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# System-Level Analysis and Design under Uncertainty

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## ABSTRACT

One major problem for the designer of electronic systems is the presence of uncertainty, which is due to phenomena such as process and workload variation. Very often, uncertainty is inherent and inevitable. If ignored, it can lead to degradation of the quality of service in the best case and to severe faults or burnt silicon in the worst case. Thus, it is crucial to analyze uncertainty and to mitigate its damaging consequences by designing electronic systems in such a way that uncertainty is effectively and efficiently taken into account.

We begin by considering techniques for deterministic system-level analysis and design of certain aspects of electronic systems. These techniques do not take uncertainty into account, but they serve as a solid foundation for those that do. Our attention revolves primarily around power and temperature, as they are of central importance for attaining robustness and energy efficiency. We develop a novel approach to dynamic steady-state temperature analysis of electronic systems and apply it in the context of reliability optimization.

We then proceed to develop techniques that address uncertainty. The first technique is designed to quantify the variability in process parameters, which is induced by process variation, across silicon wafers based on indirect and potentially incomplete and noisy measurements. The second technique is designed to study diverse system-level characteristics with respect to the variability originating from process variation. In particular, it allows for analyzing transient temperature profiles as well as dynamic steady-state temperature profiles of electronic systems. This is illustrated by considering a problem of design-space exploration with probabilistic constraints related to reliability. The third technique that we develop is designed to efficiently tackle the case of sources of uncertainty that are less regular than process variation, such as workload variation. This technique is exemplified by analyzing the effect that workload units with uncertain processing times have on the timing-, power-, and temperature-related characteristics of the system under consideration.

We also address the issue of runtime management of electronic systems that are subject to uncertainty. In this context, we perform an early investigation into the utility of advanced prediction techniques for the purpose of fine-grained long-range forecasting of resource usage in large computer systems.

All the proposed techniques are assessed by extensive experimental evaluations, which demonstrate the superior performance of our approaches to analysis and design of electronic systems compared to existing techniques.

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