. THE APPLICATIONS OF SUSTAINABLE GREEN IOT

The green computing is the “environmental aware usage of the information and the communication technologies devices such as the computers, servers and peripherals along with other resources related to it. Some of the green computing techniques adapted in the IOT to make it sustainable are. Storage links and the virtualization of the resources such as the servers minimizing the total number of the equipment’s in turn reducing the energy demands that are required for the functioning. The reduced amount of devices in turn also reduces the cost, the GHG emissions, and the time demand in the maintaining, managing of the application and the storage space. The virtualization of the desktop, the decrease in the number of consumables and the engagement of the recycling, and reuse are also proven ways of deploying the green technologies in the internet of things. The section provides the IOT applications that engage the green technologies to improve its sustainability [2]. Fig .3 shows the applications of the IOT

![Applications of IOT Diagram](image-url)
The application of the green technologies is utilized in the following applications such as the industrial automation [3][9]; it is highly utilized in the agriculture [4] to make it more sustainable. The green technologies also take a vital role in the smart cities development to make it more sustainable and safe [5] [7]. The sustainability in the supply chain is achieved by employing the green internet of things [8]

4. CHALLENGES IN DEPLOYING GREEN IOT

The creation of green IOT to make it sustainable faces certain challenges such as the number of the sensors used, the amount of information to be generated [1]. The deployment of the green technology itself remains as an issue in the IOT [3] as the communication process consumes more power and the devices associated with an IOT [4] operate using a limited energy. Other issues related to the development of the green-IOT are the adoption and employment of the software’s and the hard wares that minimizes the energy usage, progress, collaboration and the interoperability of the technologies for recognizing as well as verifying the privacy and the security. The engagement of the computing techniques and the continual progresses in the communication methodologies also serve as important issue affecting the deployment of the green-IOT [18]

5. CONCLUSION

The internet of things that is capable of involving billion of devices that range from large scale to small scale. The rapid progress in the technologies cause huge growth in the devices that are connected by the IOT, and in turn increases the energy consumption. Researchers have put forward many methods to reduce the energy demands of the internet of thing elements. The review in the paper provides the various researches that are been done to identify the possible procedures of reducing the power requirements of the IOT and the devices associated with it along with the applications that employ the green IOT. This review would create awareness in the creation of further smart application associated with the internet of things.

References

Maksimovic, M. "Greening the future: Green Internet of Things (G-IoT) as a key technological enabler of sustainable development." In Internet of things and big data analytics toward next-generation intelligence, pp. 283-313. Springer, Cham, 2018.


