GAMS

General Algebraic Modeling System

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GAMS Software GmbH

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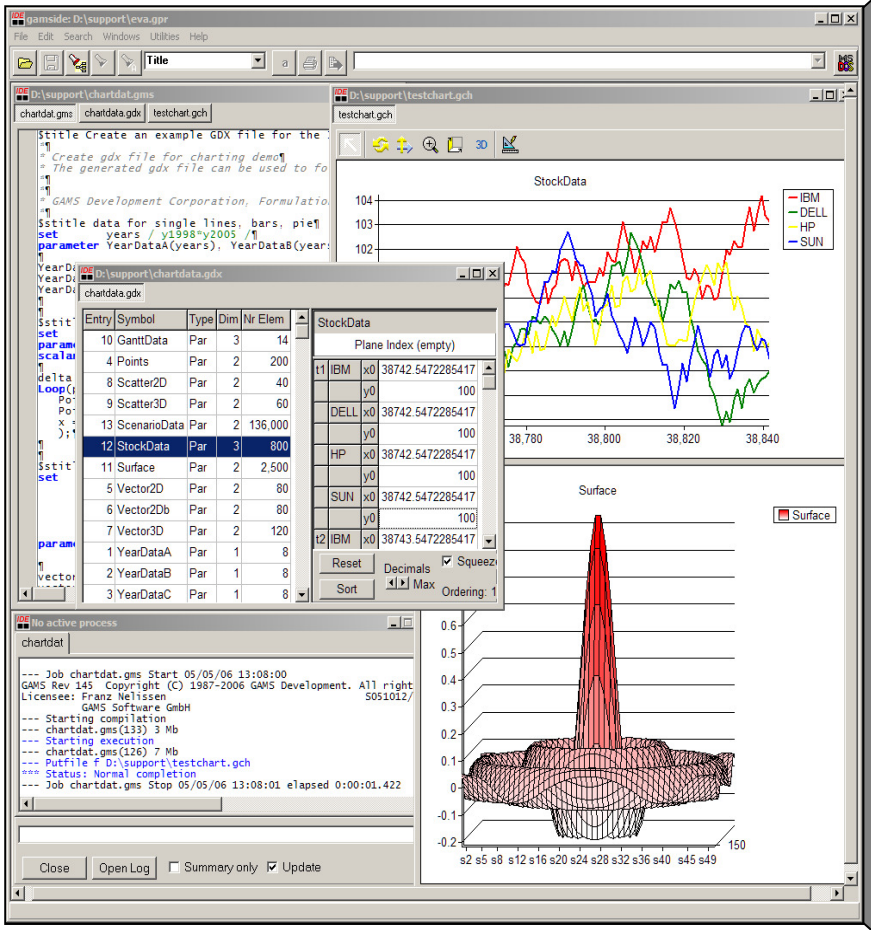
INFORMS 2009 San Diego

GAMS at a Glance



Algebraic Modeling System

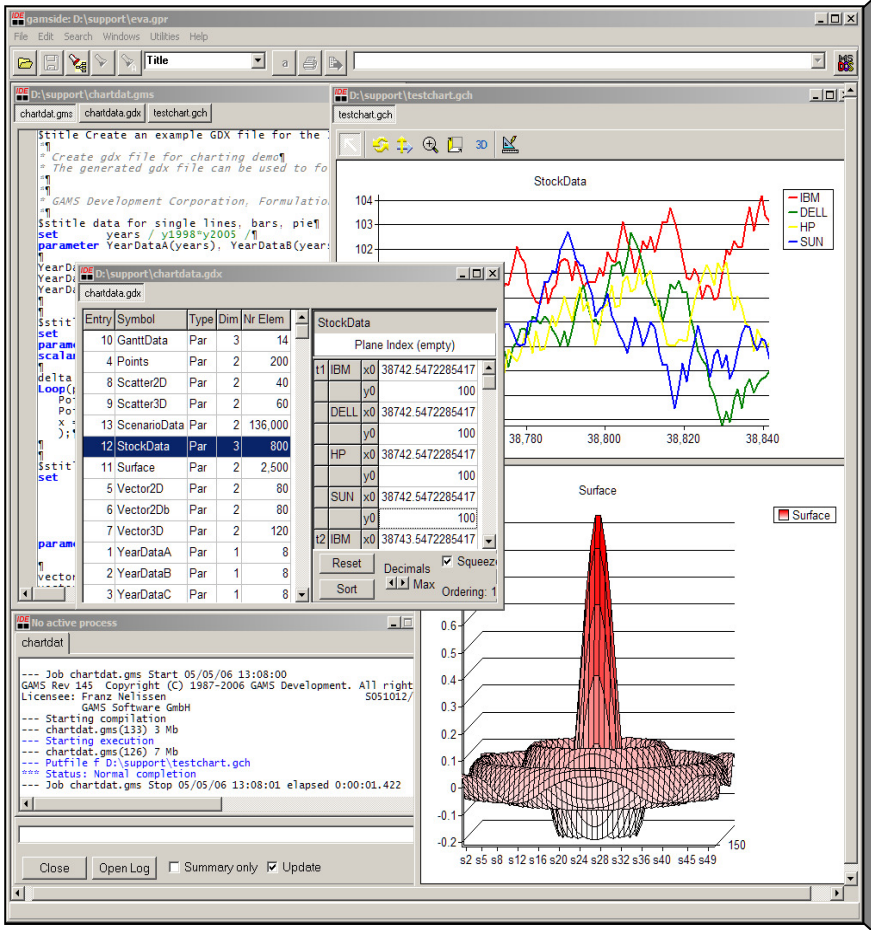
- Facilitates to formulate mathematical optimization problems similar to algebraic notation

  ➔ Simplified model building

- Provides links to appropriate state-of-the-art external algorithms

  ➔ Efficient solution process

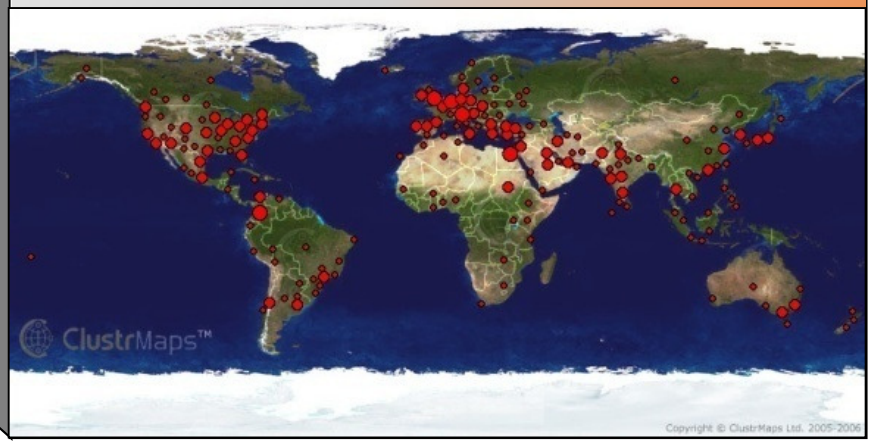
GAMS at a Glance



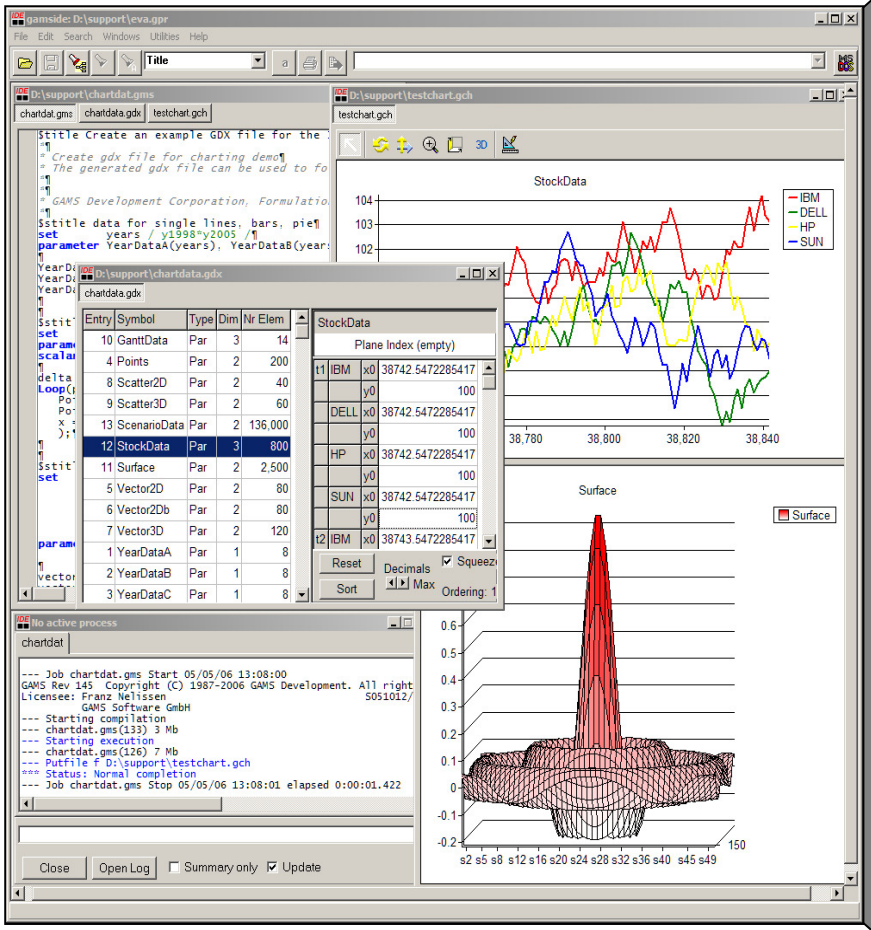
General **A**lgebraic **M**odeling **S**ystem

- Roots: World Bank, 1976
- Went commercial in 1987
- GAMS Development Corp.
- GAMS Software GmbH

- Broad academic & commercial user community and network



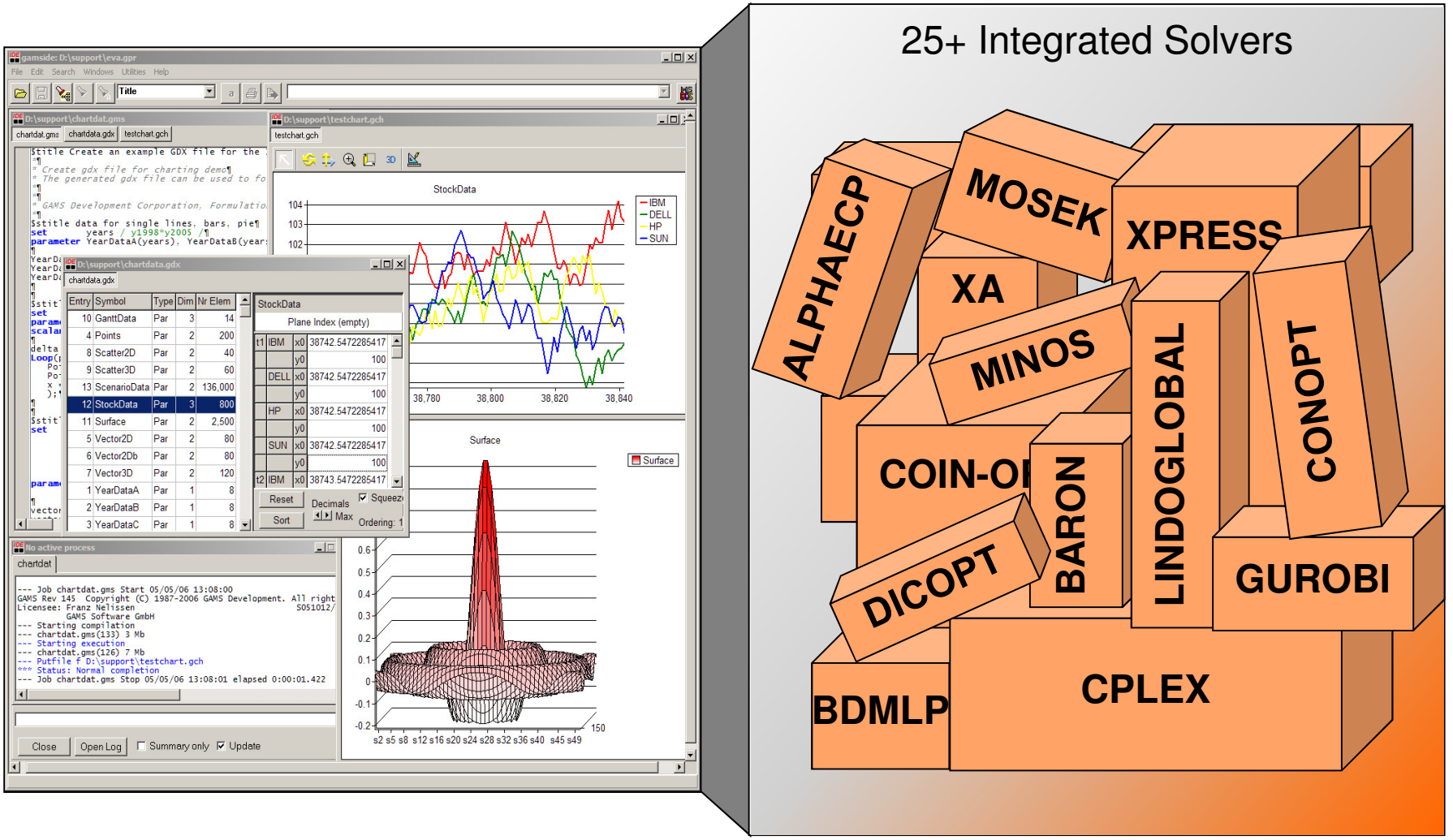
GAMS at a Glance



General **A**lgebraic **M**odeling **S**ystem

- 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



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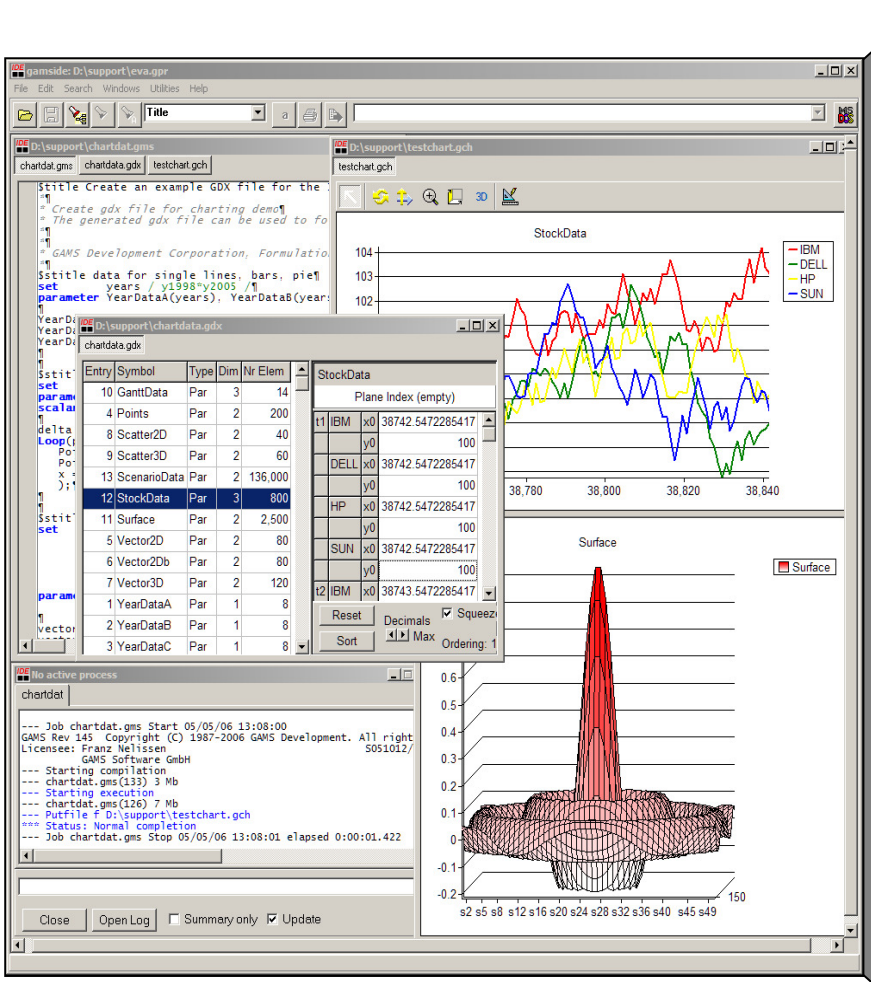

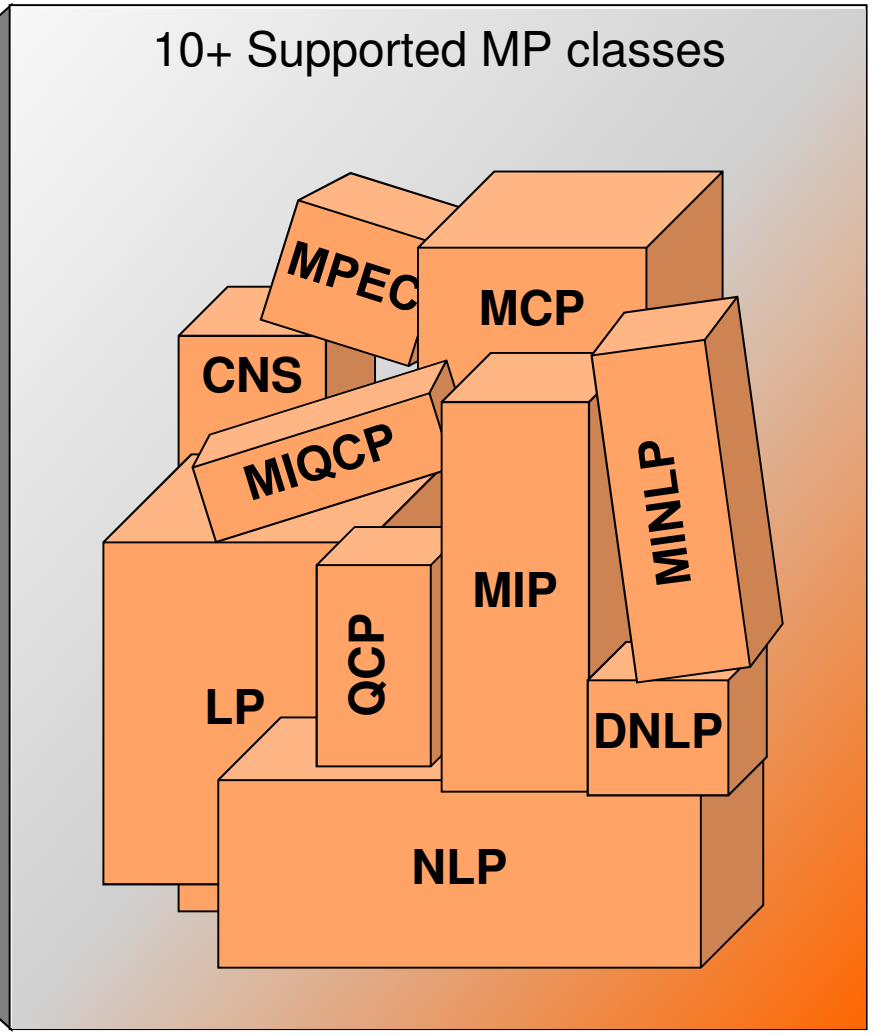

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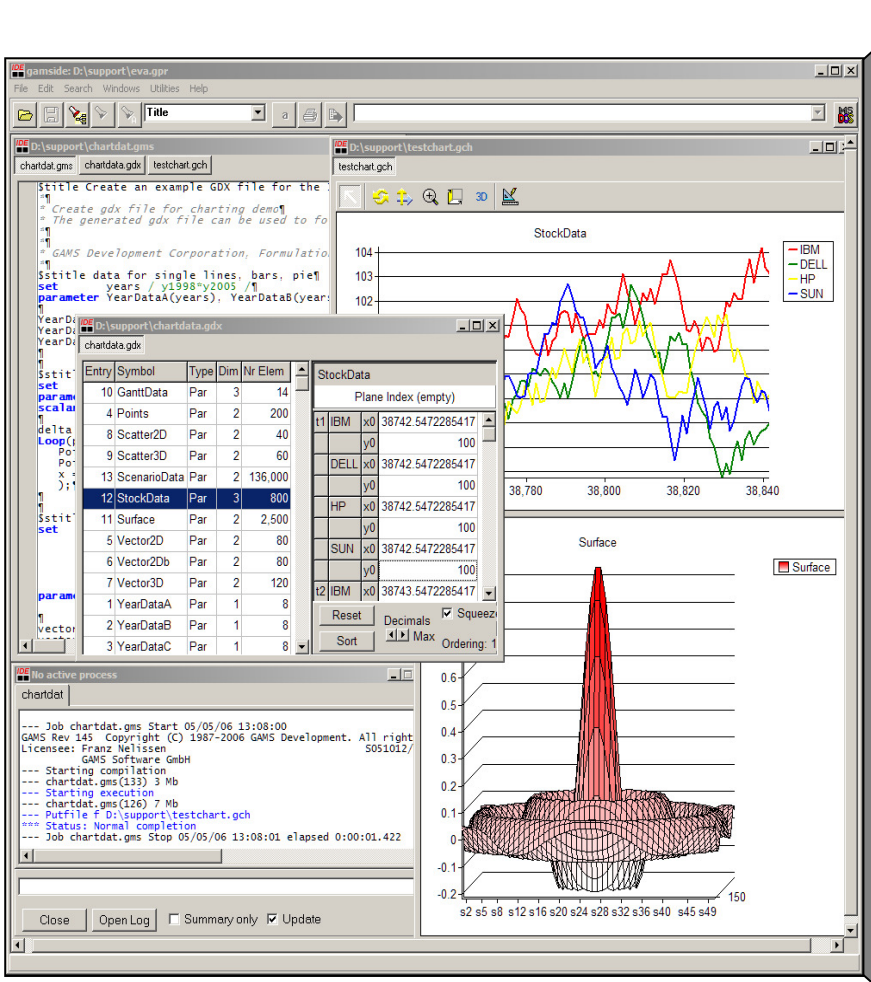
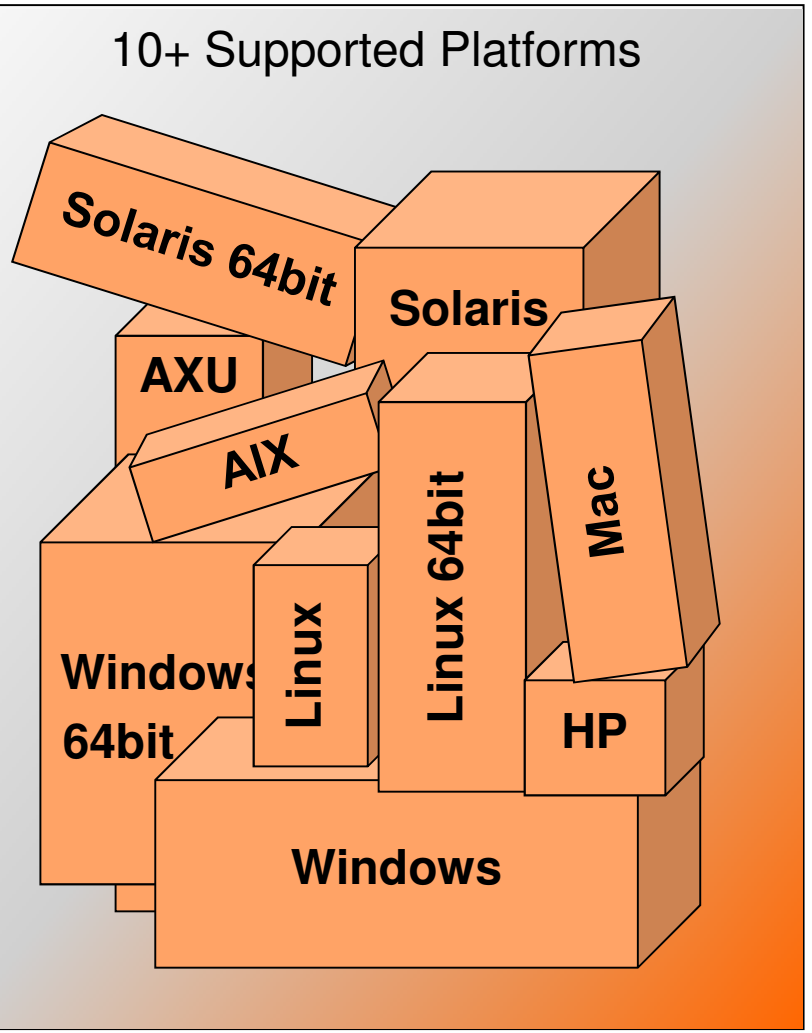




GAMS' Fundamental concepts

- **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**

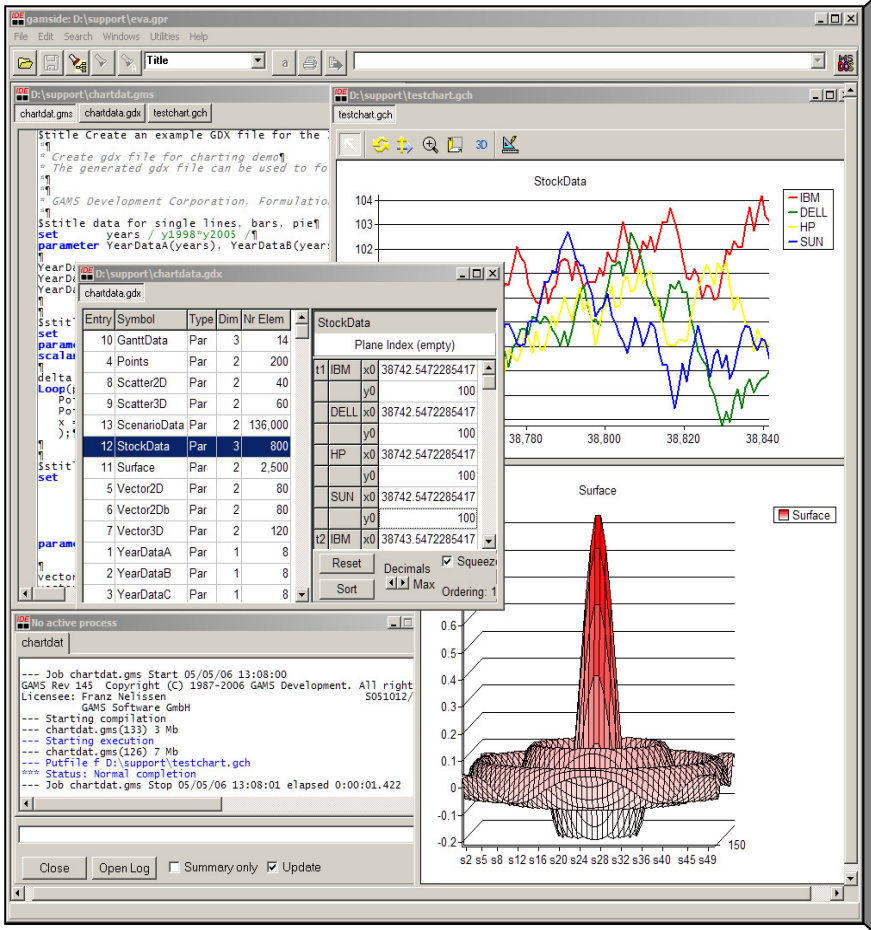
GAMS' Fundamental concepts

- **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

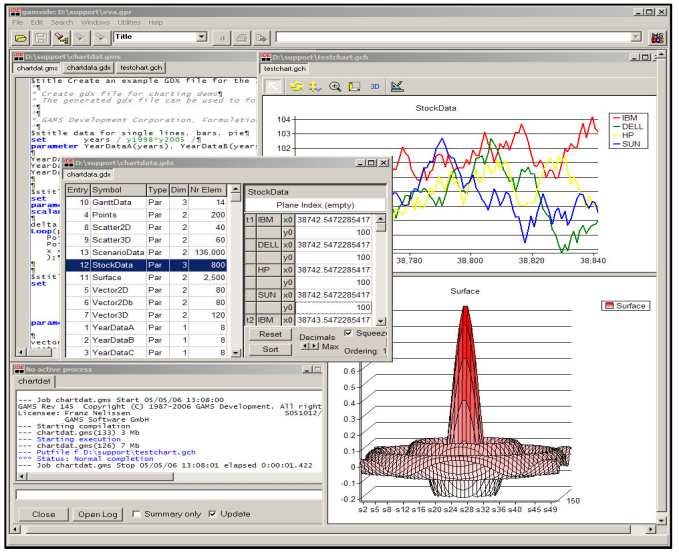


The GAMS/BASE Module

- 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

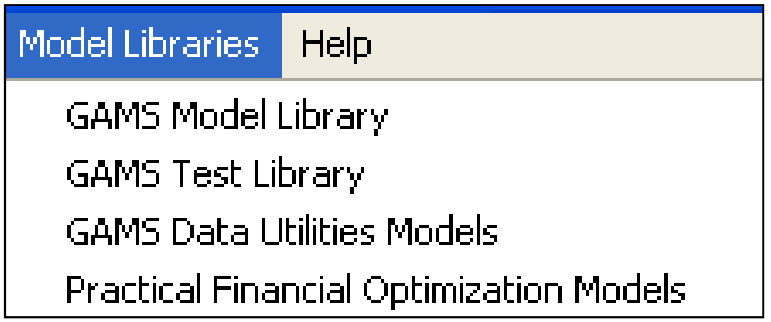
- **Wikis**
  - Support Wiki http://support.gams-software.com
  - Interfaces Wiki http://interfaces.gams-software.com

Documentation

- **Groups**
  - User Group http://www.gams.com/maillist/gams_l.htm
  - Google Group http://groups.google.de/group/gamsworld
- **Newsletter**
  - McCarl's News http://www.gams.com/maillist/newsletter.htm
  - Release List
- **Search all GAMS Websites** 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

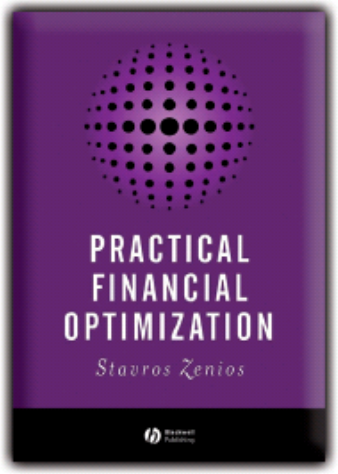


- **GAMS Test Library**
  - Transparent and reproducible Quality Assurance Tests
  - Tests for
    - Solver correctness
    - Special functions
    - GAMS utilities

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

GAMSworld Model Libraries

GAMS World

The Worlds
- CONE
- GLOBAL
- MINLP
- MPEC
- MPSGE
- Performance
- Translation

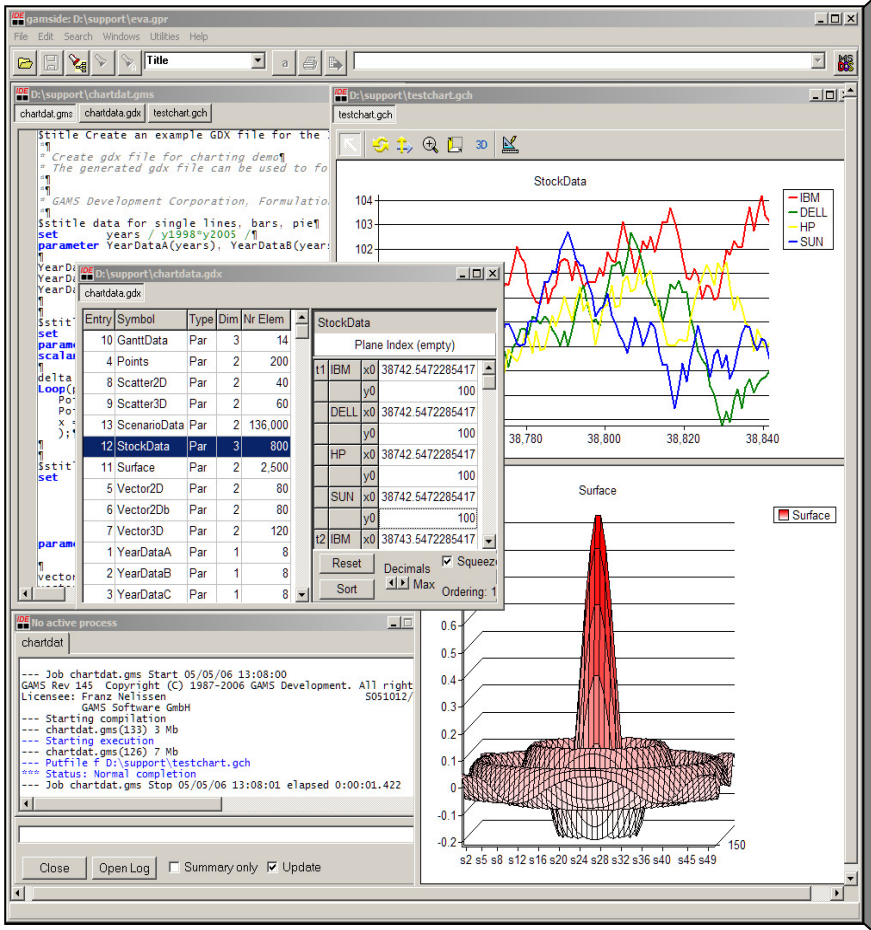
Search

Contact

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)

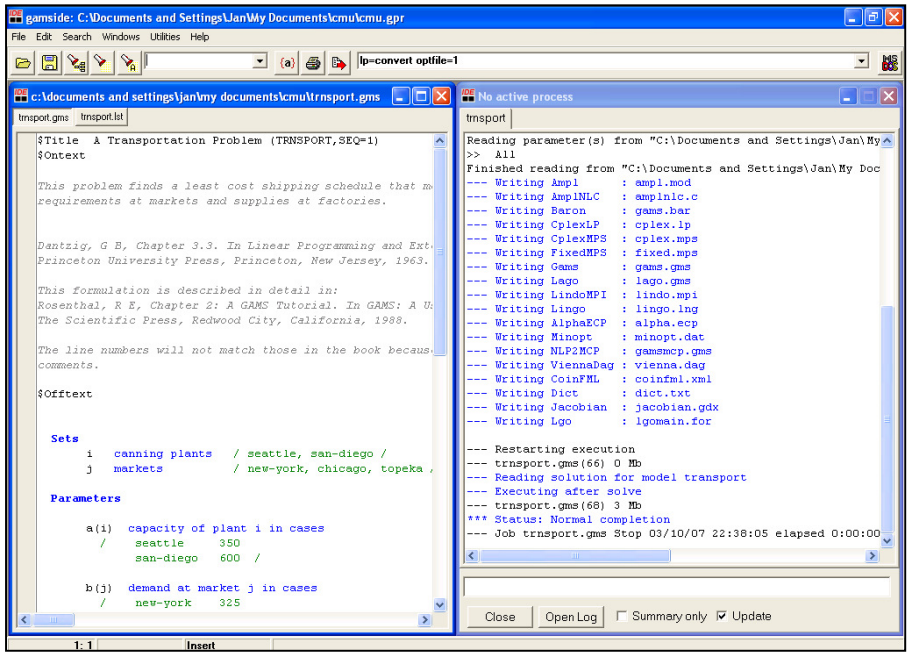
GAMS/Convert

Model translation tool

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

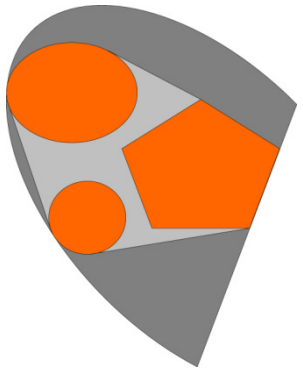
e.g.

- GAMS
- Jacobian / Hessian
- MPS / MPI
- NLP2MCP
- Chull
- C Evaluation routines



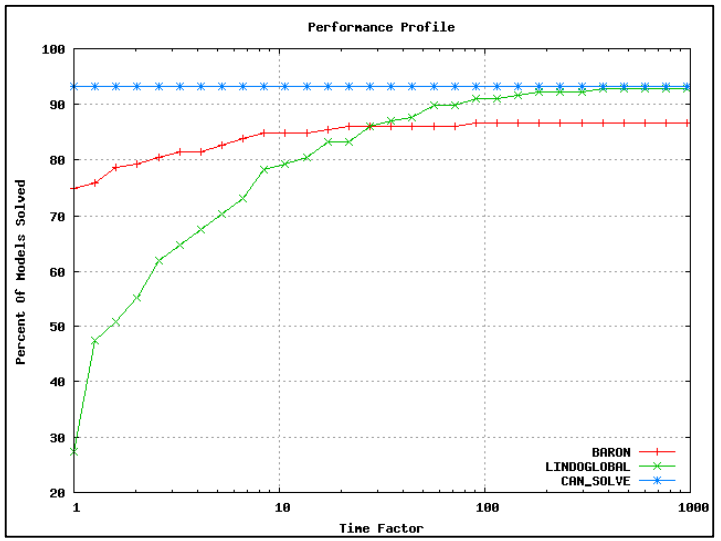
EMP + LogMIP + NLPEC

- 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

Coin-OR

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

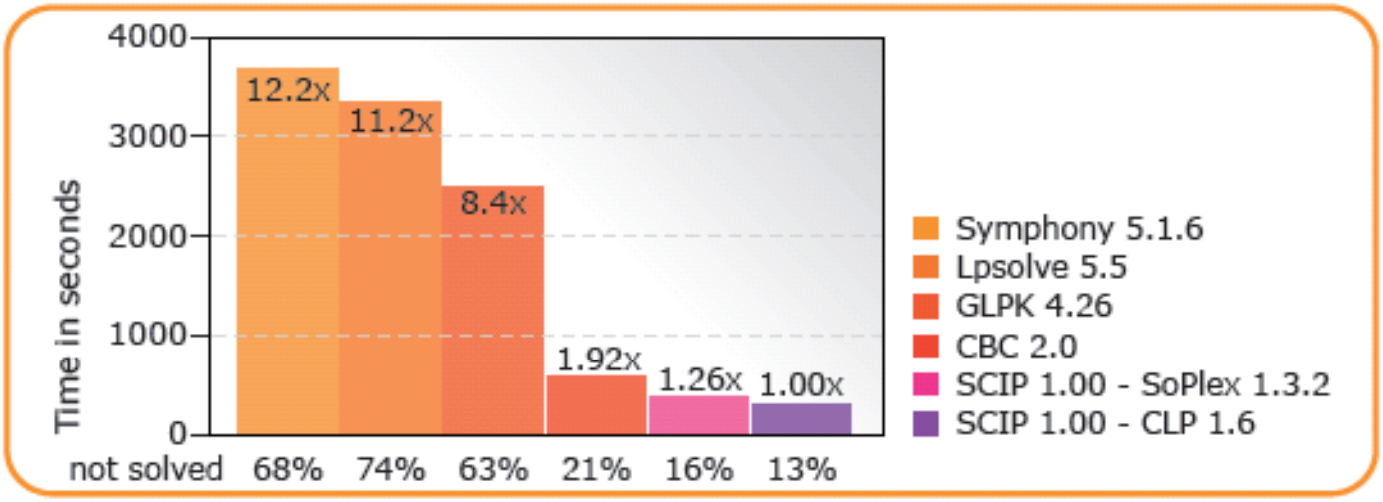
- COIN-OR Linear Programming (**CLP**) and Branch and Cut (**CBC**)
  - state of the art LP and MIP solver from J. Forrest
- Gnu Linear Programming Kit (**GLPK**)
  - LP and MIP solver from A. Makhorin
- Interior Point Optimizer (**IPOPT**)
  - large scale NLP solver from A. Wächter
- Solving Constraint 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



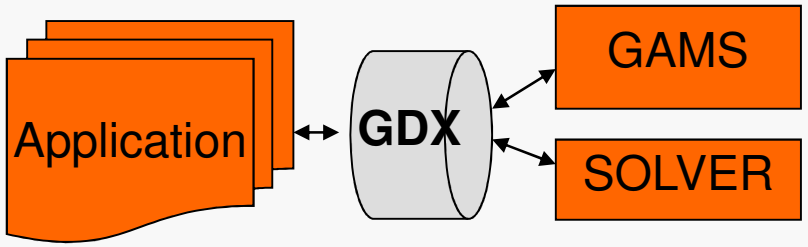
Performance Benchmark of MIP codes free for academic use by H. Mittelmann. Solution times are geometric means where unsolved instances were assigned a 2 hours solution time (time limit). Details at scip.zib.de

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

Coin-OR solvers enable GAMS to offer dependable free solvers!

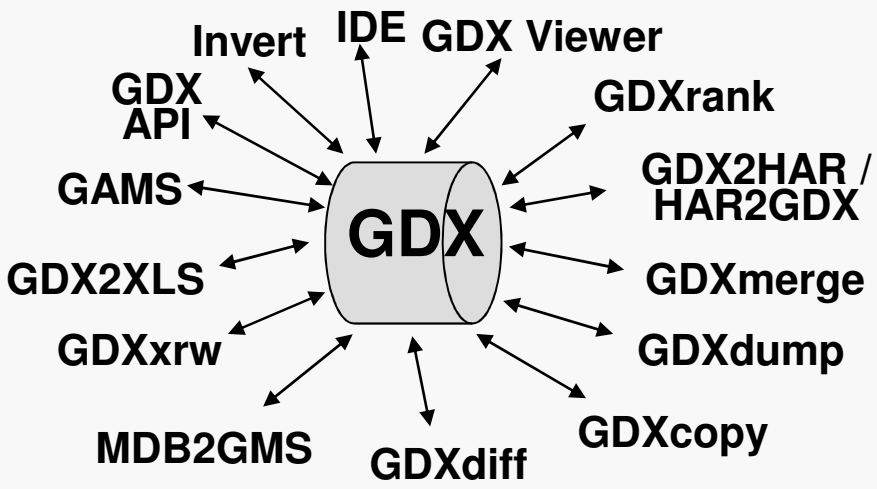
Gams Data eXchange

Binary Data Exchange

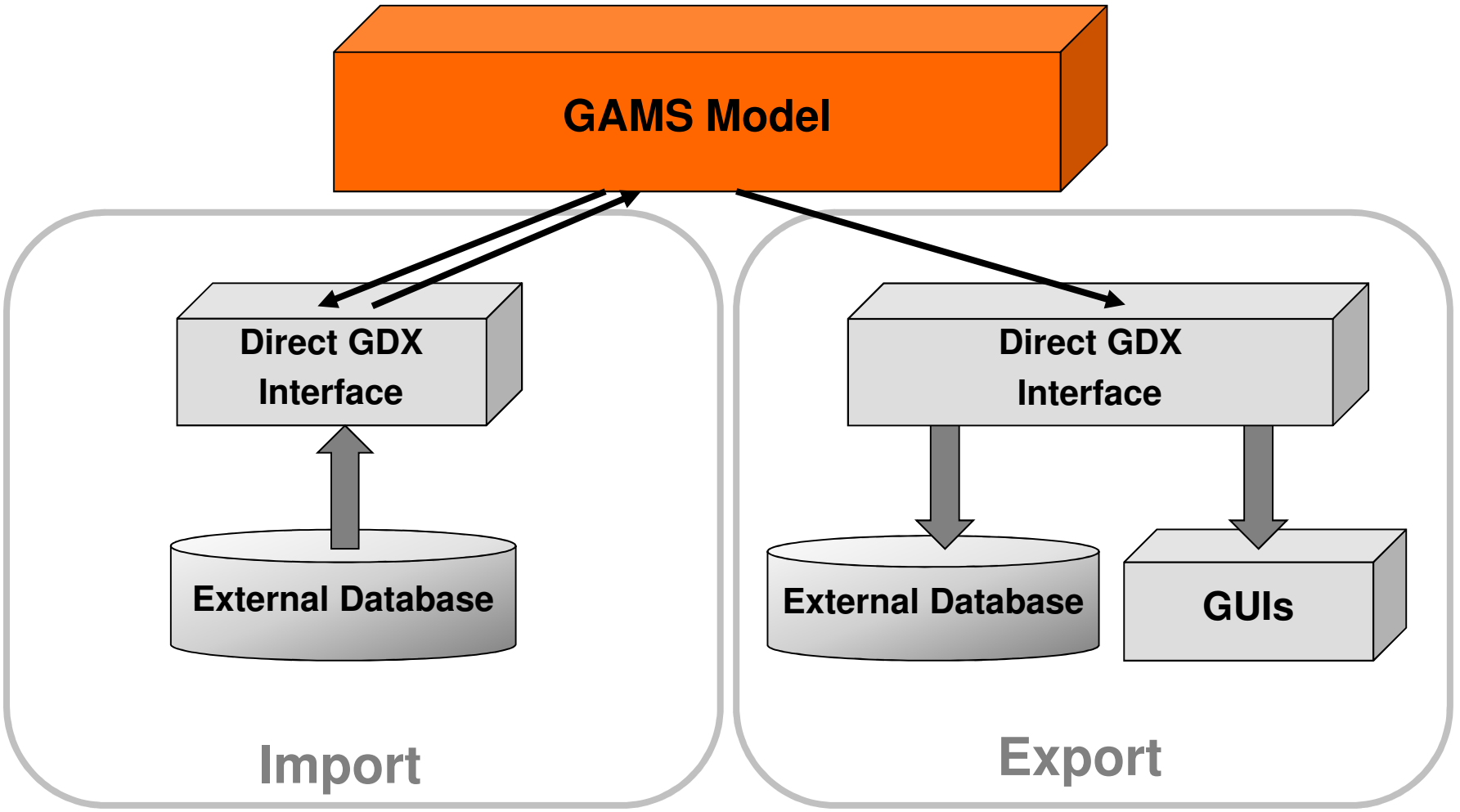


- Fast exchange of data
- Syntactical check on data before model starts
- Data Exchange at any stage (Compile and Run-time)
- Platform Independent
- Direct GDX interfaces and general API
- Scenario Management Support
- Full Support of Batch Runs

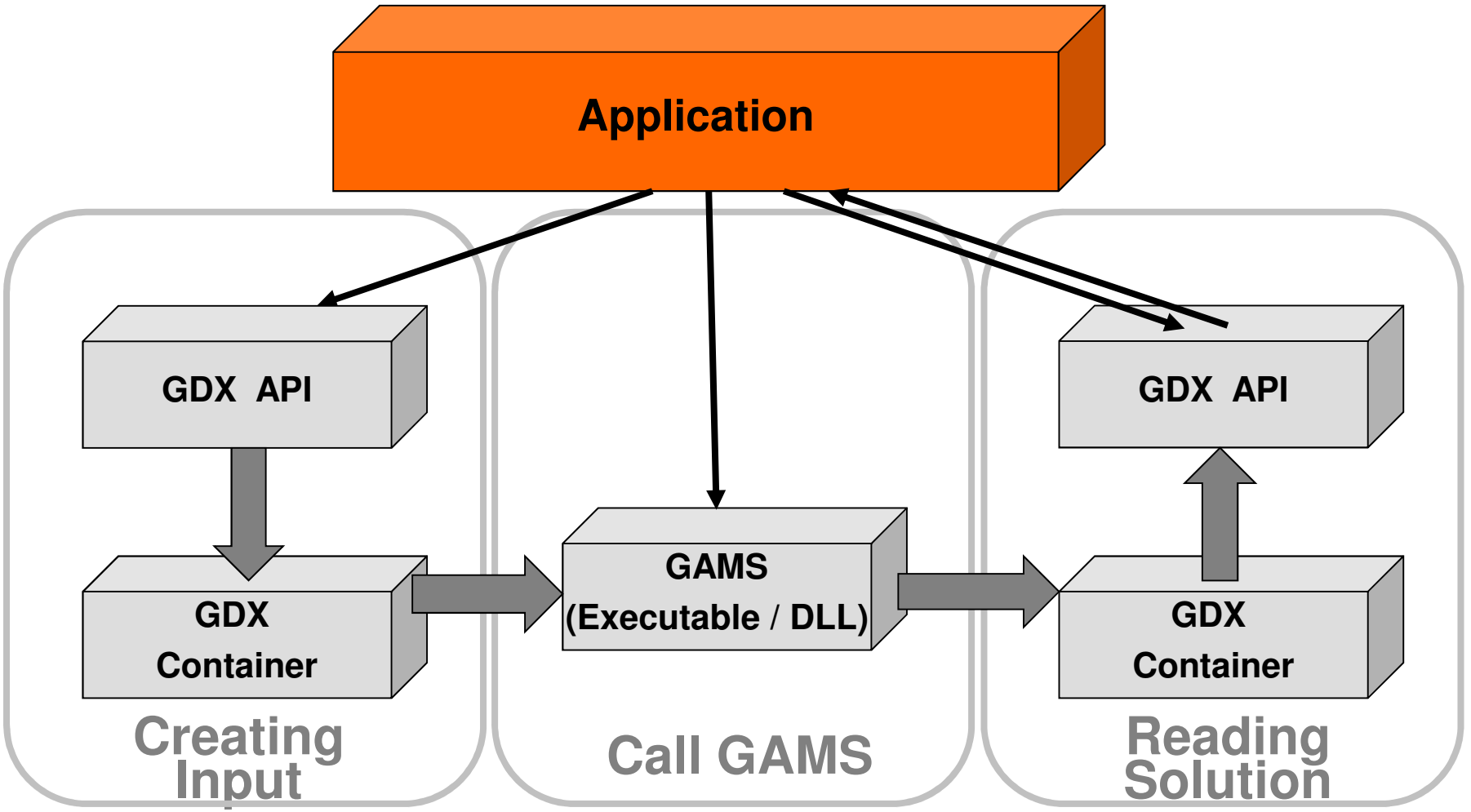
GDX Tools



GAMS in Control



Application in Control



GAMS 23.3 Beta

- Released today! www.gams.com/beta
  - 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)

GAMS Talks at INFORMS 2009

SUNDAY

Session: Software Demonstration

(11:00-12:30)

- **GAMS Development Corporation –**
  Rapid Application Prototyping with GAMS
  Lutz Westermann

Session: Algorithms and Tools for Optimization

(11:00-12:30)

- **GDXMRW:**
  Exchanging Data Between GAMS and Matlab
  Steven Dirkse

GAMS Talks at INFORMS 2009

TUESDAY

Session: Optimization in Practice V – Modeling
(13:30-15:00)

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

GAMS Talks at INFORMS 2009

WEDNESDAY

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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