HS06 Benchmark for an ARM Server

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Abstract.
We benchmarked an ARM cortex-A9 based server system with a four-core CPU running at 1.1 GHz. The system used Ubuntu 12.04 as operating system and the HEPSPEC 2006 (HS06) benchmarking suite was compiled natively with gcc-4.4 on the system. The benchmark was run for various settings of the relevant gcc compiler options. We did not find significant influence from the compiler options on the benchmark result. The final HS06 benchmark result is 10.4.

1. Introduction
CPUs with the ARM architecture promise to deliver more compute power per unit of consumed energy than the currently dominant x86 architecture CPUs. ARM CPUs have seen a rapid development in the recent years due to the emergence of hand-held devices like smartphones or tablet computers where low power consumption is essential. The available processing capacity per core in ARM CPUs has now advanced to a level, where their use in servers even with large CPU power requirements has become an option and consequently ARM CPU based server products have appeared on the market.

We estimate that in typical European computing centres for HEP, e.g. Tier-2 or Tier-3, the money spent over a period of three to four years on power costs matches the hardware costs. In addition, the large power consumption of big computing clusters triggers high costs for infrastructure such a power distribution and cooling systems.

It is therefore an interesting question, if typical tasks of todays HEP computing could be performed with ARM based servers. A positive answer could lead to installations with lower power consumption and thus also lower infrastructure costs.

We installed the HEPSPEC 2006 suite on a Boston Viridis ARM server, a candidate for typical HEP use cases, and we compared the results with traditional x86 based systems.

2. The Boston Viridis ARM server
In this study we investigate the Boston Ltd. Viridis server as an example of an ARM based server. The Boston Viridis uses the Calxeda EnergyCore system-on-chip (SoC) with four ARM cortex-A9 cores. These SoCs contain a complete system with CPU cores, 10 GBE network interface (NIC), RAM and hard disk management. Up to 4 GB of RAM can be installed per SoC.

The SoCs are supplied on cards with four units each which are installable in the Boston Viridis server enclosure. In total 12 cards with 48 SoCs may be installed. The SoCs are powered by the enclosure, hosting a 300 W power supply. The NICs are connected via a built-in 10 GBE to external LANs.
For this study we had remote administrator (root) access to a single system housed and operated by Boston Ltd. On this system the CPU frequency was 1.1 GHz and it was installed with the Ubuntu 12.04 armhf Linux OS.

Figure 1. (left) The Boston Viridis server enclosure. (right) The Calxeda EnergyCard with four EnergyCore SoCs. Pictures from [1].

3. HEPSPEC 2006 benchmark installation

The HEPSPEC 2006 [2] benchmark suite is a collection of C++ programs from the SPEC CPU 2006 benchmark [3], by spec.org. The benchmark runs one serial job per core and averages individual results. We used SPEC CPU 2006 version V1.1 together with the spec2k6-2.23 scripts available from [2].

On the ARM platform the SPEC CPU 2006 toolset does not work, because the programs are compiled for the x86 architecture. It was thus necessary to compile the tools from source following the procedure outlined in [4].

The standard C++ compiler on Ubuntu 12.04 is gcc-4.6. However, with this version of gcc not all programs of the HEPSPEC 2006 suite can be compiled successfully. We installed gcc-4.4 from the Ubuntu package archives and with this version of gcc we could compile all programs.

For the compilation of the benchmark programs we used the gcc options -O3 - PIC -pthread -mtune=cortex-a9 together with -mfpu=vfpv3 or -mfpu=neon.

4. HEPSPEC 2006 results

Table 1 shows the results of the HEPSPEC 2006 benchmark on the Boston Viridis server, on other reference x86 systems we had available, and from other sources as indicated. On the x86 systems the HEPSPEC 2006 benchmark was compiled with the standard flags for 32bit [2] and run on 64bit Linux OS.

The main result is that the Calxeda EnergyCore SoC running at a CPU frequency of 1.1 GHz delivers a HEPSPEC2006 value of 10.4. In a run with -mfpu=neon a value of 10.3 was obtained. Similar results were shown at this conference by N. Neufeld [5].

The table shows power consumption figures, under full load, from manufacturer data sheets for the Viridis server, as given by the CPU manufacturers or in the specifications of the power supplies.

From the table one can find that the Calxeda EnergyCore platform as used in the Boston Viridis server has a power efficiency measured in HS06/W which is better by a factor of 2 to 4 compared with current x86 CPU based systems. P. Szostek presented similar studies for x86 CPUs at this conference and found similar results [7]. He also showed that for the latest Intel Haswell series CPUs HS06/W values of up to 2 are possible.
Table 1. The table shows HS06 benchmark results for various ARM and x86 systems together with power consumption values under full load and the ratios of benchmark value and power consumption for each system.

| System      | CPU               | HS06 | power [W] | HS06/W |
|-------------|-------------------|------|-----------|--------|
| Viridis     | Calxeda SoC       | 10.4 | 5         | 2.1    |
| HP dc7900   | i7-2600k          | 95   | 150       | 0.63   |
| IBM HS22    | dual Xeon E5620   | 130  | 250       | 0.52   |
| IBM HS22    | dual Xeon E5645   | 179  | 250       | 0.72   |
| IBM HS23    | dual Xeon E5-2670 | 339  | 360       | 0.94   |
| Dell C6145  | dual AMD 6378     | 558  | 600       | 0.93   |

5. Discussion and conclusions

Based on our results it seems feasible to run HEP tasks on ARM based servers, since sufficient processing capacity per system is available. On the Calxeda EnergyCore platform Ubuntu and Fedora Linux are available which makes a port of the HEP software packages possible. N. Neufeld reported that the LHCb reconstruction program was successfully ported to the same ARM servers as in this work with Fedora Linux [5].

The investment costs for ARM based servers are still high such that the economic case for a large scale deployment of ARM based servers is not clear\(^1\). In addition, the Haswell generation of Intel x86 CPUs can provide similar HS06/W ratios compared with the ARM server investigated here. However, more powerful ARM CPUs supporting 64bit OS are expected on the market soon, e.g. Calxeda has released the ECX-2000 SoC with ARM cortex-A15 cores which support 64bit OS and virtualization [8].

It still seems a good investment to study alternative platforms for HEP computing in order to be ready when new technical and economical possibilities arise. Even if the outcome of such studies is negative for the moment our ability to move to other platforms if needed sends the right message to vendors.

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References

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1 This statement is based on confidential offers for ARM and x86 based servers we received in 2013.