Cuda Acceleration for BoomerAMG implementation

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Introduction

AMG is a parallel algebraic multigrid solver for linear systems arising from problems on unstructured grids. The driver provided for this benchmark builds linear systems for various 3D problems. It uses the HYPRE library(http://acts.nersc.gov/hypre/) built at Center for Applied Scientific Computing at Lawrence Livermore National Laboratory.

Problem description

The multigrid solver has to be ported for Cuda acceleration.
There are 3 major modules which we will be implementing on Cuda.
These are

1. Laplace
2. Laplacian – 27pt
3. PDE with jumps

Gprof and mpiP utilities were run on the code and we found that almost all calls are made from the HYPRE library files.
The longest call from the module when we ran the code and profiles with 64 nodes was hypre_BigBinarySearch which is called by hypre_ParCSRMatrixExtractConvBExt which basically performs multiplication across nodes.
We are aiming to optimize the PCG with AMG solver. (Boomer AMG).

Design

We propose defining a wrapper library to bypass most of the MPI calls, this will enable us to port the application to Cuda without changing much of the code. However we found that some calls for the algorithm allocated memory dynamically (using calls hypre_CTAlloc which internally called calloc based on the size of the structures passed like MPI_Status).
So we will now scan the PCG communication code and also the individual MPI calls in the other functions and replace the one used within the computation with the respective Cuda MPI calls and allocate memory accordingly.

Tasks

1. Code comprehension - October 27 (All)
2. Identify computation intensive portions of the PCG solver and port to CUDA – October 31st (All)

3. Move the communication calls in pcg_csr_communication.c file to CUDAmpi. - November 5th (All)
4. Moving Laplace calculation to CUDA - TBD (Keerthana)
5. Moving 27 pt calculation to CUDA - TBD (Poonam)
6. Moving jumps calculation to CUDA. - TBD (Karthikeyan)
7. Evaluation – TBD (All)

References

[1] Van Emden Henson and Ulrike Meier Yang, "BoomerAMG: A Parallel Algebraic Multigrid Solver and Preconditioner", Appl. Num. Math. 41 (2002), pp. 155-177. Also available as LLNL technical report UCRL-JC-141495.

[2] Hans De Sterck, Ulrike Meier Yang and Jeffrey Heys, "Reducing Complexity in Parallel Algebraic Multigrid Preconditioners", SIAM Journal on Matrix Analysis and Applications 27 (2006), pp. 1019-1039. Also available as LLNL technical reports UCRL-JRNL-206780.

[3] Hans De Sterck, Robert D. Falgout, Josh W. Nolting and Ulrike Meier Yang, "Distance-Two Interpolation for Parallel Algebraic Multigrid", Numerical Linear Algebra with Applications 15 (2008), pp. 115-139. Also available as LLNL technical report UCRL-JRNL-230844.

The report is also published at: http://www4.ncsu.edu/~ksivara/amg/index.html