Thesis Project Portfolio

AI-Optimized Cooling in Cloud Data Centers: A Feasibility Analysis

(Technical Report)

Environmental Strategies of the Cloud Computing Industry

(STS Research Paper)

An Undergraduate Thesis

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Table of Contents

Sociotechnical Synthesis

The emergence of data-intensive technologies like artificial intelligence (AI), machine learning (ML), and the Internet of Things (IoT) has led to the proliferation of data centers and increased pressures on cloud infrastructure. With the cloud computing industry already struggling to meet demand and facing significant socioeconomic, political, ethical, and environmental dilemmas, the rapid growth of those emerging technologies draws attention to critical issues surrounding sustainable resource management. To help address some of the sociotechnical challenges in the field, I conducted research in two parts. My technical report focuses on the significant energy demands of cloud infrastructure, particularly in the cooling systems of data centers, and evaluates whether AI can act as a feasible solution. The STS paper explores how and why cloud providers adopt their sustainability strategies to provide perspective on the factors shaping resource decisions. While each portion of the research examines a different aspect of sustainable resource management in cloud computing, they together try to provide a holistic view of the challenges the industry faces.

One potential path towards more sustainable resource consumption lies in optimizing data center energy expenditure. In my technical research, I investigated the potential of AI- and ML-based solutions to improve the energy efficiency of data center cooling systems—a key source of electricity consumption. Through a combination of literature reviews, case studies, simulations, and statistical analyses, I conducted a meta-study to assess whether the energy savings enabled by AI optimization justify the computational costs of training and operating such models. My findings indicate that, in most cases, the net energy savings make AI-driven cooling a worthwhile pursuit. However, further research is needed to identify which specific AI/ML techniques yield the best results and to evaluate the broader environmental and socioeconomic implications of deploying these technologies at scale.

In contrast to this technical focus, my STS paper examined the motivations and external influences that factor into the sustainability strategies adopted by cloud service providers. Using the Social Construction of Technology (SCOT) framework, along with utilitarian and deontological ethics, I analyzed how various social groups—such as consumers, corporations, and governments—influence decision-making around renewable energy, water stewardship, energy efficiency, and carbon offsetting. My research reveals that cloud providers' policies are shaped not only by technological feasibility, but also by a complex interplay of political, social, economic, and ethical pressures. This analysis underscores how technological and environmental decisions are socially constructed, offering insights into how to strike a balance between technological innovation and environmental sustainability.

While each portion of my project produced different findings, working on both simultaneously uncovered insights that neither would have made in isolation. Balancing the quantitative skills from my technical report with the analytical skills from my STS paper deepened my ability to critically examine the broader context in which technical decisions are made. Furthermore, I discovered that most problems are inherently sociotechnical, as these decisions are not made in a vacuum. Society helps shape the technology that is adopted, and looking at problems through just a technical or social lens limits the type of solutions that can be developed to effectively address a challenge. My hope for this project is that it highlights the interconnectedness between the social and the technical, furthering discussion and research on sustainable resource management to drive meaningful change.