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
GAMS at a Glance

**General Algebraic Modeling System**

- Roots: World Bank, 1976
- Went commercial in 1987
- GAMS Development Corp.
- GAMS Software GmbH
- Broad academic & commercial user community and network
GAMS at a Glance

General Algebraic Modeling System

- 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

25+ Integrated Solvers

- XA
- XPRESS
- COIN-OR
- BDMLP
- CPLEX
- MOSEK
- X PRESS
- GUROBI
- CONOPT
- DICOPT
- BARON
- LINDOGLOBAL
- LGO
GAMS at a Glance

10+ Supported MP classes

- MPEC
- MCP
- CNS
- MIQCP
- MINLP
- MIP
- QCP
- LP
- DNLCP
- NLP
GAMS at a Glance

10+ Supported Platforms

- Solaris 64bit
- Solaris
- AXU
- AIX
- Linux 64bit
- Mac
- Windows 64bit
- Windows
- Linux
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)
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 Sudoku are exactly the same, but more numbers and letters are needed.
Christmas Tree Sudoku

Daily SuDoku

Daily Seasonal Sudoku: Fri 23-Dec-2005

Instructions

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

Christmas tree Sudoku: Fri 23-Dec-2005

very hard
Demo: Basic Sudoku *(su1)*

Basic model *su1* computes solution to given Sudoku.

```gams
$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) = 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   .   6   .   .   .   5   3   .
r9  .   8   .   .   .   6   .   .   .
```

*GAMS*
Demo: Find other solutions ($su1 \rightarrow su2$)

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

- Edits for $su1 \rightarrow su2$:
  - Implement binary cuts to exclude known solution
  - Use loop to find and store solutions
Demo: Infeasible Sudoku ($su1 \rightarrow su3$)

- 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 $su1 \rightarrow su3$
  - 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
Demo: Mapping data (map1)

- We solve the Samurai as 5 basic puzzles, with linking constraints for the overlapping cells.
- Requires mapping a 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

- GAMS Model
  - Direct GDX Interface
    - External Database
    - Import
  - Direct GDX Interface
    - External Database
    - Export
    - GUIs
Application in Control

Application

GDX API
GDX Container
Creating Input

GAMS (Executable / DLL)
Call GAMS

GDX API
GDX Container
Reading Solution
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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