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

GAMS

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

* Illustrative examples in the GAMS Model Library

GAMS at a Glance

General **A**lgebraic **M**odeling **S**ystem:
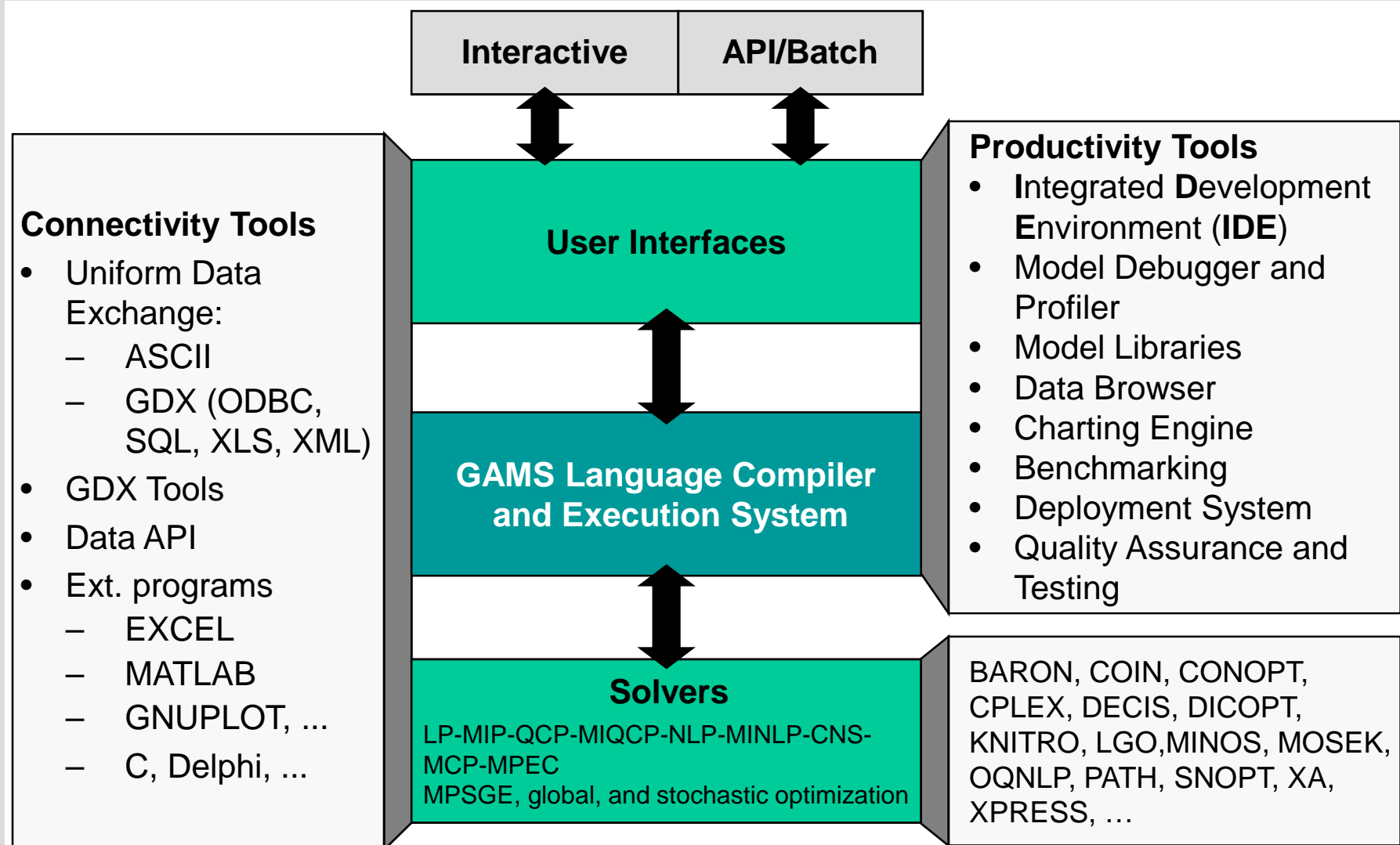 Algebraic Modeling Language,
  Integrated Solver, Model
  Libraries, Connectivity- &
  Productivity Tools

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
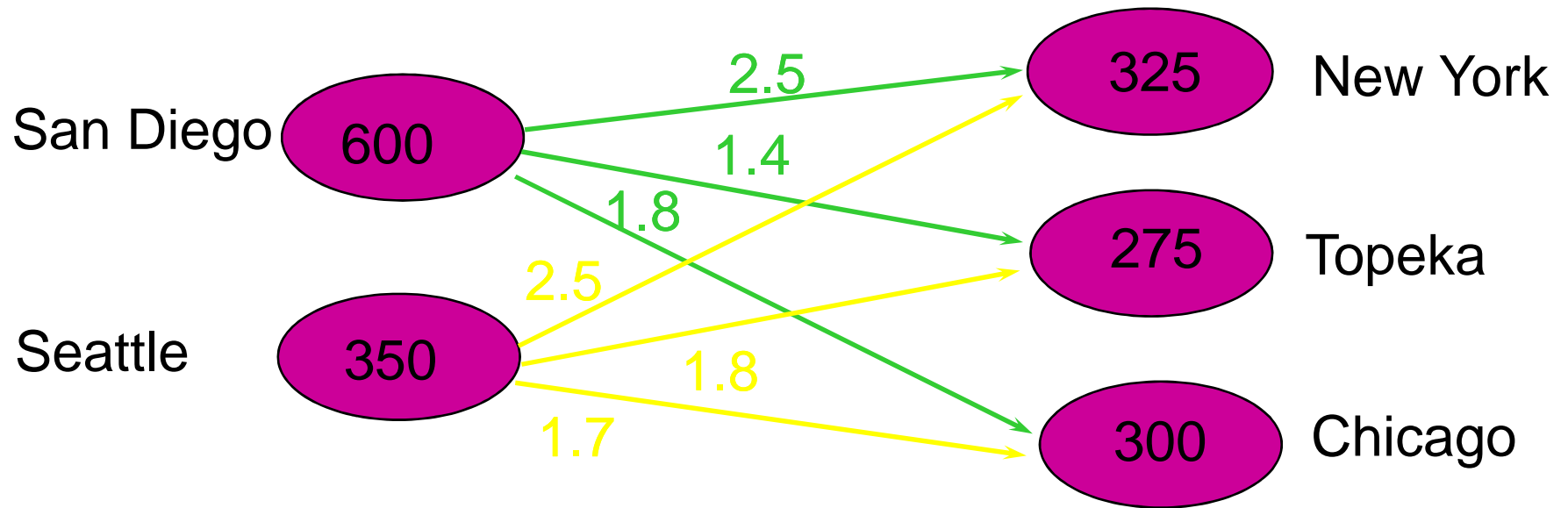 - model and interface

System Overview

Interactive | **API/Batch**

User Interfaces

GAMS Language Compiler and Execution System

Solvers
LP-MIP-QCP-MIQCP-NLP-MINLP-CNS-MCP-MPEC
MPSGE, global, and stochastic optimization

Connectivity Tools

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

Productivity Tools

- **I**ntegrated **D**evelopment **E**nvironment (**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, …

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A few Words about GAMS Syntax

San Diego **600**

Seattle **350**

325 New York

275 Topeka

300 Chicago

2.5
1.4
1.8
2.5
1.8
1.7

Minimize   Transportation cost
subject to   Demand satisfaction at markets
                Supply constraints

GAMS Syntax – Mathematical Algebra

$$\sum_{\substack{c,p: \\ (c,p)\in\mathcal{N}}} tcost \cdot dist(c,p) \cdot x_p^c \quad \rightarrow \quad \min$$

$$\sum_{\substack{c,p: \\ (c,p)\in\mathcal{N}}} x_p^c \quad \leq \quad sup(c) \quad \forall c$$

$$\sum_{\substack{c,p: \\ (c,p)\in\mathcal{N}}} x_p^c \quad \geq \quad dem(p) \quad \forall p$$

$$x_p^c \quad \geq \quad 0 \quad \forall c,p : (c,p) \in \mathcal{N}$$

GAMS Syntax – GAMS Algebra


```
Variables
     x(i,j)    shipment quantities in cases
     z         total transportation costs in thousands of dollars ;

Positive Variable x ;

Equations
     cost       define objective function
     supply(i)  observe supply limit at plant i
     demand(j)  satisfy demand at market j ;

cost ..         z  =e=  sum((i,j), c(i,j)*x(i,j)) ;

supply(i) ..    sum(j, x(i,j))  =l=  a(i) ;

demand(j) ..    sum(i, x(i,j))  =g=  b(j) ;

Model transport /all/ ;
```

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

Daily SuDoku

Home

Today's SuDoku

SuDoku Archive

SuDoku for Kids

Draw/Play

Discussion

FAQ

Books

Syndication

Links

Email and News

Contact

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

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Christmas tree Sudoku

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
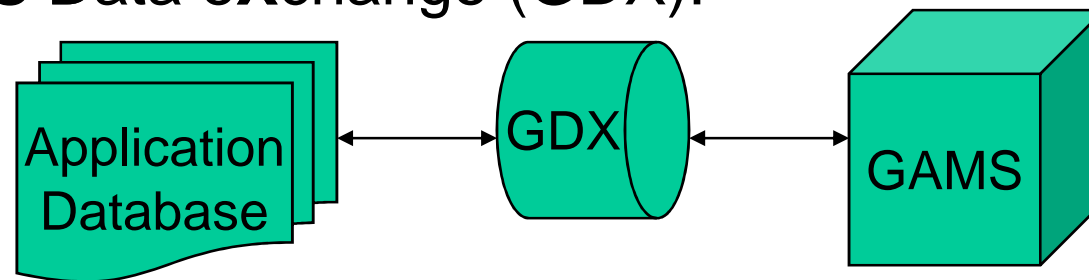
- Reduced Total Cost of Ownership (TCO)

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

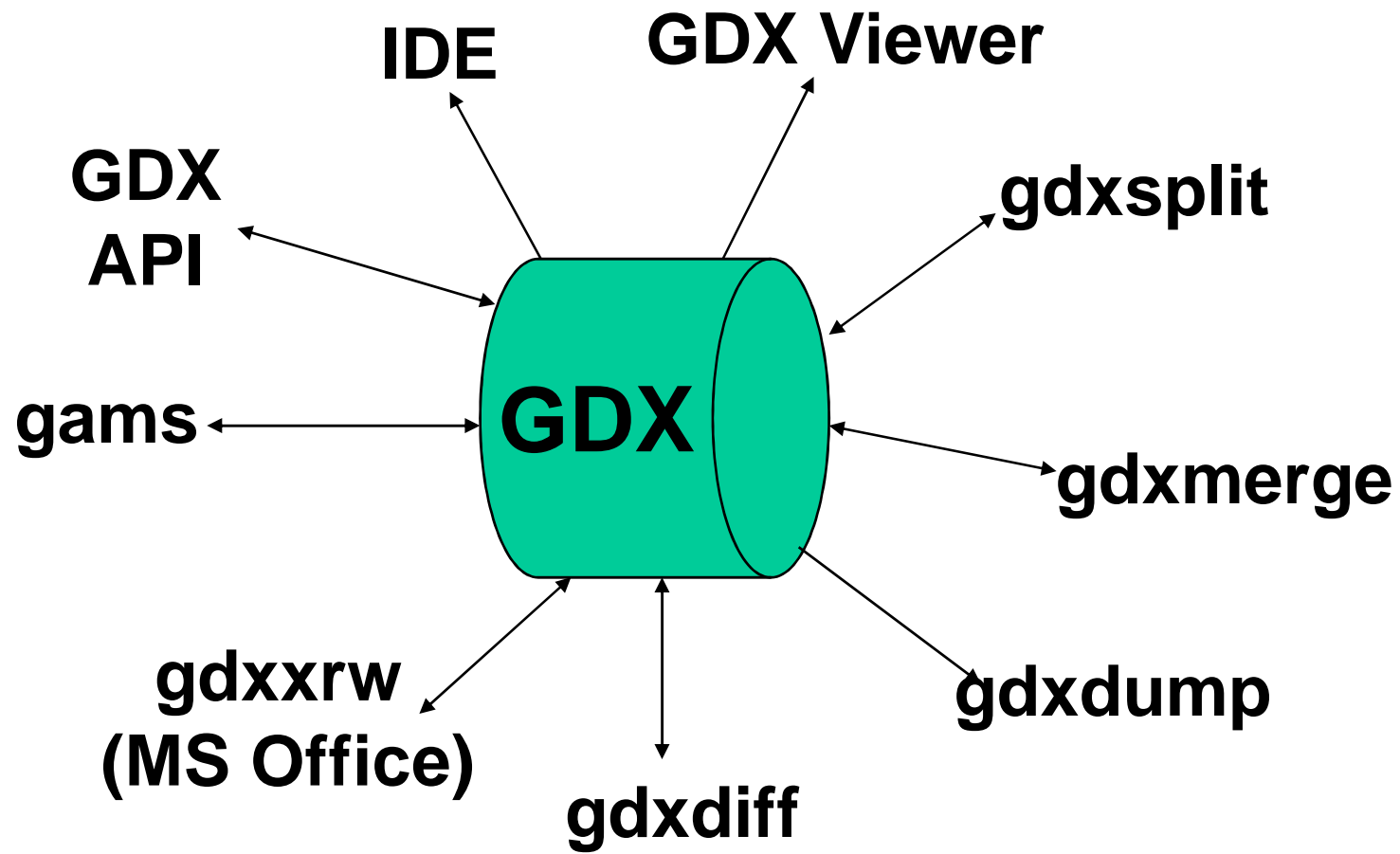- ASCII File Output
  - GAMS Put Facilities

GAMS Data eXchange

- **G**AMS **D**ata e**X**change (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

IDE   GDX Viewer

GDX
API

gams

gdxsplit

GDX

gdxmerge

gdxxrw
(MS Office)

gdxdiff

gdxdump

Samurai Sudoku

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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