



GAMS

General Algebraic Modeling System

Michael Bussieck mbussieck@gams.com

Lutz Westermann lwestermann@gams.com

GAMS Development Corporation

www.gams.com

GAMS Software GmbH

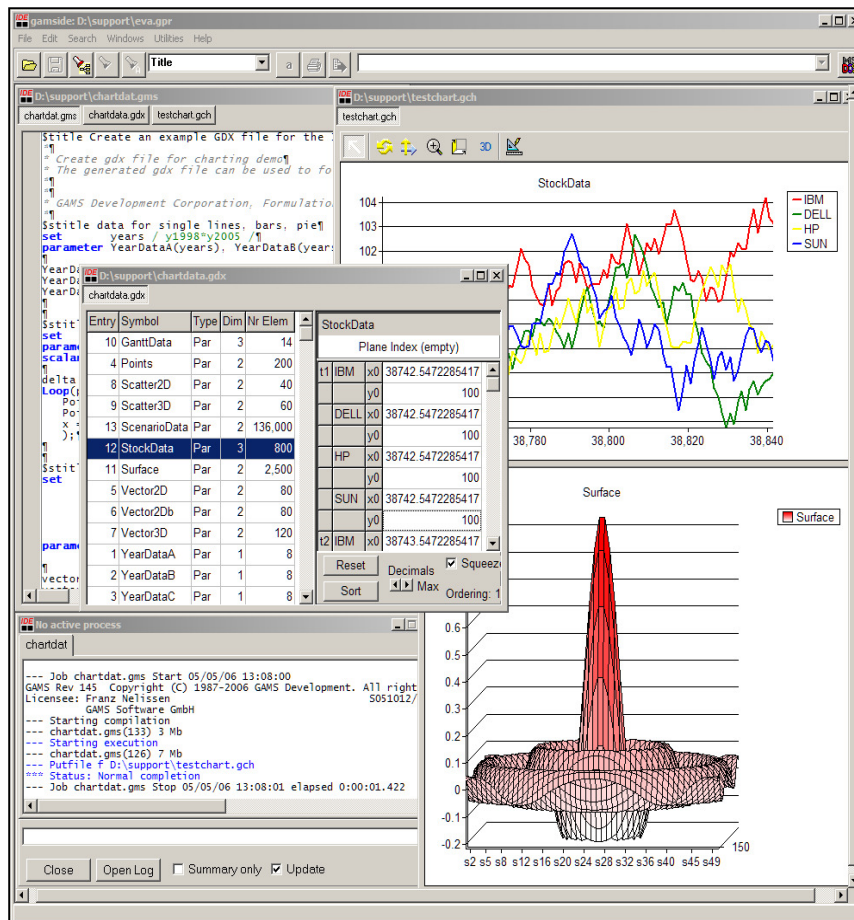
www.gams.de



INFORMS 2009 San Diego



GAMS at a Glance

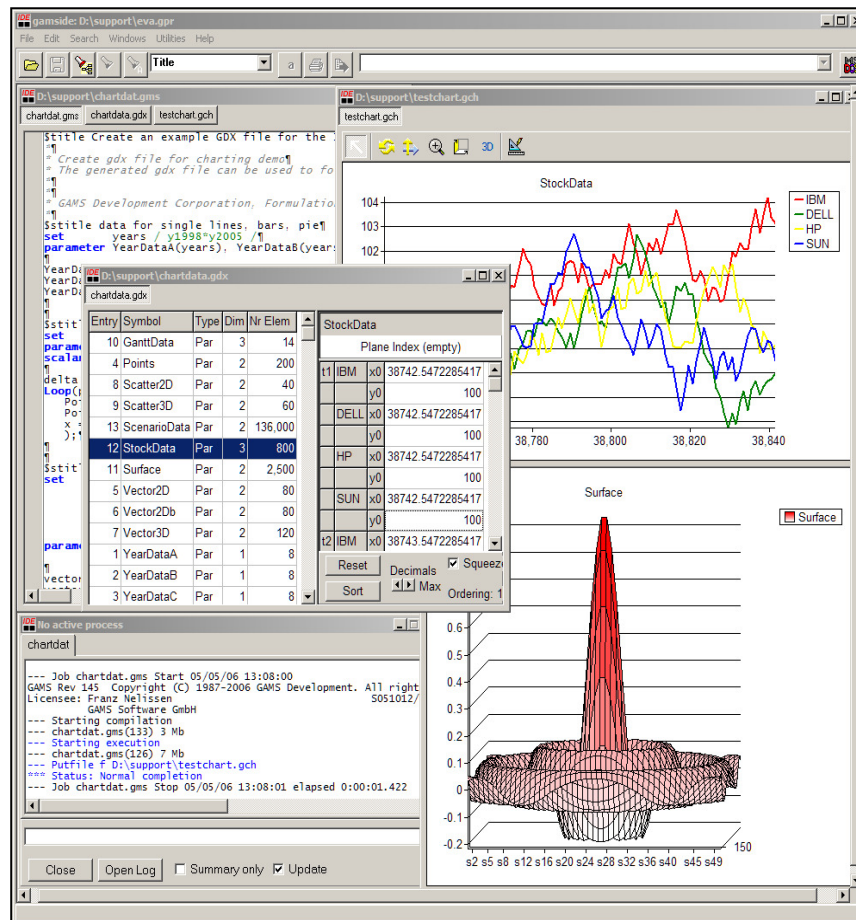


Algebraic Modeling System

- 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

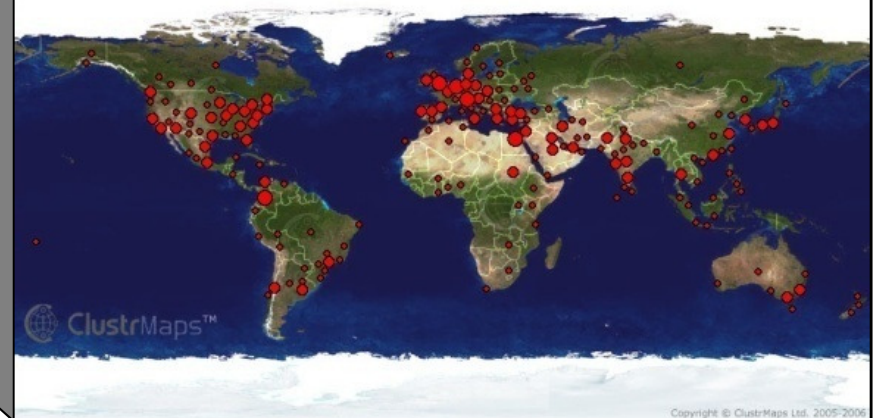


GAMS at a Glance



General Algebraic Modeling System

- Roots: World Bank, 1976
- Went commercial in 1987
- GAMS Development Corp.
- GAMS Software GmbH
- Broad academic & commercial user community and network



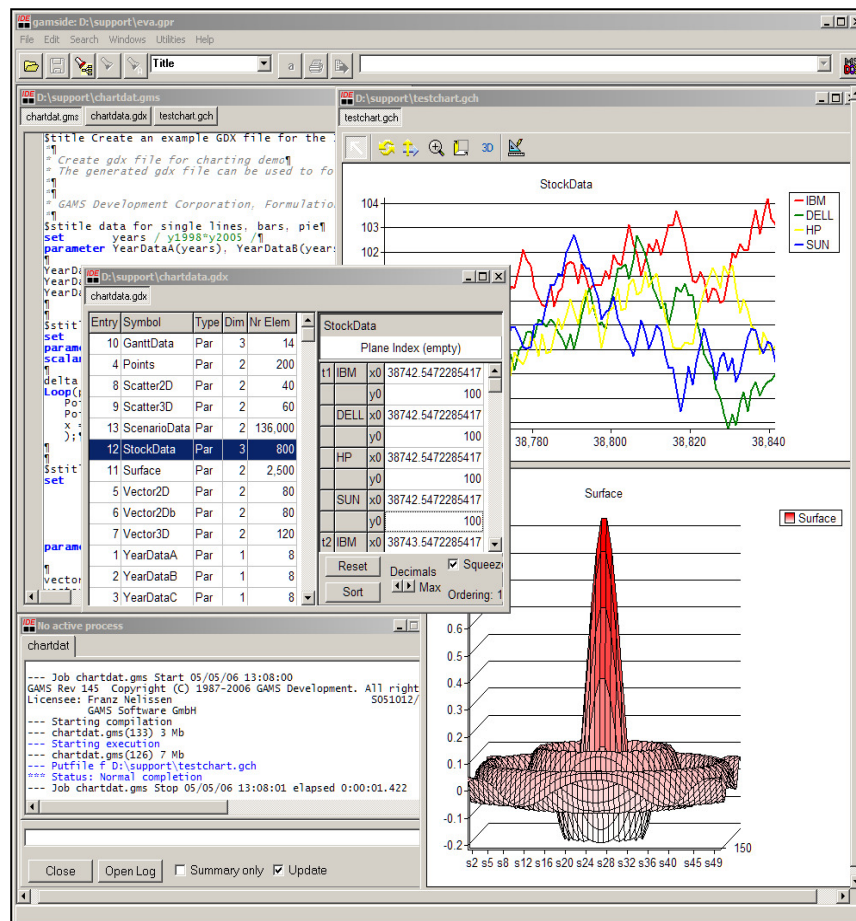
The screenshot shows the GAMS software interface with the following components:

- Top Panel:** File Edit Search Windows Utilities Help
- Left Panel:** File Explorer showing the project structure:
 - chartdat.gms
 - chartdata.gdx
 - testchart.gch
- Main Panel:** Contains a code editor and a results window.
 - Code Editor:** Displays the GAMS script for creating a GDX file for charting. It includes comments and parameters for data sets like 'StockData' and 'Surface'.
 - Results Window:** Displays the output of the GAMS execution, including the 'Job chartdat.gms' status and the 'Starting compilation' details.
- Right Panel:** Contains a 3D plot titled 'Surface' showing a surface plot of the data.

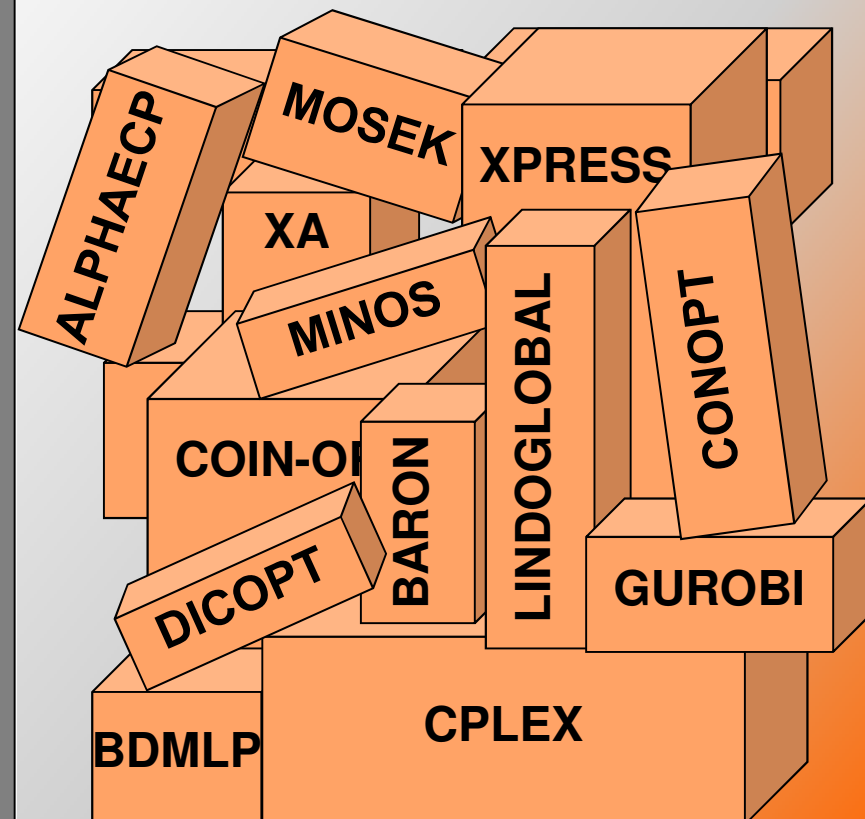
- Algebraic Modeling Language
- 25+ Integrated Solvers
- 10+ Supported MP classes
- 10+ Supported Platforms
- Connectivity- & Productivity Tools
 - IDE
 - Model Libraries
 - GDX, Interfaces & Tools
 - Grid Computing
 - Benchmarking
 - Compression & Encryption
 - Deployment System
 - ...



GAMS at a Glance



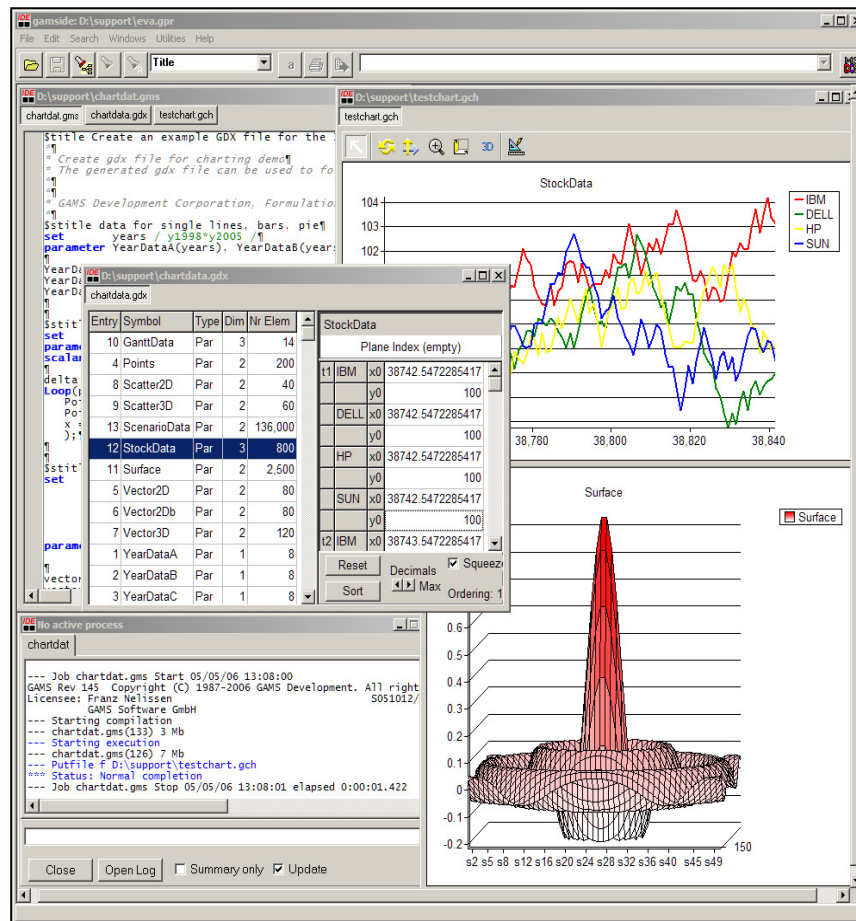
25+ Integrated Solvers



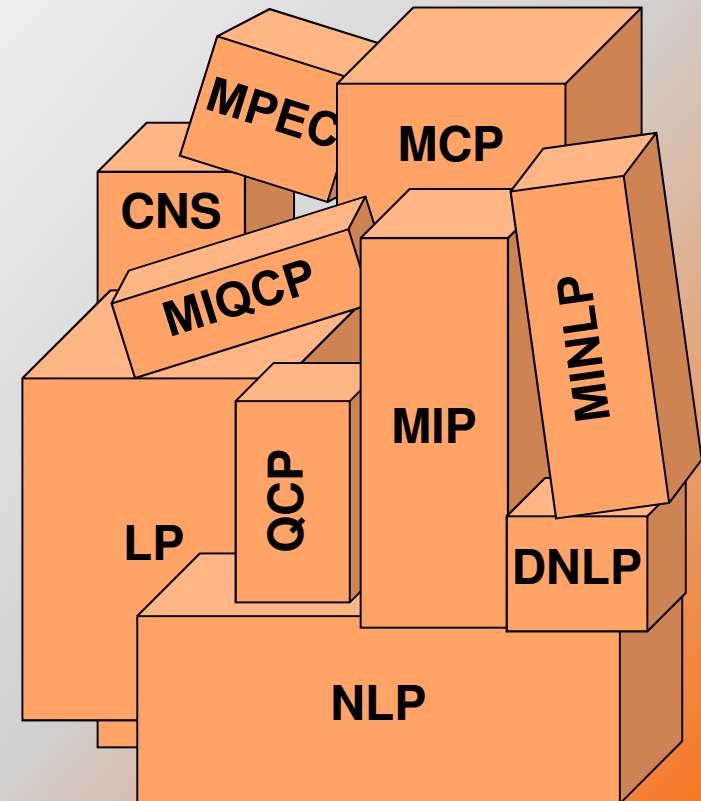
GAMS



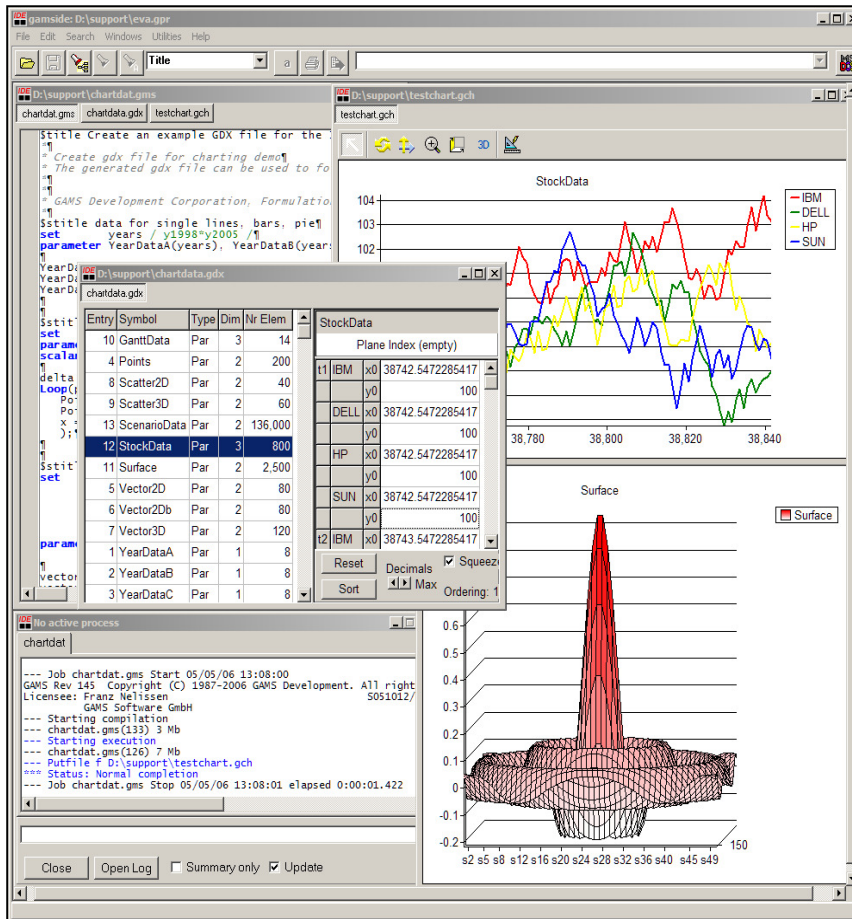
GAMS at a Glance



10+ Supported MP classes



GAMS at a Glance



10+ Supported Platforms

Solaris 64bit

Solaris

AXU

AIX

Mac

Linux

Linux 64bit

HP

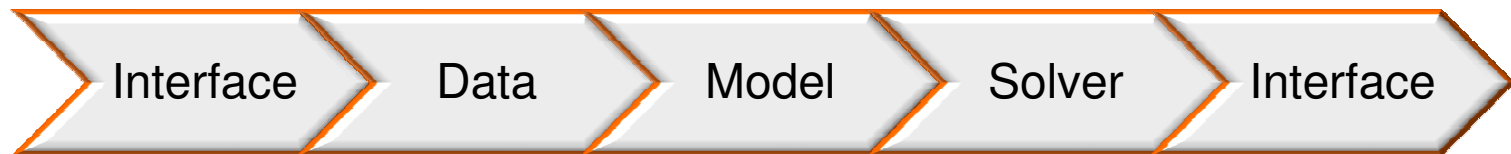
Windows 64bit

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**





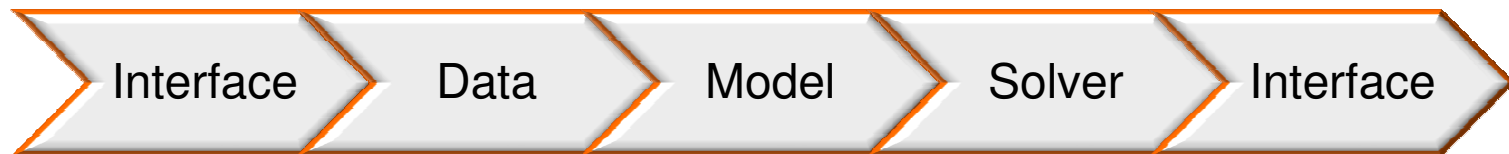
GAMS' Fundamental concepts

- **Different layers with separation of**

- model and data
- model and solution methods
- model and operating system
- model and interface

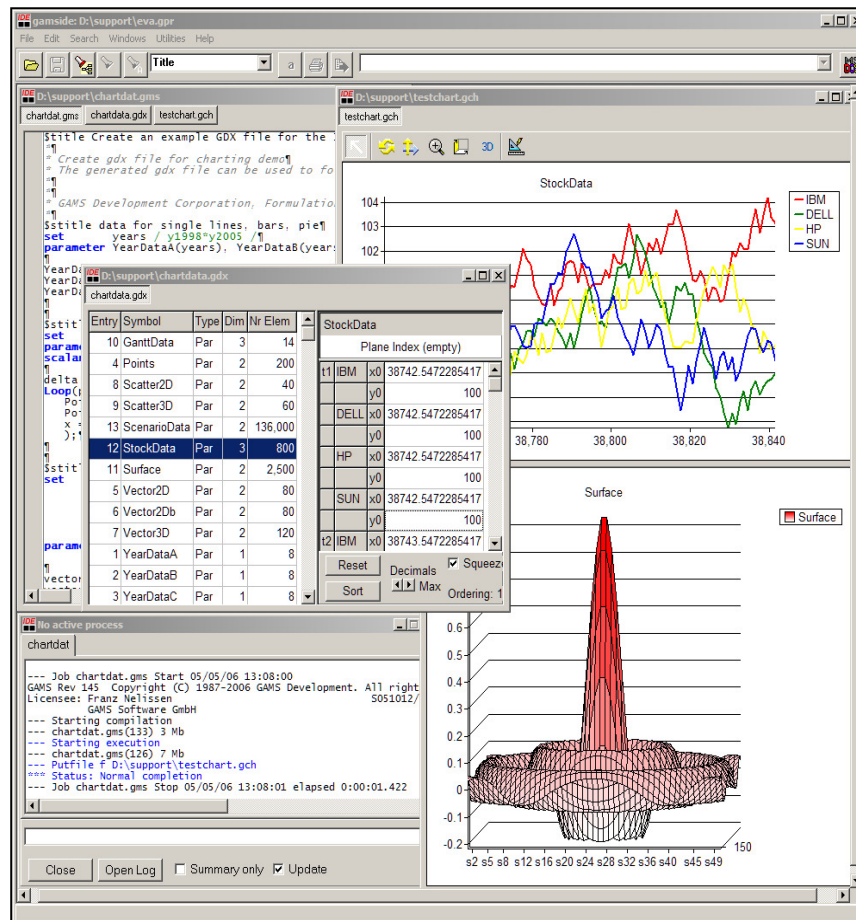
→ **Models benefit from**

- advancing hardware
- enhanced / new solver technology
- improved / upcoming interfaces to other systems





GAMS at a Glance



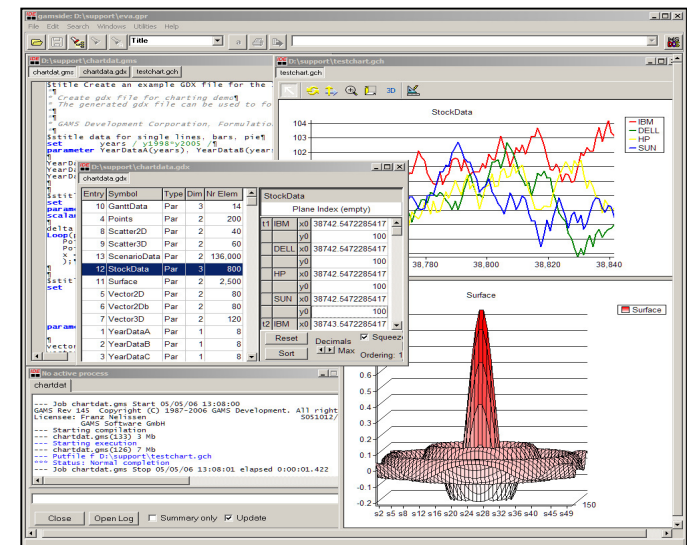
The GAMS/BASE Module

- 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>



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

Model Libraries	Help
GAMS Model Library	
GAMS Test Library	
GAMS Data Utilities Models	
Practical Financial Optimization Models	

- **GAMS Test Library**

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



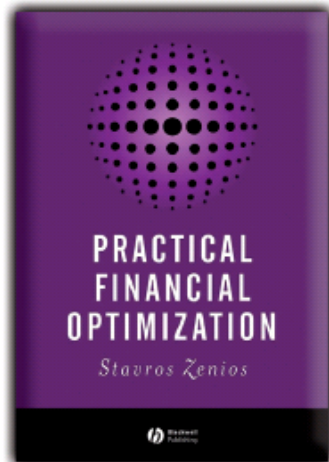
Distributed Model Libraries

- **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



The Worlds

CONE

GLOBAL

MINLP

MPEC

MPSGE

Performance

Translation

Search

Contact

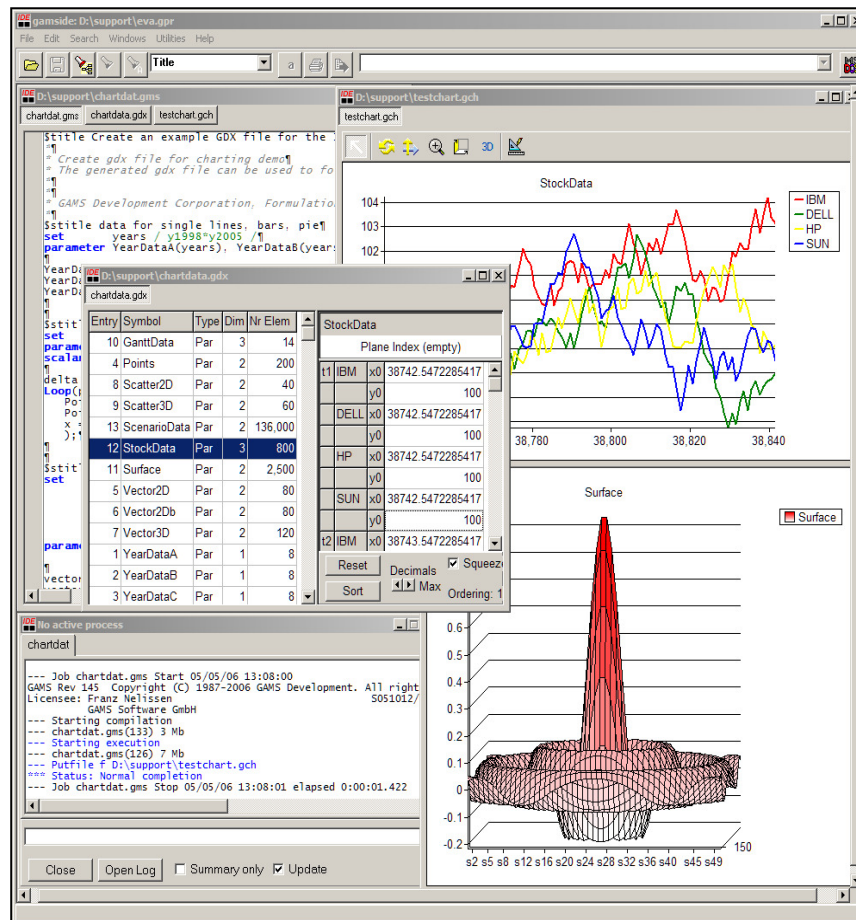
GAMS World

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

The screenshot shows the GAMS/Convert application window. The main window displays a GAMS model named 'transport.gms' with the following content:

```

$title A Transportation Problem (TRANSPORT,SEQ=1)
$ontext
This problem finds a least cost shipping schedule that m
requirements at markets and supplies at factories.

Dantzig, G B, Chapter 3.3. In Linear Programming and Ext.
Princeton University Press, Princeton, New Jersey, 1963.

This formulation is described in detail in:
Rosenthal, R E, Chapter 2: A GAMS Tutorial. In GAMS: A U
The Scientific Press, Redwood City, California, 1988.

The line numbers will not match those in the book becau
comments.
$offtext

Sets
i   canning plants / seattle, san-diego /
j   markets        / new-york, chicago, topeka,

Parameters
a(i) capacity of plant i in cases
    / seattle      350
    / san-diego    600 /
b(j) demand at market j in cases
    / new-york     325

```

The right-hand pane shows the output of the conversion process, listing the files generated for each solver:

```

Reading parameter(s) from "C:\Documents and Settings\Jan\My
>> All
Finished reading from "C:\Documents and Settings\Jan\My Doc
--- Writing Ampl      : ampl.mod
--- Writing AmplINLC  : amplinlc.c
--- Writing Baron     : baron.gms
--- Writing CplexLP   : cplex.lp
--- Writing CplexMPS   : cplex.mps
--- Writing FixedMPS   : fixed.mps
--- Writing Gams      : gams.gms
--- Writing Lingo     : lingo.gms
--- Writing LindoMPI   : lindompi.mpi
--- Writing Lingo     : lingo.ling
--- Writing AlphaECP   : alpha.ecp
--- Writing Minot      : minot.dat
--- Writing NLP2MCP    : gamsnlp2mcp.gms
--- Writing ViennaBag  : vienna.bag
--- Writing CoinFML    : coinfml.xml
--- Writing Dict       : dict.txt
--- Writing Jacobian   : jacobian.gdx
--- Writing Lgo        : lgomain.for
--- Restarting execution
--- transport.gms (66) 0 Mb
--- Reading solution for model transport
--- Executing after solve
--- transport.gms (68) 3 Mb
*** Status: Normal completion
--- Job transport.gms Stop 03/10/07 22:38:05 elapsed 0:00:00

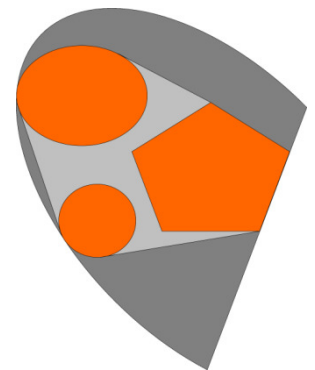
```

At the bottom, there are buttons for 'Close', 'Open Log', 'Summary only', and 'Update'.



EMP + LogMIP + NLPEC

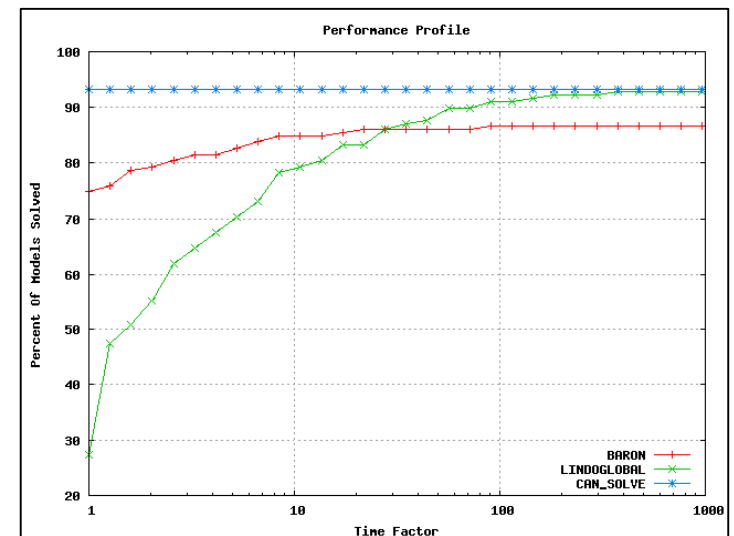
- Extended Mathematical Programming (EMP)
 - Framework for automated mathematical programming reformulations such as
 - Bilevel Programs
 - Disjunctive Programs
 - Extended Nonlinear Programs
 - Embedded Complementarity Systems
 - Variational Inequalities
- Logical Mixed Integer Programming (LogMIP)
 - 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

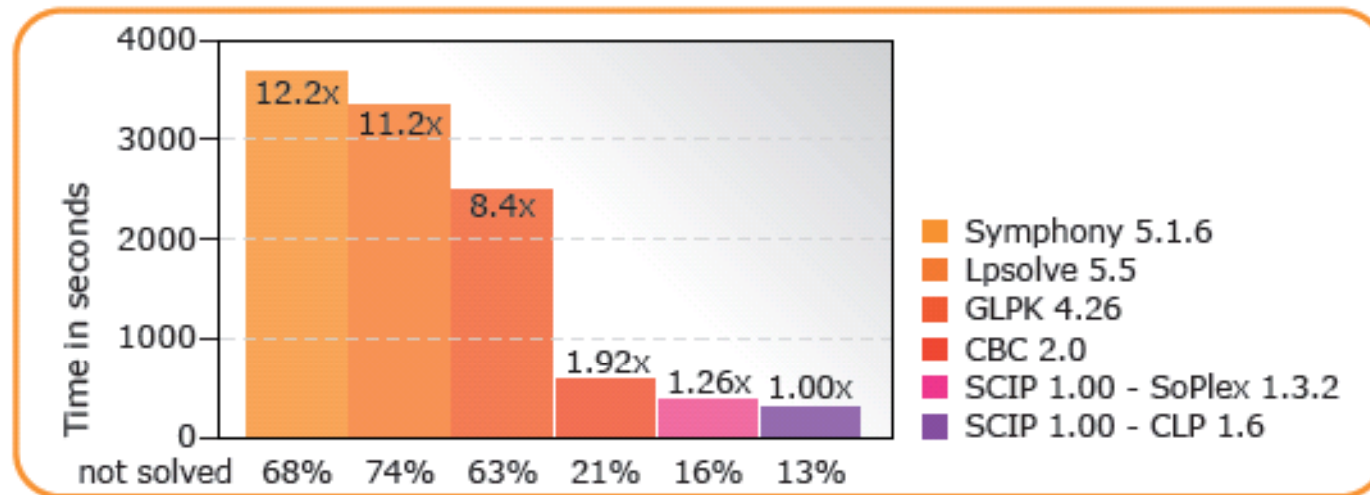
GAMS interfaces to open-source Solvers

- 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

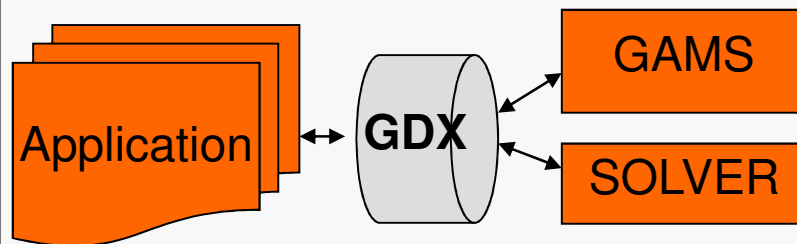
GAMS QA and testing supports maturing of COIN-OR solvers!

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



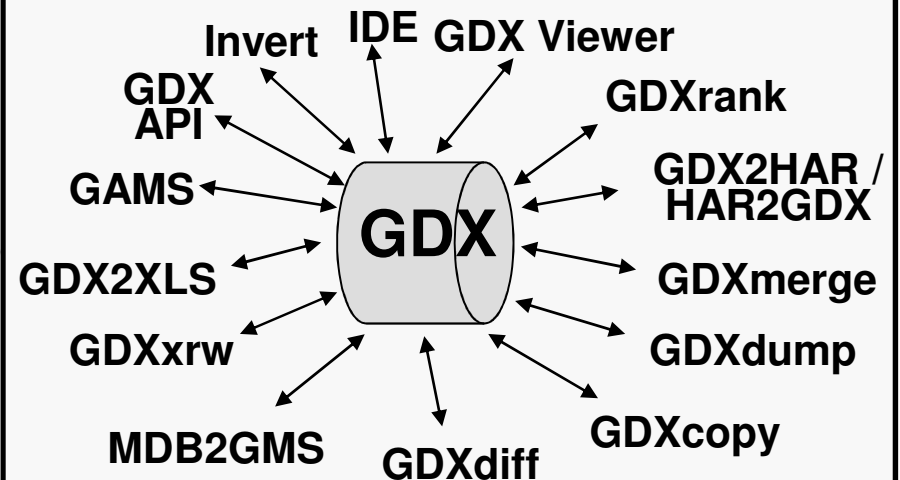
Gams Data eXchange

Binary Data Exchange



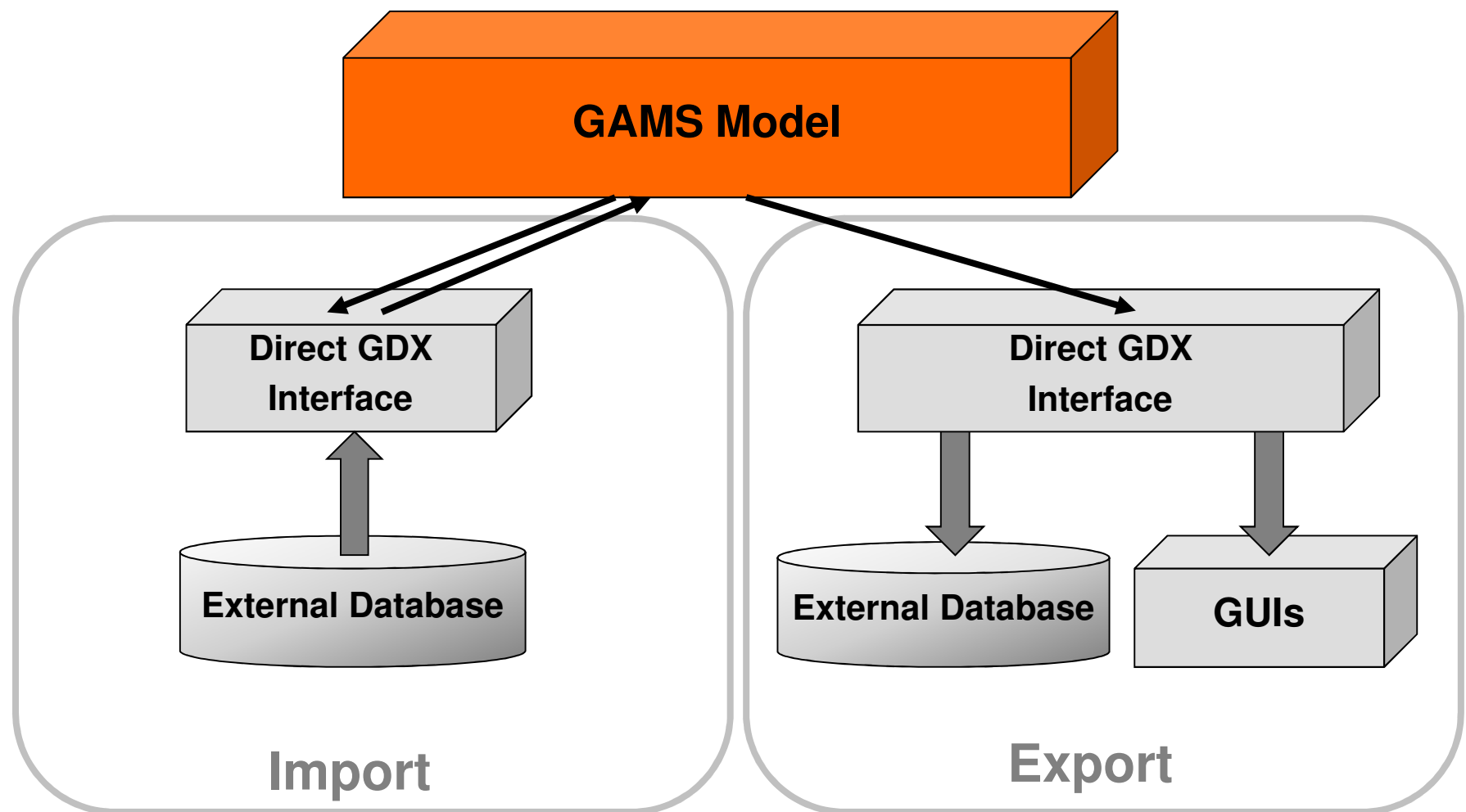
- Fast exchange of data
- Syntactical check on data before model starts
- Data Exchange at any stage (Compile and Run-time)
- Platform Independent
- Direct GDX interfaces and general API
- Scenario Management Support
- Full Support of Batch Runs

GDX Tools



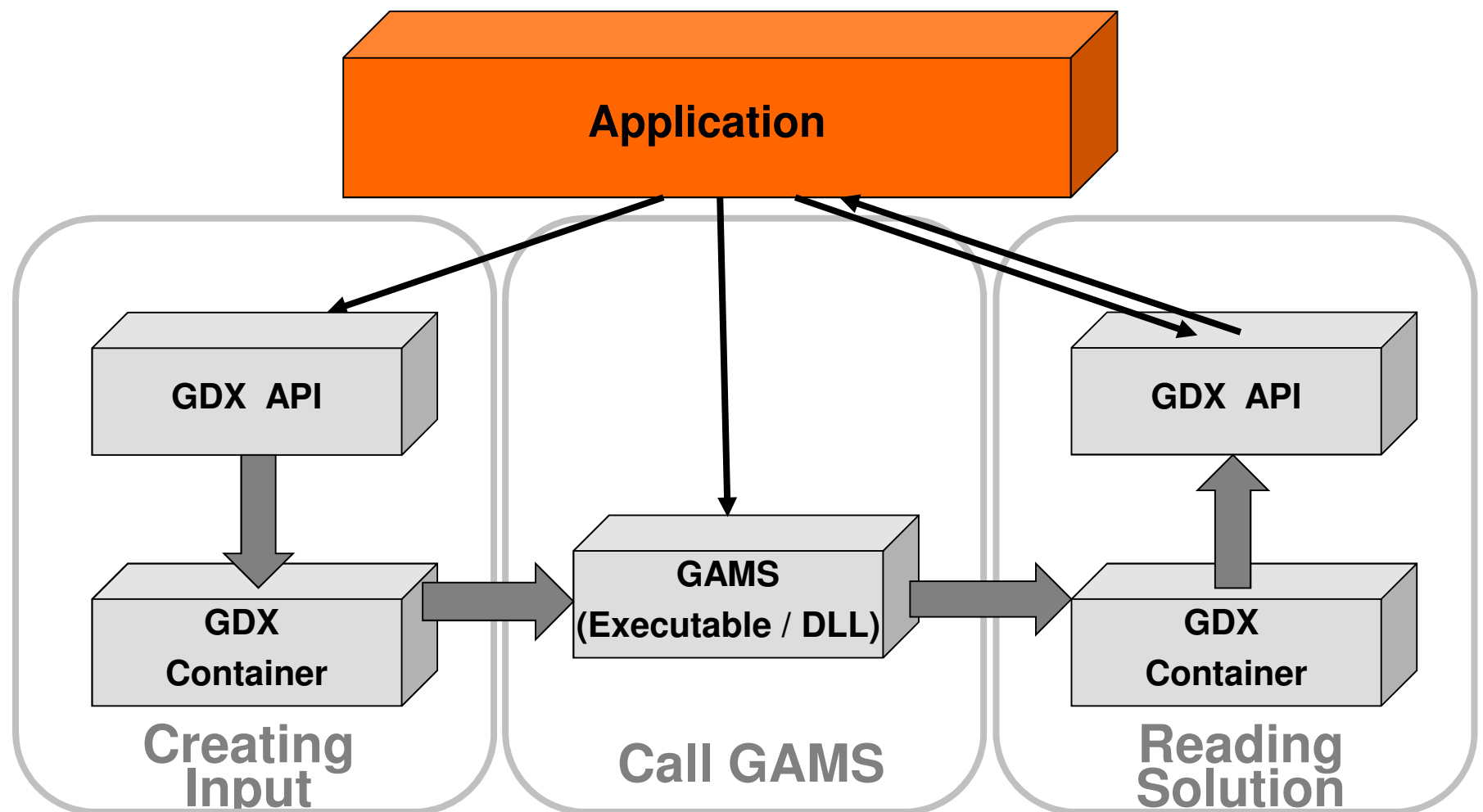


GAMS in Control





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



Contacting GAMS

Europe

GAMS Software GmbH
Eupener Str. 135-137
50933 Cologne
Germany

Phone: +49 221 949 9170

Fax: +49 221 949 9171

<http://www.gams.de>

info@gams.de

support@gams-software.com

USA

GAMS Development Corp.
1217 Potomac Street, NW
Washington, DC 20007
USA

Phone: +1 202 342 0180

Fax: +1 202 342 0181

<http://www.gams.com>

sales@gams.com

support@gams.com