Tutorial on Aztec

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outline

• what does it do
• how to use it
• questions

Aztec

A massively parallel iterative solver library for solving sparse linear systems

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Software description

- \( Ax = b \)
- Distributed (SPMD): MPI
- Matrix type: unstructured sparse data-local matrices, e.g., from finite elements
- simple parallelization: no need to -
  - define ghost variables
  - map global to local indices
  - identify neighboring processors
  - determine messages
- efficient machine utilization
  - fast (grouped) communication
  - sparse point & block matrices
  - advanced parallel preconditioning
  - builds on advanced partitioning
  - computation overlaps communication

Major Components

- Linear system solver
  - CG,
  - CGS,
  - BiCGSTAB,
  - GMRES,
  - TFQMR
- Preconditioners
  - point & block Jacobi,
  - Gauss-Seidel,
  - least-square polynomials,
  - overlapping domain decomposition using sparse LU, ILU, BILU within the domains
- Used in (with the help of the developers)
  - reacting flows
  - heat transfer
  - free surface moving-mesh
  - structural dynamics
  - ...
Preconditioners

- AZ_Jacobi -- (block) Jacobi, (options[AZ_poly_ord] steps)
- AZ_Neuman -- Neuman series polynomial, order options[AZ_poly_ord]
- AZ_ls -- least squares polynomial, order options[AZ_poly_ord]
- AZ_lu -- overlapping additive Schwarz preconditioner with ILU
- AZ_ilu -- overlapping additive Schwarz preconditioner with ILU(0)
- AZ_bilu -- overlapping additive Schwarz preconditioner with BILU(0) for VBR
- AZ_sym_GS -- additive Schwarz preconditioner with options[AZ_poly_ord] steps of symmetric Gauss-Seidel iterations

How to use it

Basic steps:

- prepare the linear system
distribute the matrix
call AZ_transform to format the distributed matrix
- set right-hand-side and initial guess
call AZ_reorder_vec
- select an iterative solver and a preconditioner
call AZ_solve
call AZ_invorder_vec to restore order of the solution
Aztec matrix format

schematics

• MSR
  bindx[NNZ+1]
  bindx[0:N] -- pointers to start of N rows
  bindx[N+1:NNZ] -- column indices
  val[NNZ+1]
  val[0:N-1] -- diagonal element values
  val[N+1:NNZ] -- off-diagonal element values

• VBR
  rpntr
  cpntr
  bpntr
  indx
  val
Overlapping domain decomposition

Features

✓ small package focused on solving linear systems
✓ good sparse matrix support -- efficient matrix-vector multiplication, block entry format, automatic analysis
✓ common Krylov subspace methods
✓ parallel preconditioners
✗ use external partitioning
✗ single right-hand side only
✗ real linear system only