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## The Green500 List - June 2014

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The June 2014 release of the Green500 list shows an increasing trend of heterogeneous supercomputing systems at the top of the list. Now the top 17 spots of the list are occupied by heterogeneous computing systems, securing six more spots at the top over the previous list, a 55% increase. A heterogeneous supercomputing system is one that uses computational building blocks that consist of two or more types of computing brains. These types of computing brains include traditional processors (CPUs), graphics processing units (GPUs), and co-processors. Of the top 17 spots,

- The first 15 systems are accelerated with NVIDIA Kepler K20 GPUs, coupled with Intel Xeon CPUs, including TSUBAME-KFC at number 1.
- The number 16 system, Shadow, is accelerated with Intel Xeon Phi co-processors and coupled with Intel Xeon CPUs.
- The number 17 system, SANAM, is accelerated with AMD FirePro S10000 GPUs, coupled with Intel Xeon CPUs

While the above results might lead one to believe that heterogeneous systems permeate throughout the Green500 list, they are only prevalent at the top end of the list. Of the 500 ranked systems, only 64 of them are heterogeneous while the other 436 are homogeneous and contain only one type of brain, that is, CPU brains. The total number of heterogeneous systems on the list remains relatively unchanged from the November 2013 list, as does their overall share of performance. The average energy efficiency of these systems, when measured in millions of floating-point operations per second per watt, or (MFLOPS/watt) is 1,938 MFLOPS/watt, whereas it is only 743.32 MFLOPS/watt for the measured homogeneous systems. As a result, heterogeneous systems dominate the top end of the list. So, perhaps the old adage of 'two heads being better than one,' or in this case, 'two types of computing brains being better than one' appears to hold.

The energy efficiency at the top end of the Green500 list remains largely unchanged with TSUBAME-KFC still at the top and remaining the only system above the 4,000 MFLOPS/watt mark. The 10 greenest machines from the previous Green500 list all remain in the top 15 of this Green500 list and were joined by similarly heterogeneous architectures. In addition, the ranking

of the most energy-efficient heterogeneous supercomputing systems is based more on the GPU than on the CPU. For instance, the 15 greenest systems are all accelerated by NVIDIA Kepler K20 GPUs, but different Intel CPUs are sprinkled throughout the top 15 with Piz Daint at number 5 and CSIRO at number 7 having Intel Sandy Bridge CPUs and TSUBAME at number 8 having Intel Westmere CPUs, both older CPU generations. The rest of the top 15 systems all use Intel Ivy Bridge, the latest generation of CPU.

Homogeneous supercomputing systems from IBM, dubbed BlueGene/Q, dominate 24 of the next 25 spots of the Green500 with energy efficiency ranging between 2,178 MFLOPS/watt and 2,182 MFLOPS/watt. In the meantime, Tianhe-2, the fastest supercomputer in the world according to the Top500 list, still ranks as one of the 50 most energy-efficient supercomputers in the world at number 49. Its heterogeneous architecture, accelerated by Intel Xeon Phi, achieves an efficiency of 1,902 MFLOPS/watt even in spite of its tremendous size.

Assuming that TSUBAME-KFC's energy efficiency could be scaled linearly to an exaflop supercomputing system, one that can perform one trillion floating-point operations per second, such a system would consume on the order of 225 megawatts (MW). Although this 225-megawatt power envelope is still quite far from DARPA's optimistic target of a 67-megawatt power envelope, it is an order of magnitude better than the initial projection of a nearly 3000-megawatt power envelope from 2007 when the first official Green500 list was launched, says Wu Feng of the Green500.

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