FICO Xpress

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FICO is the leader in Decision Management — transforming business by making every decision count

Agenda

- FICO
  - Overview
  - Decisioning
  - Optimisation tools
  - Case study
- FICO Xpress
  - Overview
  - Recent Developments
    - MIP
    - LP
    - QP
    - Mosel

Profile	The leader in decision management Founded: 1956 NYSE: FIC Revenues: $745 million (fiscal 2008)
Products & Services	Analytics: scores and models Decision management applications Decision management tools
Clients & Market	5,000+ clients in 80 countries Primary Industries: Financial services, insurance, retail, healthcare
Offices	20+ offices worldwide HQ in Minneapolis, Minnesota Regional Hubs: London, Birmingham (UK), Madrid, Sao Paulo, Bangalore, Beijing, Singapore

We Take a Systematic Approach to Decisions

Automate
complex decisions in real time

» Increase consistency

» Reduce manual reviews

» Increase speed to market

Improve
decision quality with analytics

» Reduce credit, fraud, claims losses

» Identify the best next offer

» Optimize results

Connect
decisions across the enterprise

» Manage across product lines and business silos

» Execute coordinated customer-level strategies

Increase the Success of Your Decisions

Predictive analytics for greater precision

» Execute more relevant and targeted customer offers

» Control risk exposure and reduce losses

» Identify and stop fraud faster

Business rules management for greater control

» Control decisions across business lines and geographic borders

» Change faster than the competition to seize new opportunities

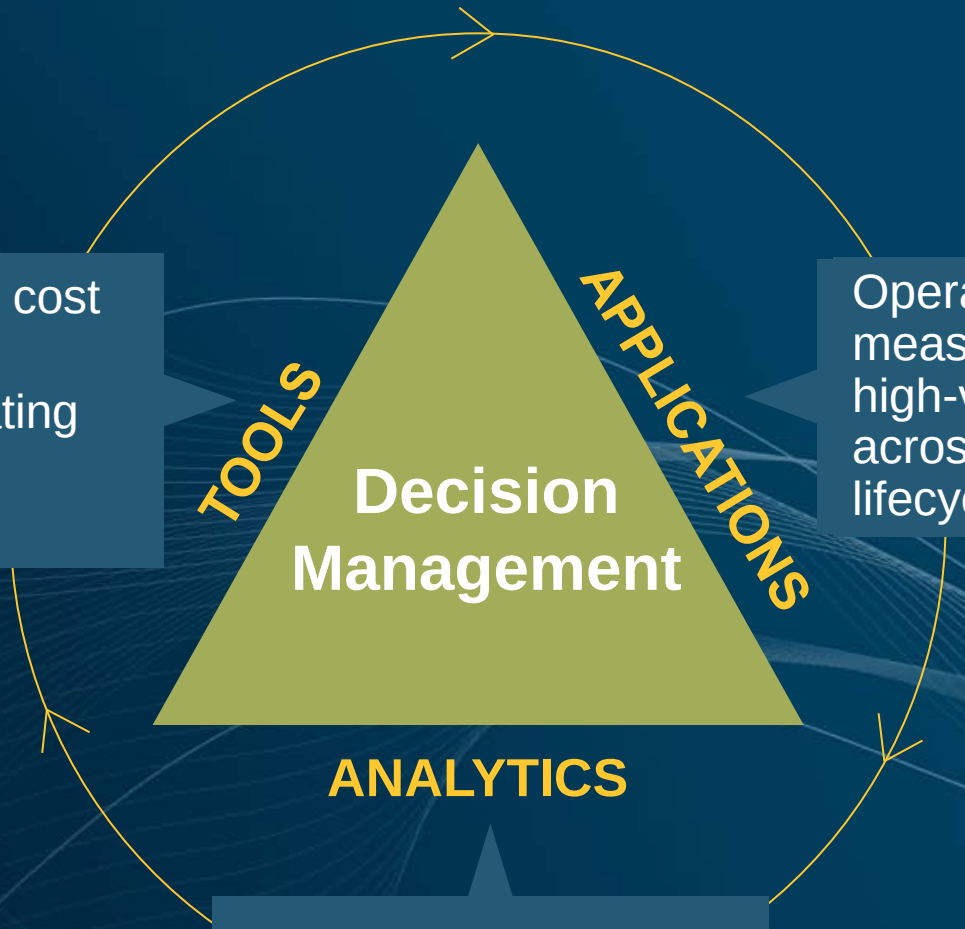
» Comply with regulatory requirements faster and at lower cost

Optimization for new levels of performance

» Advance your business strategy systematically, with every decision

» Assign optimal actions to reach specified objectives

We Offer the Most Complete Set of Solutions for Decision Management



Simplify & reduce cost of developing, managing & updating complex decision processes

Operationalize & measure complex, high-volume decisions across the customer lifecycle

Improve predictions & determine optimum decisions

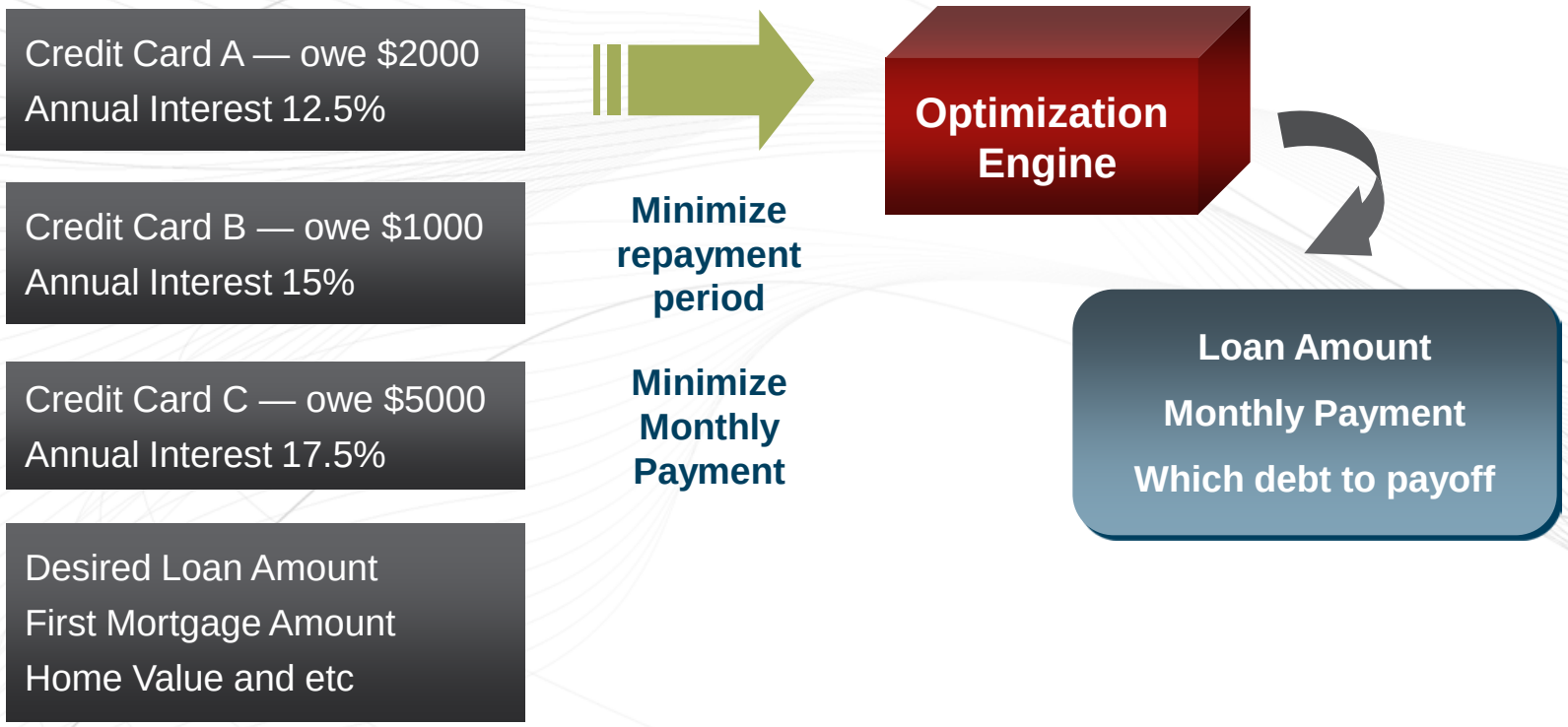
Fair Isaac's Optimization Offerings

- Optimization software tools
  - Xpress product suite
    - Mathematical modelling
    - Optimization
  - Decision Optimizer
- Optimization software together with business rules management system
  - Xpress and Blaze Advisor® business rules management system
- Industry-specific point solutions, optimization software, business rules and analytics
  - Pricing optimization
  - Shelf optimization
  - Marketing optimization

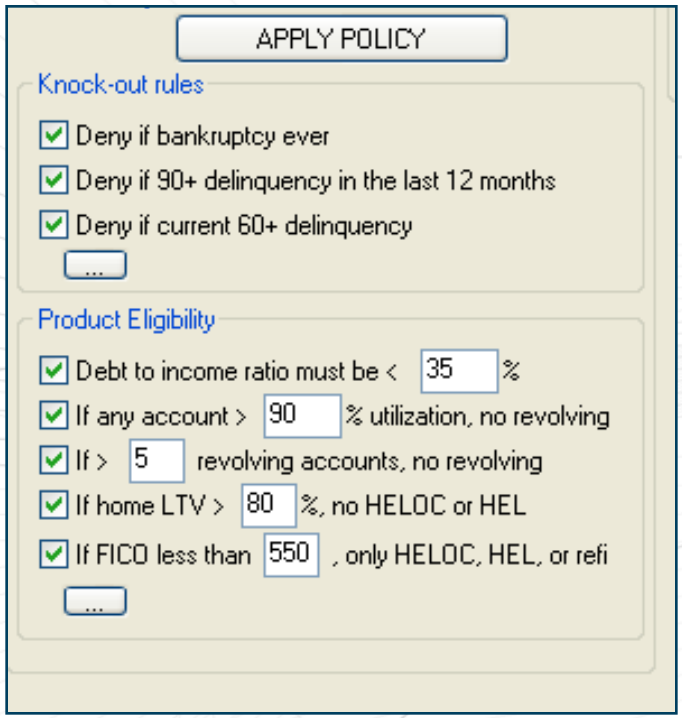
Case Study: Debt Consolidation

Debt Consolidation — Problem Statement

- Consolidation Problem
  - Based on user inputs and preferences determine:
    - Loan product, exact loan amount, outgoing debt ratio, etc.
  - While managing the payoff of debts



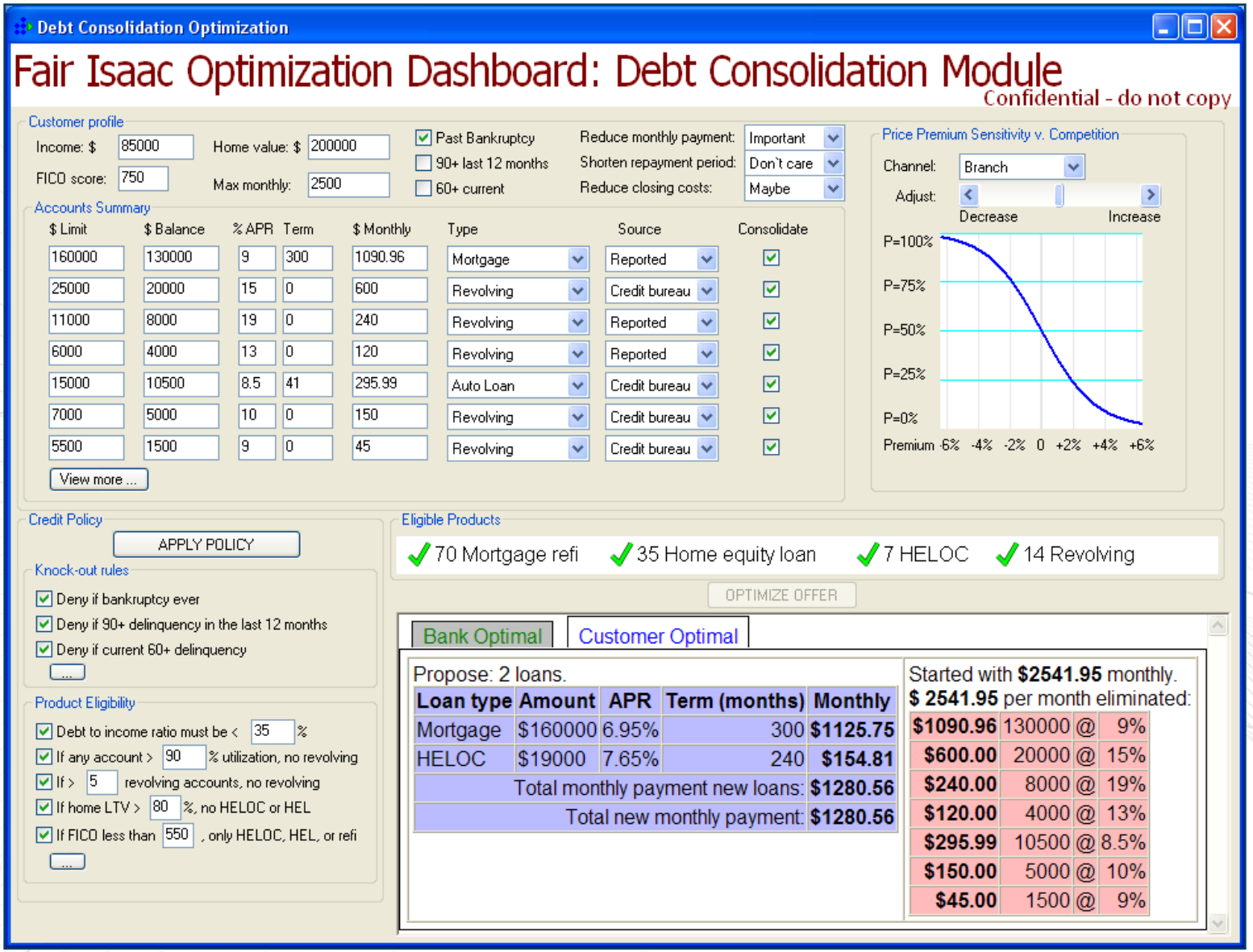
Business Rules: Eligibility: Product



Eligible Products :

- Loan A
- Loan B
- ….
- Loan M

Debt Consolidation
Reporting Metrics



FICO Xpress

Xpress History

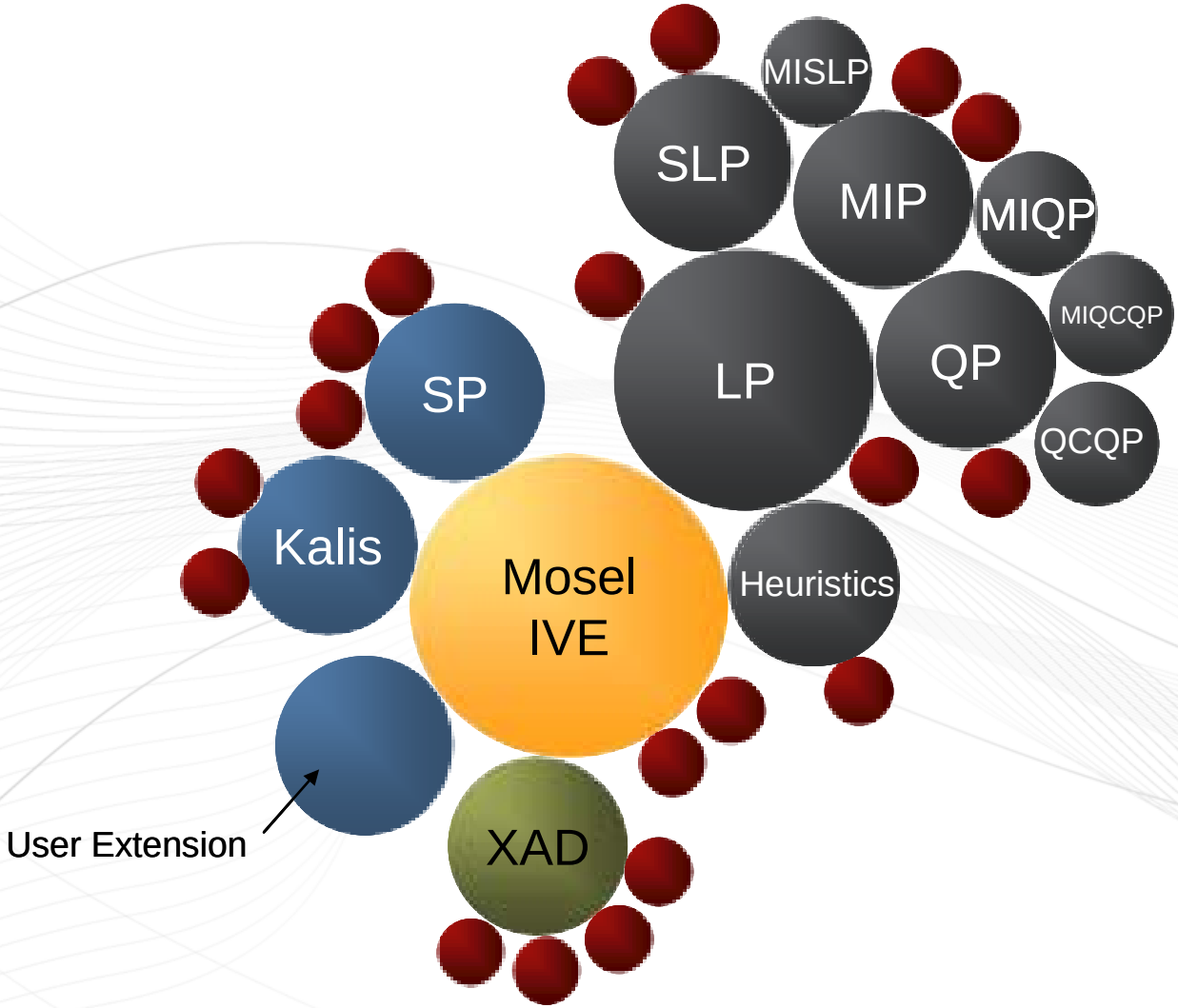
- 25+ years of experience in modelling and optimization
- 20+ years of experience in mixed integer optimization
- 10+ years of experience in nonlinear optimization
- 9 years Xpress-Mosel, modelling and solving environment

- Focus on
  - (potentially) exact solution methods and
  - integrating modelling and optimization

- Since Januar 2008 part of Fair Isaac / FICO

Fair Isaac Optimization Offers Multiple Solvers

- Solvers
- GUI / studio
- Extensions / NI
- Vertical applications
- Modeling platform



What's in the Integrated Suite?

- Xpress-Optimizer, Xpress-SLP, Xpress-Kalis
  - A set of robust, high performance multi-threaded solvers covering all of the major optimization problem types.
- Xpress-Mosel
  - An easy-to-learn rapid development modelling language.
- Xpress-BCL
  - A powerful API for programmatic model construction.
- Xpress-IVE
  - Visual development environment with deployment wizards.
- Xpress-Tuner
  - Automatic configuration tuning for maximum performance.

Benefits Our Customers Value

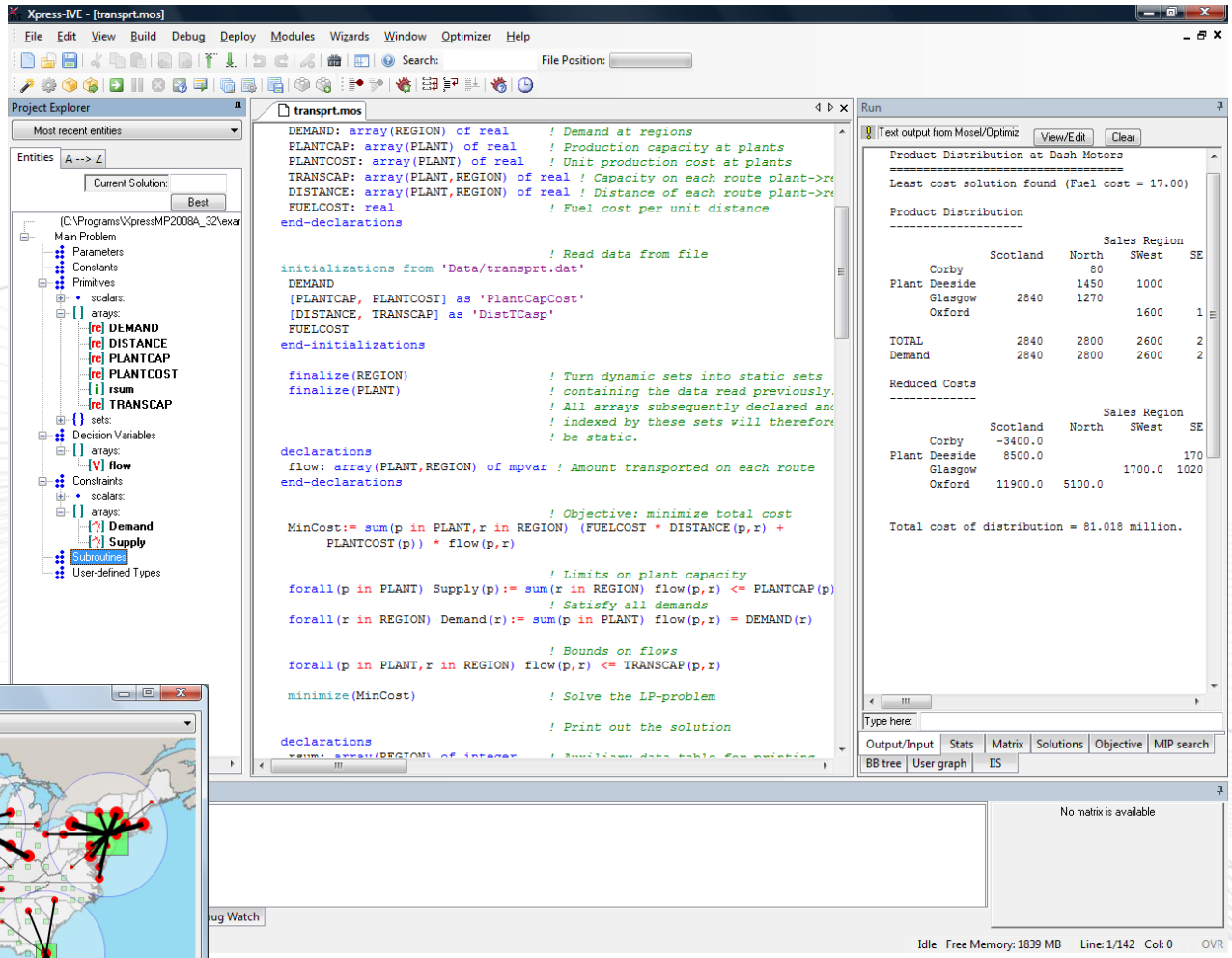
Benefits	Customer Insight
Superior technology	» Provide reliable solutions to problems with millions of variables and constraints » Able to solve numerically difficult or unstable problems » Finds high quality solutions – fast
Greater efficiencies	» Rapid prototyping, analysis and deployment
Ease of use	» Sophisticated yet easy-to-use tools for building, solving, testing and deploying optimization models

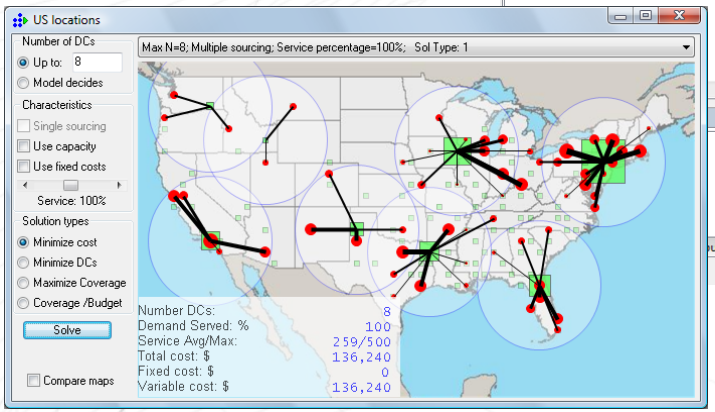
Key Features and Benefits of Xpress-Mosel

Features	Benefits
» Advanced programming languages: » Algebraic modeling language » Procedural programming language	» Entire Mathematical Model can be stored in one place for rapid development and easy maintenance.
» Utilize different solvers in the same model	» From Mosel you can solve LPs, MIPs, MIQPs, Non-Linear problems, Stochastic problems, and Constraint problems
» Decompose & parallelize a model to take advantage of multiple CPUs/cores	» Faster solve times
» Build a GUI exclusively within Mosel code	» Decreases development time, gets optimization in front of business user quicker
» Portable across operating systems	» Mosel Model compiled in one OS can be deployed on all other supported Operating Systems, decreasing development time
» Open, modular architecture, User extensible	» User flexibility to solve the most complicated optimization problems
» Compiled	» Protects intellectual property

Xpress-IVE: Mosel & Optimizer

- Editor
- Debugger
- Profiler
- Progress graphs
- Visualization
- Wizards
- Mosel extensions
- Deployment





Xpress Customers

ORACLE

AVIS

We try harder.

P&G

aspentech

process. to the power of e.

Budget

Honeywell

JEPPESEN

A BOEING COMPANY

AA

AmericanAirlines

RedPrairie

amazon.com

FICO Xpress 7

Xpress 7 - MIP performance

- Multi-threaded performance
- Reengineered B&B tree
- Improved cuts, branching
- Parallel heuristics
- Improved decision space reduction (presolve)
- N-Best and the multiple solution pool

Xpress 7 vs 2008A on the “internal” sets

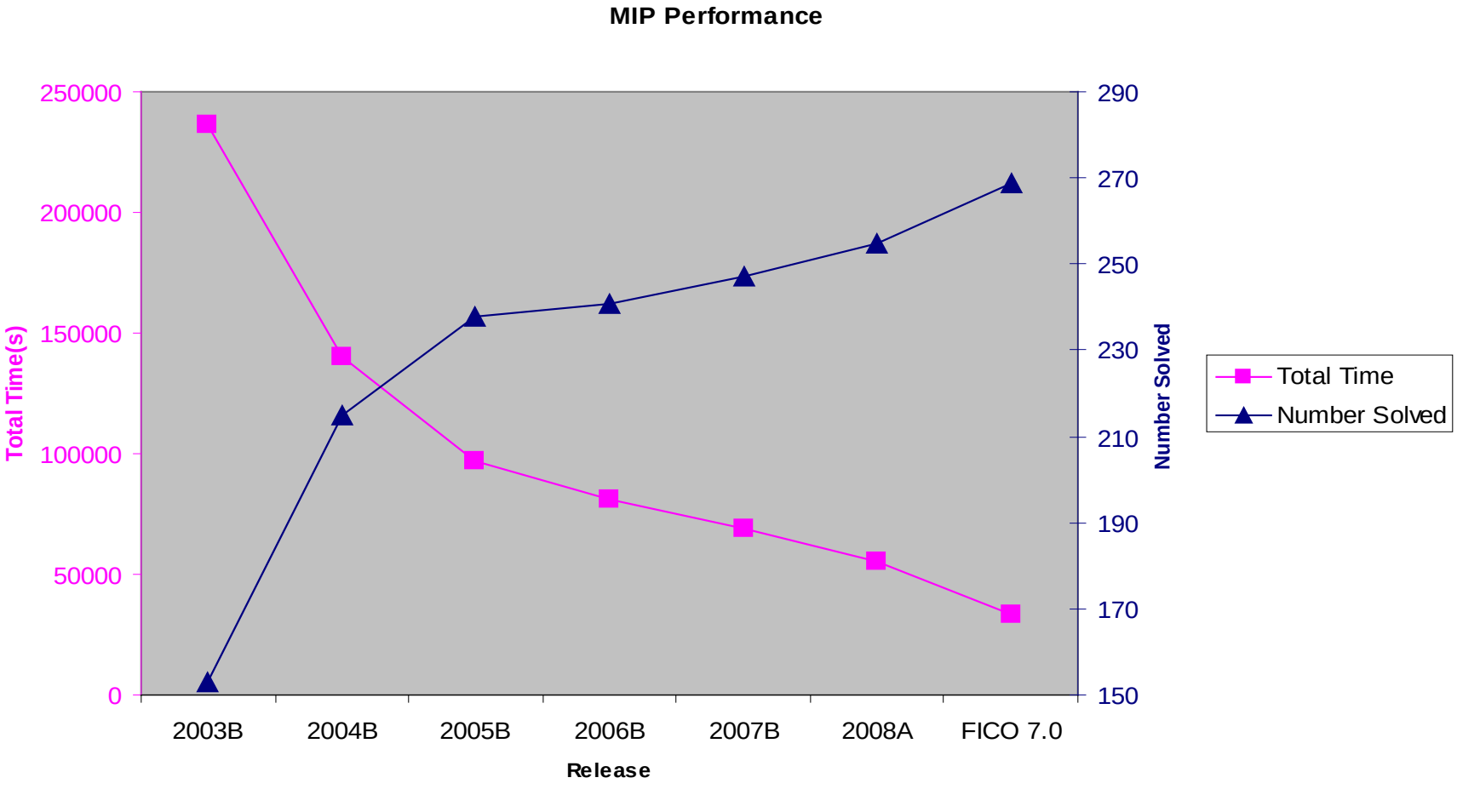
	2008A 1 thread	Xpress 7 1 thread	Change
“Internal” Number of instances solved	277	294	+6%
“Internal” Total solution time	63,000	37,375	-70%

Internal test set of 320 public and customer models

Xpress 7 parallel speed ups

	Xpress 7 1 thread	Xpress 7 4 thread	Improvement
"Internal" deterministic	25,724	17,447	-47%
"Internal" opportunistic	25,724	13,067	-96%
Coral deterministic	24,484	16,129	-52%
Coral opportunistic	24,484	11,137	-120%

MIP Performance across releases



Internal test set of 320 public and customer models

Reengineered B&B tree

» No global file
(unless getting close to – adjustable – memory limit)

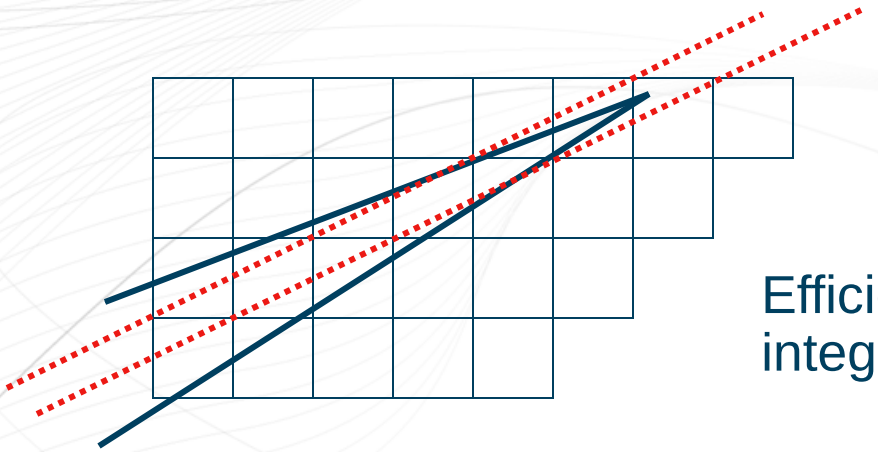
» Auto compression of node information

» New user branching object
allows user to add own global entities,
let the optimizer decide to pick the most promising one
(essential just provide a list of candidate branches)

New MIP features

» Improved cuts including zero-half cuts
(combining integer rows with 0.5 weights to get integer row with an odd rhs)

» Branching on split disjunctions (e.g. on sum of variables)
(e.g. branch on the sum of generals)



Efficient for general integers

More new MIP features

- Parallel heuristics
  Efficient on problems where the root solve is expense

- Improved decision space reduction (presolve)
  (extended probing and implications from multiple rows)

Multiple Solution Storage - revisited

- A MIP Solution Pool (MSP) stores the solution vector values for multiple solutions
- This can be useful in cases when there are constraints or costs not reflected in the problem that the user wants to use to select a solution from a set that have been found by Xpress
- Many functions to manage/query the pool
  - e.g. the user perhaps want to get the list of solutions that are feasible for a given problem
- Solution Pools have Attributes
  - e.g. number of solution nonzeros
  - e.g. number of solutions in the pool
  - e.g. objective value of a solution in the pool for a given problem

Computing the *N*-best Solution

- MIP Solution Enumerator (MSE)
- Runs a customized MIP search on a user provided problem (XPRSprob)
- The search is customized such that nodes are not cut-off by bounding and integer solution nodes are branched
- The MSE stores the solutions found in a user provided MIP Solution Pool
- Is useful for generating a set of solutions for a problem
- It can be used to generate the *N*-best solutions to a problem

```
/* Run the enumeration */
nMaxSols = 10;
XPRS_mse_minim(mse, prob, msp, XPRS_mse_defaulthandler, NULL, &nMaxSols);
```

  - XPRS_mse_defaulthandler function manages the storage of at most nMaxSols (=10) solutions
    - either rejects the current solution or deletes the worst existing solution depending on their objective values

MSE Solution Metrics

» In addition to the MIP objective, the MSE provides a metric for solutions based on the 'diversity' of the solution with respect to the other stored solutions

» The user can delete *p* solutions based on the MIP objective values and then delete the remaining nMaxSols - *p* solutions based on a diversity metric

» The diversity metric for a solution is the sum of difference metrics between the solution and the other stored solutions

» The user can provide their own difference metric calculation for solution pairs by using a callback

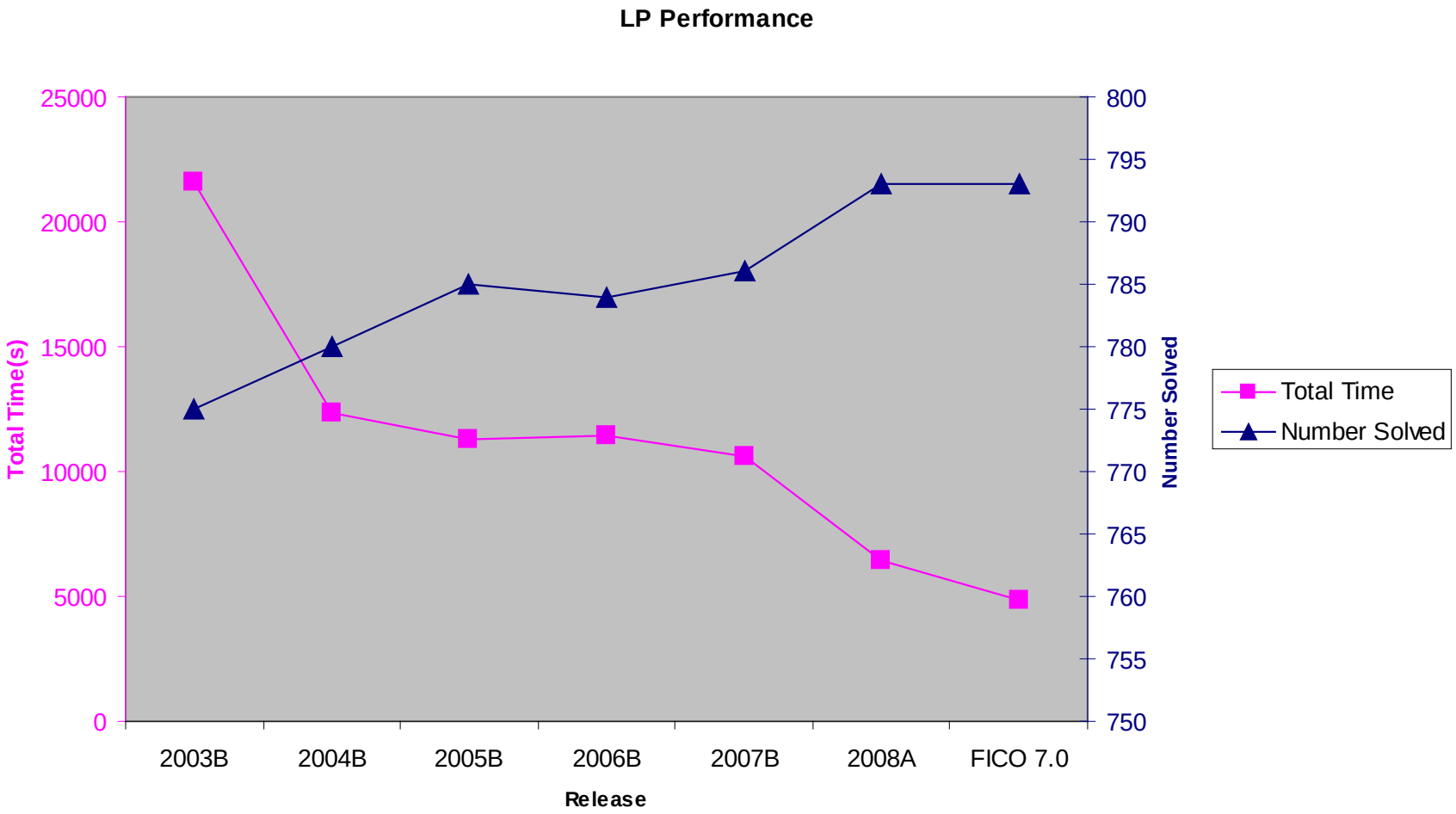
Xpress 7 – Linear models

- Barrier improvements
- Improved primal simplex performance

“Serial” LP improvements

- Improved barrier sparser
- Steepest edge pricing in primal simplex (18% average speed up)
- Dual simplex improvements (9% average speed up)

LP Performance across releases



Internal test set of 796 public and customer models

Xpress 7 – Nonlinear models

- Improved QCQP
- New problem class: MIQCQP
- Linear constrained convex nonlinear solver
- Dramatically improved quadratic simplex

Convexity and Convex Nonlinear Programming (CNP)

- The convexity checker now attempts to reformulate nonconvex problems if possible, like binary MIQP / MIQCQP
- Greatly improved CNP / QCQP presolve
- Notes on CNP:
  - Given any solution to the problem, these callbacks are used to evaluate the value, the gradient and the Hessian of the nonlinear objective respectively
  - The problem is expected to be convex, which means that all Hessians must be defined and positive semi-definite for minimization (negative for maximization)
    (even outside the feasible region)

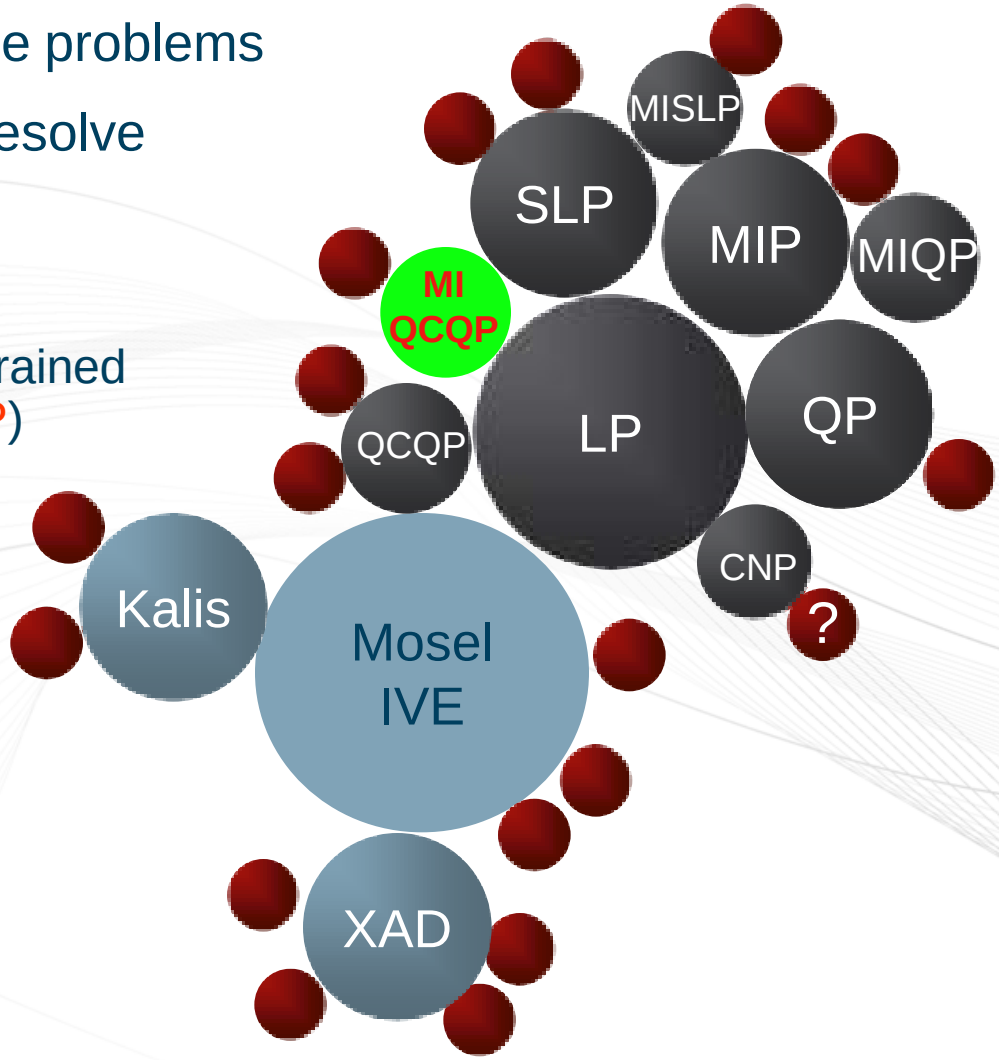
The many Qs

» Quadratically Constrained Quadratic Programming (QCQP) solver:

» support for very large sparse problems

» greatly increased QCQP presolve

» New model class support:
Mixed Integer Quadratically Constrained Quadratic Programming (MIQCQP)



The Q

- Reengineered quadratic primal simplex
  (dramatic performance improvement)

- New quadratic dual simplex
  (fast dual reoptimize, less fractional solutions)

- Spectacular MIQP improvements on many problem classes
  (expected to improve even further)

Xpress 7 vs 2008A on the “internal” test sets

	2008A	Xpress 7	Improvement
Quadratic primal	283,107 (3227)	44,296 (3299)	-539% (+3%)
QCCP barrier	3,510 (210)	219 (227)	-1500% (+8%) (presolve)
MIQP barrier	58,168 (142)	38,002 (195)	-53% (+35%)
Convex barrier	547 (255)	142 (280)	-284% (+10%)

Xpress 7 – Mosel

- Several Models in One File
- Advanced Modelling
- Automatic Finalization and Counters
- XAD Drag and Drop

Multi-problem vs. multi-model

- Multi-problem (mpproblem)
  - single model file
  - problems share data
  - integrated; no direct access to (sub)problems by other models/applications
  - sequential access to problems
- Multi-model (*mmjobs*)
  - several model files
  - communication of data (in memory)
  - stand-alone execution of submodels or use of submodels with other master models/applications
  - sequential or parallel execution of models

Multiple problem handling

» The new statement with allows to open a problem (= select the active problem):

```
declarations
  myprob: mpproblem
end-declarations

...

with myprob do

  x+y >= 0

end-do
```

Multiple problem handling

- Problem types support assignment: `P1:= P2`
  and additive assignment: `P1 += P2`
- The same decision variable (type `mpvar`) may be used in several problems
- Constraints belong to the problem where they are defined

Module advmod: Logic constructs

- Type `logctr` for defining and working with logic constraints in MIP models
- Implementation of these constraints is based on indicator constraints
- Build logic constraints with linear constraints using the operations `and, or, xor, implies,` and `not`
- Must include the package `advmod` instead of the Optimizer library `mmxprs`

Counters

» The aggregate operator count returns the number of times that a test succeeds

```
S:= {1, 5, 8, -1, 4, 7, 2}

writeln("Number of odd numbers in S: ",
   count(i in S | isodd(i)) )
```

» Use the construct as counter to specify a counter variable in a bounded loop (*i.e.*, forall or aggregate operators such as sum): at each iteration, the counter is incremented

```
S:= {1, 5, 8, -1, 4, 7, 2}

cnt:=0.0

writeln("Average of odd numbers in S: ",
     (sum(cnt as counter, i in S | isodd(i)) i) / cnt)
```

Xpress 7 – Something extra

Solvable model size was increased by a factor 2

Due to customer demand, the solvable model size was increased by a factor of 2.

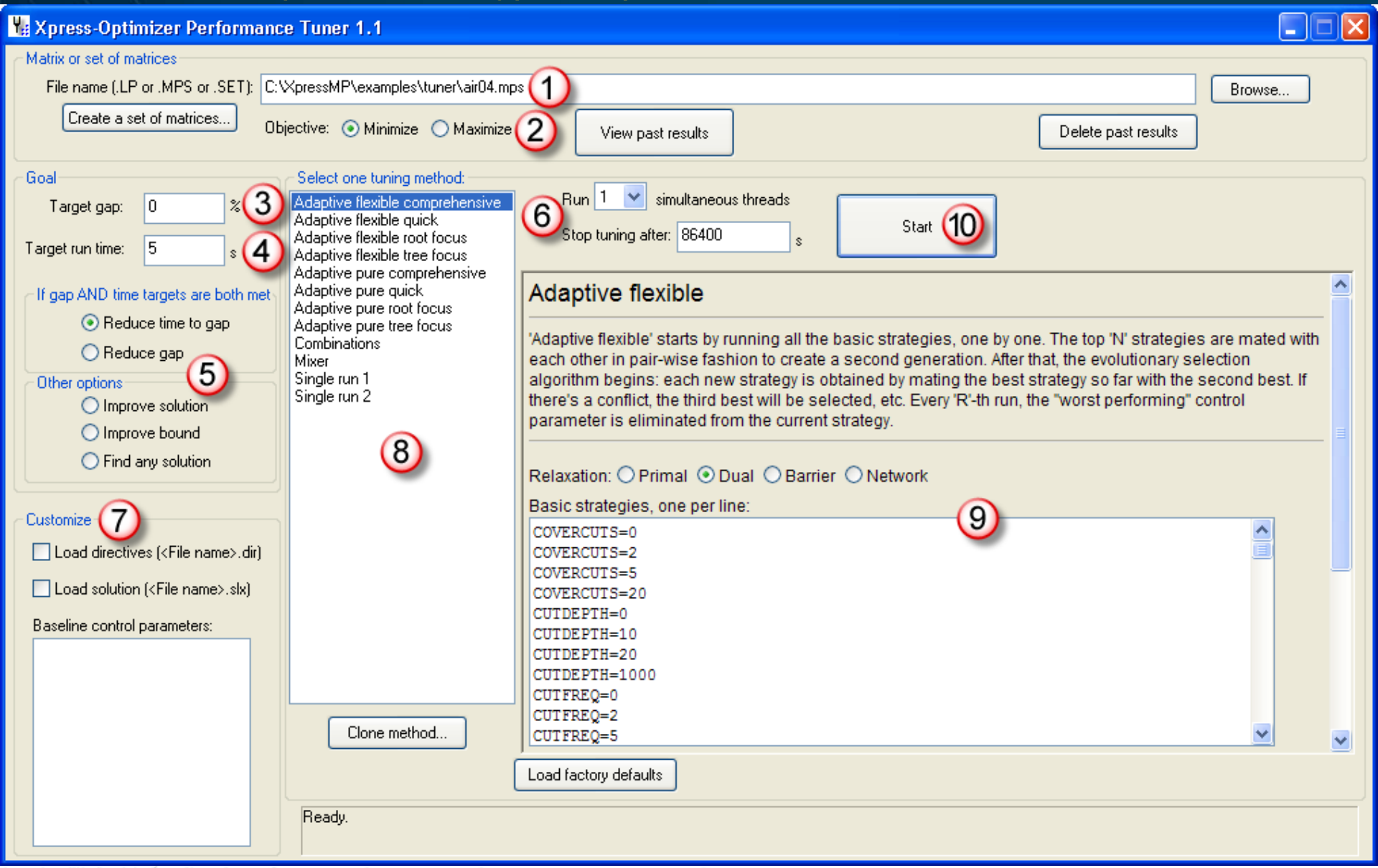
Examples of user problems solved by Xpress:

Rows	Columns	Nonzeros	Entities
55 501	2 313 900	**406 828 000**	**2 313 500**
1 344 660	18 525 200	244 245 000	0
1 344 660	18 525 200	244 245 000	0
11 741	2 339 830	200 214 000	2 339 430
897 662	9 488 130	152 017 000	0
1 687 180	10 000 000	121 892 000	0
229 441	28 765 300	86 084 800	0
554 013	6 327 120	79 489 300	0
8 917 760	16 207 100	77 966 100	12 497
1 200 130	4 884 110	72 813 678	0
546 304	6 163 666	69 583 836	0
160 218	19 884 900	59 507 200	0
436 562	5 500 097	58 915 368	0
644 584	5 628 760	57 468 100	0
5 034 580	7 448 220	53 129 400	7 215

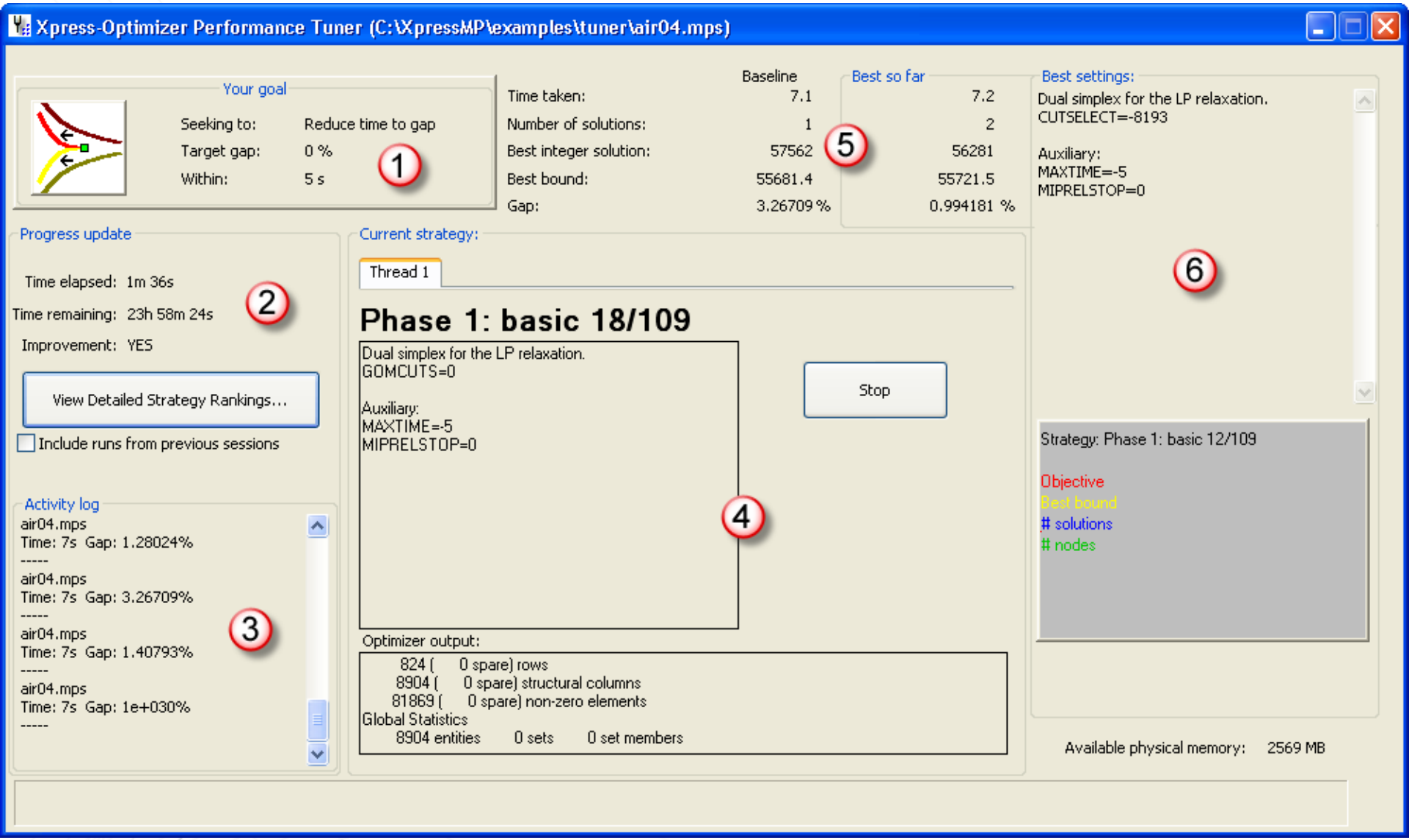
Xpress-Tuner:
How to Tune (Automatically) an Optimization Problem?

- Hard MIPs can benefit from speedups at the range of 10X with proper problem class specific tuning.
- The tuner provides a convenient way of checking what you (or us) will check first anyway…
- … taking it to lengths humans just don't have the time to.

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

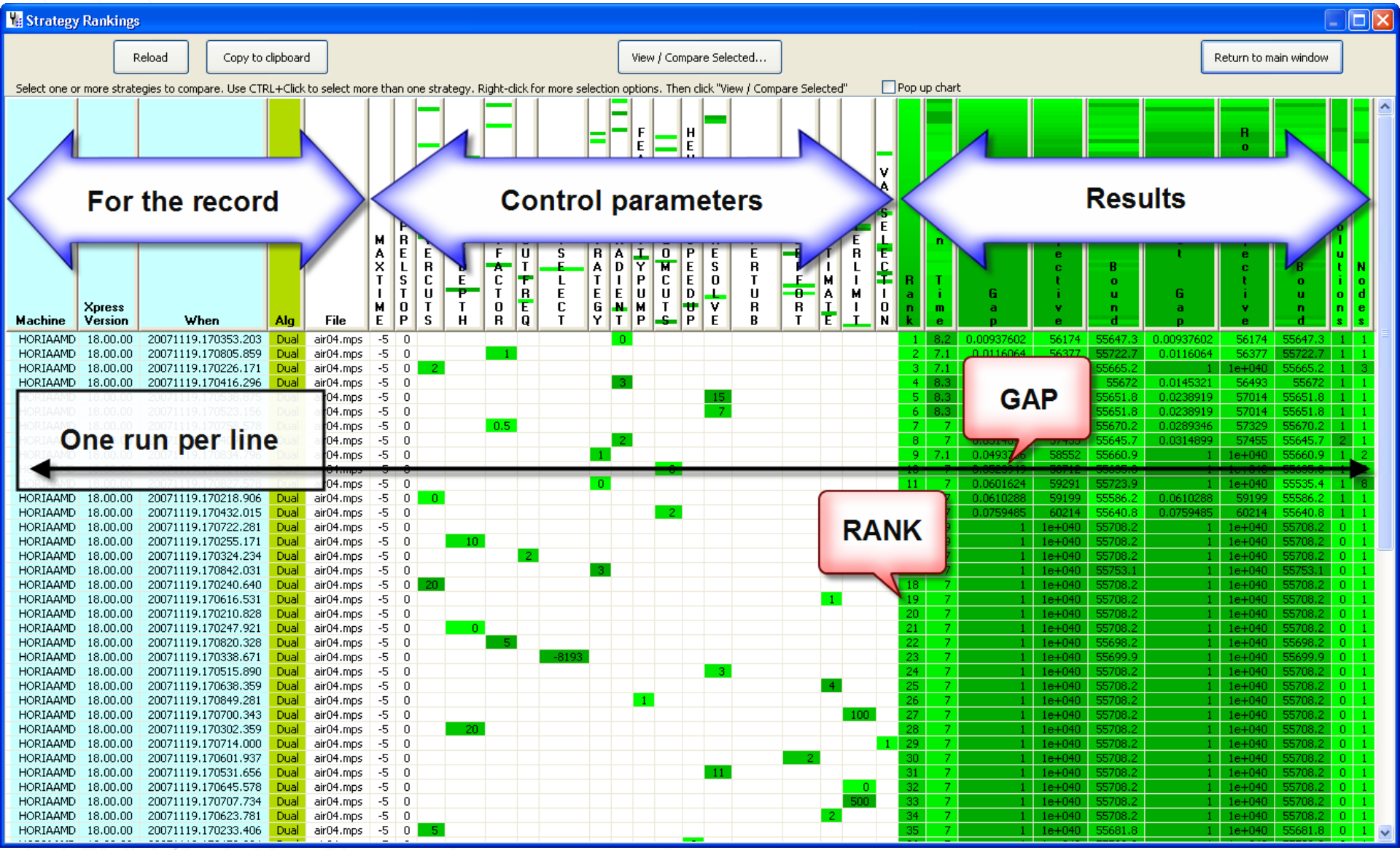


Xpress-Tuner: Tuning Process



Xpress-Tuner:

Detailed Results



THANK YOU

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