

The CPLEX Library: A Brief CPLEX MIP History

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CPLEX MIP History

- **Original version: CPLEX 2.0, 1992**
 - Simple branch-and-bound
 - Limited cuts (cover cuts, simple clique cuts)
- **Later version: CPLEX 6.0, 1998**
 - Simple branch-and-bound
 - Limited cuts (improved cover cuts, simple clique cuts)
 - Simple heuristic
 - *Faster dual simplex*

Cut Literature: 1998

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Cut References (1)

- **Knapsack Covers**
 - Crowder, Johnson, and Padberg (1983)
 - Weismantel (1997)
- **Cliques**
 - Johnson and Padberg (1991)
 - Atamturk, Nemhauser, and Savelsbergh (1999)
- **Flow Covers**
 - Padberg, Van Roy, and Wolsey (1985)
 - Gu, Nemhauser, and Savelsbergh (1999)
- **GUB Covers**
 - Gu, Nemhauser, and Savelsbergh (1998)
- **Implied Bounds**
 - Hoffman and Padberg (1991)

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Cut References (2)



- **Gomory Fractional Cuts**
 - Gomory (1960)
 - Balas, Ceria, Cornuejols, and Natraj (1996)
- **MIR (Mixed Integer Rounding)**
 - Marchand and Wolsey (1998)
- **Flow Path**
 - Van Roy and Wolsey (1985)
- **Disjunctive Cuts**
 - Balas (1971)
 - Balas, Ceria, and Cornuejols (1993)

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No Commercial Implementations?



- **Different mindset**
 - MIP too hard to consider general purpose solvers
 - Problem-specific methods required
- **Consequences:**
 - No evaluation outside of target problem domain
 - Little attention to implementation issues
 - Methods considered in isolation

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Closing the Gap



- Aggressive implementation, evaluation of various techniques
- CPLEX 6.6 had:
 - 7 types of cutting planes
 - 5 different node heuristics
- A “barrage” of algorithms:
 - Find methods that are:
 - Effective when they apply
 - Inexpensive when they do not

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Sample CPLEX Output



Default settings

Node	Nodes		Objective	IInf	Best Integer	Cuts/		Gap
	Left	Right				Best Node	ItCnt	
0	0		4533.5033	40		4533.5033	125	
			8517.6222	29		Cuts: 100	236	
*	0+	0		0	9715.0000	8517.6222	236	12.33%
			8651.9219	10	9715.0000	Cuts: 51	266	10.94%
*	0+	0		0	8701.0000	8651.9219	266	0.56%
			8662.8458	4	8701.0000	Cuts: 7	273	0.44%
			8665.4678	7	8701.0000	Covers: 2	276	0.41%
			8667.9363	7	8701.0000	Covers: 1	278	0.38%
*	4	3		0	8691.0000	8688.0000	282	0.03%

GUB cover cuts applied: 23
Clique cuts applied: 10
Cover cuts applied: 31
Implied bound cuts applied: 1
Gomory fractional cuts applied: 30

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Recent Example



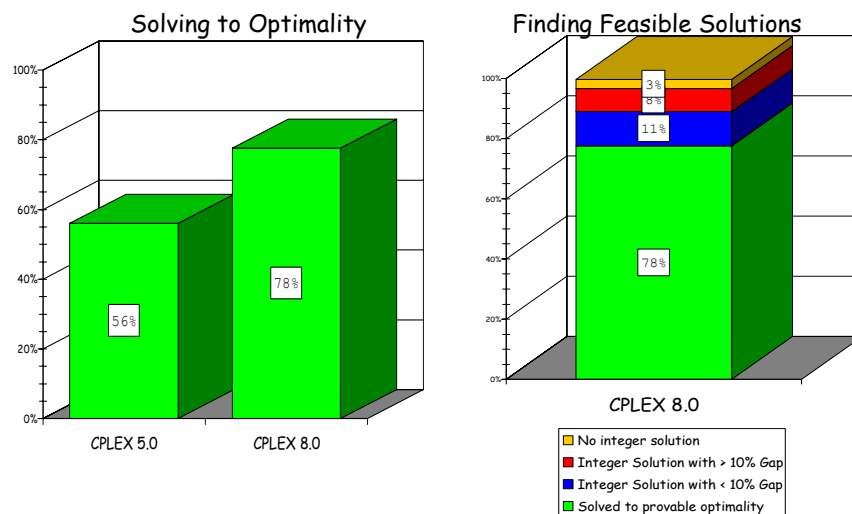
- **Large MIP model:**
 - 70K constraints
 - 230K integer variables
- **Pre-6.0:**
 - Hopeless
- **CPLEX 9.0:**
 - **76 seconds, solves at the root:**
 - Cutting planes tighten relaxation
 - Heuristic finds the optimal solution

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Difficulty of Solving a MIP



978 models, 30 hour time limit



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