NEW FEATURES AND IMPROVEMENTS IN SAS/OR

INFORMS Annual Meeting

November 12, 2014

Philipp M. Christophel, Menal Güzelsoy, Amar Narisetty
Matthew Galati
Imre Pólik
Yan Xu

OVERVIEW

1. Simplex algorithm
2. MILP solver
3. MILP decomposition
4. Ongoing work

ABOUT SAS/OR

Features

- Standard optimization solvers
- Network and graph algorithms
- Constraint programming
- Modeling language
- Discrete event simulation
- Integration with the rest of SAS

Release history

SAS/OR 13.1: December 2013

SAS/OR 14.1: Sometime in 2015

BLOG | OUR NEW BLOG

http://blogs.sas.com/content/operations

Hybrid row-matrix

- Mix of full and partial row
- Store $+1$ and -1 row-matrices separately
- Saves memory, also faster row-matrix operations
- More can be done for network matrices
- (We have a special network simplex)

Other improvements

- Retuned automatic dualization
- Dynamically adjusted Markowitz tolerance
- Improved objective limit/cutoff handling

Probing and implications

- Completely rewritten for SAS/OR 13.2 (released in August)
- Can be called from any part of the solver
- Keeps the clique table updated
- Very fast:
  - Fast bound propagation exploiting special row structures
  - Using information gathered in previous probings
  - Fast data structures for storing cliques and implications
- Example: ex9 from MIPLIB2010
  - Typically solved in the root node after presolve fixes most of it
  - Default: 20 seconds
  - Without special rows: 120 seconds
  - Without reusing previous implications: 500 seconds
  - Current development version: 4 seconds

Cliques

- Implemented Bron-Kerbosch for maximal clique separation
- Non-recursive implementation with two data structures
  - Stack and current state
- Runs on original clique table
  - Does not need an explicit conflict/fractional graph construction
- Considers current fractional variables present in the clique table for the abstract fractional graph
- Adds some non-basic variables to the abstract fractional graph

Reusing dual information

- Use dual rays to tighten bounds
  - Both local and global
  - Similar to reduced cost fixing
- Store important dual rays and solutions
- Use them later as needed
  - Prune nodes by bound or infeasibility
  - Tighten bounds
  - Branch towards infeasibility
  - Combine rays
- More general than conflict analysis
- Great for feasibility instances
- No upper bound/incumbent needed for dual ray tightening
- Yields about 7% speedup on average

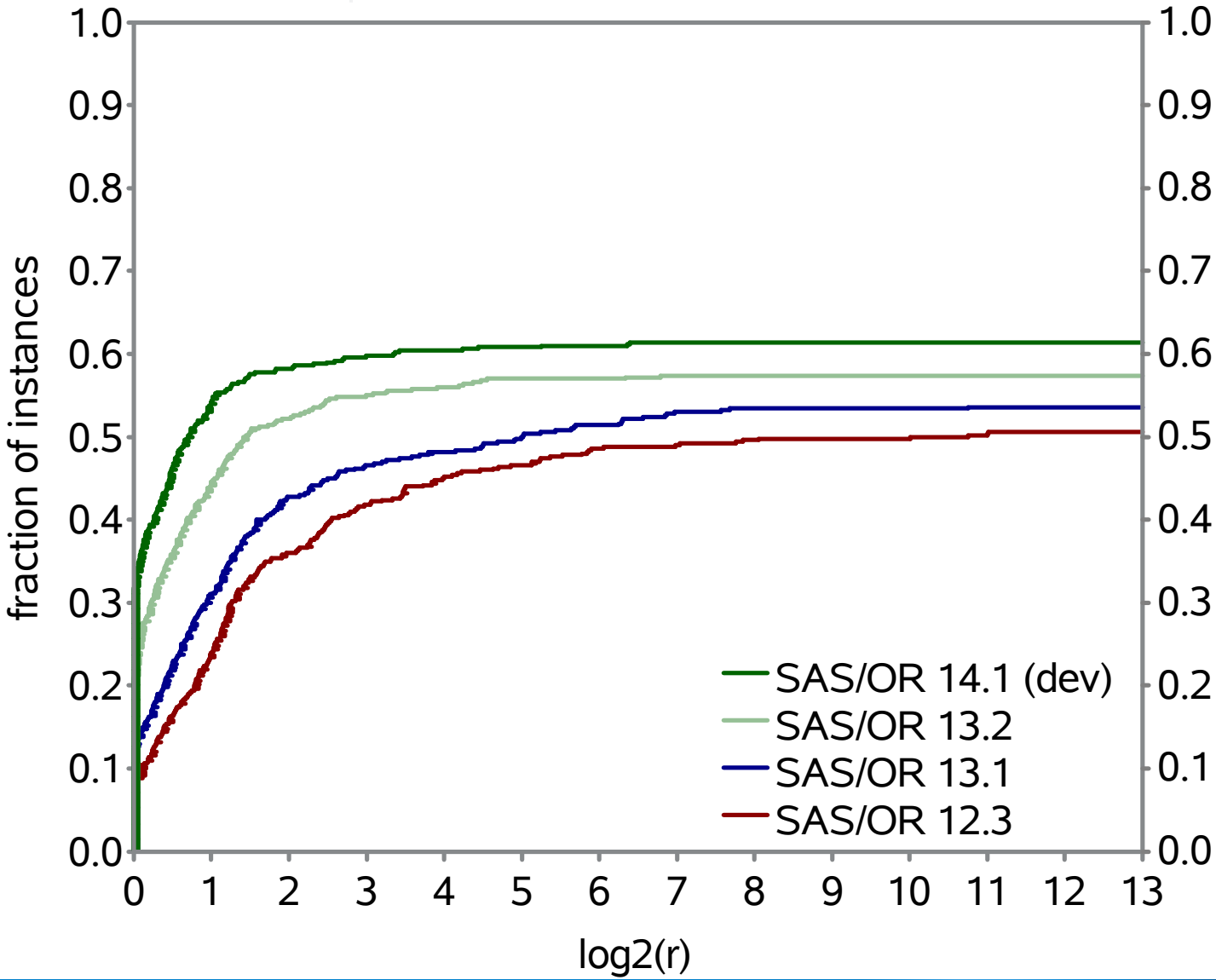
Restarts in the tree

- Restart with presolve if:
  - Enough fixings
  - Dense columns got fixed
  - Good incumbent found
  - No progress
- Effect: 10% on average

Rewritten node presolver

- Can be called from other parts of the solver
- Uses primal and dual tightenings
- Effect: 15% on average

MILP | VERSION-TO-VERSION IMPROVEMENT



DECOMP | MILP DECOMPOSITION

Overview

- Generic Dantzig-Wolfe decomposition
- Blocks from user, network, or auto
- Solves LP or MILP
- The first and only commercial implementation

Block detection

- Automatic block detection reworked
- Seeks to identify block-angular structure in constraint matrix
- Intelligently sets the number of threads for the solves
- Finds identical subproblems, performs Ryan-Foster branching

Other improvements

- Hybrid option
  - Runs root node of standard cutting plane method
  - Then runs DECOMP on the tightened model
- Reliability branching
  - initializing pseudocosts is extremely expensive in B&P so it takes extreme care
- Column pool management (similar to cut pools)
- Warmstart of a tree node with appropriate potential columns
- Analysis of pricing steps to avoid useless solves
- Skip solves that have low probability of finding useful columns
- Benchmark – 13.2 to 14.1: 40% faster

ONGOING AND FUTURE WORK

Simplex

- Sifting
- Even better integration with MILP
- Symmetry and degeneracy

MILP

- New presolver
- Cutting plane improvements
- Symmetry heuristics

Decomposition

- Special network oracles for pricing

BLOG | OUR NEW BLOG

http://blogs.sas.com/content/operations

http://support.sas.com/or

New Features and Improvements in SAS/OR