

# Rapid Application Prototyping using GAMS

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#### Welcome/Agenda

Working with GAMS – A Guided Tour

Basic Sudoku

Samurai Sudoku



#### **GAMS Development / GAMS Software**

- Roots: Research project World Bank 1976
- Pioneer in Algebraic
   Modeling Systems
   used for economic modeling
- Went commercial in 1987
- Offices in Washington, D.C and Cologne
- Professional software tool provider
- Operating in a segmented niche market
- Broad academic & commercial user base and network



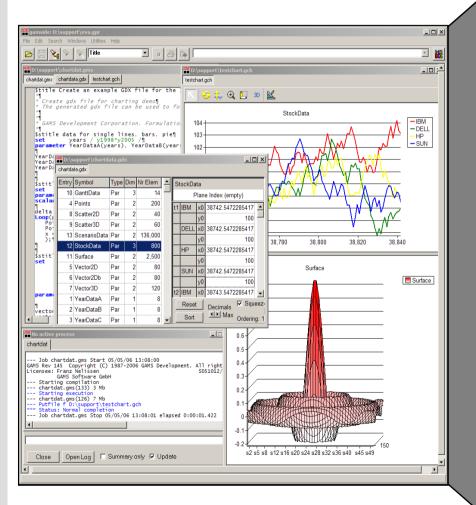
#### **Application\* Areas:**

- Agricultural Economics
- Chemical Engineering
- Econometrics
- Environmental Economics
- Finance
- International Trade
- Macro Economics
- Management Science/OR
- Micro Economics

- Applied General Equilibrium
- Economic Development
- Energy
- Engineering
- Forestry
- Logistics
- Military
- Mathematics
- Physics



#### **GAMS** at a Glance



General Algebraic Modeling System:
Algebraic Modeling Language,
Integrated Solver, Model
Libraries, Connectivity- &
Productivity Tools

#### Design Principles:

- Balanced mix of declarative and procedural elements
- Open architecture and interfaces to other systems
- Different layers with separation of:
  - model and data
  - model and solution methods
  - model and operating system
  - model and interface



#### **System Overview**

#### **Connectivity Tools**

- Uniform Data Exchange:
  - ASCII
  - GDX (ODBC, SQL, XLS, XML)
- GDX Tools
- Data API
- Ext. programs
  - EXCEL
  - MATLAB
  - GNUPLOT, ...
  - C, Delphi, ...

## Interactive API/Batch **User Interfaces GAMS Language Compiler** and Execution System **Solvers**

LP-MIP-QCP-MIQCP-NLP-MINLP-CNS-

MPSGE, global, and stochastic optimization

MCP-MPEC

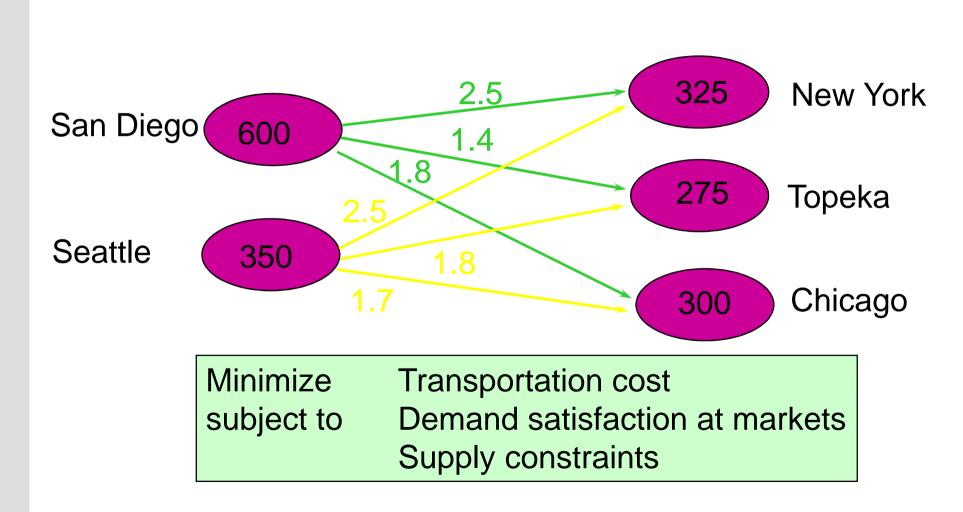
#### **Productivity Tools**

- Integrated Development Environment (IDE)
- Model Debugger and Profiler
- Model Libraries
- Data Browser
- Charting Engine
- Benchmarking
- Deployment System
- Quality Assurance and Testing

BARON, COIN, CONOPT, CPLEX, DECIS, DICOPT, KNITRO, LGO,MINOS, MOSEK, OQNLP, PATH, SNOPT, XA, XPRESS, ...



## A few Words about GAMS Syntax





## **GAMS Syntax – Mathematical Algebra**



## GAMS Syntax – GAMS Algebra

```
gamside: C:\Documents and Settings\bussieck\My Documents\gamsdir\project.gpr - [c:\documents an...
🍱 File Edit Search Windows Utilities Help
🗁 📳 🗞 🔖 🔽 call
                            🔽 (a) 🎒 🖒
trnsport.gms
     Variables
          x(i,j) shipment quantities in cases
                   total transportation costs in thousands of dollars ;
     Positive Variable x :
     Equations
                   define objective function
          cost.
          supply(i) observe supply limit at plant i
          demand(j) satisfy demand at market j ;
             z = e = sum((i,j), c(i,j)*x(i,j));
     cost ..
     supply(i) .. sum(j, x(i,j)) = l = a(i);
     demand(\dot{j}) .. sum(\dot{i}, \dot{x}(\dot{i}, \dot{j})) =q= \dot{b}(\dot{j});
     Model transport /all/ ;
       1: 1
                     Insert
```



#### **GAMS IDE – notable features**

- IDE Project Management
- Documentation
  - User's Guide/McCarl UG, Solver Manual
- Model Library
- Editor
- Solver Selection
- Option Selection
- Listing file/Tree view/Error navigation
- GDX Viewer
  - Data cube
  - Export to Excel
  - Graphs



#### Sudoku

Address (a) http://www.dailysudoku.com/sudoku/index.shtml

## Daily SuDoku



Sauigaly

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Today's SuDoku

SuDoku Archive

SuDoku for Kids

Draw/Play

Discussion

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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

						6		1	
			7	3	1			4	
5					9				
5 6			2				1		<del>-</del> i
		8				4			reservec
	1				5			8	/ Sudoku Ltd 2008. All rights reserved.
			9					3	.td 2006.
7			8	6	3				Sudoku L
									5

Kids

Daily SuDoku: Thu 2-Nov-2006

Classic Monster

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]

	3			2			9		
		1				2			
			7		3				
	7		4		9		2		
	6	2				8	2		reserved
			1		5				All rights
									.td 2005.
			8		4				Sudoku L
3								5	(c) Daily Sudoku Ltd 2005. All rights reserved.

Christmas tree Sudoku: Fri 23-Dec-2005

very hard



## **Important Principles**

- Deployed models have often 15+ years lifecycle
  - Changing environment:
    - hardware, operating system, interface (GUI/data)
- Backward compatibility
- Platform/Solver/Interface Independence
  - Model benefits from
    - Advanced hardware
    - Advanced solver technology
- Reduced Total Cost of Ownership (TCO)



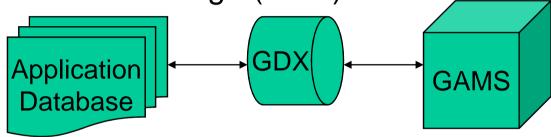
## Input/Output through ASCII Files

- ASCII Input Data
  - Part of model input (\$include file.txt)
  - Posix Utilities are part of GAMS Windows System
    - Platform independent data file preparation
    - sed, awk, grep, cut, ...
       \$call cut -d, -f1,3- file.txt > filenew.txt
- ASCII File Output
  - GAMS Put Facilities



#### **GAMS** Data eXchange

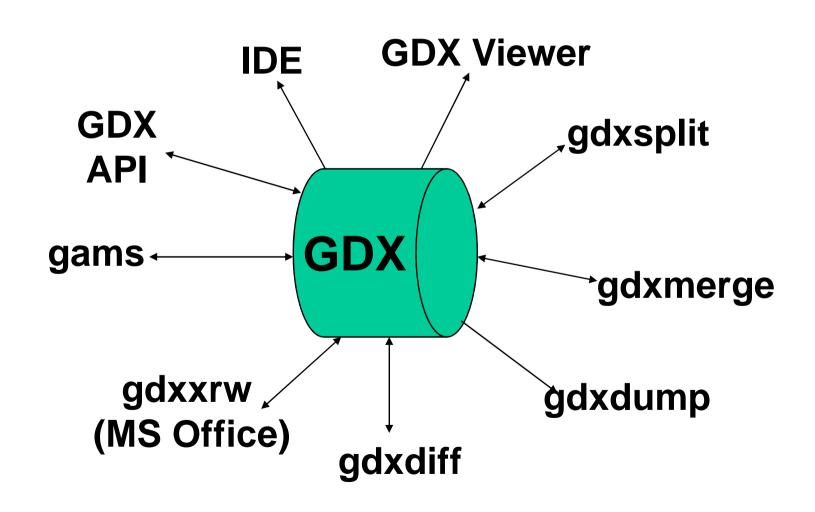
• GAMS Data eXchange (GDX):



- Complements the ASCII text data input
- Advantages:
  - Fast exchange of data (factor >20)
  - Syntactical check on data before model starts
  - Compile-time and Run-time Data Exchange
  - Platform Independent
- IDE GDX browser



#### **GDX Tools**





#### Samurai Sudoku

Address 🎒 http://sudoku.top-notch.co.uk/gattai5.asp



Samurai Sudoku

SAMURAL

The classic five merged grid Samurai Sudoku. We have one free puzzle each week and three additional weekly puzzles for registered users. See below for previous puzzles.

We also have a printable blank Gattai-5 grid for those of you who want to print out some copies to work on.

Free Samurai #33 (Easy)

Access key:

To access the premium Samurais, you will need to enter an access key in the box above. The same key will also let you access our Sensei, Shogun, Sumo and Wordoku puzzles and use both the samurai and standard solvers as many times as you like.

#### To obtain an access key:

Click the "Buy now" button below to use secure PayPal pages to purchase an access key. Each key costs £2.00 and is valid for 14 days. The key will be sent to you by email. We will only use your email address to administer this service, and will not pass your details to any third party.

BuyNow

#### Top Notch Free Samurai #33 (Easy)

Get the solution to this puzzle from our solver. Registered users can view, save or print this Samurai in Acrobat PDF format.

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



## **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
- Hands-on! samurai\_vb.xls



## **Contacting GAMS**

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