Customers want multiple alternative solutions
Example: air04

» Set partitioning problem for airline crew scheduling

» Available from MIPLIB 2003

	Default Solver	5-Best Solution Solver
1st Solution	56137	56137
2nd Solution	56166	56137
3rd Solution	56307	56137
4th Solution	56854	56137
5th Solution	57562	56137
Total B&B Nodes	141	15 981
Total Time	26 sec	29 sec

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Customers want multiple alternative solutions
Example: air04

» Set partitioning problem for airline crew scheduling

» Available from MIPLIB 2003

Strategies-Business Rules → Robust - Strategies → Strategy Refinenement Rebalancing

		Best Solution Solver
1		7
2		7
3		7
4th Solution	56054	56137
5th Solution	57562	56137
Total B&B Nodes	141	15 981
Total Time	26 sec	29 sec

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How to Solve the Challenging MIPs?

- » If Out-of-Box performance does not scale well then Model needs to be reformulated (e.g. decomposition, aggregation of decisions)
- » If Model is numerically "Robust" and Scales "Well" then:
  - » Have our Optimizer Experts
    - » tuning the Solver Manually
  - » Have our Optimizer Experts (since 2006)
    - » tuning the Solver Automatically using the Xpress-Tuner
    - » tuning the Solver Manually and/or Automatically
  - » Have our Clients (since 2007)
    - » tuning the Solver Automatically using the Xpress-Tuner
    - » tuning the Solver Manually and/or Automatically

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The MIPLIB 2003 Experience

Problem	Old Best Known Obj. Value (*)	Xpress Improved Obj. Value (**)	GAIN (|1-(**)/(*)|)
atlanta-ip	95.009549704	90.00987861	5.3%
msc98-ip	20980991.006	19839497.006	5.4%
protfold	-30	-31	3.3%
t1717	193221	170195	11.9%
liu	1172	1102	5.9%
dano3mip	691.2	687.733333	0.5%

Solving Hard Mixed Integer Programming Problems with Xpress-MP: A MIPLIB 2003 Case Study, Informs Journal on Computing

by Richard Laundy, Michael Perregaard, Gabriel Tavares, Horia Tipi, and Alkis Vazacopoulos

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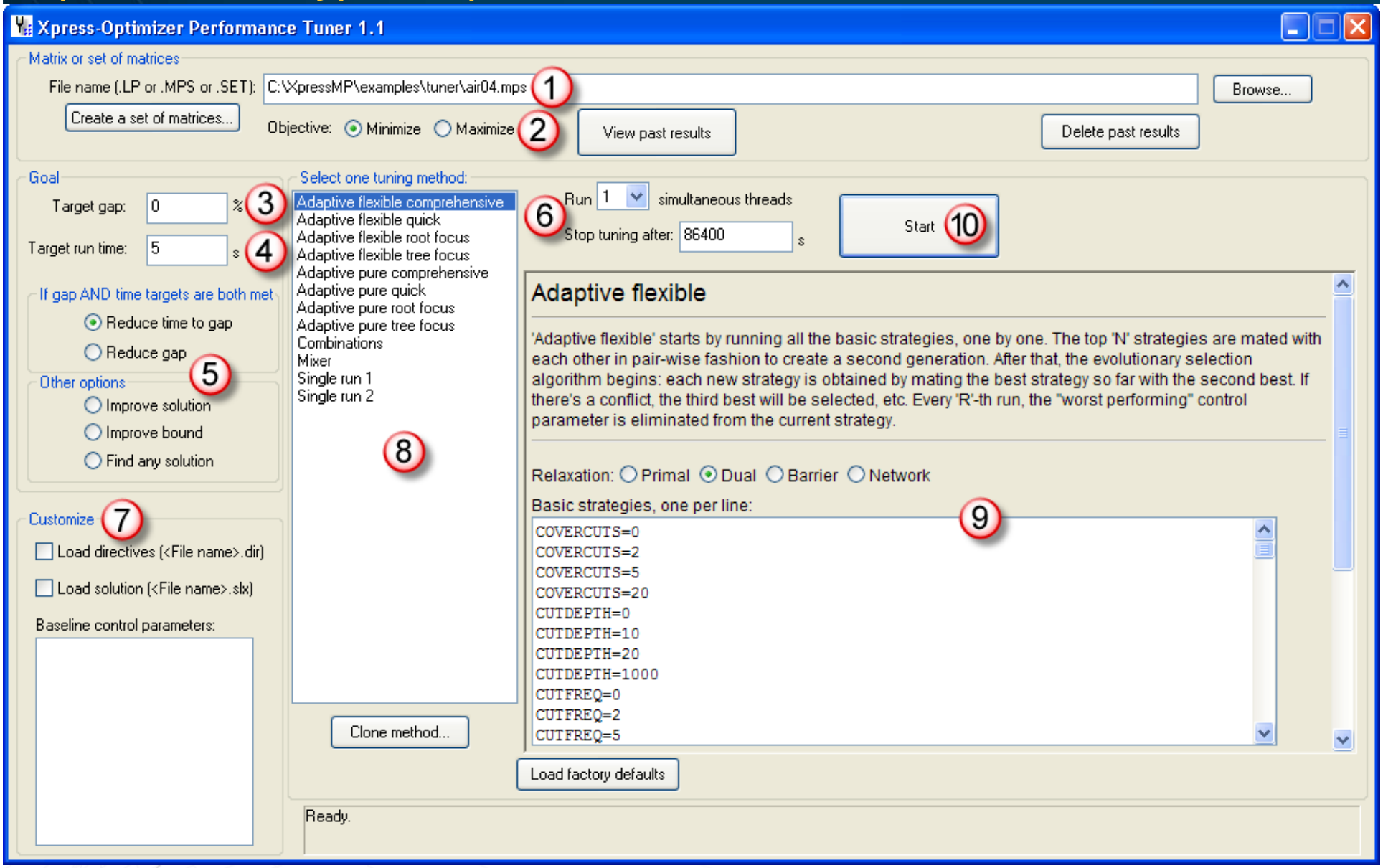
Xpress-Tuner: How to Tune (Automatically) an Optimization Problem?



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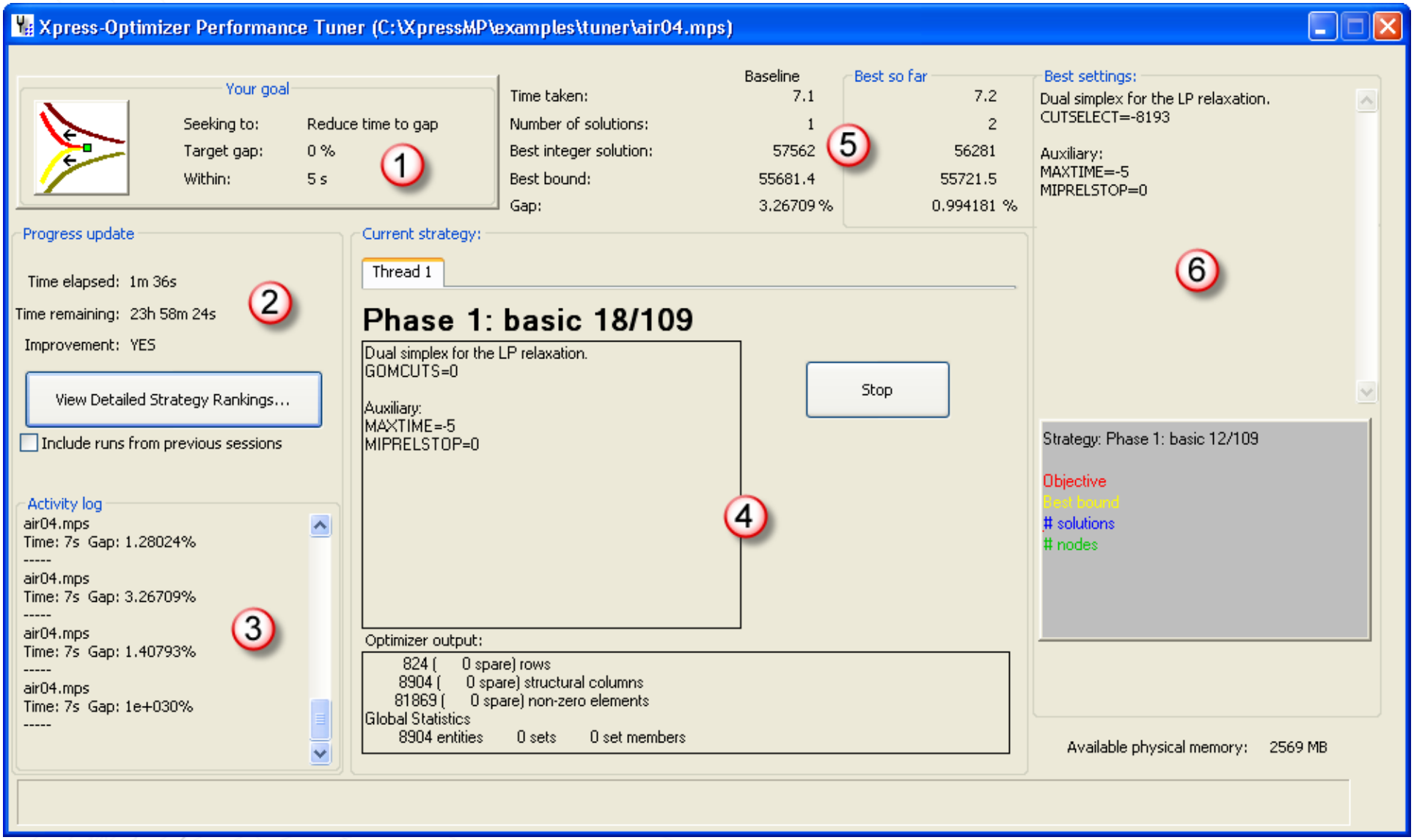
Xpress-Tuner: Tuning Process



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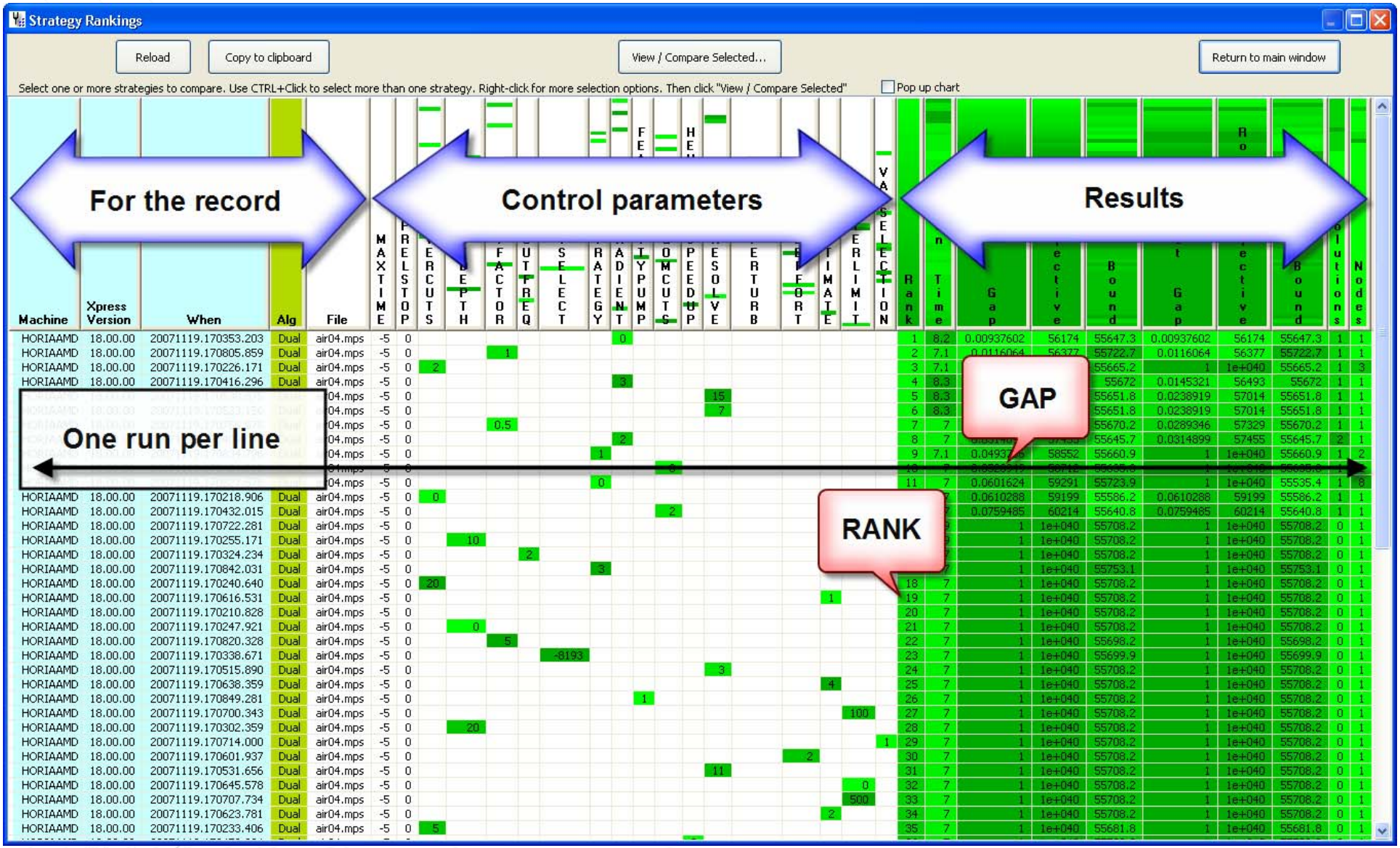
Xpress-Tuner:

Detailed Results



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Xpress-Tuner: Comparing logs

Compare logs side by side

☑ Use fixed font ☑ Scroll windows together

20071119.170353.203

Strategy: Phase 1: basic 14/109

Objective
Best bound
solutions
nodes

```
==>TUNER SETTING: DUALGRADIENT=0
==>TUNER SETTING: MAXTIME=-5
==>TUNER SETTING: MIPRELSTOP=0
Reading Problem air04
Problem Statistics
         824 (       0 spare) rows
        8904 (       0 spare) structural columns
       81869 (       0 spare) non-zero elements
Global Statistics
        8904 entities         0 sets         0 set members
Presolved problem has:     564 rows     7604 cols    33570 non-zeros
LP relaxation tightened

   Its         Obj Value      S   Ninf  Nneg        Sum Inf  Time
     0        632.000000      D    359     0     365.000000     0
   100      17587.00000       D    287     0     365.000000     0
   200      32417.00000       D    236     0     304.000000     0
   300      41955.00000       D    265     0     933.333333     0
   400      45628.56383       D    311     0     933.333333     0
   500      46916.33750       D    327     0     718.125000     0
   600      47453.08174       D    335     0     881.931697     0
   700      48167.75049       D    328     0     422.246608     0
   800      48779.80052       D    348     0     515.475588     0
   900      49483.22886       D    396     0     340.504621     0
  1000      49872.30775       D    356     0     669.355239     0
```

20071119.170805.859

Strategy: Phase 1: basic 48/109

Objective
Best bound
solutions
nodes

```
==>TUNER SETTING: MAXTIME=-5
==>TUNER SETTING: CUTFACTOR=1
==>TUNER SETTING: MIPRELSTOP=0
Reading Problem air04
Problem Statistics
         824 (       0 spare) rows
        8904 (       0 spare) structural columns
       81869 (       0 spare) non-zero elements
Global Statistics
        8904 entities         0 sets         0 set members
Presolved problem has:     564 rows     7604 cols    33570 non-zeros
LP relaxation tightened

   Its         Obj Value      S   Ninf  Nneg        Sum Inf  Time
     0        632.000000      D    359     0     365.000000     0
   100      17587.00000       D    287     0     365.000000     0
   200      32526.00000       D    230     0     309.000000     0
   300      42367.00000       D    196     0     309.000000     0
   400      44685.00000       D    181     0     299.500000     0
   500      46070.50000       D    212     0     308.000000     0
   600      47098.00000       D    199     0     447.333333     0
   700      47663.43697       D    302     0     341.500000     0
   800      48441.97450       D    293     0    1875.828589     0
   900      49685.82331       D    308     0     575.630916     0
  1000      50588.55770       D    277     0    4299.938466     0
```

Xpress-Tuner:

Tuning MIP families

Strategy Rankings

Reload | Copy to clipboard | View / Compare Selected... | Return to main window

Select one or more strategies to compare. Use CTRL+Click to select more than one strategy. Right-click for more selection options. Then click "View / Compare Selected" ☐ Pop up chart

Machine	Xpress Version	When	Alg	File	MAXTIME	MIPRELSTOP	COVERCUTS	CUTDEPTH	CUTFREQ	Rank	Run Time	Gap	Objective	Bound	Root Gap	Root Objective	Root Bound	Solutions	Nodes
HORIAAMD	18.00.00	20071119.141725.421	Dual	air04.mps	-5	0	2			1	7.1	0.0133086	56416	55665.2	1	1e+040	55665.2	1	3
HORIAAMD	18.00.00	20071119.200656.015	Dual	air.set	-5	0	0			1	12.8	0.0426847	1e+100	1e+100	1e+100	1e+100	1e+100	7	0
HORIAAMD	18.00.00	20071119.200656.015	Dual	air05.mps	-5	0	0			1	5.7	0.0243406	26592	25944.7	1	1e+040	25911	6	5
HORIAAMD	18.00.00	20071119.141718.093	Dual	air04.mps	-5	0	0			2	7.1	0.0610288	59199	55586.2	0.0610288	59199	55586.2	1	1
HORIAAMD	18.00.00	20071119.200701.890	Dual	air.set	-5	0	2			2	12.7	0.0686501	1e+100	1e+100	1e+100	1e+100	1e+100	2	0
HORIAAMD	18.00.00	20071119.200707.734	Dual	air05.mps	-5	0	5			2	5.7	0.0486998	27387	26053.3	1	1e+040	25982.1	5	7
HORIAAMD	18.00.00	20071119.141815.859	Dual	air04.mps	-5	0			0	3	7	1	1e+040	55708.2	1	1e+040	55708.2	0	1
HORIAAMD	18.00.00	20071119.200707.734	Dual	air.set	-5	0	5			3	12.8	0.52435	1e+100	1e+100	1e+100	1e+100	1e+100	5	0
HORIAAMD	18.00.00	20071119.200756.390	Dual	air05.mps	-5	0			0	3	5.6	0.0779729	28174	25977.2	0.0779729	28174	25977.2	1	1
HORIAAMD	18.00.00	20071119.141801.421	Dual	air04.mps	-5	0		20		4	7	1	1e+040	55708.2	1	1e+040	55708.2	0	1
HORIAAMD	18.00.00	20071119.200731.031	Dual	air.set	-5	0		20		4	12.6	0.538986	1e+100	1e+100	1e+100	1e+100	1e+100	1	0
HORIAAMD	18.00.00	20071119.200750.546	Dual	air05.mps	-5	0		1000		4	5.7	0.0779729	28174	25977.2	0.0779729	28174	25977.2	1	1
HORIAAMD	18.00.00	20071119.141739.843	Dual	air04.mps	-5	0	20			5	7	1	1e+040	55708.2	1	1e+040	55708.2	0	1
HORIAAMD	18.00.00	20071119.200713.593	Dual	air.set	-5	0	20			5	12.6	0.538986	1e+100	1e+100	1e+100	1e+100	1e+100	1	0
HORIAAMD	18.00.00	20071119.200731.031	Dual	air05.mps	-5	0		20		5	5.5	0.0779729	28174	25977.2	0.0779729	28174	25977.2	1	1
HORIAAMD	18.00.00	20071119.141746.000	Dual	air04.mps	-5	0		0		6	7	1	1e+040	55708.2	1	1e+040	55708.2	0	1
HORIAAMD	18.00.00	20071119.200713.593	Dual	air05.mps	-5	0	20			6	5.6	0.0779729	28174	25977.2	0.0779729	28174	25977.2	1	1
HORIAAMD	18.00.00	20071119.200719.406	Dual	air.set	-5	0		0		6	12.7	0.538986	1e+100	1e+100	1e+100	1e+100	1e+100	1	0
HORIAAMD	18.00.00	20071119.141808.625	Dual	air04.mps	-5	0		1000		7	7	1	1e+040	55708.2	1	1e+040	55708.2	0	1
HORIAAMD	18.00.00	20071119.200719.406	Dual	air05.mps	-5	0		0		7	5.6	0.0779729	28174	25977.2	0.0779729	28174	25977.2	1	1
HORIAAMD	18.00.00	20071119.200725.234	Dual	air.set	-5	0		10		7	12.7	0.538986	1e+100	1e+100	1e+100	1e+100	1e+100	1	0
HORIAAMD	18.00.00	20071119.141710.781	Dual	air04.mps	-5	0				8	7	1	1e+040	55708.2	1	1e+040	55708.2	0	1
HORIAAMD	18.00.00	20071119.200649.937	Dual	air.set	-5	0				8	12.8	0.538986	1e+100	1e+100	1e+100	1e+100	1e+100	1	0
HORIAAMD	18.00.00	20071119.200725.234	Dual	air05.mps	-5	0		10		8	5.6	0.0779729	28174	25977.2	0.0779729	28174	25977.2	1	1
HORIAAMD	18.00.00	20071119.141754.203	Dual	air04.mps	-5	0		10		9	7.1	1	1e+040	55708.2	1	1e+040	55708.2	0	1
HORIAAMD	18.00.00	20071119.200649.937	Dual	air05.mps	-5	0				9	5.7	0.0779729	28174	25977.2	0.0779729	28174	25977.2	1	1
HORIAAMD	18.00.00	20071119.200756.390	Dual	air.set	-5	0			0	9	12.7	0.538986	1e+100	1e+100	1e+100	1e+100	1e+100	1	2
HORIAAMD	18.00.00	20071119.141823.062	Dual	air04.mps	-5	0			2	10	7.1	1	1e+040	55708.2	1	1e+040	55708.2	0	1
HORIAAMD	18.00.00	20071119.200701.890	Dual	air05.mps	-5	0	2			10	5.6	0.123992	29642	25966.6	1	1e+040	25966.6	1	3
HORIAAMD	18.00.00	20071119.200750.546	Dual	air.set	-5	0		1000		10	12.8	0.538986	1e+100	1e+100	1e+100	1e+100	1e+100	1	2
HORIAAMD	18.00.00	20071119.141732.640	Dual	air04.mps	-5	0	5			11	7.1	1	1e+040	55681.8	1	1e+040	55681.8	0	1

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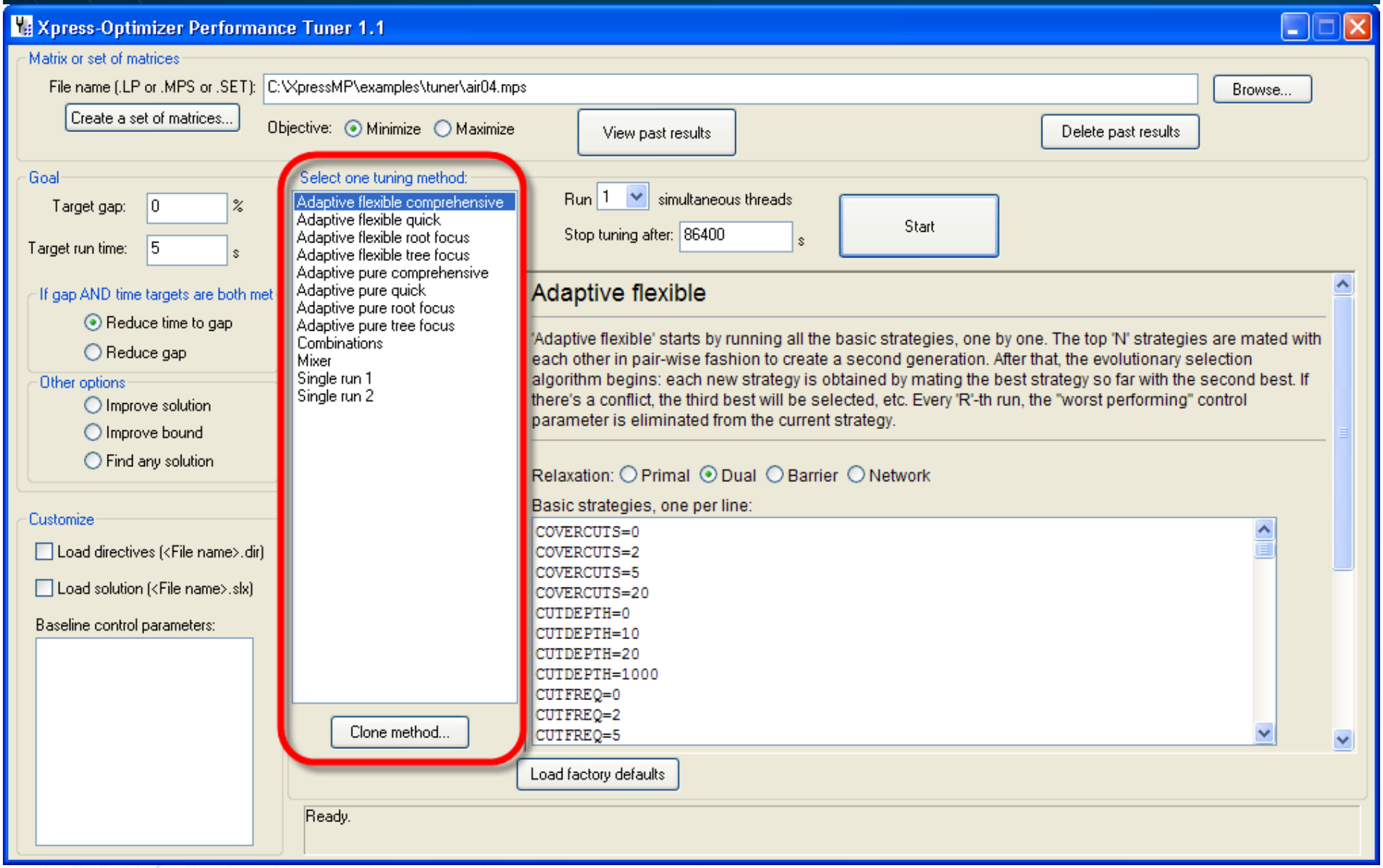
Xpress-Tuner: Tuning Methods



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Xpress-Tuner in Action

» **Planogram Optimization**

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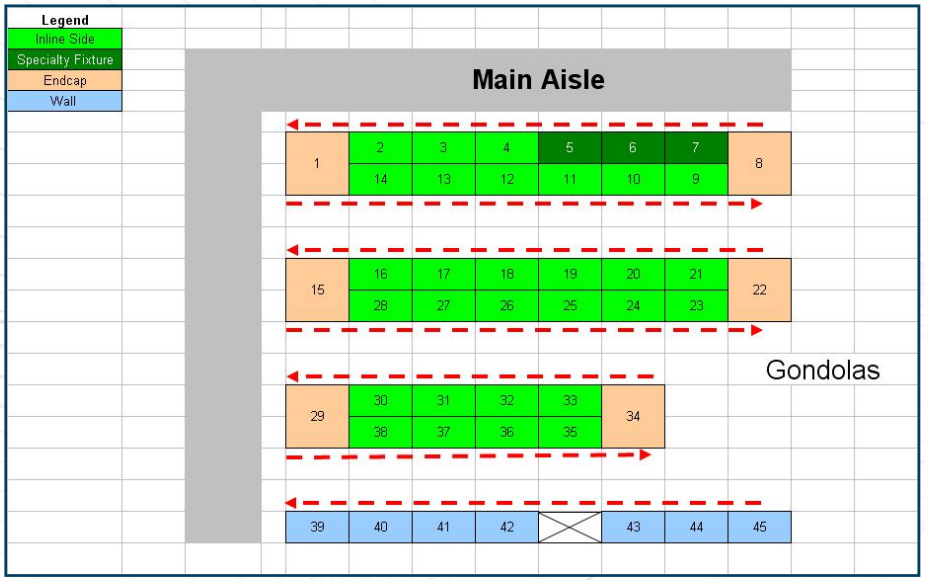
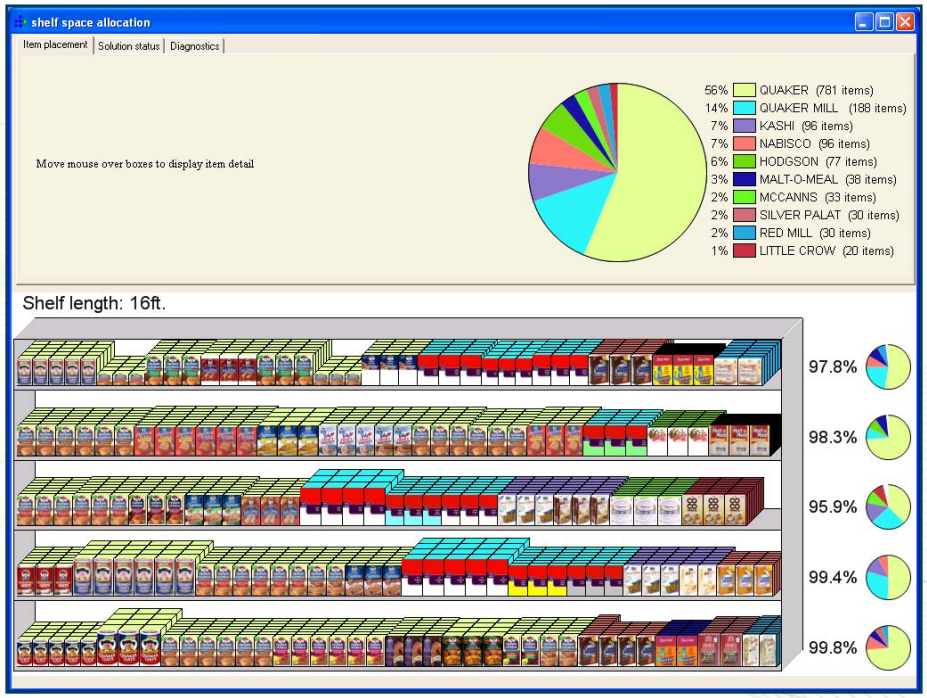
Customer Example: Retail Shelf Space Planning

Rule-Based Systems

Macro Space Planning



Micro Space Planning



Goal: To reduce manual effort in merchandising 6,000+ adjacencies

Goal: Link POS stats to merchandising quality

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Decision Areas Inside Space Planning Solution

Powered by Blaze Advisor Business Rules Engine

Assortment/planogram rules codified for future use

- **»Manage key learnings as a corporate asset**
- **»Assign priority / ranking to rules**
- **»Create different rule sets & rule flows by store / cluster**

Assortment/planogram decisions based on customer demand

Shelf layout parameters factored in—by cluster or store

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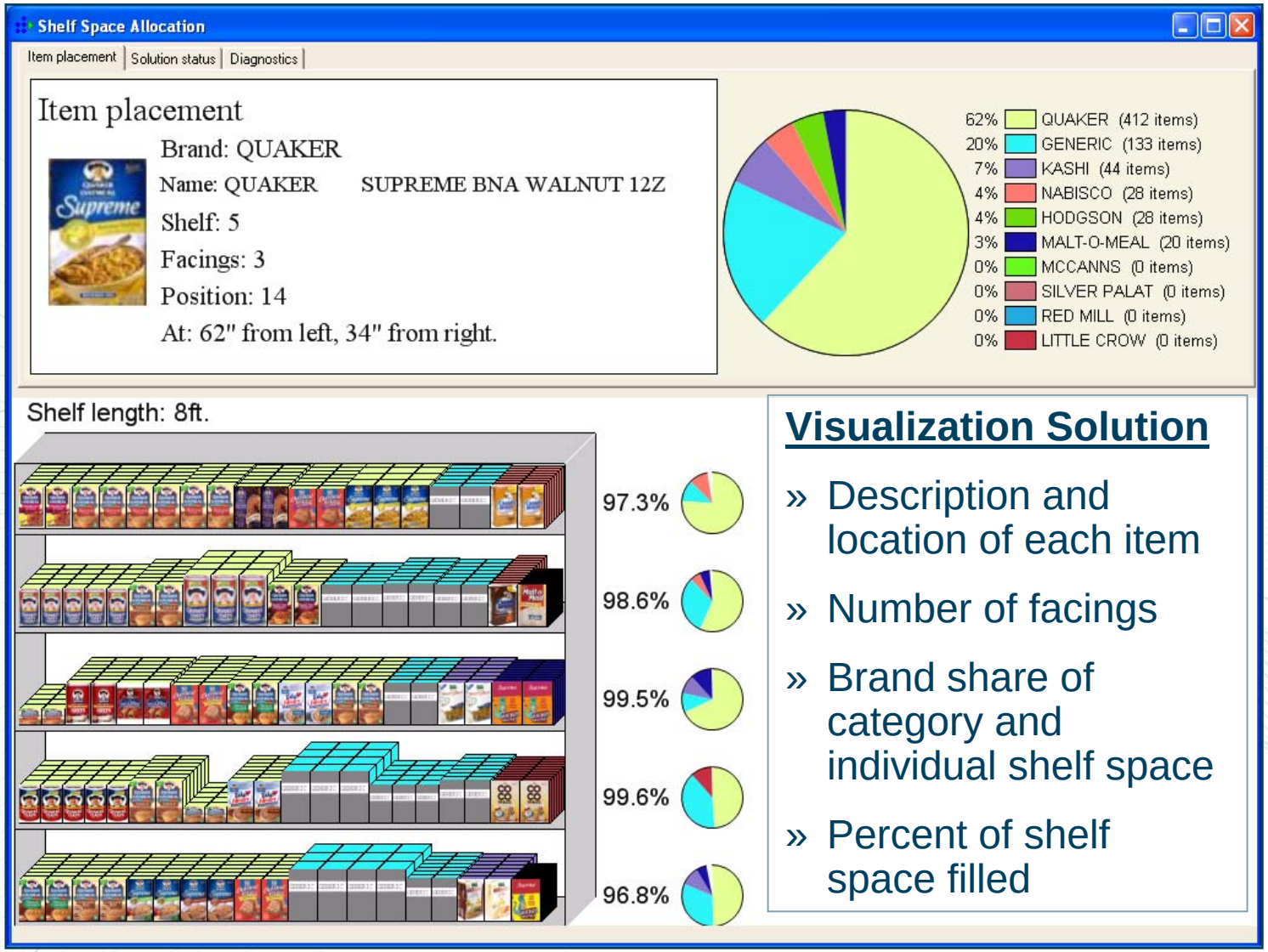
Visualization Results—8 foot shelf



Visualization Solution

- » Description and location of each item
- » Number of facings
- » Brand share of category and individual shelf space
- » Percent of shelf space filled

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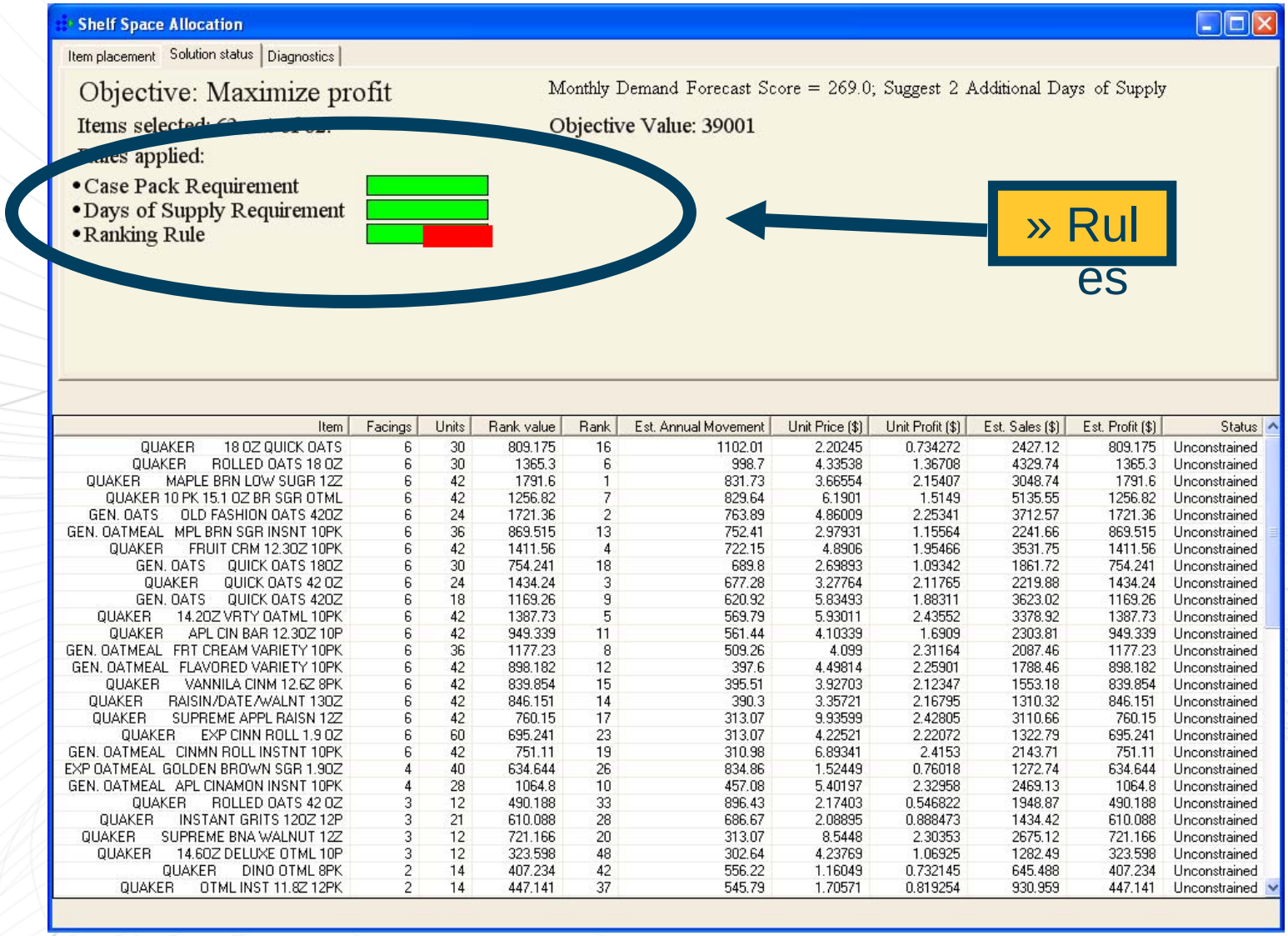
Space Optimization:
Constrained Assortment Optimization



Item	Facings	Units	Rank value	Rank	Est. Annual Movement	Unit Price ($)	Unit Profit ($)	Est. Sales ($)	Est. Profit ($)	Status
QUAKER 18 OZ QUICK OATS	6	30	809.175	16	1102.01	2.20245	0.734272	2427.12	809.175	Unconstrained
QUAKER ROLLED OATS 18 OZ	6	30	1365.3	6	998.7	4.33538	1.36708	4329.74	1365.3	Unconstrained
QUAKER MAPLE BRN LOW SUGR 12Z	6	42	1791.6	1	831.73	3.66554	2.15407	3048.74	1791.6	Unconstrained
QUAKER 10 PK 15.1 OZ BR SGR OTML	6	42	1256.82	7	829.64	6.1901	1.5149	5135.55	1256.82	Unconstrained
GEN. OATS OLD FASHION OATS 42OZ	6	24	1721.36	2	763.89	4.86009	2.25341	3712.57	1721.36	Unconstrained
GEN. OATMEAL MPL BRN SGR INSNT 10PK	6	36	869.515	13	752.41	2.97931	1.15564	2241.66	869.515	Unconstrained
QUAKER FRUIT CRM 12.3OZ 10PK	6	42	1411.56	4	722.15	4.8906	1.95466	3531.75	1411.56	Unconstrained
GEN. OATS QUICK OATS 18OZ	6	30	754.241	18	689.8	2.69893	1.09342	1861.72	754.241	Unconstrained
QUAKER QUICK OATS 42 OZ	6	24	1434.24	3	677.28	3.27764	2.11765	2219.88	1434.24	Unconstrained
GEN. OATS QUICK OATS 42OZ	6	18	1169.26	9	620.92	5.83493	1.88311	3623.02	1169.26	Unconstrained
QUAKER 14.2OZ VRTY OATML 10PK	6	42	1387.73	5	569.79	5.93011	2.43552	3378.92	1387.73	Unconstrained
QUAKER APL CIN BAR 12.3OZ 10P	6	42	949.339	11	561.44	4.10339	1.6909	2303.81	949.339	Unconstrained
GEN. OATMEAL FRT CREAM VARIETY 10PK	6	36	1177.23	8	509.26	4.099	2.31164	2087.46	1177.23	Unconstrained
GEN. OATMEAL FLAVORED VARIETY 10PK	6	42	898.182	12	397.6	4.49814	2.25901	1788.46	898.182	Unconstrained
QUAKER VANNILA CINM 12.6Z 8PK	6	42	839.854	15	395.51	3.92703	2.12347	1553.18	839.854	Unconstrained
QUAKER RAISIN/DATE/WALNT 13OZ	6	42	846.151	14	390.3	3.35721	2.16795	1310.32	846.151	Unconstrained
QUAKER SUPREME APPL RAISN 12Z	6	42	760.15	17	313.07	9.93599	2.42805	3110.66	760.15	Unconstrained
QUAKER EXP CINN ROLL 1.9 OZ	6	60	695.241	23	313.07	4.22521	2.22072	1322.79	695.241	Unconstrained
GEN. OATMEAL CINMN ROLL INSTNT 10PK	6	42	751.11	19	310.98	6.89341	2.4153	2143.71	751.11	Unconstrained
EXP OATMEAL GOLDEN BROWN SGR 1.9OZ	4	40	634.644	26	834.86	1.52449	0.76018	1272.74	634.644	Unconstrained
GEN. OATMEAL APL CINAMON INSNT 10PK	4	28	1064.8	10	457.08	5.40197	2.32958	2469.13	1064.8	Unconstrained
QUAKER ROLLED OATS 42 OZ	3	12	490.188	33	896.43	2.17403	0.546822	1948.87	490.188	Unconstrained
QUAKER INSTANT GRITS 12OZ 12P	3	21	610.088	28	686.67	2.08895	0.888473	1434.42	610.088	Unconstrained
QUAKER SUPREME BNA WALNUT 12Z	3	12	721.166	20	313.07	8.5448	2.30353	2675.12	721.166	Unconstrained
QUAKER 14.6OZ DELUXE OTML 10P	3	12	323.598	48	302.64	4.23769	1.06925	1282.49	323.598	Unconstrained
QUAKER DINO OTML 8PK	2	14	407.234	42	556.22	1.16049	0.732145	645.488	407.234	Unconstrained
QUAKER OTML INST 11.8Z 12PK	2	14	447.141	37	545.79	1.70571	0.819254	930.959	447.141	Unconstrained

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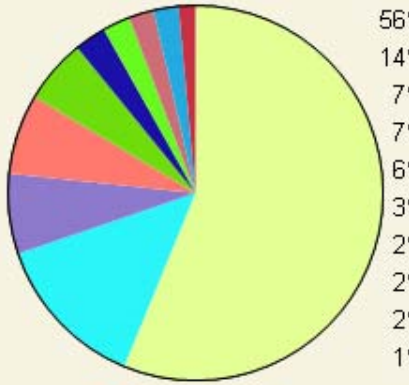
shelf space allocation

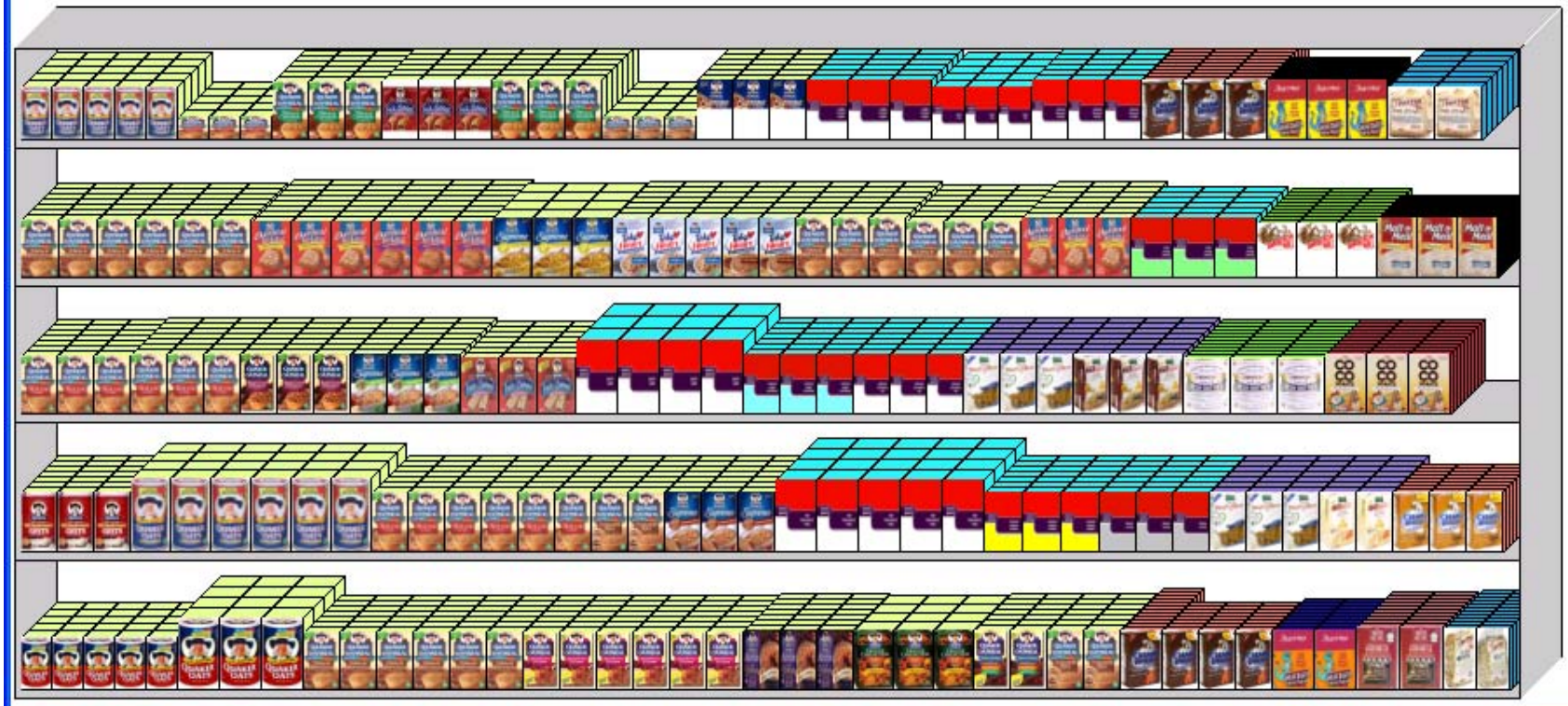
Item placement | Solution status | Diagnostics

Move mouse over boxes to display item detail



56% QUAKER (781 items)
14% QUAKER MILL (188 items)
7% KASHI (96 items)
7% NABISCO (96 items)
6% HODGSON (77 items)
3% MALT-O-MEAL (38 items)
2% MCCANNS (33 items)
2% SILVER PALAT (30 items)
2% RED MILL (30 items)
1% LITTLE CROW (20 items)

Shelf length: 16ft.



97.8%

98.3%

95.9%

99.4%

99.8%

Xpress-MP for Planogram Optimization

- Five “hard” MIPs obtained from a Large Retailer
- Goal was to get a 1.5% solution gap within 5 minutes, for each problem
- Computer used
  - 2 GHz Intel Core 2 (2GB, Windows, 32 bit)

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Xpress-MP for Planogram Optimization: Out-of-the-Box vs Tuned

MIP	Xpress Default Settings	Xpress-Tuned
P2871	300 s (2.0% gap)	187 s (1.3% gap)
P2879	300 s (1.7% gap)	35 s (1.4% gap)
P2750	31 s (1.3% gap)	31 s (1.3% gap)
P2757	33 s (1.1% gap)	10 s (0.7% gap)
P2864	300 s (8.8% gap)	300 s (3.5% gap)

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Xpress-MP for Planogram Optimization: Out-of-the-Box vs Tuned

MIP	Xpress Default Settings	Xpress-Tuned
		87 s
P2757	33 s (1.1% gap)	10 s (0.7% gap)
P2864	300 s (8.8% gap)	300 s (3.5% gap)

Family of problems

Use Data mining to set parameters

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Next steps

» Data mining

» Support Vector Machines

» Shochastic Integer Programming

» Grids-Parallelism

» Business Rules – Smart grids

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