GAMS
General Algebraic Modeling System

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www.gams.de
GAMS Development Corporation
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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
- BARON
- LINDOGLOBAL
- GUROBI
- CONOPT
- MINOS
- DICOPT
- ALPHAECP
- MOSEK
GAMS at a Glance

10+ Supported MP classes

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

10+ Supported Platforms

Solaris 64bit
Solaris
AXU
AIX
Linux 64bit
Mac
Windows 64bit
Linux
HP
Windows
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
  – Interfaces Wiki http://interfaces.gams-software.com
• **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
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
GAMSworld Model Libraries

Maintained libraries of established and varied set of both theoretical and practical test models:

- CONELib
- GLOBALLib
- LinLib
- MINLPLib
- MPECCLib
- MPSGELib
- PrincetonLib
- XPRESSLib
- …
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

GDX Tools

- Invert
- IDE
- GDX Viewer
- GDXrank
- GDX2HAR/HAR2GDX
- GDXmerge
- GDXdump
- MDB2GMS
- GDXdiff
- GDXcopy
GAMS in Control

GAMS Model

Import
- Direct GDX Interface
- External Database

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
Layout of an Integrated Model

Integrated Model

- Data Import Module
- Data Manipulation Module
- Solution Module
- Report Module

GDX Container

GDX Container

GDX Container

GDX Container

GDX Container

MS Excel

MS Excel
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)
Model translation tool

- GAMS \(\rightarrow\) 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
The Coin-OR / GAMSLinks Project

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

Download

www.gams.de  www.gams.com

Free Euro 2009 Evaluation License

www.gams.com/evals/e09
GAMS Talks at EURO 2009 – Monday

Session: Optimization Modeling in Practice I (MA-22)

• Using utility computing to provide mathematical programming resources
  Franz Nelissen
• GAMS - features you might not know about
  Alex Meeraus  (08:00-09:20)

Session: Stochastic programming II (MD-13)

• Stochastic optimization: recent enhancements in algebraic modeling systems
  Michael Bussieck  (13:35-14:55)
GAMS Talks at EURO 2009 - Tuesday

Session: Software for OR/MS II (TE-42)

• Rapid application prototyping with GAMS
  
  Lutz Westermann

  (14:30-15:50)

Session: Parallel Nonlinear Programming Algorithms

• Formulating and solving non-standard model types using gams/emp
  
  Jan-Hendrik Jagla

  (16:05-17:25)