Cross-Layer Thermal-Aware Scheduling: A Mini Literature Review

Rising power density in modern processors has intensified thermal management challenges, particularly in high-performance and mobile computing systems. Conventional approaches rely mainly on hardware and operating system techniques such as dynamic voltage and frequency scaling (DVFS), clock throttling, and active cooling. Although effective, these methods are reactive and can negatively impact performance and energy efficiency (Skadron *et al.*, 2004).

Cross-layer thermal-aware scheduling introduces a proactive methodology by incorporating thermal considerations into the compiler. In this approach, temperature is treated as an optimization constraint during compilation, enabling the restructuring of program execution to reduce thermal hotspots before runtime.

Brooks and Martonosi (2001) demonstrated that instruction scheduling decisions significantly affect processor temperature, showing that software-level optimizations can complement hardware thermal control. Thermal-aware compilers exploit this by reordering high-power and low-power instructions to distribute heat generation more evenly without reducing clock frequency.

Thermal modeling frameworks further support this methodology by allowing compilers to estimate the temperature impact of scheduling decisions during static analysis (Skadron *et al.*, 2004). Recent work by Li *et al.* (2019) extends thermal-aware compilation through feedback-directed and machine learning techniques, enabling adaptive scheduling across workloads and platforms.

Overall, cross-layer thermal-aware scheduling shifts thermal management from reactive hardware mechanisms to proactive software-driven optimization, offering a promising path toward energy-efficient and fanless computing systems.

References (IEEE-Adapted Harvard Style)

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