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Evaluation and optimization of thermal solutions in air and liquid cooling systems for data centers

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Abstract

Data centers serve as repositories for substantial amounts of information technology hardware and associated systems. Their inherent dynamism stems from the frequent fluctuations in IT workloads, continuous extraction, incorporation, and substitution of IT apparatus in accordance with business requisites, distribution and allotment of workloads, regulation of cooling equipment, and design of unoccupied spaces, among other factors. The escalating power densities of microchips necessitate an enhanced and efficient cooling capacity, which constitutes the principal impetus behind the present research endeavor.

This study is centered upon three distinct cooling methodologies, namely: (1) Air cooling – encompassing the enhancement of control parameters within air-cooled data centers that employ chilled water, employing machine learning techniques; the effects of spray distribution on an indirect evaporative heat exchanger within an air handling unit; and a comprehensive assessment of the feasibility and energy considerations pertaining to Rear Door Heat eXchangers (RDHx) as compared to conventional systems reliant upon Computer Room Air Handling (CRAH) technology; (2) direct-to-chip single phase liquid cooling – encompassing an investigation into the influence of the heat capture ratio on energy efficiency within a data center employing a hybrid cooling approach; and (3) Single phase immersion cooling – involving an in-depth analysis and optimization of thermal performance with regard to cold plates and heat sinks and immersion compatible fluids.