Rare events and worst-case execution times

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1 Motivation

During the last years the arrival of multi-core processors or many-core processors as well as the increased complexity of programs have made more difficult the estimation of the worst case execution times (WCETs) of programs. The existing methods may produce estimates that are too pessimistic for some systems. As result new analyses based on probabilities and statistics have appeared to cope with this complexity by taking into account the fact that large values of WCET may have low probability of appearance.

The first paper introducing probabilistic distributions for the description of execution times of tasks had associated to large values of execution times low probabilities [7] as illustrated in Figure 1. Different papers propose since methods to obtain such distributions. In [3] the authors provide a framework for obtaining the probabilistic execution times (pETs) of a program. Another method for estimating a pWCET bound in the presence of permanent faults in instruction caches was introduced in [6]. Papers like [4, 9] propose the estimation of pWCET using extreme value theory. Such theory is applied in [2] to platforms with randomized timing behavior and an associated avionics case study is presented in [8]. Only for this type of architecture, to our best knowledge, it is provided a proof that a large value of an execution time of a program is a rare event [1].

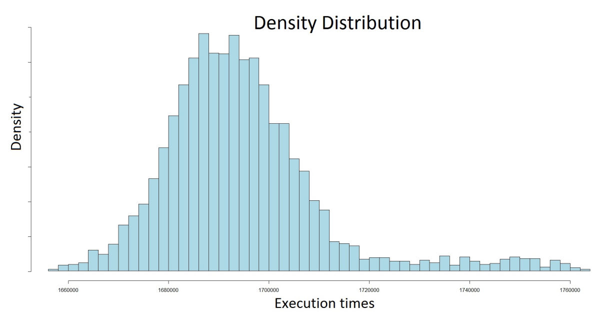

Figure 1: Distribution of execution times

2 Open Problem

In practice, it is noticeable that the higher the measured execution time is, the smaller its probability of occurrence is. In reality, the WCET is not easy to measure, and the analysis tools can either overestimate the WCET (static analysis), or underestimate it (taking in consideration only measurements), or predict it with a certain probability of occurrence (measurement-based probabilistic timing analyses). Figure 2 shows a description of the currently common accepted relation between observed execution times, WCET, etc [5].

As stated in the introduction associating low probability of appearance to large values of pETs was proved valid in the context of cache randomized architectures. One would expect to have **higher** probability of appearance for large values of pETs on existing real-world deterministic architectures (from which the vast majority are deterministic), but how one would prove it? For cache randomized architectures the proof was built using static probabilistic analysis and this does not seem to be trivial for any architecture. In conclusion our open problem is

How do we prove that large values of pETs are rare events for real-world programs executed on existing deterministic architectures?

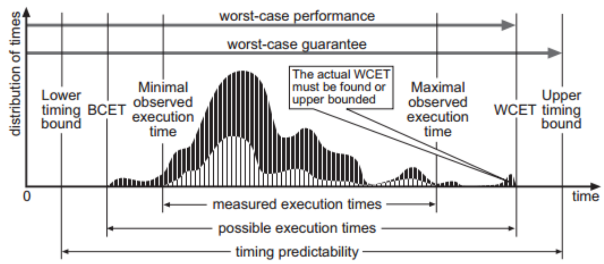

Figure 2: Commonly accepted relation between possible execution times

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