

Green Computing: An Overview of Energy-Efficient and Sustainable IT Systems

Deepa V¹, Pavithramuki Ms N²

¹Assistant Professor, Department of Computer Science, Sri Ramakrishna College of Arts & Science, Coimbatore

²III B.COM CA, Sri Ramakrishna College of Arts & Science, Coimbatore

ABSTRACT

Green computing focuses on making information technology more environmentally friendly by designing, developing, and operating computing systems that consume minimal energy and generate minimal environmental impact. The concept emphasizes energy-efficient hardware, optimized software, sustainable networks, and responsible disposal of electronic waste. Recent research highlights significant efforts toward adopting green computing practices across multiple sectors. Studies examining various industries identify current trends, challenges, and future opportunities in sustainable computing. The primary objective of green computing is to support researchers, organizations, industries, governments, and environmental agencies in reducing carbon emissions and energy consumption. This study provides a comprehensive overview of green computing concepts, highlights key research areas, and identifies gaps that offer scope for future innovation.

Keywords: Green Computing, Sustainable Technology, Energy-Efficient Computing, Carbon Footprint Reduction, Eco-Friendly IT, Green Data Centers

INTRODUCTION

Green computing refers to the environmentally responsible design, use, and disposal of computing resources. It aims to reduce the carbon footprint of technology and promote sustainability in the digital era. The concept emerged in the 1990s as environmental awareness increased and concerns over energy consumption and electronic waste grew. With rapid technological advancement, energy-efficient computing solutions have become essential. Green computing encompasses hardware, software, networks, data centers, and cloud infrastructure. Key practices include the use of energy-efficient equipment, virtualization, optimized software design, renewable energy sources, and effective electronic waste management.

Adopting green computing practices benefits organizations by reducing operational costs while minimizing environmental impact. Moreover, these practices help industries comply with environmental regulations and contribute to the growth of a sustainable and eco-friendly technology ecosystem.

OVERVIEW OF THE STUDY

Green computing research is becoming a hot topic globally. China is at the forefront with the highest number of studies, followed by India and the US. It's very reassuring to see governments dedicate their efforts to creating sustainable tech solutions.

The domain has been gradually expanding since 2007, with a significant growth spurt in the last ten years. The research foci include energy, efficient data centers, cloud computing, and various optimization techniques. The research world is flooded with keywords such as "data, center", "green", and "energy".

A large part of the research is in the form of journal articles, which points to the field's level of maturity. Elsevier, Springer, and IEEE Xplore are the main publishing houses. Green data centers, cloud computing, and IoT are main focus areas, whereas machine learning and e, commerce remain less explored.

REVIEW OF LITERATURE

Green computing has attracted increasing interest across disciplines such as software engineering, cloud computing, networking, and data center management. Researchers have explored strategies to reduce energy consumption, improve hardware efficiency, and promote sustainable IT practices.

Several studies investigate the role of emerging technologies such as blockchain, 5G, and IoT in supporting green computing initiatives. Other works focus on energy management systems and green data centers, emphasizing environmentally responsible infrastructure design. Although awareness of sustainable computing practices is growing, existing literature highlights a lack of integrative studies that combine multiple domains to present a holistic view of green computing. Future research should focus on developing comprehensive frameworks and implementing innovative technologies to enhance sustainability across computing environments.

IMPACT OF GREEN COMPUTING

Technology and the environment are closely interconnected, and green computing plays a crucial role in reducing the environmental impact of the IT industry. From system design to device disposal, green computing promotes sustainability throughout the technology lifecycle.

Data centres are among the largest contributors to global energy consumption and carbon emissions. Implementing green computing practices—such as energy-efficient cooling systems, virtualization, and renewable energy usage—can significantly reduce emissions and electronic waste.

Green computing supports sustainable manufacturing, responsible disposal of electronic devices, and environmentally conscious product design. By adopting these practices, the technology industry can contribute to environmental protection while maintaining performance and innovation.

RECENT ADVANCES IN GREEN COMPUTING

Recent breakthroughs in energy-efficient hardware, renewable energy-powered data centres, and

intelligent energy management systems are revolutionizing the tech scene. Cloud computing, IoT, and data centre tech are being revamped to use less energy without sacrificing performance. We're talking green databases, energy-aware algorithms, and eco-friendly AI models that are making sustainability and performance best buddies.

Companies like Google and Microsoft are leading the charge, shifting to 100% renewable energy and innovating like crazy. It's not just about reducing carbon footprint; it's about making tech more efficient and cost-effective too. The future's looking bright, with AI and machine learning optimizing energy usage and new cooling tech on the horizon. Innovations such as green databases, energy-aware algorithms, and environmentally friendly artificial intelligence models are driving progress in this domain. These developments demonstrate that sustainability and performance can coexist in modern computing systems

FUTURE GREEN COMPUTING

The future of green computing is looking super exciting! We're on the cusp of some major breakthroughs that'll make tech way more eco-friendly. Imagine data centres powered by solar energy, biodegradable electronics that dissolve in water, and AI managing power consumption like a pro. The goal's clear: reduce e-waste, lower carbon footprint, and cut energy consumption.

Innovators are getting creative with materials, using bioplastics and recycled metals to build greener gadgets. Quantum computing is going to be a game-changer for climate modelling, helping us predict and tackle environmental issues way better. And edge computing's stepping up to reduce energy consumption, making tech more efficient.

Countries are investing big time in sustainable tech, so the future looks bright. But let's be real, there are still hurdles to jump - like making green tech affordable and scalable.

CONCLUSION

The tech world is absolutely buzzing about sustainability, and honestly, it's about time! We're seeing some seriously cool innovations - eco-

friendly data centers, smart IoT systems, and clever algorithms that are making a real difference. It's not just about jumping on the green bandwagon; these innovations are actually making tech more efficient and reducing environmental impact. Energy-harvesting wearables, biodegradable electronics, and data centers powered by solar or wind energy are just a few examples of what's out there.

The real challenge is making sustainable tech affordable and scalable. But innovators are getting super creative, exploring bioplastics, recycled gadgets, and other game-changing materials. And it's working! Countries like China, the US, and India are leading the charge towards greener tech, pushing boundaries and setting new standards. It's an exciting time to be in tech, and we're just getting started! The future of tech is looking greener, and we're here for it. As more people demand eco-friendly options, sustainable tech is becoming the new cool, and we're loving the shift.

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