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MINT: A Reliability Modeling Frameworkfor Energy-Efficient Parallel Disk Systems

Abstract:

The Popular Disk Concentration (PDC) technique and the Massive Array of Idle Disks (MAID) technique are two effective energy conservation schemes for parallel disk systems. The goal of PDC and MAID is to skew I/O load toward a few disks so that other disks can be transitioned to low power states to conserve energy. I/O load skewing techniques like PDC and MAID inherently affect reliability of parallel disks, because disks storing popular data tend to have high failure rates than disks storing cold data. To study reliability impacts of energy-saving techniques on parallel disk systems, we develop a mathematical modeling framework called MINT. We first model the behaviors of parallel disks coupled with power management optimization policies. We make use of data access patterns as input parameters to estimate each disk's utilization and power-state transitions. Then, we derive each disk's reliability in terms of annual failure rate from the disk's utilization, age, operating temperature, and power-state transition frequency. Next, we calculate the reliability of PDC and MAID parallel disk systems in accordance with the annual failure rate of each disk in the systems. Finally, we use real-world trace to validate out MINT model. Validation result shows that the behaviors of PDC and MAID which are modeled by MINT have a similar trend as that in the real-world.