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OPTIMIZING ENERGY EFFICIENCY AND PERFORMANCE IN HIGH-PERFORMANCE COMPUTING THROUGH ADVANCED DIRECT-TO-CHIP LIQUID COOLING AND LABVIEW-BASED MONITORING AND ANALYSIS

By: Chandraprakash Ashok Hinge

Thesis advisor: Dr. Dereje Agonafer

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Abstract

This research endeavors to significantly enhance energy efficiency and performance in the realm of high-performance computing (HPC). This goal is pursued through a synergistic approach that leverages advanced direct-to-chip liquid cooling systems and integrates LabVIEW for real-time monitoring and analysis within data centers.

The primary aims of this study are manifold. First, it seeks to evaluate the effectiveness of different single-phase liquid coolants when employed in direct-to-chip cold plate cooling for HPC systems. Additionally, the research focuses on characterizing row manifolds, crucial elements in the design of efficient data centers. The study also endeavors to devise a strategic control mechanism that ensures stability in secondary supply temperature, particularly at very low loads. Further, the development of a LabVIEW-based software solution for efficient data logging and analysis forms an integral part of the study's objectives.

In the current landscape, the surge in demand for high-performance computing, propelled by technologies such as AI, IoT, and machine learning, necessitates advancements in thermal management strategies. The research pays specific attention to the efficacy of direct-to-chip liquid cooling in mitigating challenges associated with thermal design power and form factor within HPC systems. It distinguishes itself by conducting a thorough and comprehensive evaluation of various single-phase liquid coolants, emphasizing their performance and reliability under diverse conditions. Furthermore, the study sets itself apart by delving into the characterization of row manifolds, a critical aspect for optimizing data center design. The integration of LabVIEW for real-time monitoring introduces a unique and valuable dimension to this research.

At its core, this study is driven by the urgent need for efficient cooling solutions to counter the significant thermal power generated by high-end CPUs and GPUs. Direct-to-chip liquid cooling emerges as a viable solution due to its inherent efficiency. The study endeavors to scrutinize a range of liquid coolants to optimize thermal performance and provide a reliable cooling approach for HPC systems.

Reflecting on the progress made thus far, the preliminary work has been substantial. It encompassed a thorough literature review and the setup of experimental configurations to evaluate coolant performance and characterize row manifolds. Furthermore, a strategic control mechanism was developed to stabilize the secondary supply temperature, even at exceedingly low loads. Additionally, a software solution leveraging LabVIEW was crafted to efficiently log and analyze data, a crucial step toward streamlined data center management.

Looking ahead, the research will delve into a more comprehensive set of experiments to evaluate the reliability and long-term performance of selected single-phase liquid coolants. A specific focus will be placed on examining propylene glycols at concentrations of 25%. This entails an in-depth analysis of the effectiveness of corrosion inhibitors, employing standardized testing apparatus. Additionally, the meticulously gathered experimental data will undergo thorough analysis. This analysis is expected to facilitate the calculation of the Total Cost of Ownership (TCO) associated with each coolant. Insights gleaned from this calculation will shed light on the economic implications of coolant selection at the data center level. Simultaneously, the LabVIEW-based software solution will undergo further validation, finetuning, and optimization. This iterative process aims to ensure seamless integration into data center management processes, ultimately bolstering operational efficiency and reliability.
In conclusion, the remaining work holds significant promise, aligned closely with the study's objectives. It promises to offer a comprehensive understanding of coolant reliability, economic considerations in coolant selection, and the augmentation of data center operational efficiency through advanced data logging and analysis.