Chapter 18
Green Software Engineering Development Paradigm:
An Approach to a Sustainable Renewable Energy Future

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ABSTRACT

A major software engineering process of the twenty-first century is green software engineering (GSE), which represents a complete paradigm shift in the software development process. Previously, software engineers were primarily concerned with developing hardware and software, with little attention paid to sustainability, or to the technical, economic, environmental, social, and individual aspects of environmental sustainability. It is necessary to determine the elements that affect the sustainability of GSE on an individual basis as well as how they interact with team and organizational practices, policies, and decisions. The fundamental goal is to create best practices and recommendations that have been experimentally established for measuring, enhancing, and preserving sustainability from the standpoint of the software engineers. It is anticipated that these steps will guarantee engineers' sustainable approach to the software engineering profession and facilitate regular, high-quality software development towards carbon emission reduction.

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1. INTRODUCTION

The creation of useful and user-friendly software is just one aspect of software engineering development process; that focused on the environmental sustainability that track and manage consumption and compute related carbon emissions by processing environmental data on energy, transportation, waste, water, and fugitive gasses(Da Fonseca-Soares, Eliziário, Galvinicio, & Ramos-Ridao, 2023). Green software engineering(GSE), also known as sustainable software, maximizes energy efficiency and reduces its negative effects on the environment throughout the course of its lifetime(Lorincz, Capone, & Wu, 2019). This kind of software considers the environment during its design, development, and implementation. A fundamental set of skills that can assist in defining, developing, and implementing sustainable software applications are the principles of sustainable software engineering, which must be adhered to in order to produce sustainable software. Aspects like data, testing, deployment, operations, architecture, design, code, infrastructure, and monitoring are all covered by these concepts(Raturi, Tomlinson, & Richardson, 2015). The ability and duty to produce software that is sustainable and can lessen the environmental impact of an organization's goods and services falls on software developers and architects. In order to lessen the information technology (IT) industry's environmental impact with relation to its practice of contributing to toxic waste and global warming, GSE is essential(Almusaed, Almssad, Alasadi, Yitmen, & Al-Samaraee, 2023). Software can be made to use less energy and hardware resources by implementing modern application architectures, such as serverless computing or functions-as-a-service (FaaS) architecture, localizing computer processing, optimizing logical constructs, and reducing data exchanges and service calls. Software engineers may design systems that are responsible, resource-efficient, and energy-efficient by implementing sustainable software engineering techniques into software development practice(Heithoff, Hellwig, Michael, & Rumpe, 2023).

The objective of green software engineering is to minimize greenhouse gas emissions and lower an organization's carbon footprint. Software that emits the least amount of carbon is considered green software, or carbon-efficient software(Schmidt et al., 2023). Energy efficiency, carbon awareness, and hardware efficiency are the only three actions that lower software's carbon emissions. Organizations can achieve environmental, social, and governance compliance by making the most of their current resources and developing green software(Wu & Tham, 2023). Corporate performance evaluation criteria evaluate a company's ability to oversee its social and environmental impacts and how well its governance mechanisms are in place. The field of software engineering has grown to be vital to society's professional aspirations, and as its use has grown, so too have the demands on energy and resources. IT finds more effective software solutions to solve environmental issues, which helps to promote sustainability. The GSE takes into account the needs for computer hardware and software in order to solve sustainability's environmental implications(Jiang, Ni, Ni, & Guo, 2023). In an IT system, hardware and software are meaningless without the application layer that integrate it with other cyber physical systems and Internet of Things (IoT) infrastructures. Operating on hardware, the software offers features like paperless workplaces, smart heating, smart lighting, and smart logistics. Because software development is a human endeavor, sustainability ought to be taken into account.

The environmental and energy aspects of software engineering sustainability have received the majority of research attention. There are several reasons why adopting a GSE approach is imperative.

i. **Cost Reduction:** Software product operation and maintenance costs can be decreased with the use of GSE techniques, such as resource optimization.

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