Rapid Application Prototyping With GAMS

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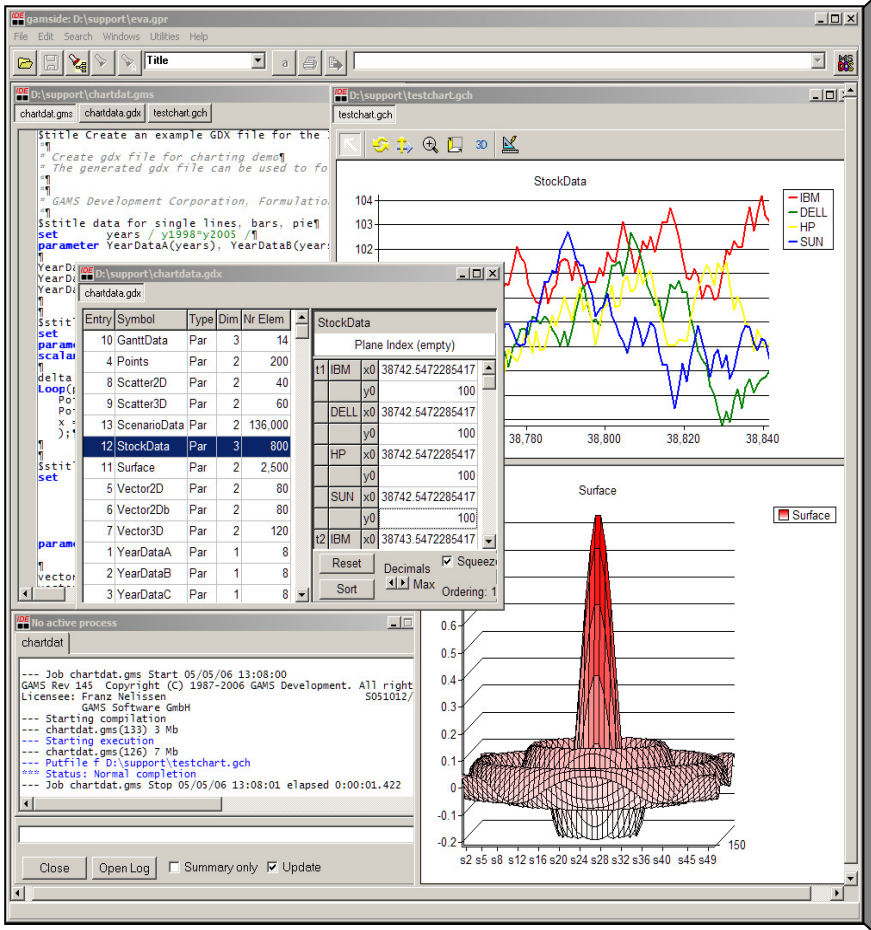
GAMS at a Glance



Algebraic Modeling System

- Facilitates to formulate mathematical optimization problems similar to algebraic notation

  ➔ Simplified model building

- Provides links to appropriate state-of-the-art external algorithms

  ➔ Efficient solution process

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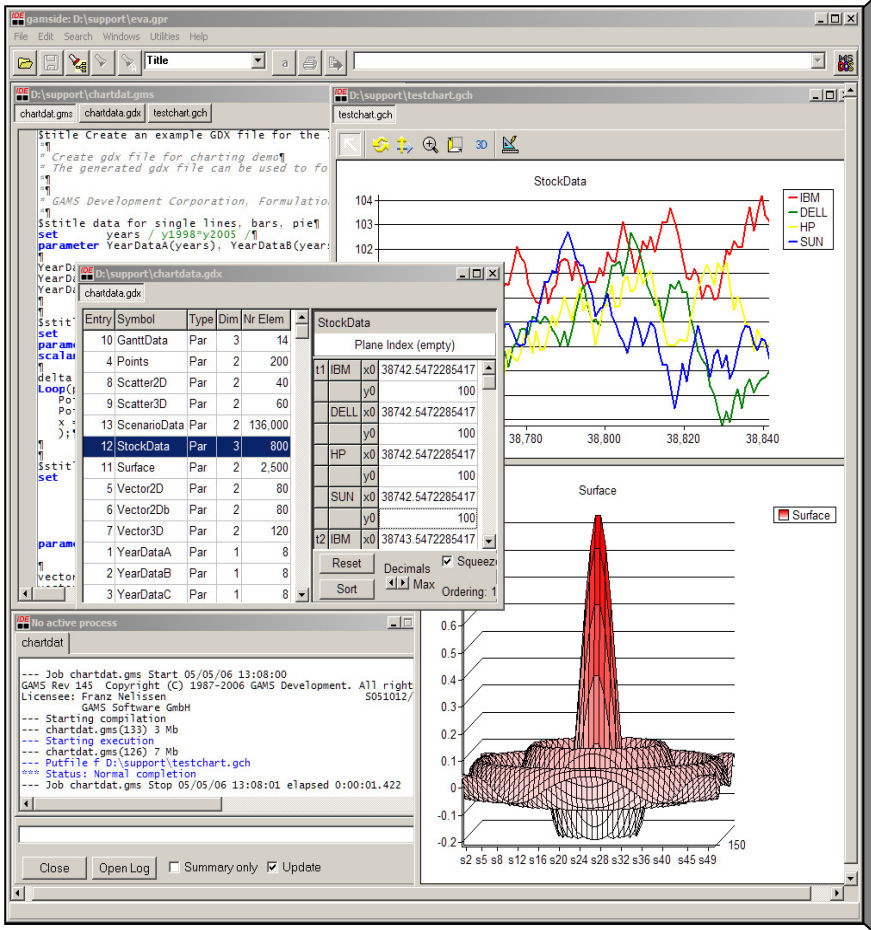
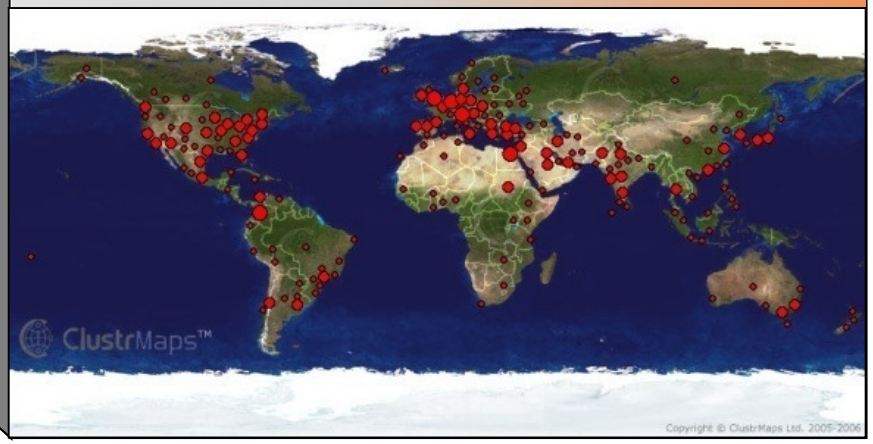


General **A**lgebraic **M**odeling **S**ystem

- Roots: World Bank, 1976
- Went commercial in 1987
- GAMS Development Corp.
- GAMS Software GmbH

- Broad academic & commercial user community and network



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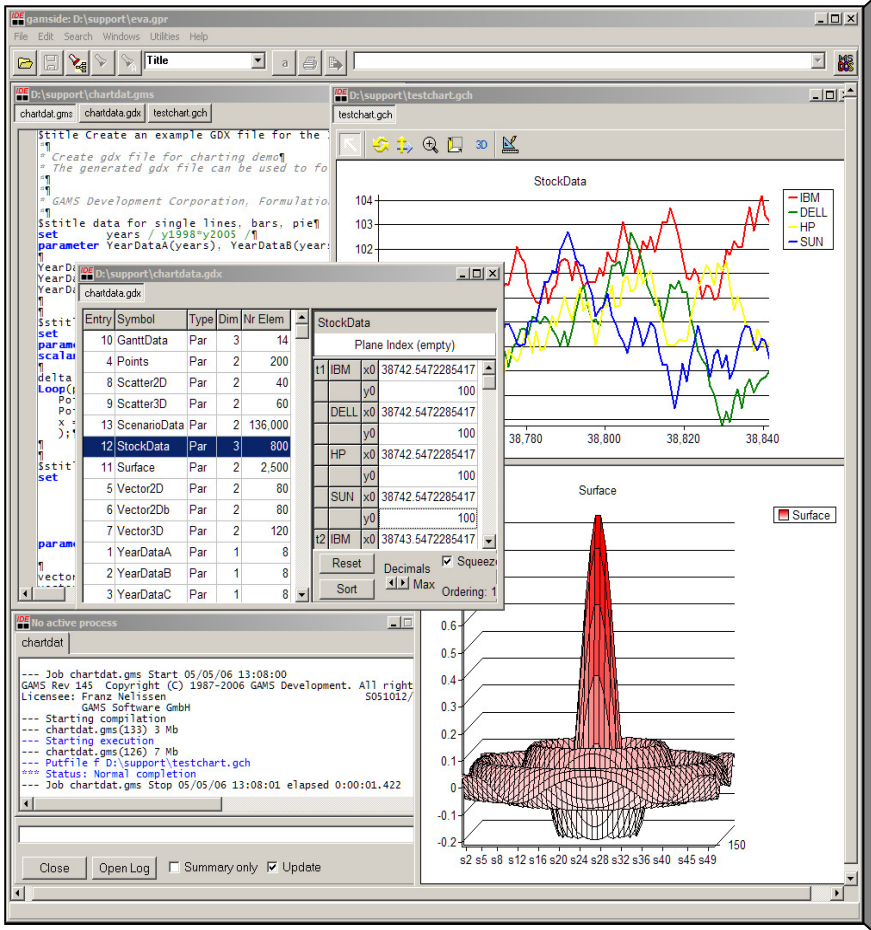
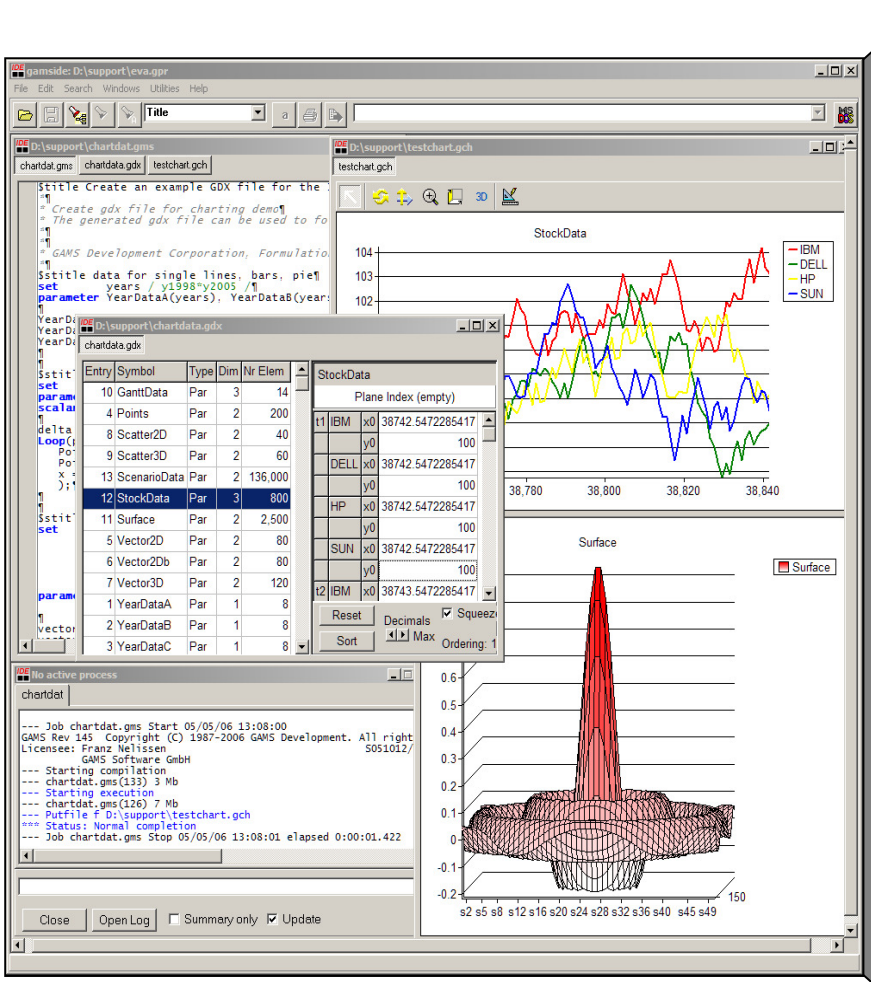
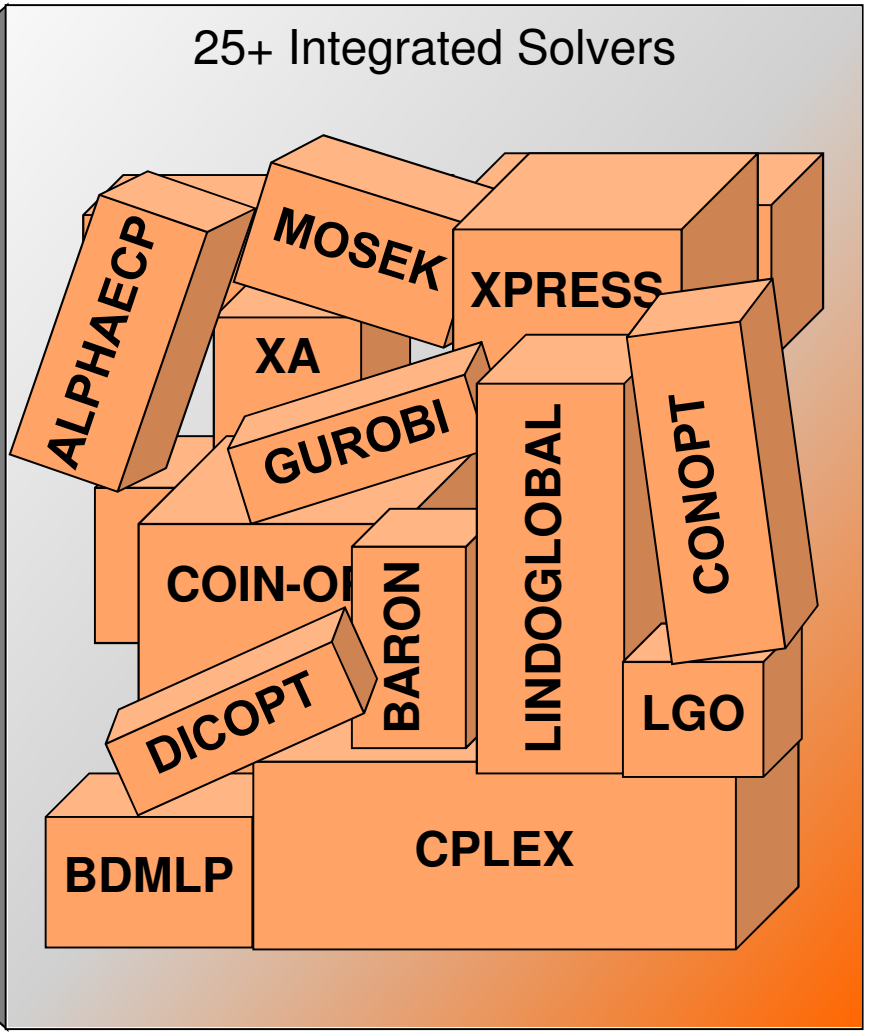


General **A**lgebraic **M**odeling **S**ystem

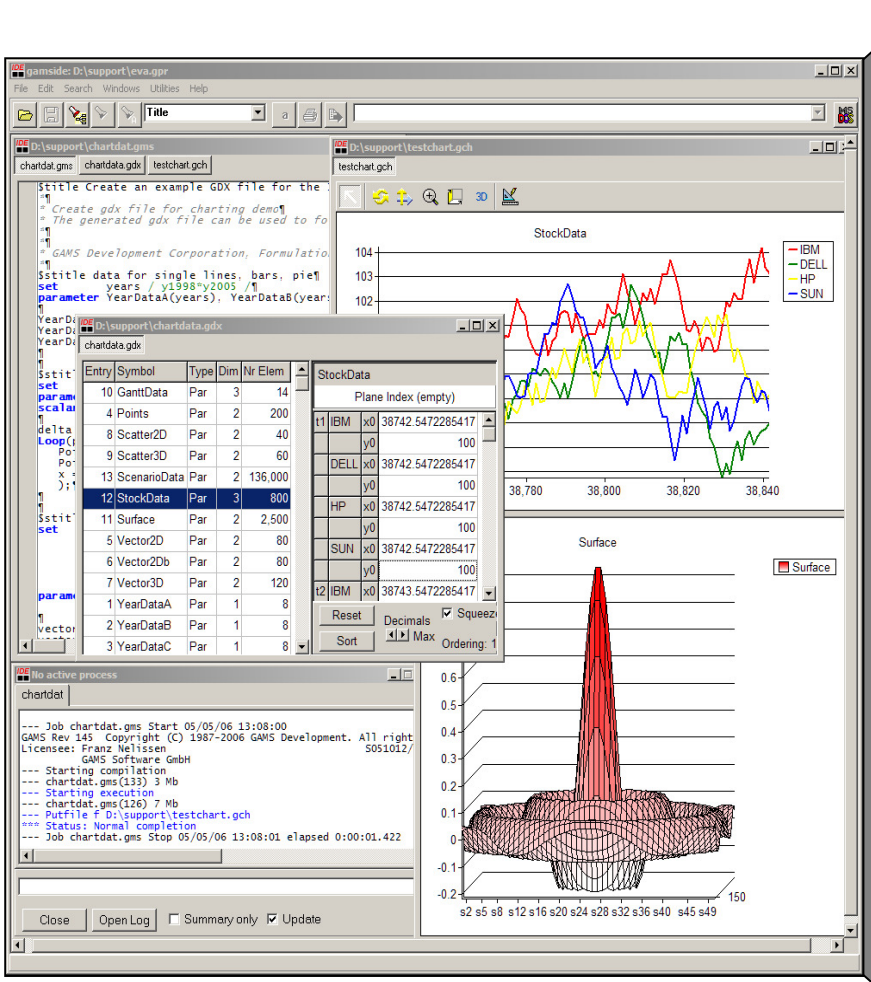
- Algebraic Modeling Language
- 25+ Integrated Solvers
- 10+ Supported MP classes
- 10+ Supported Platforms
- Connectivity- & Productivity Tools
  - IDE
  - Model Libraries
  - GDX, Interfaces & Tools
  - Grid Computing
  - Benchmarking
  - Compression & Encryption
  - Deployment System
  - …

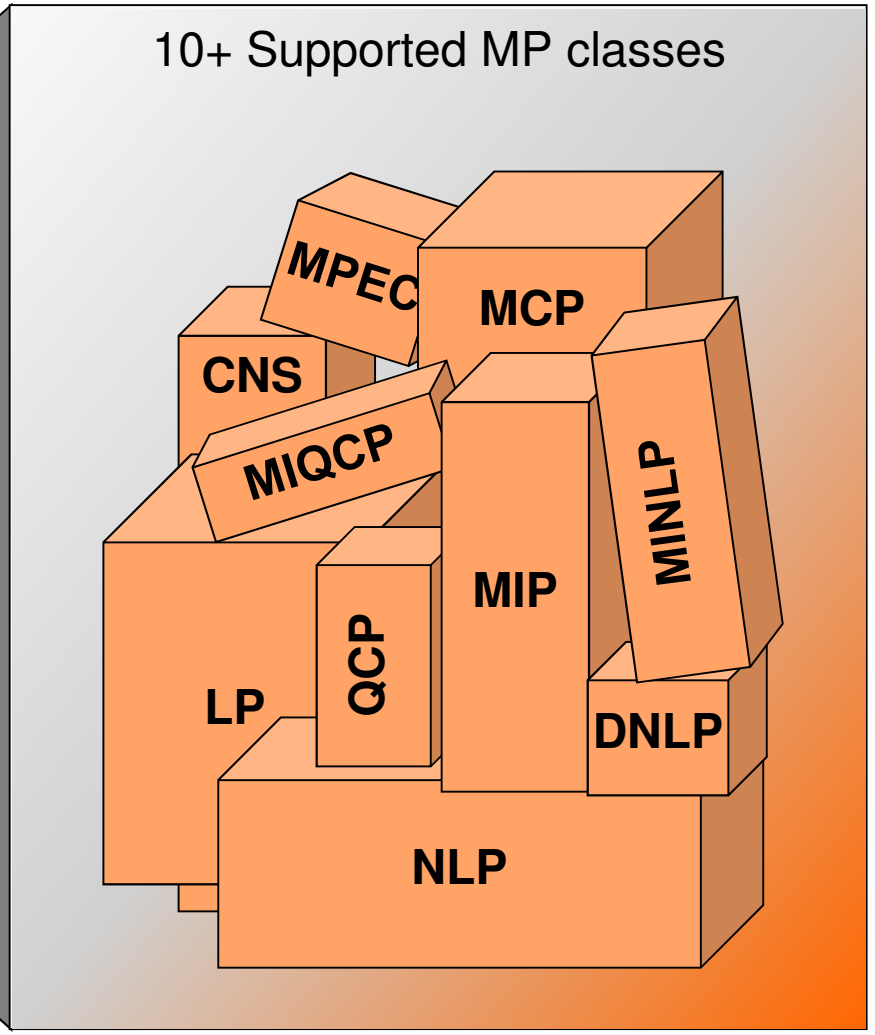
GAMS at a Glance





GAMS at a Glance





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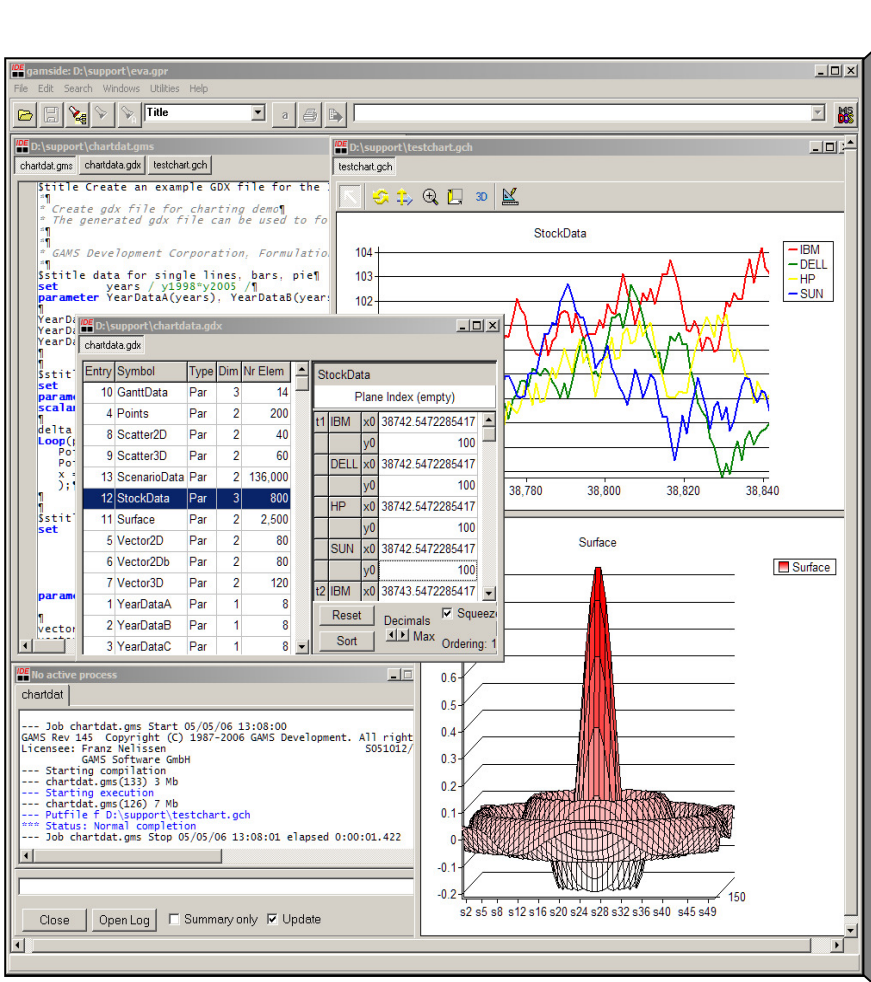

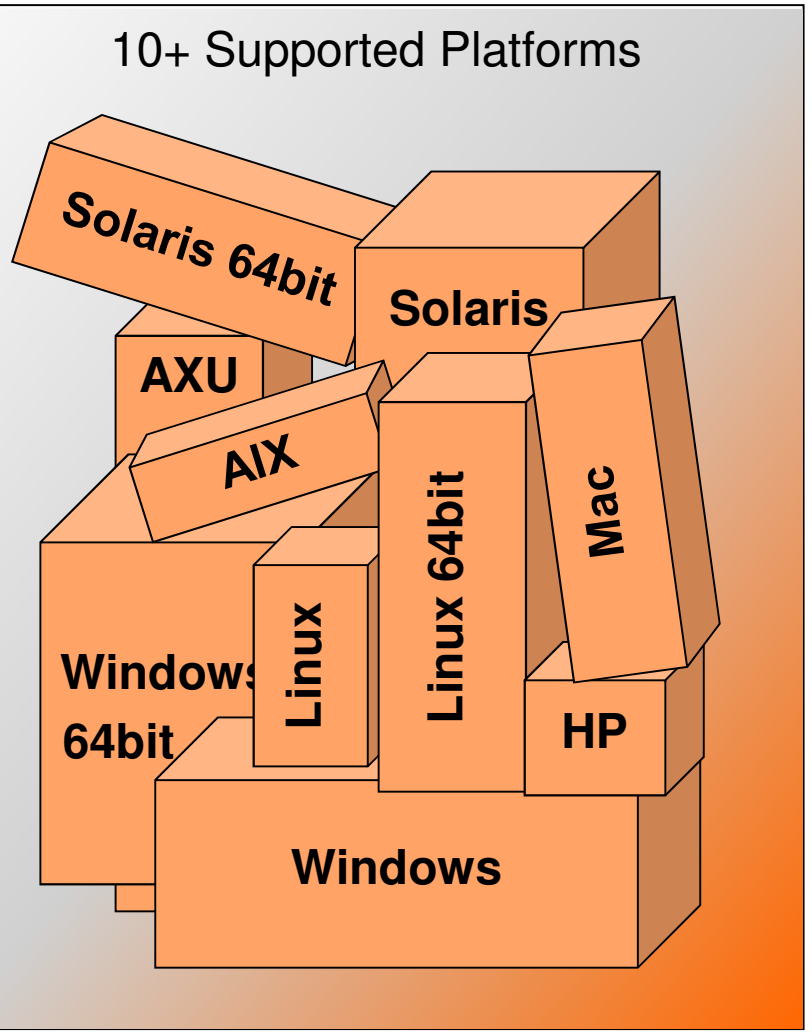

GAMS' Fundamental concepts

- **Platform independence**
- **Open architecture and interfaces to other systems**
- **Balanced mix of declarative and procedural elements**
  - Declaration of Sets, Parameters, Variables, Equations, Models, …
  - Procedural Elements like loops, if-then-else, …
- **Layers of separation**

GAMS' Fundamental concepts

- **Different layers with separation of**
  - model and data
  - model and solution methods
  - model and operating system
  - model and interface

→ Models benefit from

- advancing hardware
- enhanced / new solver technology
- improved / upcoming interfaces to other systems

GAMS 23.3 Beta

- Released yesterday! www.gams.com/beta
  - Solver updates:
    - Baron 9 (Conopt as an NLP solver)
    - Gurobi 2.0
    - Mosek 6 (beta)
    - Xpress 20.00
    - Coin-OR (various)
    - Coin-OR based Cplex, Gurobi, Mosek, Xpress links
  - GAMS on Amazon EC2 (pay by the hour)

Basic Sudoku

Address http://www.dailysudoku.com/sudoku/index.shtml

Daily SuDoku

- Home
- Today's SuDoku
- SuDoku Archive
- SuDoku for Kids
- Draw/Play
- Discussion
- FAQ
- Books
- Syndication
- Links
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Welcome to the Daily SuDoku!

Today's SuDoku is shown on the right. Click the grid to download a printable version of the puzzle. Visit **the archive** for previous daily puzzles and solutions. Play online, print a Sudoku, solve and get hints using the new improved **Draw/Play** function.

But how do I do it?

The object is to insert the numbers in the boxes to satisfy only one condition: each row, column and 3x3 box must contain the digits 1 through 9 exactly once. What could be simpler?

The rules of the new **Monster Sudokus** are exactly the same, but more numbers and letters are needed.

Classic | Monster | Kids | Squiggly

						6		1
			7	3	1			4
5					9			
6			2				1	
		8				4		
	1				5			8
			9					3
7			8	6	3			
9		2						

Daily SuDoku: Thu 2-Nov-2006 very hard

Christmas Tree Sudoku

Address http://www.dailysudoku.com/sudoku/archive.shtml?year=2005&month=12&day=23&type=seasonal

Daily SuDoku

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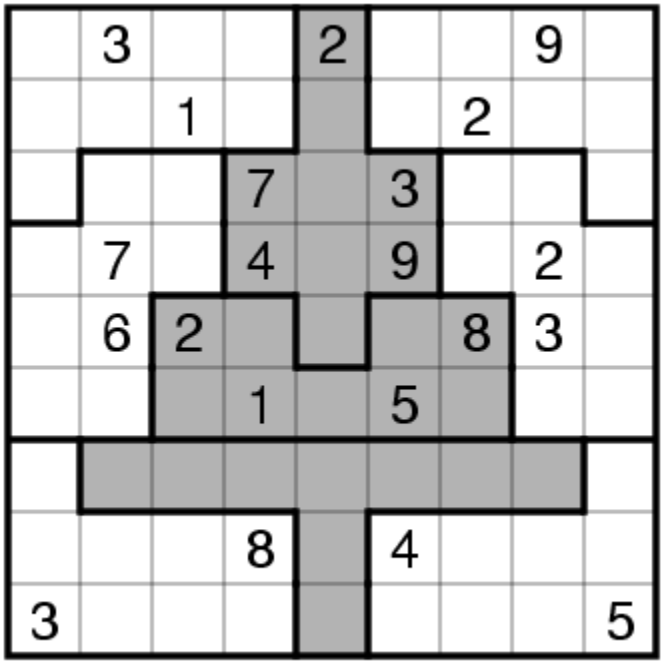
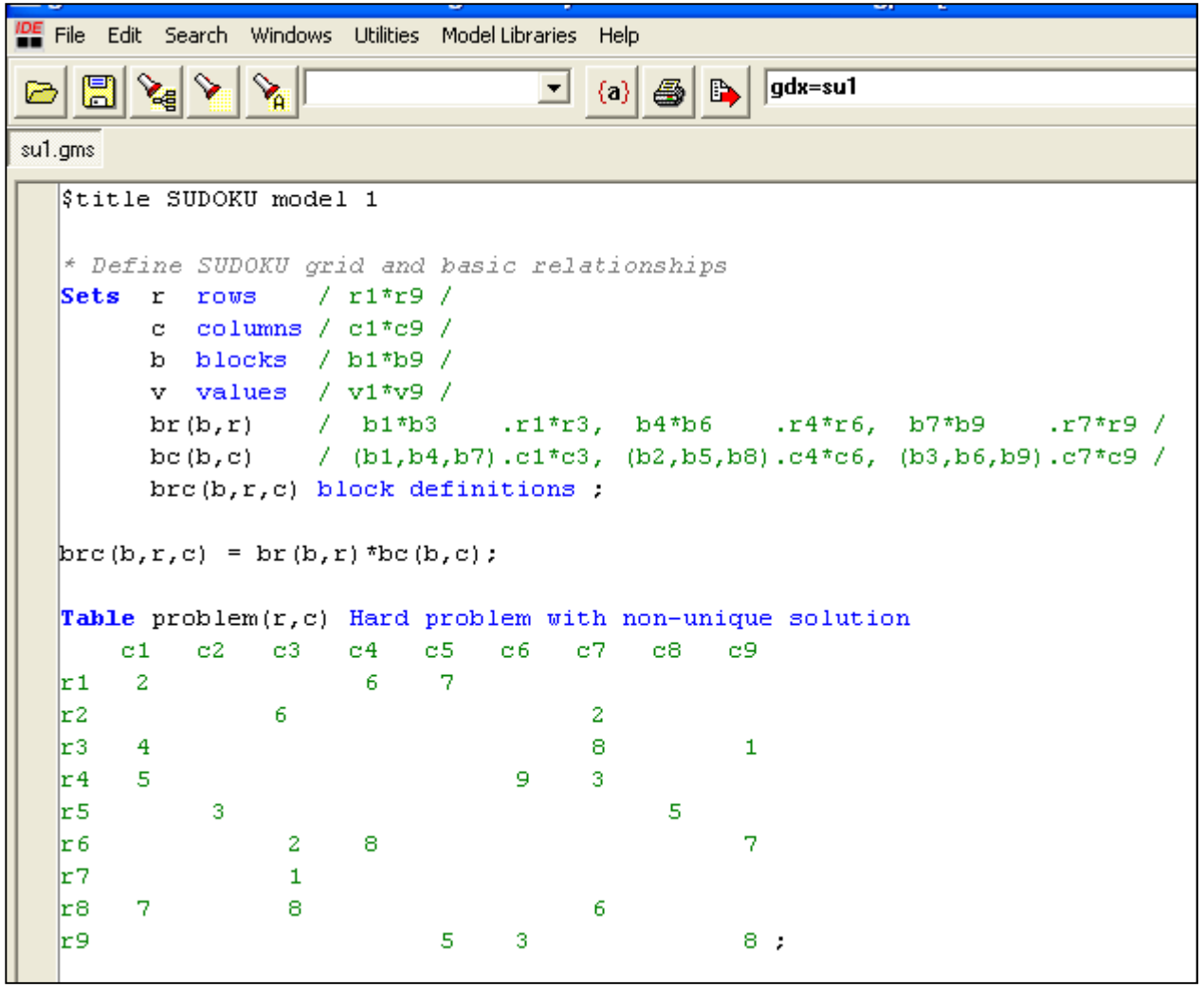
Daily Seasonal Sudoku: Fri 23-Dec-2005 [instructions]



Christmas tree Sudoku: Fri 23-Dec-2005 very hard

Demo: Basic Sudoku (*su1*)

Basic model *su1* computes solution to given Sudoku




```
$title SUDOKU model 1

* Define SUDOKU grid and basic relationships
Sets  r  rows    / r1*r9 /
      c  columns / c1*c9 /
      b  blocks  / b1*b9 /
      v  values  / v1*v9 /
      br(b,r)    /  b1*b3    .r1*r3,  b4*b6    .r4*r6,  b7*b9    .r7*r9 /
      bc(b,c)    / (b1,b4,b7).c1*c3, (b2,b5,b8).c4*c6, (b3,b6,b9).c7*c9 /
      brc(b,r,c) block definitions ;

brc(b,r,c) = br(b,r)*bc(b,c);

Table problem(r,c) Hard problem with non-unique solution
    c1   c2   c3   c4   c5   c6   c7   c8   c9
r1   2              6    7
r2             6                   2
r3   4                             8         1
r4   5                        9    3
r5        3                             5
r6             2    8                        7
r7             1
r8   7         8                   6
r9                       5    3              8 ;
```

Demo: Find other solutions (*su1* → *su2*)

- Is the solution unique?
- If not, how many solutions exist?

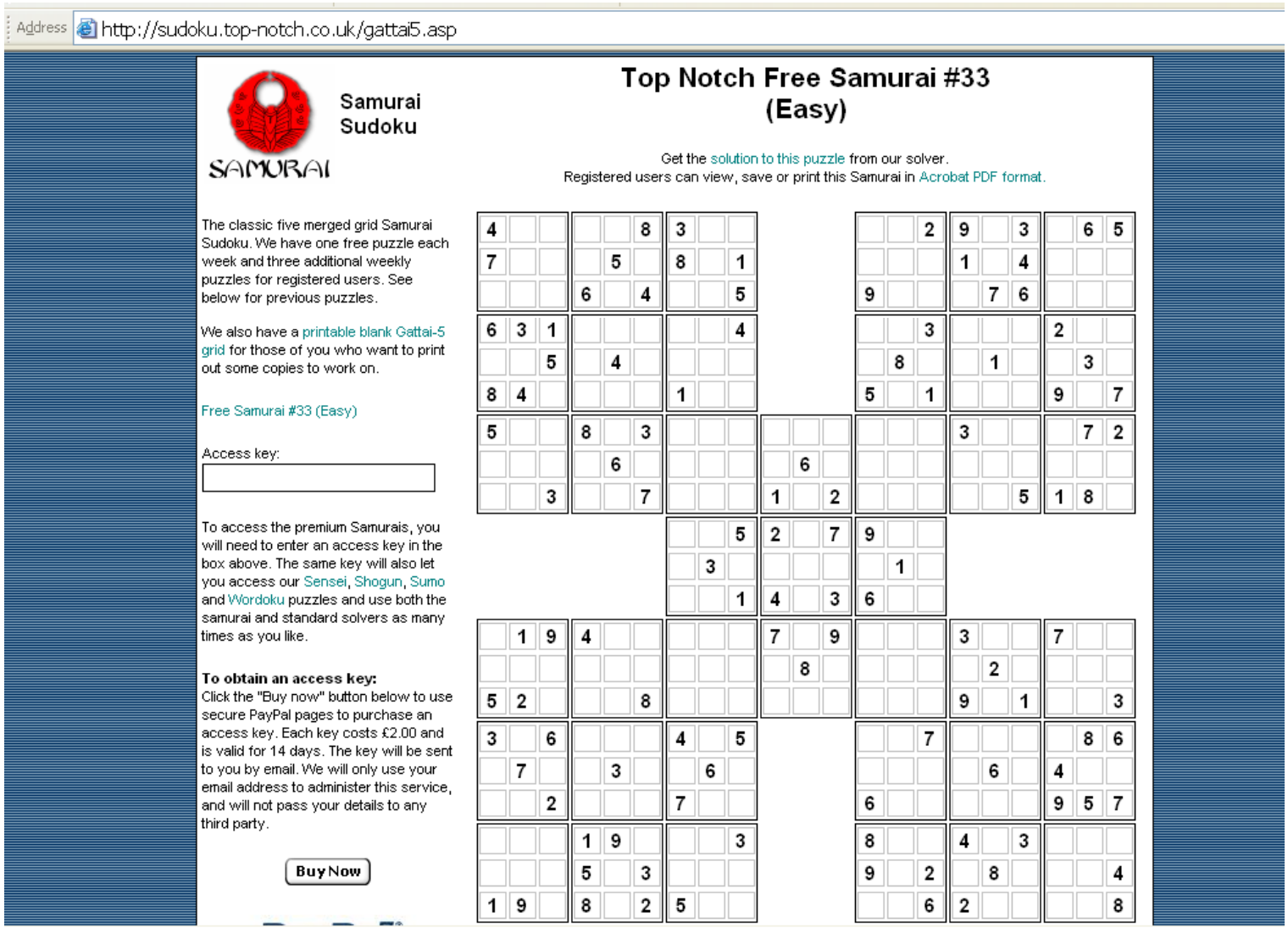
- Edits for *su1* → *su2*:
  - Implement binary cuts to exclude known solution
  - Use loop to find and store solutions

Demo: Infeasible Sudoku (*su1* → *su3*)

- What should we do with an infeasible Sudoku?
  - Not enough to just report the infeasibility
  - Here, repair the data to make the model feasible

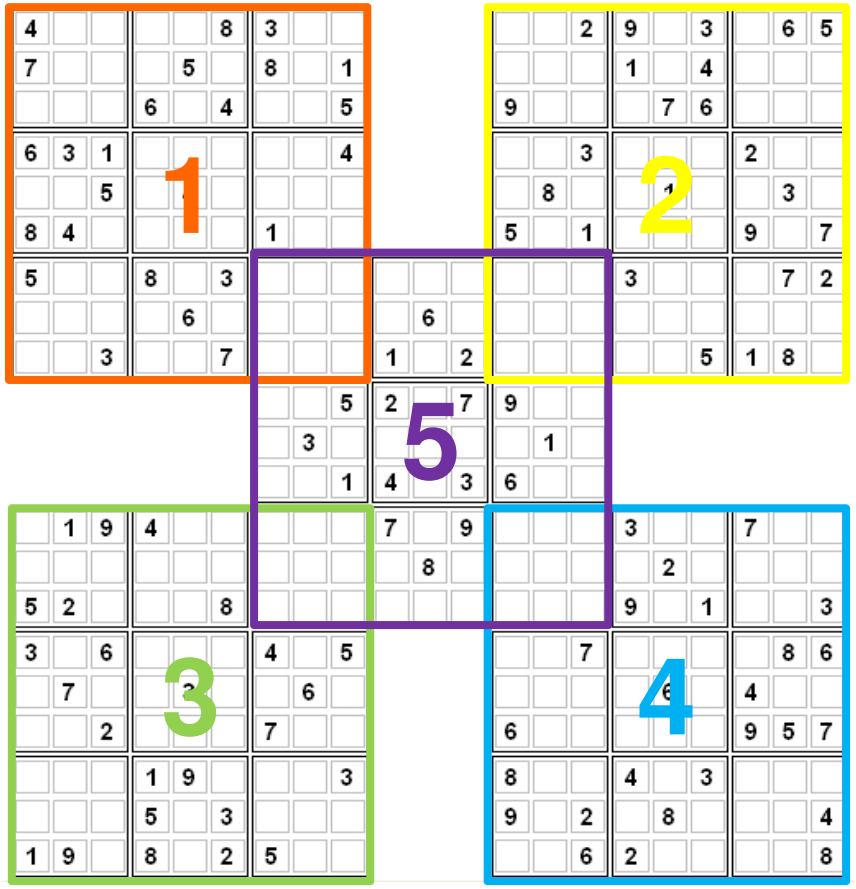
- Edits for going from *su1* → *su3*
  - Use random generation to get bogus data
  - Remove X.fx for fixed cells
  - Add binary variable UNDO (relaxes fixed cells)
  - Add equation fix using the UNDO variables
  - Add new objective function: Minimize sum over all UNDOs
  - Write short report

Samurai Sudoku



Demo: Mapping data (map1)

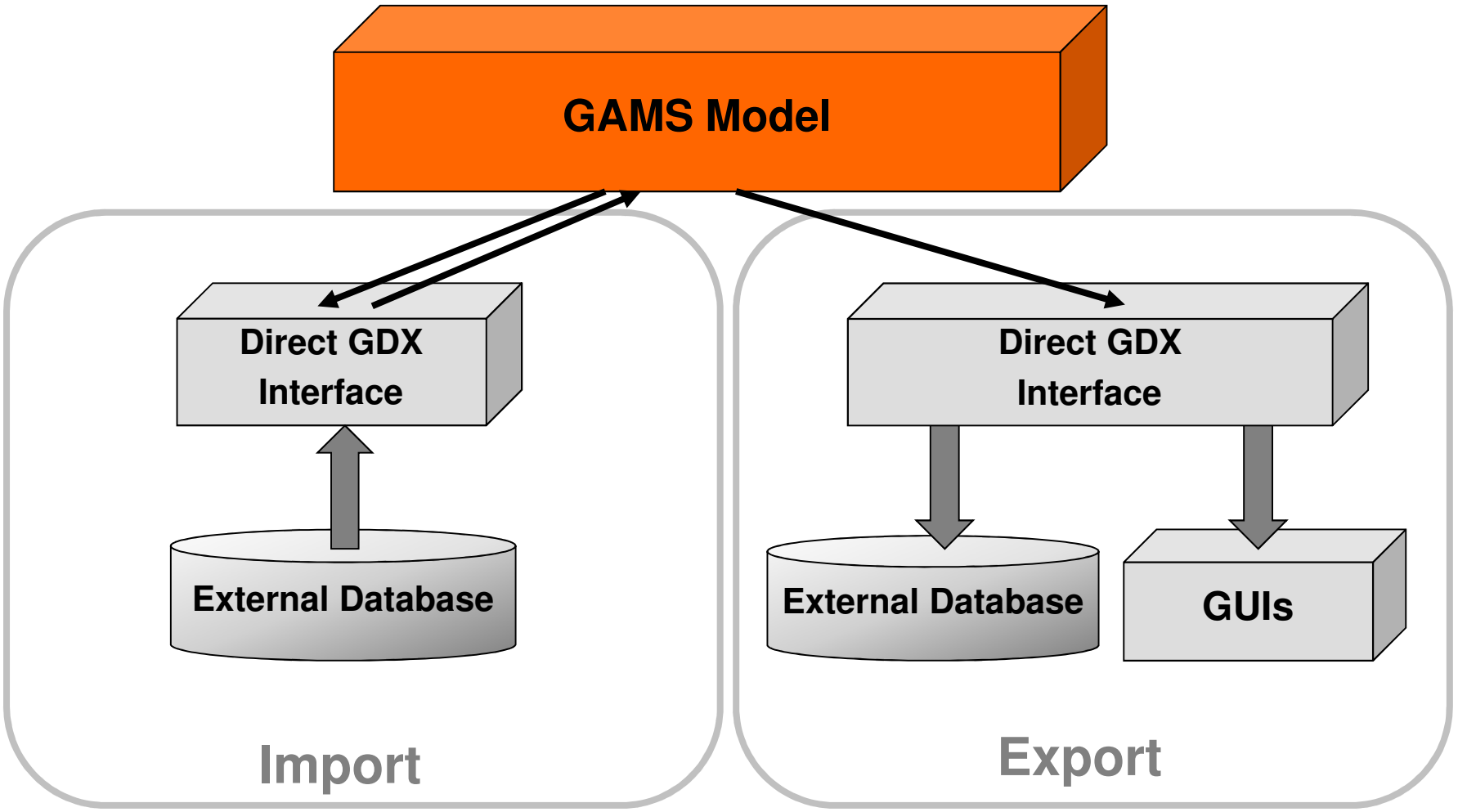
- We solve the Samurai as 5 basic puzzles, with linking constraints for the overlapping cells
- Requires mapping 21x21 Samurai puzzle into 5 separate 9x9 puzzles



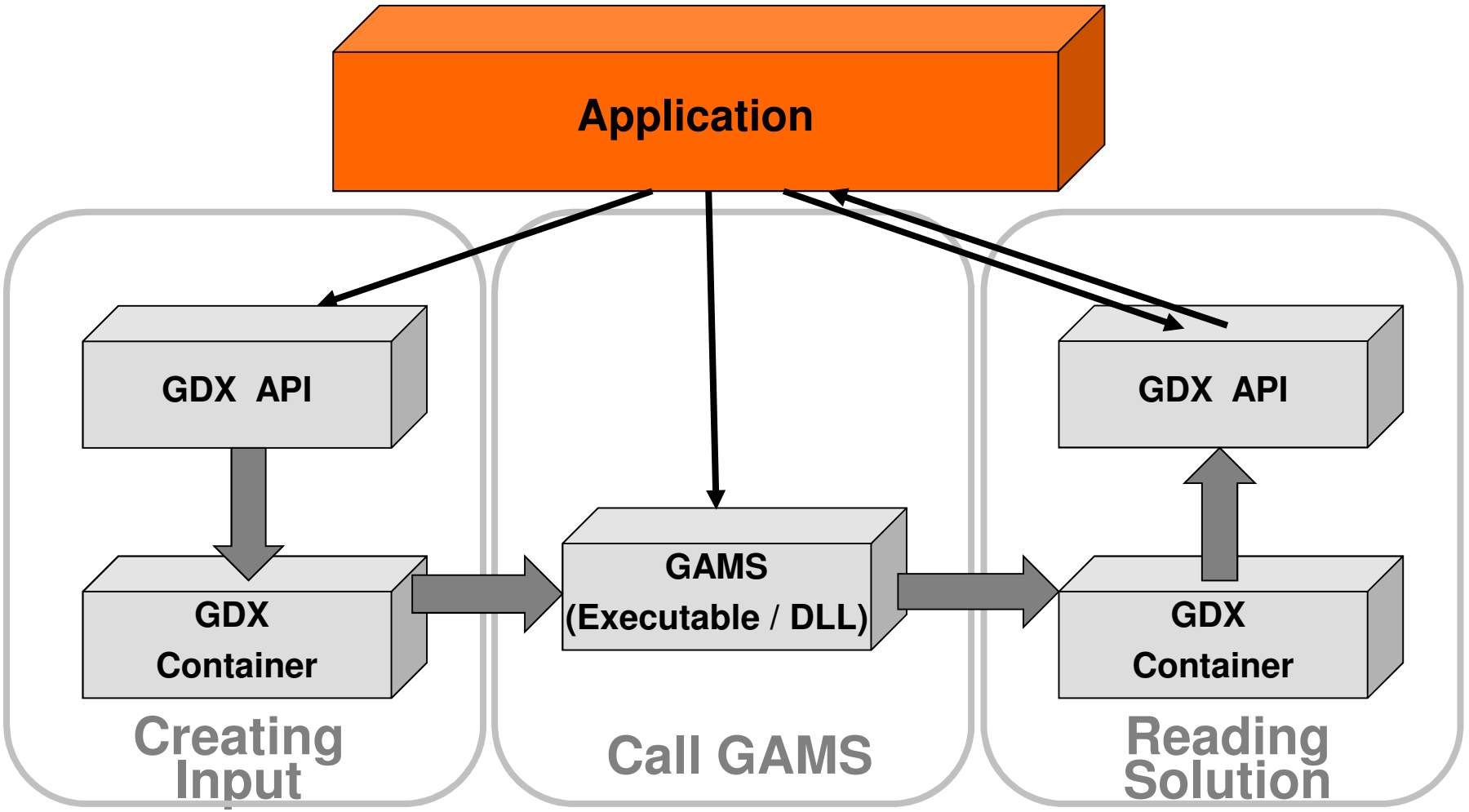
Demo: Samurai model (su3 → su4)

- Add puzzle index p to all variables/equations
- Add linking constraints
- Use random data to test
- Fix undo variables initially to 0
  - If the model is feasible, it will solve quickly
  - If infeasible, we unfix undo and resolve

GAMS in Control



Application in Control



Calling GAMS from an Application

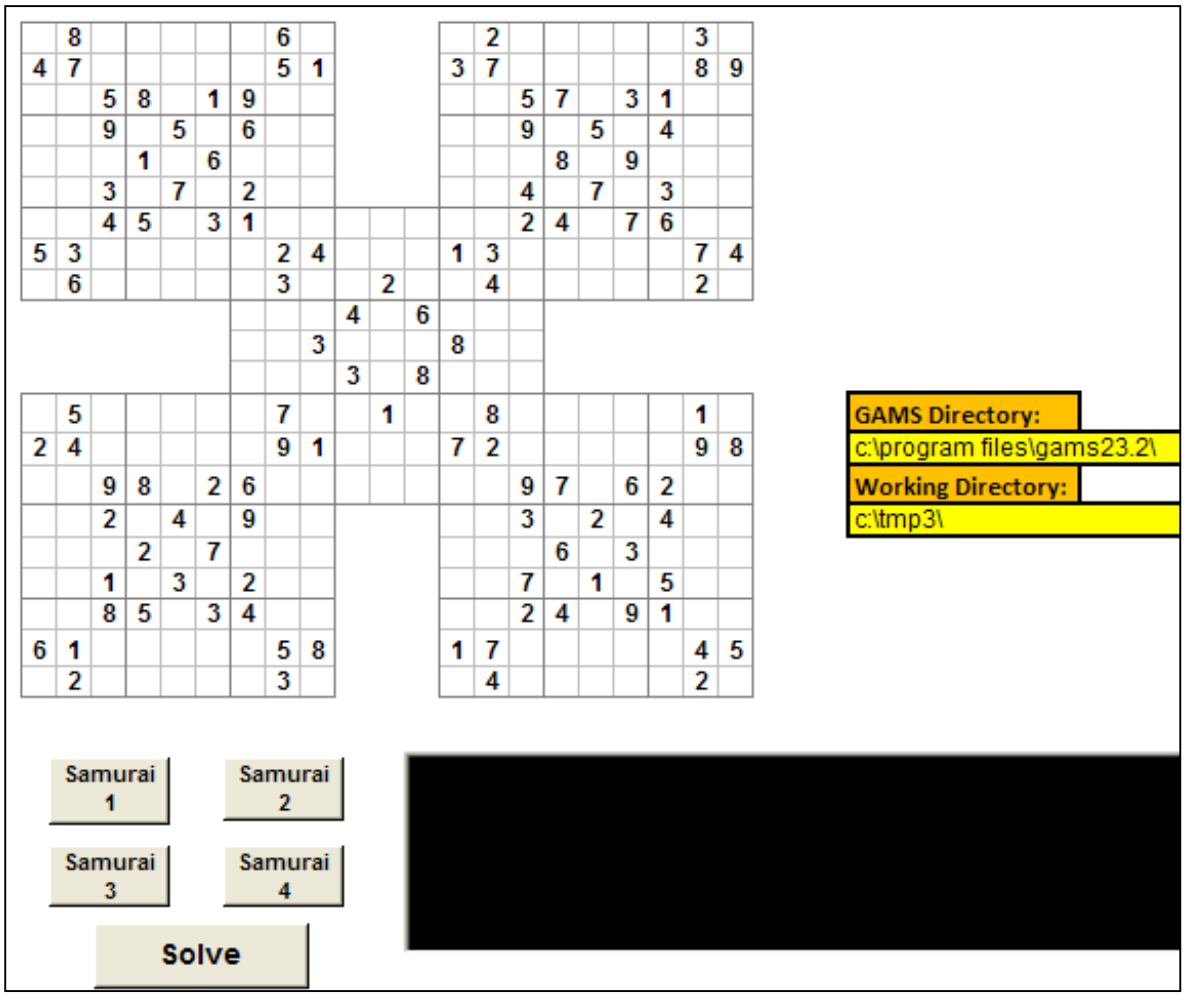
Creating Input for GAMS Model
Callout to a GAMS Process/Executable
Reading Output from GAMS Model

- Works from basically every environment
  - Web application (server side)
  - Application Builder
    - Oracle, Eclipse, .NET, …
    - Regular Programming language C++, Java, VB, …
  - MS Office Application / VBA

- Integrates with existing user IT infrastructure

Demo: Excel in charge (samurai_vb)

- Existing Samurai model with Excel GUI
- Look at data communication between model and GUI



Demo: Samurai data input (su4 → su5)

- Prepare our Samurai model *su4* to plug in to spreadsheet
- Import 21x21 data from GUI (via GDX)
- Use mappings from map1 to map 21x21 → 5x9x9
- Export 21x21 solution to GDX

Demo: Clean up (su5 → su6)

- Create text file for display in GUI

```
Solver: CPLEX
equations: 1945 variables: 3646
model status: 1 OPTIMAL
solver status: 1 NORMAL COMPLETION
iterations: 0 solve time: 0.08
```

Contacting GAMS

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