Flexible and High-Speed System-Level Performance Analysis using Hardware-Accelerated Simulation

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1 Abstract

Application performance is critical; state-of-the-art mobile systems are expected to deliver performance on demand, whilst remaining extremely power efficient. Therefore, it is vital to fine-tune the operating system, the set of applications running and the hardware in question, as well as ensuring that the performance of each application is able to meet the end-user's expectations.

The performance of an application can be measured *accurately* in hardware. However, this approach is *inflexible* and the *observability* is limited by the availability of hardware counters. Moreover, hardware-based performance analysis is *quick*, but it is restricted to the actual hardware and, in some situations, this technique can lead to large perturbations due to probing effects — i.e. the act of measuring changes the outcome.

On the other hand, the performance of an application can be measured using a full-system simulator, such as gem5 [2]. This offers considerably more *observability* and *flexibility* without affecting the performance of the simulated system. Most simulators, however, will produce only a low level, often text-based, statistics output, which does not integrate well with existing tool-sets, and requires the designer to use ad-hoc visualisation. Simulator performance is also significantly *slower* than running on real hardware, and this slowdown becomes more noticeable when more detailed simulation models are utilised.

The Linux Kernel-based Virtual Machine (KVM) provides a well documented API that enables software to use hardware virtualisation outside of the scope of traditional virtualisation environments, and can therefore be used as a core in a simulator. KVM is able to execute any code, provided the peripheral devices are emulated. However, due to limited *observability* of the virtualised hardware, it is difficult to gather detailed performance metrics whilst running with KVM. Therefore, KVM must be switched for an *accurate*, simulated CPU model at points of interest.

In this work, the gem5 simulator is augmented with KVM-based hardware acceleration, and is extended with a portable advanced visualisation tool which allows for various types of statistics output, depending on the particular requirements of the analysis conducted. This provides a platform for *high-performance* system simulation without sacrificing the *accuracy*, *observability* or *flexibility* of the simulator. We demonstrate:

1. hardware acceleration of the open source gem5 full-system simulator on a Samsung Exynos 5 Dual [3] based development board,
2. visualisation of a large number of statistics using the publicly available ARM Streamline Performance Analyser [1].

Hardware virtualisation on an ARM based development board is used to fast-forward the simulation to a point of interest, at which moment the virtualised core is switched for a gem5 software model. Employing the gem5 core model we demonstrate that a large number of statistics can be extracted using the publicly available ARM Streamline Performance Analyser [1]. A comparison of the statistics gathered with those collected from real, comparable hardware shows that they provide significantly greater insights into the factors which govern application performance.

References

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