Dynamic Voltage Scaling for Multitasking Real-Time Systems with Uncertain Execution Time

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Abstract— **Dynamic voltage and frequency scaling (DVS)can save energy for real-time systems. Frequencies are generally assumed proportional to voltages. Previous studiesconsider the probabilistic distributions of tasks' executiontime to assist DVS in task scheduling. These studies useprobability information for intra-task voltage schedulingbut do not sufficiently explore the opportunities for inter-task scheduling to save more energy. This paper presents anew approach to combine intra-task and inter-task voltagescheduling for better energy savings in hard real-time systems with uncertain task execution time. Our approachtakes three steps: (a) We calculate statistically optimal voltage schedules for multiple concurrent tasks using earliestdeadline first (EDF) scheduling for an ideal processor thatcan change the frequency continuously. (b) We then adaptthe solution to a processor with a limited range of discretefrequencies using a polynomial-time heuristic algorithm.**

(c) Finally, we improve our solution considering the timeoverhead and the energy overhead of frequency-switchingfor schedulability and energy reduction. Our simulationshows that the new approach can save more energy thanexisting solutions while meeting hard deadlines.

***Index Terms*— Dynamic voltage scaling, hard real-time,probability, multitasking, low energy**