NEW FEATURES AND IMPROVEMENTS IN SAS/OR
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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 13.2: August 2014
- SAS/OR 14.1: Sometime in 2015
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

![Graph showing version-to-version improvement](image)

- **Fraction of instances** vs. **log2(r)**

  - **SAS/OR 14.1 (dev)**
  - **SAS/OR 13.2**
  - **SAS/OR 13.1**
  - **SAS/OR 12.3**
## 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**
Simplex
- Sifting
- Even better integration with MILP
- Symmetry and degeneracy

MILP
- New presolver
- Cutting plane improvements
- Symmetry heuristics

Decomposition
- Special network oracles for pricing
http://blogs.sas.com/content/operations
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