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ZCCloud: Exploring Wasted Green Power for High-Performance Computing

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Abstract:

In supercomputer centers, available power, cooling, or carbon footprint often limits supercomputer performance. We propose a new approach to continue scaling that avoids many of these limits, augmenting a traditional system with another that employs only "wasted" renewable power, stranded power. This excess power cannot be economically distributed through grid, and is only intermittently available. We call this approach Zero-carbon Cloud (ZCCloud). We explore the potential benefits of unreliable resources with production DOE HPC workloads using a simple periodic model, and identify job types that benefit most (capability jobs and on-time jobs). The benefits scale with duty factor and resource quantity. Next, to create realistic models of "stranded power" we study 28 months of Mid-continent Independent System Operator (MISO) power market history (1,259 generators, 77 million 5-minute intervals). We find that opportunity varies, but the best single wind site can provide 80% duty factor, and 20MW average stranded power. Combining sites further improves duty factor. With resource volatility models from the MISO study, we simulate production DOE HPC workloads and find that stranded power HPC, ZCCloud, can provide significant benefit, decreasing average job-wait time by 50%.

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I. Introduction

With the end of Dennard scaling [1], [2], power has become an increasingly important concern for supercomputing centers. Today's 10-petaflop systems draw more than 10 MW [3], [4], and near-exascale machines announced by the US DOE continue this trend [5], [6]. A study examining hardware challenges for Exascale computing [2] proposed a ceiling of 20 MW as maximum acceptable for an exascale system. While this limit is likely to be exceeded, there is broad agreement that power is a critical challenge for these systems because of the energy cost, cooling cost, facilities cost, and the associated environmental impact [7].

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