Tutorial on Aztec

Kesheng John Wu

outline

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

Aztec

A massively parallel iterative solver library for solving sparse linear systems

Sandia National Laboratories

Ray S. Tuminaro

John N. Shadid

Scott A. Hutchinson

Lydie Provost

Charles H. Tong

web address

http://www.cs.sandia.gov/CRF/aztec1.html

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

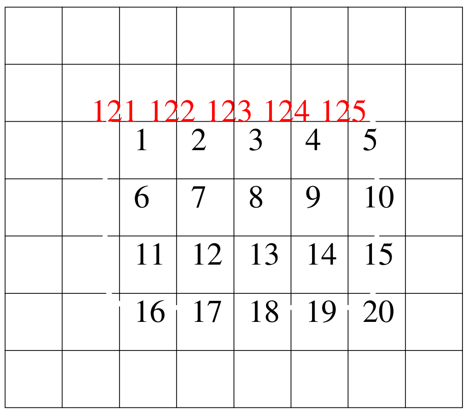
How to use it

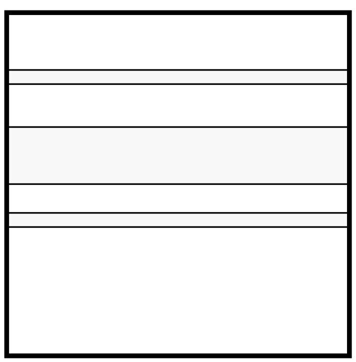
Basic steps:

- 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





Aztec matrix format

- 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

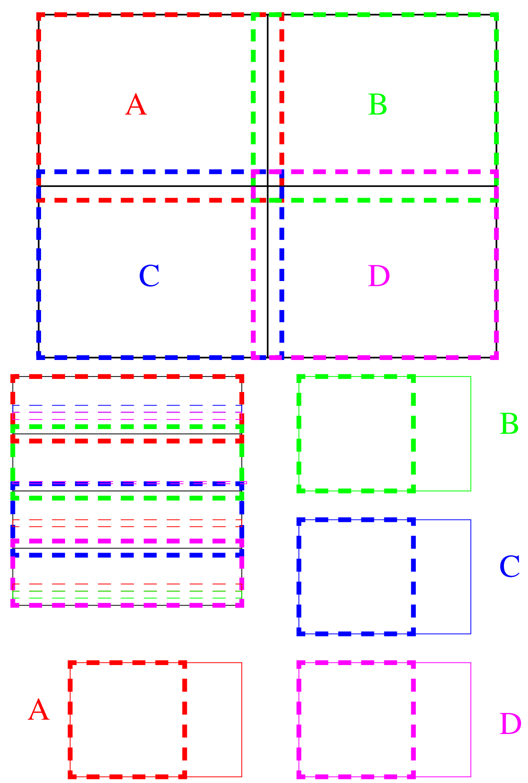
  cpntr

  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