GAMS
General Algebraic Modeling System

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GAMS Development Corporation
www.gams.com
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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

- MOSEK
- XPRESS
- XA
- MINOS
- COIN-OR
- BARON
- LINDOLOBAL
- CONOPT
- DICOPT
- GAMS
- BDMLP
- CPLEX
- GUROBI
- ALPHAEC
- LINDOLOBAL
- CONOPT
- BDMLP
- XA
- XPRESS
GAMS at a Glance

10+ Supported MP classes

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

The GAMS/BASE Module

- Compiler and Execution System
- GAMS IDE (Windows)
- Documentation + Model libraries
- GDX Utilities
- Free Solvers
Integrated Development Environment

- Project management
- Editor / Syntax coloring / Spell checking
- Launching and monitoring of (multiple) GAMS processes
- Listing file / Tree view / Syntax-error navigation
- Solver selection / Option selection
- GDX viewer
  - Data cube
  - Data export (e.g. to MS Excel)
  - Charting facilities
- Model libraries
- Documentation
Documentation

• **Distributed Documentation**
  – GAMS Users Guide
  – Expanded GAMS Users Guide (McCarl)
  – Solver Manuals
  – GAMS Utility Manuals

• **Wikis**
  – Support Wiki  [http://support.gams-software.com](http://support.gams-software.com)
  – Interfaces Wiki  [http://interfaces.gams-software.com](http://interfaces.gams-software.com)
Documentation

• **Groups**
  – Google Group [http://groups.google.de/group/gamsworld](http://groups.google.de/group/gamsworld)

• **Newsletter**
  – Release List

• **Search all GAMS Websites** [http://www.gams.com/search.htm](http://www.gams.com/search.htm)
Distributed Model Libraries

- **GAMS Model Library**
  - Example and user-contributed models
  - Very often used as templates
  - Tests for
    - Solver robustness and correctness
    - Backward compatibility

- **GAMS Test Library**
  - Transparent and reproducible Quality Assurance Tests
  - Tests for
    - Solver correctness
    - Special functions
    - GAMS utilities
Distributed Model Libraries

- **GAMS Data Utilities Library**
  - Demonstration of the various utilities interfacing GAMS with other applications
  - E.g. gdxxrw, mdb2gms, sql2gms

- **GAMS EMP Library**
  - Examples for the use of Extended Mathematical Programming

- **Practical Financial Optimization Models**
  Models of the book

  “PRACTICAL FINANCIAL OPTIMIZATION – A Library of GAMS Models”

  by Consiglio, Nielsen and Zenios
Maintained libraries of established and varied set of both theoretical and practical test models:

- CONELib
- GLOBALLib
- LinLib
- MINLPLib
- MPECLib
- MPSGELib
- PrincetonLib
- XPRESSLib
- …
GAMS at a Glance

The GAMS/BASE Module

Free Solvers

- Convert (convert model to different formats)
- EMP, LOGMIP, NLPEC
- BENCH, EXAMINER, GAMSCHK
- BDMLP, LS, and MILES
- COIN-OR Cbc, IpOpt, BonMin, Couenne
- Glpk, Scip (academic only)
GAMS/Convert

Model translation tool

- GAMS → other formats/languages
- Algebraic information still available

e.g.
- GAMS
- Jacobian / Hessian
- MPS / MPI
- NLP2MCP
- Chull
- C Evaluation routines
EMP + LogMIP + NLPEC

• Extended Mathematical Programming (EMP)
  – Framework for automated mathematical programming reformulations such as
    • Bilevel Programs
    • Disjunctive Programs
    • Extended Nonlinear Programs
    • Embedded Complementarity Systems
    • Variational Inequalities

• Logical Mixed Integer Programming (LogMIP)
  – Reformulation and logic-based methods on Generalized Disjunctive Programs (GDP)

• GAMS/NLPEC
  – Solves MPECs as NLPs
  – 20+ different reformulation strategies
GAMS/Bench + Examiner

• Bench
  – Benchmarks GAMS solvers
  – Creates problem matrix once and gives it to all solvers
  – Creates trace files for visualization
  – Can call GAMS/Examiner to verify correctness of solutions

• Examiner
  – produces an unbiased, independent report on the merit of points
  – Points may come from GAMS or a solver
  – tolerances can be adjusted, default is tight
An initiative to spur the development of open-source software for the OR community

http://www.coin-or.org/

• A repository of currently ~30 open-source projects
  – Solvers
  – Interfaces
  – Tools

• An active OR community
  – Mailing lists
  – Google group
  – Wikis
The Coin-OR / GAMSLinks Project

https://projects.coin-or.org/GAMSLinks

Stefan Vigerske (Humboldt-University Berlin)

Goals

• easy access to COIN-OR solvers via GAMS
• broadening the audience of COIN-OR
• broadening the audience of GAMS
• help developers to connect their solvers to GAMS
• provide access to GAMS benchmarking and quality assurance tools
GAMS interfaces to open-source Solvers

- COIN-OR Linear Programming (CLP) and Branch and Cut (CBC)
  - state of the art LP and MIP solver from J. Forrest

- Gnu Linear Programming Kit (GLPK)
  - LP and MIP solver from A. Makhorin

- Interior Point Optimizer (IPOPT)
  - large scale NLP solver from A. Wächter

- Solving Constraint Integer Programs (SCIP)
  - LP/MIP solver developed at Zuse Institute Berlin (ZIB)
The Coin-OR / GAMSLinks Project

GAMS interfaces to open-source Solvers

- Basic Open-source Nonlinear Mixed Integer programming (**BONMIN**)
  - Branch and Cut based MINLP solver from P. Bonami et.al.

- Convex Over and Under Envelopes for Nonlinear Estimation (**COUENNE**)
  - Branch and Bound MINLP solver

- Lagrangian Global Optimizer (**LaGO**)
  - Convexification and Branch and Cut based MINLP solver from I. Nowak and S. Vigerske
The Coin-OR / GAMSLinks Project

Performance Benchmark of MIP codes free for academic use by H. Mittelmann. Solution times are geometric means where unsolved instances were assigned a 2 hours solution time (time limit). Details at scip.zib.de

GAMS QA and testing supports maturing of COIN-OR solvers!

Coin-OR solvers enable GAMS to offer dependable free solvers!
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 GDX interfaces and general API
- Scenario Management Support
- Full Support of Batch Runs
GAMS in Control

GAMS Model

Direct GDX Interface

External Database

Import

Export

Direct GDX Interface

External Database

GUIs
Application in Control

Application

- GDX API
- GDX Container
- Creating Input
- GAMS (Executable / DLL)
- Call GAMS
- GDX API
- GDX Container
- Reading Solution
GAMS 23.3 Beta

- Released today!  
  
  - 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)
Session: Software Demonstration

• GAMS Development Corporation – Rapid Application Prototyping with GAMS
  Lutz Westermann

Session: Algorithms and Tools for Optimization

• GDXMRW:
  Exchanging Data Between GAMS and Matlab
  Steven Dirkse
Session: Optimization in Practice V – Modeling
(13:30-15:00)

- GAMS – Features You Might Not Know About
  Alex Meeraus
WEDNESDAY

GAMS Talks at INFORMS 2009

Session: Data Mapping Frameworks for Interfacing Modeling System Data to Other Tools
(12:45-14:15)

• GAMS Data Exchange (GDX) Tools and Utilities
  Paul van der Eijk

• GAMS Branch-and-cut and Heuristic Facility
  Michael Bussieck
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