GAMS
An Introduction

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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’ Fundamental concepts

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

• Open architecture and interfaces to other systems

• Balanced mix of declarative and procedural elements
System Overview

Connectivity Tools
- Uniform Data Exchange:
  - ASCII
  - GDX (ODBC, SQL, XLS, XML)
- GDX Tools
- Component Library with Interfaces to C++, Java, .NET,…
- Ext. programs
  - EXCEL
  - MATLAB
  - GNUPLOT, …
- CONVERT

GAMS Language Compiler and Execution System

Interactive

API / Batch

User Interfaces

Productivity Tools
- Integrated Development Environment (IDE)
- Integrated Data Browser and Charting Engine
- Model Libraries
- Benchmarking and Deployment
- Model Debugger and Profiler
- Transparent and reproducible Quality Assurance and Testing System
- Data and Model Encryption
- Grid Computing
- Scenario Reduction
- MPSGE for general equilibrium modeling

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

Solvers
- LP/MIP-QCP-MIQCP-NLP/DNLP-MINLP-CNS-MCP-MPEC, global, and stochastic
Supported Model Types (GAMS 22.7)

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Contributed Plug & Play solvers:
- AMPLwrap
- DEA
- Kestrel
## Supported Platforms (GAMS 22.7)

| Solver/Platform availability - 22.7: May 1, 2008 | x86 MS Windows | x86-64 MS Windows | x86 Linux | x86-64 Linux | Sun Solaris | Sun Sparc SOLARIS | Sun Ultra SOLARIS | HP 9000 | DEC 2000-6000 | IBM RS 6000 | Mac PowerPC Darwin | Mac Intel32 Darwin | SGI IRIS3
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1 GAMS distribution for HP 9000/HP-UX is 22.1
2 GAMS distribution for SGI IRIS is 22.3

### Contributed Plug-Play solvers

| Solver | x86 MS Windows | x86-64 MS Windows | x86 Linux | x86-64 Linux | Sun Solaris | Sun Sparc SOLARIS | Sun Ultra SOLARIS | HP 9000 | DEC 2000-6000 | IBM RS 6000 | Mac PowerPC Darwin | Mac Intel32 Darwin | SGI IRIS3
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Downloads by Platform

GAMS 22.5

525+ Downloads a week

GAMS 22.6

550+ Downloads a week
Integrated Development Environment

- Project Management
- Documentation
  - User’s Guide
  - McCarl User’s Guide
  - Solver Manuals
- Model Libraries
- Solver Selection
- Option Editor
- Listing file
  - Tree view
  - Error navigation
- Spell checking
- ...
What is a Model?

• Mathematical Programming (MP) Model
  – List of Equations

• Collection of several intertwined MP Models
  – Data Preparation
  – Data Calibration
  – “Solution” Module (e.g. sequential, parallel, loop)
  – Report Module
A Transportation Model

**Minimize** Transportation cost

**subject to** Demand satisfaction at markets

Supply constraints
\[
\sum_{c,p: (c,p) \in \mathcal{N}} \text{tcost} \cdot \text{dist}(c, p) \cdot x^c_p \rightarrow \min \\
\sum_{c,p: (c,p) \in \mathcal{N}} x^c_p \leq \text{sup}(c) \quad \forall c \\
\sum_{c,p: (c,p) \in \mathcal{N}} x^c_p \geq \text{dem}(p) \quad \forall p \\
x^c_p \geq 0 \quad \forall c, p : (c, p) \in \mathcal{N}
\]
GAMS Algebra

Variables

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

Positive Variable \( x \);

Equations

\( \text{cost} \) define objective function
\( \text{supply}(i) \) observe supply limit at plant \( i \)
\( \text{demand}(j) \) satisfy demand at market \( j \);

\[ z = \text{sum}(i,j), c(i,j) \times x(i,j) \];

\[ \text{supply}(i) = \text{sum}(j, x(i,j)) = a(i) \];

\[ \text{demand}(j) = \text{sum}(i, x(i,j)) = b(j) \];

Model transport /all/ ;
A few Word about GAMS Syntax

- Symbols:
  - Sets
  - Parameters
  - Variables
  - Equations
  - Models
  - ASCII Output Files

- Statements
  - Declarations
  - Data Assignments
  - Equation Definition
  - Programming Flow Control
  - Option statement

```
Sets i    canning plants  / seattle, san-diego /;
Parameters a(i)  capacity of plant i in cases
              / seattle  350
              san-diego  600 /;
Variables x(i,j)  shipment quantities in cases;
Equations supply(i)  observe supply limit at plant i;
Model   transport / all / ;
File    fx    some file / 'c:\t\text.txt' /

Parameter c(i,j);
c(i,j) = f * d(i,j) / 1000 ;
supply(i) ..  sum(j, x(i,j)) =l= a(i);
loop(i, put fx i.t1);
option reslim=10;
```
Input/Output through ASCII Files

• ASCII Input Data
  – Part of model input ($include file.txt)
  – Posix Utilities are part of GAMS System
    • Platform independent data file preparation
    • sed, awk, grep, cut, ...

$call cut -d, -f1,3-5 file.txt > filenew.txt

• ASCII File Output
  – GAMS Put Facilities

file fy /result.csv/;
fy.pc = 5; fy.nd = 4;
loop((i,j)$x.l(i,j),
  put fy i.te(i) j.te(j) x.l(i,j) /;
);
Output using Put Utility

```
file fx /result.txt/;

put fx 'Shipped quantities between plants and markets' /;
put '---------------------------------------------' /;
loop((i,j)$x.l(i,j),
    put 'Shipment from 'i.te(i):10' to 'j.te(j):10' in cases:'x.l(i,j) /;
);
putclose;
```

Shipped quantities between plants and markets
---------------------------------------------

<table>
<thead>
<tr>
<th>Shipment from</th>
<th>to</th>
<th>in cases:</th>
</tr>
</thead>
<tbody>
<tr>
<td>seattle</td>
<td>new-york</td>
<td>50.00</td>
</tr>
<tr>
<td>seattle</td>
<td>chicago</td>
<td>300.00</td>
</tr>
<tr>
<td>san-diego</td>
<td>new-york</td>
<td>275.00</td>
</tr>
<tr>
<td>san-diego</td>
<td>topeka</td>
<td>275.00</td>
</tr>
</tbody>
</table>
### Default Output in .lst File

--- VAR x shipment quantities in cases

<table>
<thead>
<tr>
<th></th>
<th>LOWER</th>
<th>LEVEL</th>
<th>UPPER</th>
<th>MARGINAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>seattle .new-york</td>
<td>.</td>
<td>50.000</td>
<td>+INF</td>
<td>.</td>
</tr>
<tr>
<td>seattle .chicago</td>
<td>.</td>
<td>300.000</td>
<td>+INF</td>
<td>.</td>
</tr>
<tr>
<td>seattle .topeka</td>
<td>.</td>
<td>0.036</td>
<td>+INF</td>
<td>0.036</td>
</tr>
<tr>
<td>san-diego.new-york</td>
<td>.</td>
<td>275.000</td>
<td>+INF</td>
<td>0.009</td>
</tr>
<tr>
<td>san-diego.chicago</td>
<td>.</td>
<td>.</td>
<td>+INF</td>
<td>0.009</td>
</tr>
<tr>
<td>san-diego.topeka</td>
<td>.</td>
<td>275.000</td>
<td>+INF</td>
<td>.</td>
</tr>
</tbody>
</table>
Default Output using Display Statement

---- 68 VARIABLE x.L shipment quantities in cases

<table>
<thead>
<tr>
<th>City</th>
<th>Value 1</th>
<th>Value 2</th>
<th>Value 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>new-york</td>
<td>50.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>seattle</td>
<td>300.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>san-diego</td>
<td>275.000</td>
<td>275.000</td>
<td></td>
</tr>
</tbody>
</table>

---- 68 VARIABLE x.M shipment quantities in cases

<table>
<thead>
<tr>
<th>City</th>
<th>Value 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>seattle</td>
<td>0.036</td>
</tr>
<tr>
<td>san-diego</td>
<td>0.009</td>
</tr>
</tbody>
</table>
Gams Data eXchange

Binary Data Exchange

- Fast exchange of data
- Syntactical check on data before model starts
- Data Exchange at any stage (Compile and Run-time)
- Platform Independent
- Direct Excel connectivity
- General API
- Scenario Management Support
- Full Support of Batch Runs

GDX Tools

GDX Viewer
GDXRank
GDXMerge
GDXDump
GDXDiff
GDXxrw (MS Office)
GAMS
IDE
GDX API
GAMS in Control

Import

External Database

Text Files

GAMS Model

Text Files

Direct Interface (Office Appl.)

Direct Interface (Office Appl.)

Visualization Tools

Export
Application in Control

- Call GAMS

- GAMS

- Call external program (including GAMS)

- External Application

- Programming Language or other Application

- Application
Calling GAMS from an Application

- Through ASCII files or using GDX API

**Creating Input for GAMS Model**

**Callout to a GAMS (DLL/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
GAMS API Files and Examples
Sources of GAMS Information

Download: http://download.gams-software.com/
Contributed Documentation: http://www.gams.com/docs/contributed
Contributed Software: http://www.gams.com/contrib/contrib.htm
Presentations: http://www.gams.com/presentations
Workshops: http://www.gams.com/courses.htm

Bruce McCarl’s Newsletter: http://www.gams.com/maillist/newsletter.htm
GAMS User Group: http://www.gams.com/maillist/gams_l.htm
GAMS Google Group: http://groups.google.de/group/gamsworld
Support Wiki: http://support.gams-software.com

Other relevant sites on the Web: http://www.gams.com/hotlinks.htm
Thanks for your time!

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