HPCG

The HPC Conjugate Gradient (HPCG) benchmark uses a preconditioned conjugate gradient (PCG) algorithm to measure the performance of HPC platforms with respect to frequently observed, yet challenging, patterns of execution, memory access, and global communication.
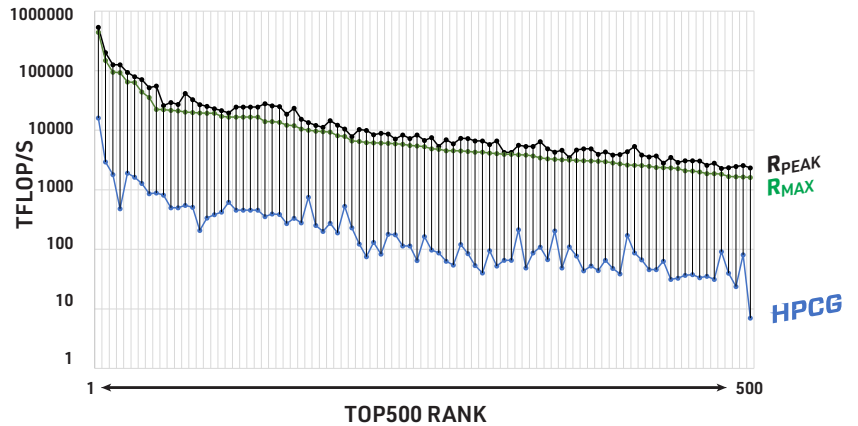
The PCG implementation uses a regular 27-point stencil discretization in 3 dimensions of an elliptic partial differential equation (PDE) with zero Dirichlet boundary condition. The 3-D domain is scaled to fill a 3-D virtual process grid of all available MPI process ranks. The CG iteration includes a local and symmetric Gauss-Seidel preconditioner, which computes a forward and a back solve with a triangular matrix. All of these features combined allow HPCG to deliver a more accurate performance metric for modern HPC hardware architectures.

27-point discretization of a regular 3-D grid

$$\mathcal{L}[u] \equiv \nabla^2 u = f$$

$$f(\Omega) = 0$$

GEOEMTRIC MULTIGRID PRECONDITIONER

3-D Data Grid mapped onto a 3-D Process Grid of MPI

Halo Exchange via MPI

$$Au = f$$

SAMPLE RESULTS
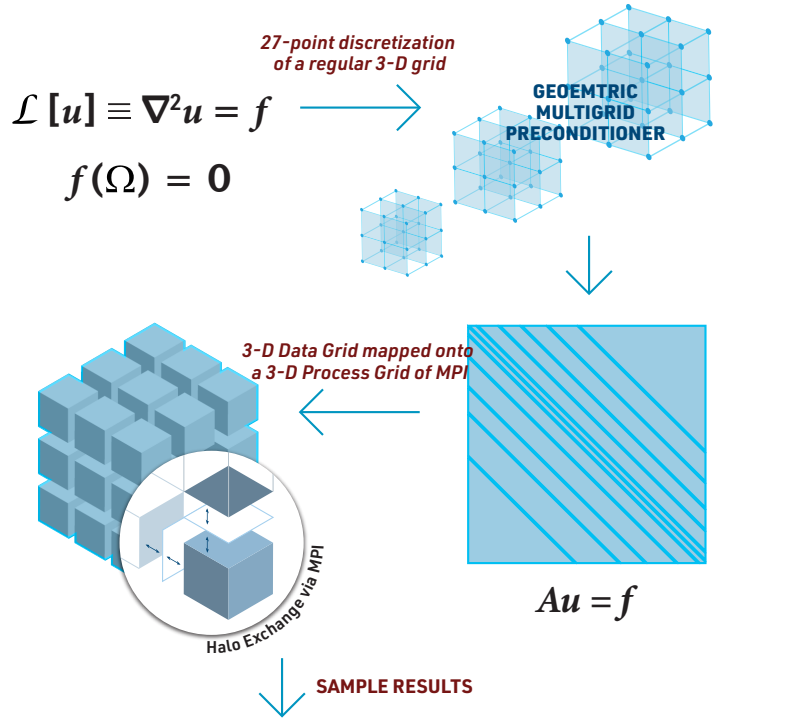
PRECONDITIONED CONJUGATE GRADIENT SOLVER

$p_0 \leftarrow x_0, r_0 \leftarrow b - Ap_0$
for $i = 1, 2,$ to $\boxed{\text{max\_iterations}}$ **do**
  $z_i \leftarrow M^{-1} r_{i-1}$
  if $i = 1$ **then**
    $p_i \leftarrow z_i$
    $\alpha_i \leftarrow \text{dot\_prod}(r_{i-1}, z_i)$
  else
    $\alpha_i \leftarrow \text{dot\_prod}(r_{i-1}, z_i)$
    $\beta_i \leftarrow \alpha_i / \alpha_{i-1}$
    $p_i \leftarrow \beta_i p_{i-1} + z_i$
  end if
  $\alpha_i \leftarrow \text{dot\_prod}(r_{i-1}, z_i) / \text{dot\_prod}(p_i, Ap_i)$
  $x_{i+1} \leftarrow x_i + \alpha_i p_i$
  $r_i \leftarrow r_{i-1} - \alpha_i Ap_i$
  if $\|r_i\|_2 < \boxed{\text{tolerance}}$ **then**
    STOP
  end if
end for

TFLOP/S

R$_{PEAK}$
R$_{MAX}$

HPCG

TOP500 RANK

FIND OUT MORE AT
http://www.hpcg-benchmark.org/

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HPCG

The chart to the right shows various performance statistics from the past HPCG result lists. The sum of performance indicates steady growth of results accumulated on the list. The median and smallest values decrease as HPCG list increases the number of systems on the list, thus expanding the range of recorded values.
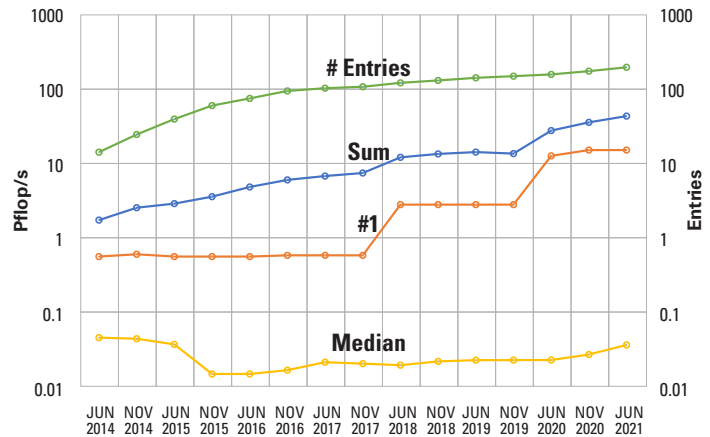
The chart to the right shows all performance results from the past HPCG result lists. Different lists are represented by different colors. The number of entries on the lists keeps increasing and reached 211 in June 2021.
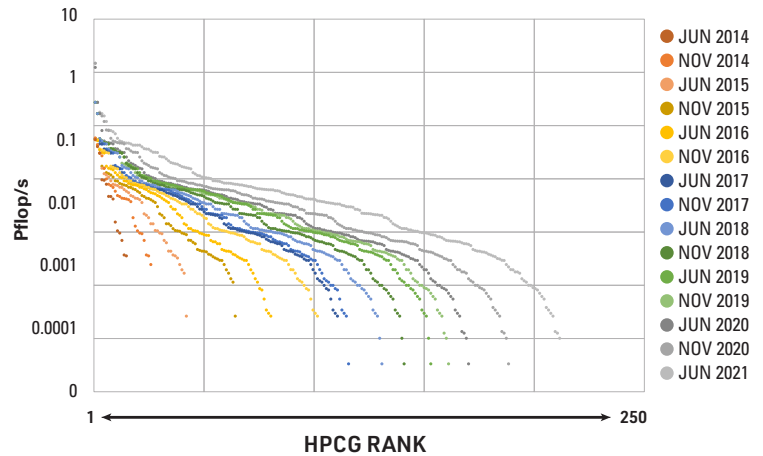
The chart to the right shows scaling performance results of the reference HPCG code on 780-core cluster with 180 InfiniBand interconnect. The scaling is 160 linear (blue marks) with constant per-core performance (red marks) for 140 small core counts (below about 200 cores). Beyond that point, the scaling 120 slowly deteriorates to reveal hardware's deficiency for codes that 100 HPCG was designed to represent.

+ Gflop/s

● Gflop/s per core