



The MIP Landscape

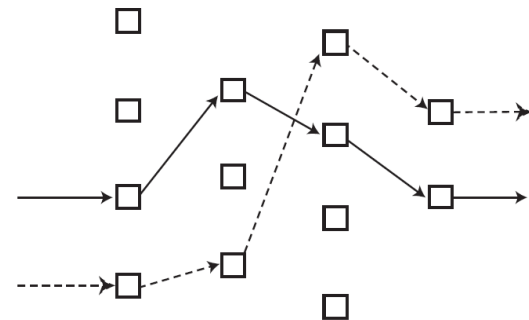
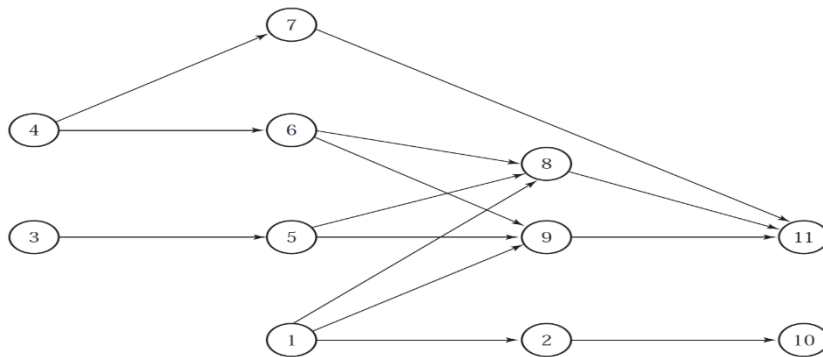
By Creatrol & Bolun

A typical situation today

– Supply-chain scheduling

Model description:

- Weekly model, daily buckets: Objective to minimize end-of-day inventory.
- Production (single facility), inventory, shipping (trucks), wholesalers (demand known)



LP still can be HARD

SGM: Schedule Generation Model

157323 rows, 182812 columns, 6348437 nzs

☐ LP relaxation at root node:

- 18 hours

☐ Branch-and-bound

- 1710 nodes, first feasible
- 3.7% gap
- Time: 92 days!!

MIP really is HARD

A customer model: 44 cons, 51 vars, 167 nzs, maximization
51 general integer variables (*and no bounds*)

Branch-and-bound: Initial integer solution -2186.0

Initial upper bound -1379.4

...after 1.4 days, 32,000,000 B&B nodes, 5.5 Gig tree

Computational History: 1950 –1998

- **1954 Dantzig, Fulkerson, S. Johnson:** 42 city TSP
 - Solved to optimality using LP and cutting planes
- **1957 Gomory**
 - Cutting plane algorithms
- **1960 Land, Doig, 1965 Dakin**
 - B&B
- **1971 MPSX/370**
- **1972 UMPIRE**
 - LP-based B&B
 - MIP became commercially viable
- **1972 – 1998** Good B&B remained the state-of-the-art in commercial codes, in spite of
 - Edmonds, polyhedral combinatorics
 - 1973 Padberg, cutting planes
 - 1973 Chvátal, revisited Gomory
 - 1974 Balas, disjunctive programming
 - 1983 Crowder, Johnson, Padberg: PIPX, pure 0/1 MIP
 - 1987 Van Roy and Wolsey: MPSARX, mixed 0/1 MIP
 - TSP, Grötschel, Padberg, ...

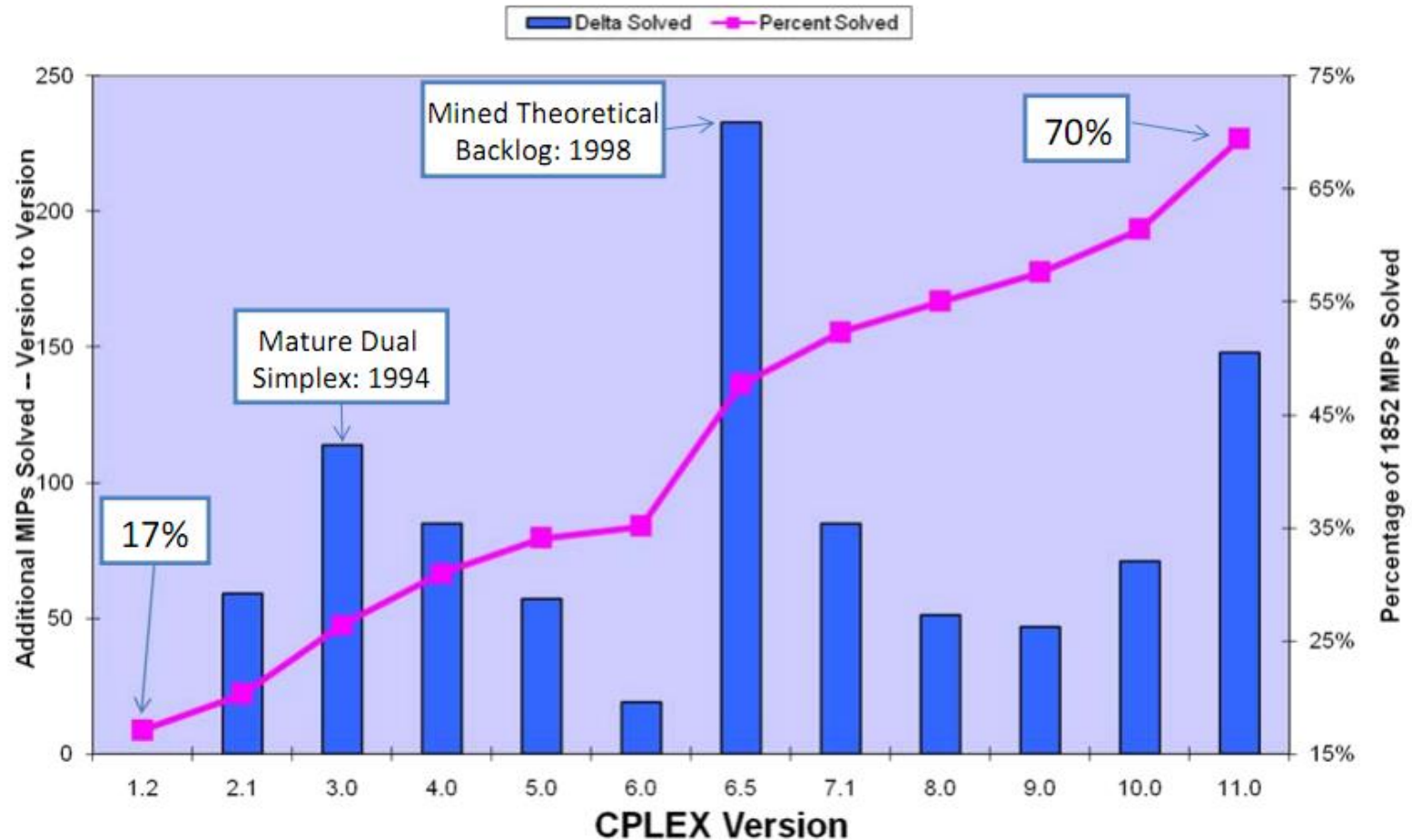
Some Test Results

- **Test set: 1852 real-world MIPs**
 - Full library
 - 2791 MIPs
 - Removed:
 - 559 “Easy” MIPs
 - 348 “Duplicates”
 - 22 “Hard” LPs (0.8%)
- **Parameter settings**
 - Pure defaults
 - 30000 second time limit
- **Versions Run**
 - CPLEX 1.2 (1991) -- CPLEX 11.0 (2007)



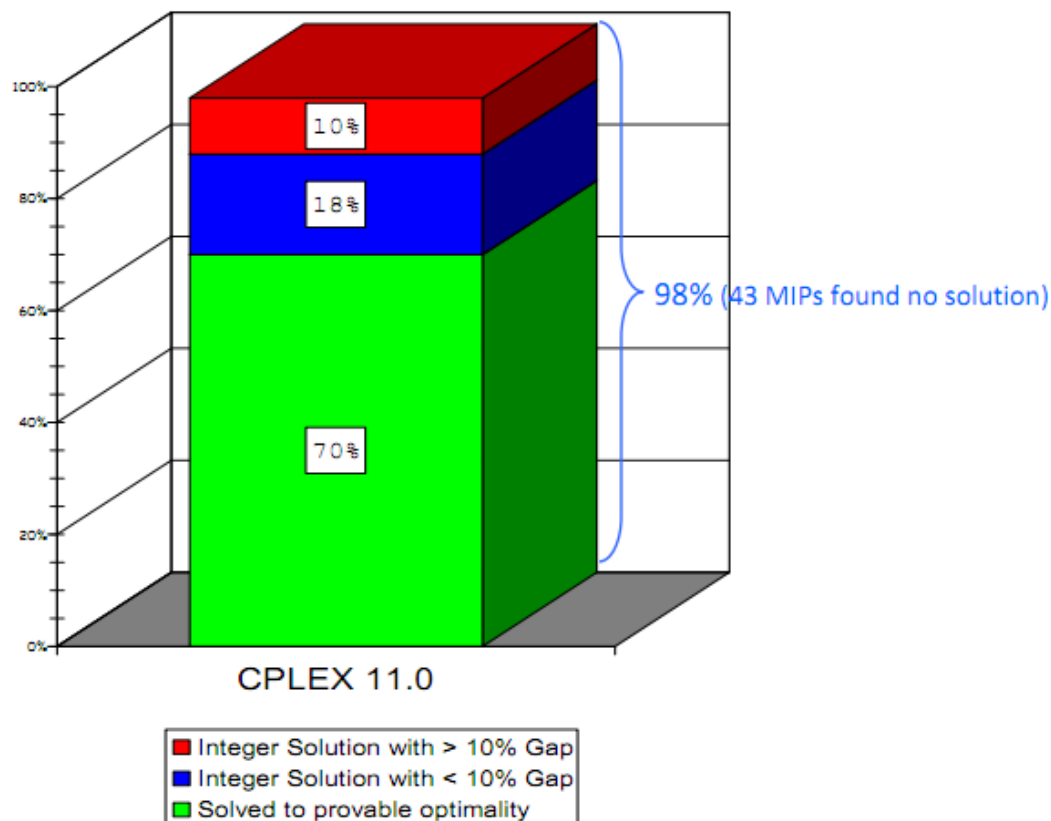
MIP Solvability

Solvability of MIPS 1991-Present



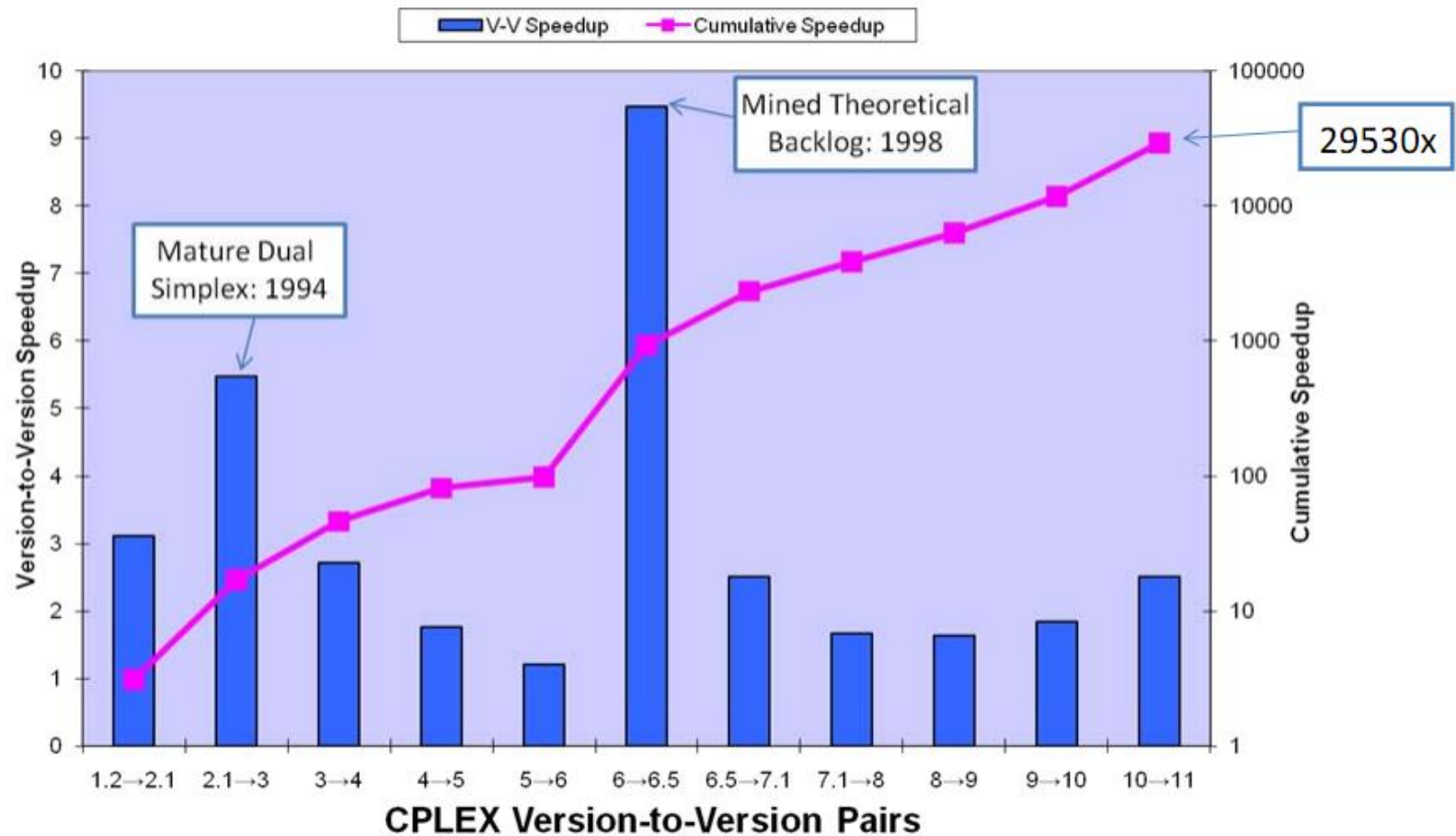
Solvability of MIPs – CPLEX 11.0

1852 MIPs, 30000 second time limit



MIP Speedups

Speedups 1991-Present



Inferences:

- R.J.Dakin. A tree-search algorithm for mixed integer programming problems
- Santosh.Kumar & Brian.C.Jones. Fifty Years of Integer Programming: A Review of the Solution Approaches



Thank you for attention