



EURO XXII GAMS - Workshop

Jan-Hendrik Jagla

jhagla@gams.com

GAMS Software GmbH

www.gams.de



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Agenda

GAMS Development / GAMS Software

Working with GAMS – A Guided Tour

GAMS Grid Computing

Compressed and Encrypted Input Files

Summary



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Working with GAMS – A Guided Tour

GAMS Grid Computing

Compressed and Encrypted Input Files

Summary



GAMS

- Roots: Research project World Bank, 1976
- Pioneer in Algebraic Modeling Systems
- Went commercial in 1987
- GAMS Development Corp. (Washington, D.C)
- GAMS Software GmbH (Cologne)

- Used for economic modeling
- Professional software tool provider, not a consulting company
- Operating in a segmented niche market
- Broad academic & commercial user base and network



Typical Application Areas *

-
- | | |
|---------------------------|-------------------------------|
| • Agricultural Economics | • Applied General Equilibrium |
| • Chemical Engineering | • Economic Development |
| • Econometrics | • Energy |
| • Environmental Economics | • Engineering |
| • Finance | • Forestry |
| • International Trade | • Logistics |
| • Macro Economics | • Military |
| • Management Science/OR | • Mathematics |
| • Micro Economics | • Physics |
-

* Illustrative examples in the GAMS Model Library

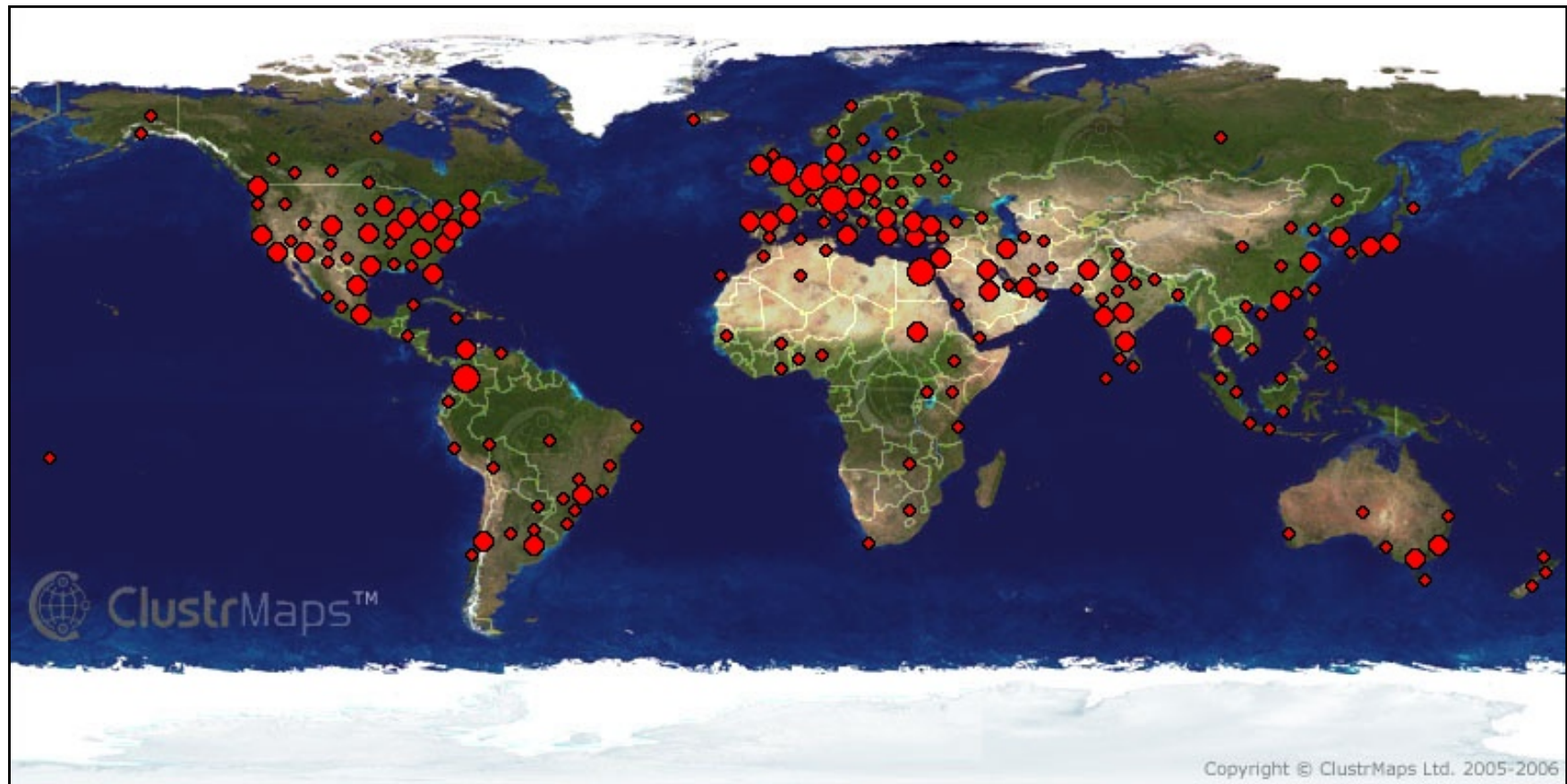


GAMS Solutions Specialists Network

Companies with wide experience in GAMS modeling
à Details at: <http://www.gams.com/specialists/>



Academic + Commercial Users Worldwide





Downloads

Total Downloads of Distribution 22.5 since 2007-06-01: 2097

Sorted by Platform:

- 1 AIX
- 4 AXU
- 46 Darwin
- 35 Linux64
- 94 Linux32
- 12 Solaris (x86)
- 10 Solaris (Sparc)
- 1671 Windows32
- 224 Windows64

**~ 500 downloads
per Week**



Algebraic Modeling Languages

- High-level programming languages for large scale mathematical optimization problems
- Algebraic formulation
 - § Syntax similar to mathematical notation
 - § Does not contain any hints how to process it
- Do not solve optimization problems directly, but call appropriate external algorithms (solvers)

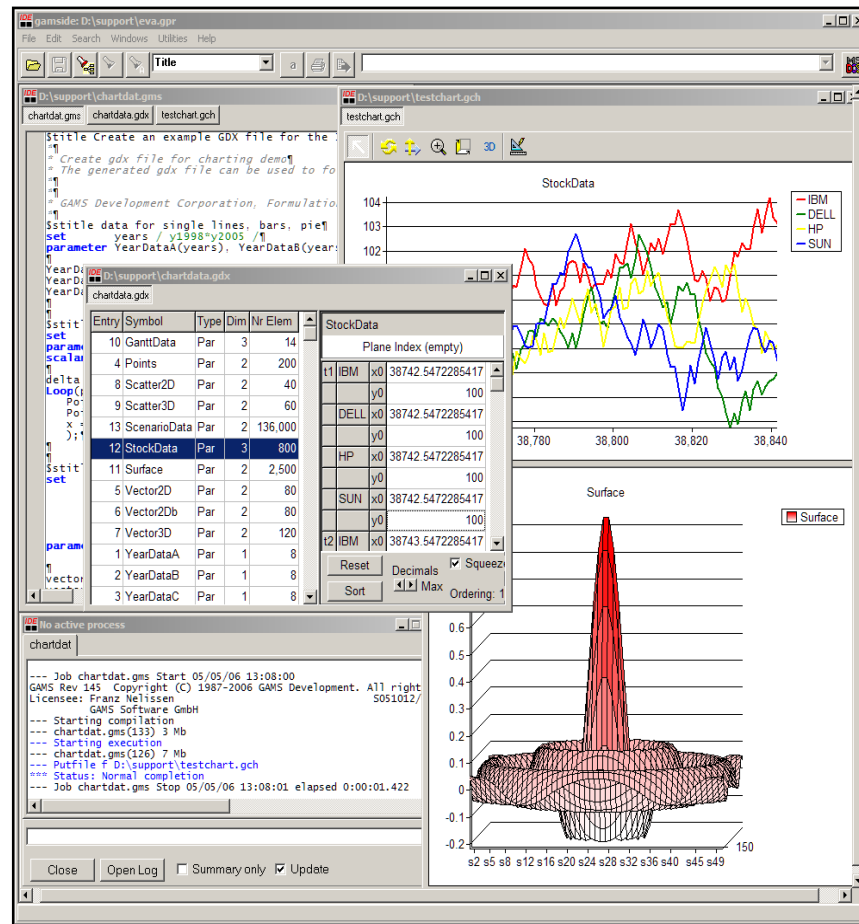


Goals

- Support of decision making process
- Efficient handling of mathematical optimization problems
- Simplify model building and solution process
- Increase productivity and support maintainable models



GAMS at a Glance



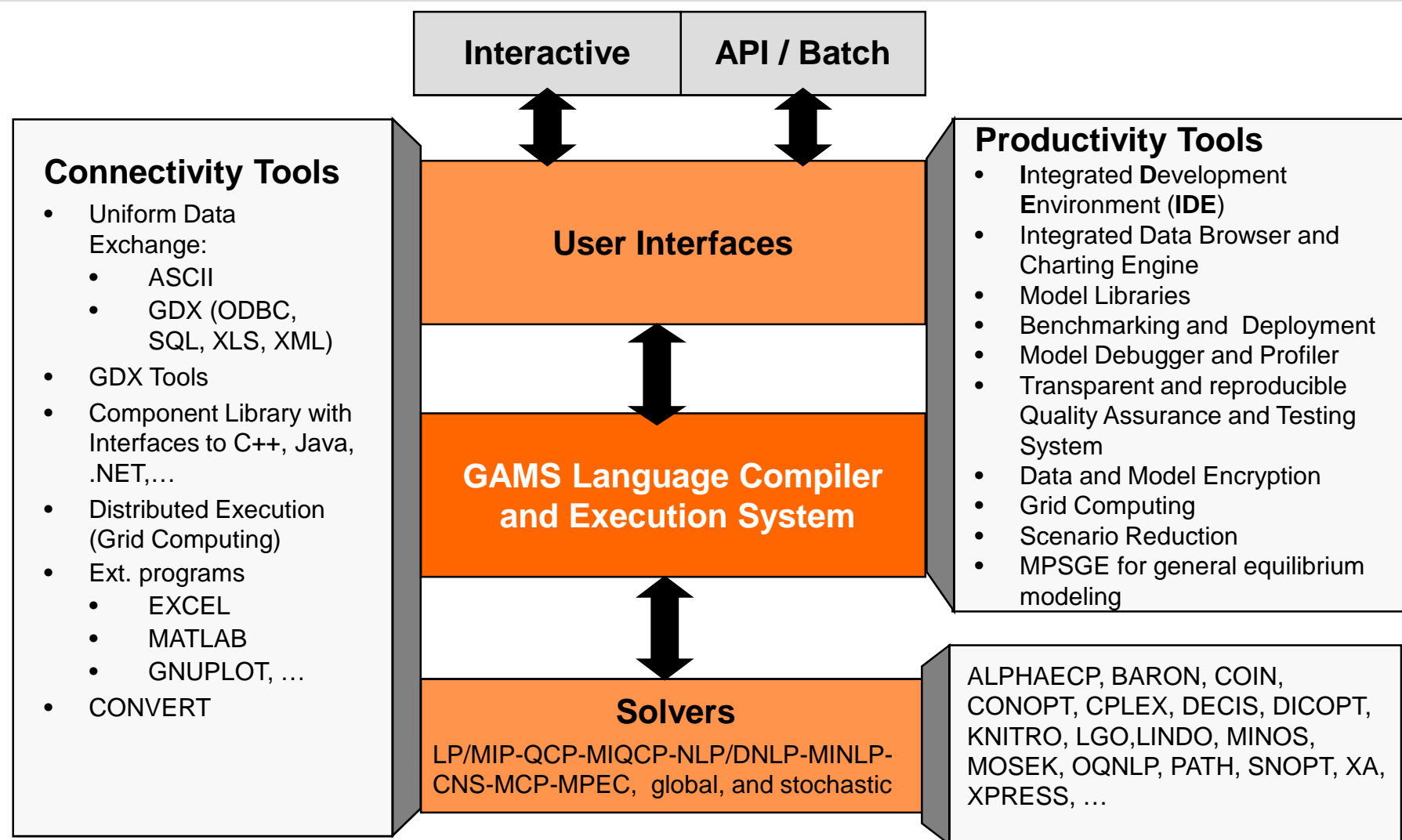
General Algebraic Modeling System:
Algebraic Modeling Language,
Integrated Solver, Model Libraries,
Connectivity- & Productivity Tools

Design Principles:

- Balanced mix of declarative and procedural elements
- Open architecture and interfaces to other systems
- Different layers with separation of:
 - model and data
 - model and solution methods
 - model and operating system
 - model and interface



System Overview





Agenda

GAMS Development / GAMS Software

Working with GAMS – A Guided Tour

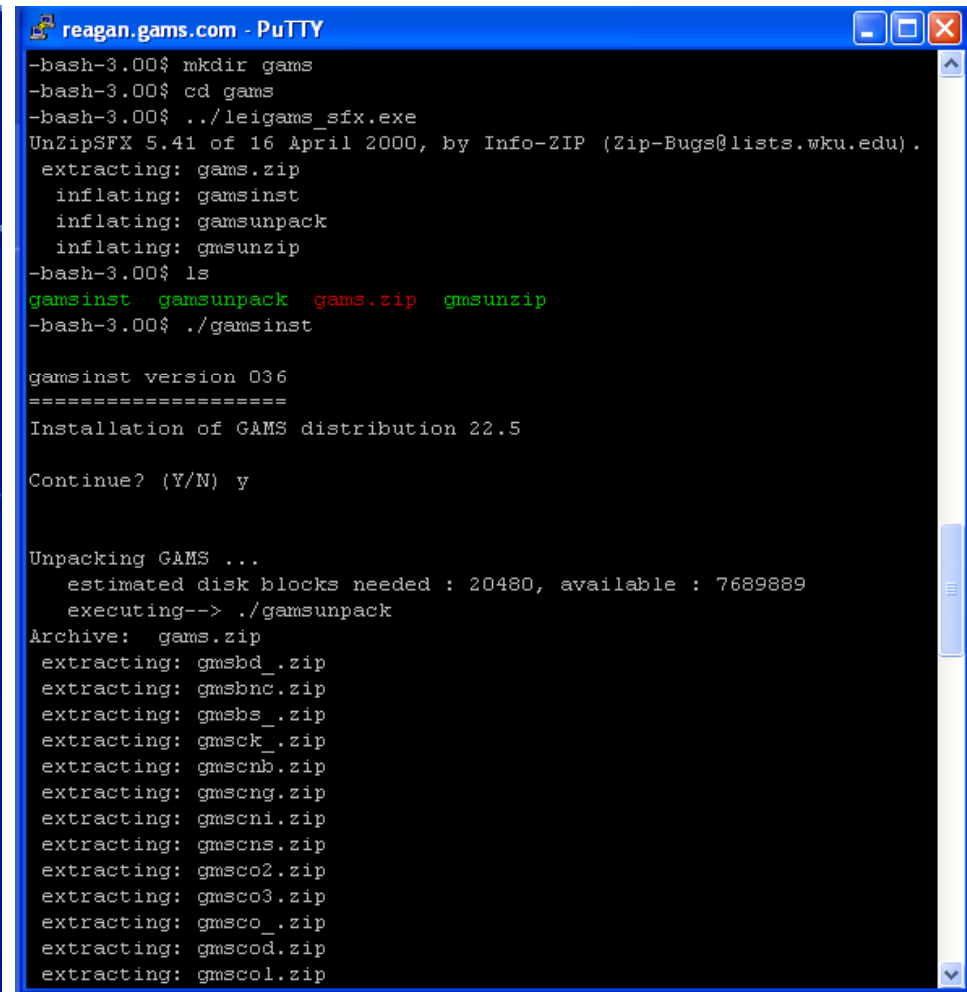
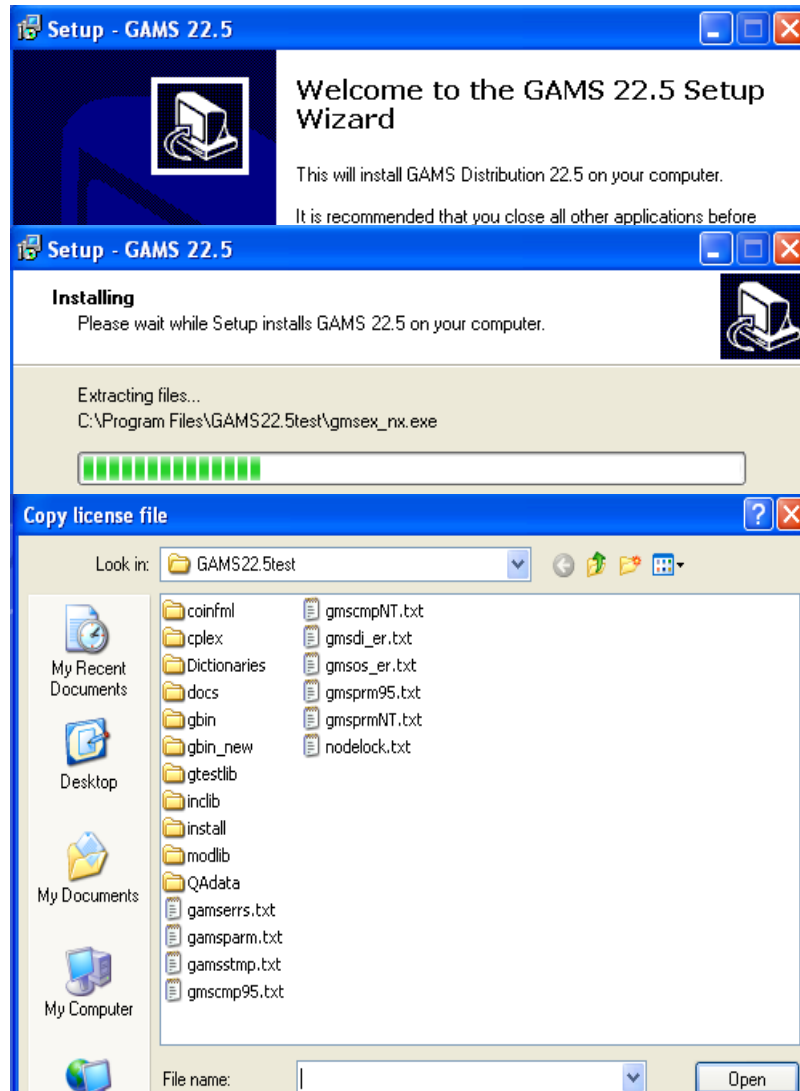
GAMS Grid Computing

Compressed and Encrypted Input Files

Summary



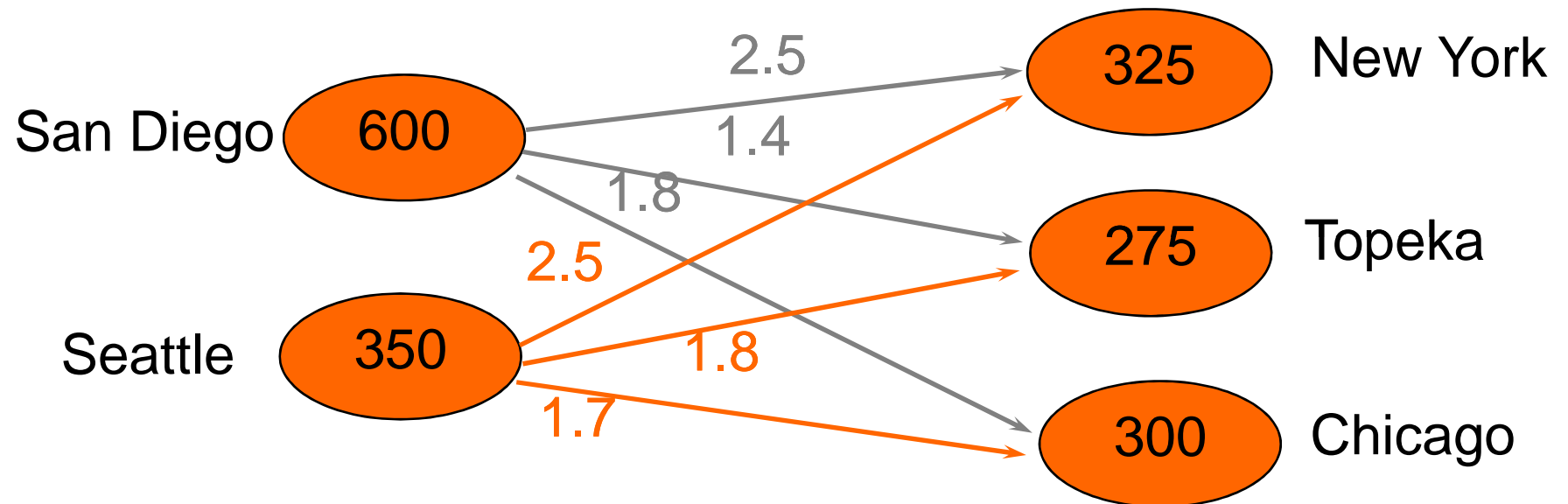
Hands-on! Installing GAMS



export PATH=/home/jhjagla/gams:\$PATH



A few Words about GAMS Syntax



Minimize	Transportation cost
subject to	Demand satisfaction at markets
	Supply constraints



Mathematical Algebra

$$\sum_{\substack{c,p: \\ (c,p) \in \mathcal{N}}} tcost \cdot dist(c,p) \cdot x_p^c \rightarrow \min$$

$$\sum_{\substack{c,p: \\ (c,p) \in \mathcal{N}}} x_p^c \leq sup(c) \quad \forall c$$

$$\sum_{\substack{c,p: \\ (c,p) \in \mathcal{N}}} x_p^c \geq dem(p) \quad \forall p$$

$$x_p^c \geq 0 \quad \forall c, p : (c, p) \in \mathcal{N}$$



GAMS Algebra

```
IDE gamside: C:\Documents and Settings\bussieck\My Documents\gamsdir\project.gpr - [c:\documents an...
IDE File Edit Search Windows Utilities Help
[Icons] call [a] [Icons]
transport.gms

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

Positive Variable x ;

Equations
    cost          define objective function
    supply(i)     observe supply limit at plant i
    demand(j)     satisfy demand at market j ;

cost ..          z  =e=  sum((i,j), c(i,j)*x(i,j)) ;

supply(i) ..     sum(j, x(i,j))  =l=  a(i) ;

demand(j) ..     sum(i, x(i,j))  =g=  b(j) ;

Model transport /all/ ;
```




GAMS Syntax

- Symbols:

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

```

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' /
  
```

- Statements

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

```

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;
  
```



Hands-on! Testing the installation

gamside: C:\tmp\tmp.gpr

- New Ctrl+N
- Open Ctrl+O
- Open in Editor
- Open in project directory
- Reopen Alt+R
- Open in New Window Shift+Ctrl+O
- View in Explorer
- Model Library
 - Open GAMS Model Library
 - Open User Model Library
- Project
 - 1 C:\Program Files\GAMS22.5\wttools\lib\wttools.glb
 - 2 C:\Program Files\GAMS22.5\gtestlib\testlib.glb
- Run F9
- Compile Shift+F9
- Save Ctrl+S
- Save in Unix format
- Save as Shift+Ctrl+S
- Save All
- Close
- Options
- Print
- Previous
- Exit

GAMS Model Library Version 27.0

Seq#	Name	Application Area	Type	Contributor	Description
001	TRANSPORT	Management Science and OR	LP	Dantzig, G. B.	A Transportation Problem
002	BLEND	Management Science and OR	LP	Dantzig, G. B.	Blending Problem I
003	PRODMIX	Management Science and OR	LP	Dantzig, G. B.	A Production Mix Problem
004	WHOUSE	Management Science and OR	LP	Dantzig, G. B.	Simple Warehouse Problem
005	JOBT	Management Science and OR	LP	Dantzig, G. B.	On-the-Job Training
006	SROUTE	Management Science and OR	LP	Dantzig, G. B.	The Shortest Route Problem
007	DIET	Micro Economics	LP	Dantzig, G. B.	Stigler's Nutrition Model
008	AIRCRAFT	Management Science and OR	LP	Dantzig, G. B.	Aircraft Allocation Under Uncertain Demand
009	PRODSCH	Management Science and OR	MIP	CDC	APEX - Production Scheduling Model
010	PDI	Management Science and OR	LP	ARCNET	ARCNET - Production Distribution and Inventory
011	UMP	Management Science and OR	LP	Ellison, E. F.	UMP - Production Scheduling Problem
012	MAGIC	Management Science and OR	MIP	Garver, L. L.	Magic Power Scheduling Problem
013	FERTS	Micro Economics	LP	Chokris, A. M.	Egypt - Static Fertilizer Model
014	FERTD	Micro Economics	MIP	Chokris, A. M.	Egypt - Dynamic Fertilizer Model
015	MEXSS	Micro Economics	LP	Kendrick, D.	Mexico Steel - Small Static
016	MEXSD	Micro Economics	MIP	Kendrick, D.	Mexico Steel - Small Dynamic
017	MEXLS	Micro Economics	LP	Kendrick, D.	Mexico Steel - Large Static
018	WEAPONS	Management Science and OR	NLP	Bracken, J.	Weapons Assignment
019	BID	Micro Economics	MIP	Bracken, J.	Bid Evaluation
020	PROCESS	Chemical Engineering	NLP	Bracken, J.	Alkylation Process Optimization
021	CHEM	Chemical Engineering	NLP	Bracken, J.	Chemical Equilibrium Problem
022	SHIP	Engineering	NLP	Bracken, J.	Structural Optimization
023	LINEAR	Econometrics	DNLP	Bracken, J.	Linear Regression with Various Criteria
024	LEAST	Econometrics	NLP	Bracken, J.	Nonlinear Regression Problem
025	LIKE	Econometrics	NLP	Bracken, J.	Maximum Likelihood Estimation
026	CHANCE	Agricultural Economics	NLP	Bracken, J.	Chance Constrained Feed Mix Problem
027	SAMPLE	Statistics	NLP	Bracken, J.	Stratified Sample Design
028	PINDYCK	Energy Economics	NLP	Pindyck, R. S.	Optimal Pricing and Extraction for OPEC
029	ZLOOF	Management Science and OR	GAMS	Zlot, M. M.	Relational Database Example
030	VIETNAM	Micro Economics	MIP	Manne, A. S.	Vietnam's Manne Fertilizer Model 1961
031	ALUM	International Trade	MIP	Brown, M.	World Aluminum Model
032	MARCO	Micro Economics	LP	Aronofsky, J.	Mini Oil Refining Model

A Transportation Problem (TRANSPORT, SEQ=1)

c:\tmp\transport.gms

```

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
            chicago    300
            topeka     275 / ;

Table d(i,j) distance in thousands of miles
        new-york   chicago   topeka
seattle      2.5       1.7       1.8
san-diego    2.5       1.8       1.4 ;

Scalar f freight in dollars per case per thousand miles /90/ ;

Parameter c(i,j) transport cost in thousands of dollars per case
  
```

No active process

```

transport

--- Job transport.gms Start 07/03/07 10:25:45
GAMS Rev 148 Copyright (C) 1987-2007 GAMS Development. All rights reserved.
Licensee: Jan-Hendrik Jagla G070418/0001C
GAMS Software GmbH
--- Starting compilation
--- transport.gms(69) 3 Mb
--- Starting execution
--- transport.gms(45) 4 Mb
--- Generating LP model transport
--- transport.gms(66) 4 Mb
--- 6 rows 7 columns 19 non-zeroes
--- Executing CPLEX

GAMS/Cplex Jun 1, 2007 WIN.CP.CP 22.5 034.037.041.VIS For Cplex 10
Cplex 10.2.0, GAMS Link 34
  
```

Close Open Log ☐ Summary only ☒ Update



Hands-on! Testing the installation

```

reagan.gams.com - PuTTY
-bash-3.00$ gamslib trnsport
Model trnsport.gms retrieved
-bash-3.00$ gams trnsport
--- Job trnsport Start 07/03/07 10:33:08
GAMS Rev 148 Copyright (C) 1987-2007 GAMS Development. All rights reserved
Licensee: GAMS Development Corporation, Washington, DC G871201/0000CA-ANY
Free Demo, 202-342-0180, sales@gams.com, www.gams.com DC0000
--- Starting compilation
--- trnsport.gms(69) 3 Mb
--- Starting execution
--- trnsport.gms(45) 4 Mb
--- Generating LP model transport
--- trnsport.gms(66) 4 Mb
--- 6 rows 7 columns 19 non-zeroes
--- Executing CPLEX

GAMS/Cplex Jun 1, 2007 LEX.CP.NA 22.5 034.037.041.LEI For Cplex 10.2
Cplex 10.2.0, GAMS Link 34

Reading data...
Starting Cplex...
Tried aggregator 1 time.
LP Presolve eliminated 1 rows and 1 columns.
Reduced LP has 5 rows, 6 columns, and 12 nonzeros.
Presolve time = 0.00 sec.

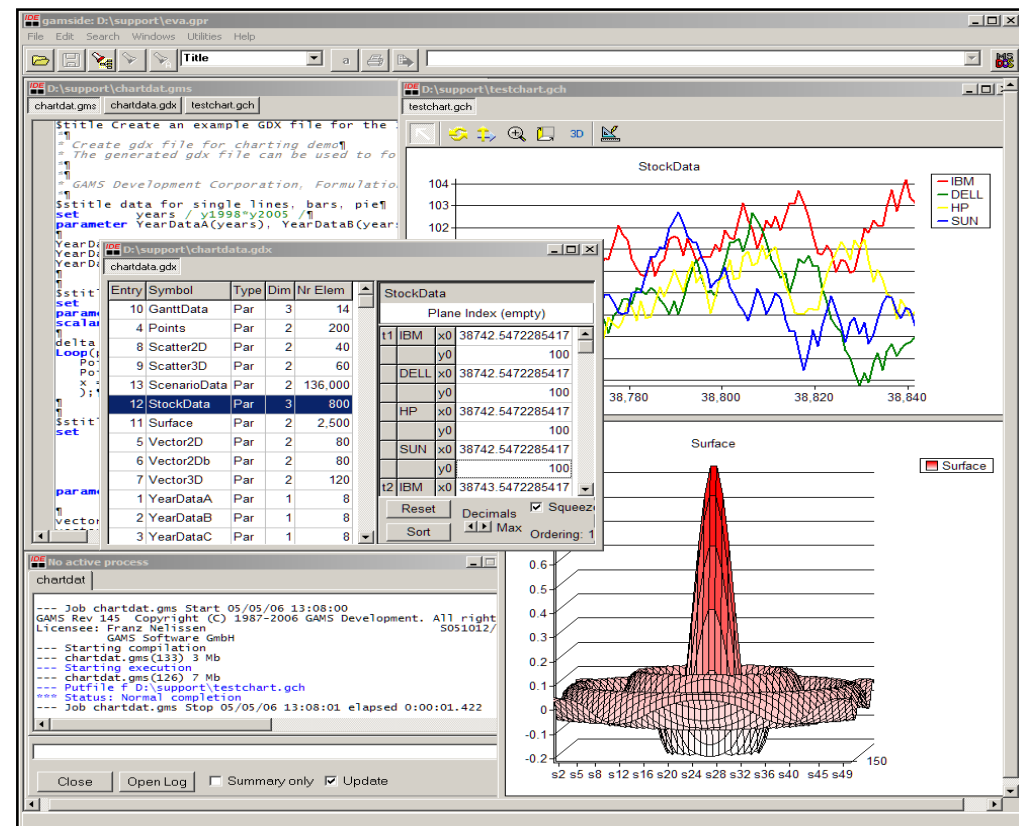
Iteration      Dual Objective      In Variable      Out Variable
1              73.125000      x(seattle.new-york) demand(new-york) slack
2             119.025000      x(seattle.chicago) demand(chicago) slack
3             153.675000      x(san-diego.topeka) demand(topeka) slack
4             153.675000      x(san-diego.new-york) supply(seattle) slack

```



Hands-on! IDE - A Guided Tour

- IDE Project Management
- Documentation
 - User's Guide
 - McCarl User's Guide
 - Solver Manuals
- Model Library
- Solver Selection
- Option Editor
- Listing file
 - Tree view
 - Error navigation
- Spell checking





Solver Option Files

- Pass solver specific options
 - e.g. tolerances, limits, algorithm selection
- Solver option file `solver.opt` e.g. `cplex.opt` with solver specific options (one per line)
- Activate solver option file
 - `optfile=1` on command line/parameter window
 - `<modelname>.optfile=1;` before solve
- Multiple option files:
 - `solver.opt` `optfile=1`
 - `solver.op2` `optfile=2`
 - ...
 - `solver.999` `optfile=999`



Multiple Solvers & Platforms

Solver/Platform availability - 22.5 June 1, 2007											
	x86 MS Windows	x86_64 MS Windows	x86 Linux	x86_64 Linux	Sun Sparc SOLARIS	Sun Intel SOLARIS	HP 9000 HP-UX 11 ¹	DEC Alpha Digital Unix 4.0	IBM RS-6000 AIX 4.3	Mac PowerPC Darwin	SGI IRIX ²
ALPHAECF	✓	✓	✓	✓	✓	✓		✓	✓	✓	
BARON 7.8	✓	32bit	✓	32bit					✓		
BDMLP	✓		✓		✓	✓	✓	✓	✓	✓	✓
COIN	✓	32bit	✓	✓						✓	
CONOPT 3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CPLEX 10.1	✓	✓	✓	✓	✓	✓	10.0	8.1	✓		9.1
DECIS	✓	✓	✓	✓	✓		✓	✓	✓		✓
DICOPT	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
KNITRO 5.1	✓	32bit	✓	✓						✓	
LINDOGLOBAL 4.1	✓	✓	✓	✓	✓					✓	
LGO	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
MILES	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MINOS	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MOSEK 4	✓	✓	✓	✓	✓		3.2			✓	
MPSGE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
MSNLP	✓	✓	✓	✓	✓		✓			✓	
NLPEC	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
OQNLP	✓	32bit	✓	32bit							
OSL V3	✓	32bit	✓	32bit	✓		V2		✓		V2
OSLSE	✓	32bit	✓	32bit	✓				✓		
PATH	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SBB	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SNOPT	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
XA	✓	32bit	✓	✓	✓		✓	✓	✓		
XPRESS 17.10	✓	32bit	✓	32bit	✓		16.10		✓		
¹ GAMS distribution for HP 9000/HP-UX is 22.1.											
² GAMS distribution for SGI IRIX is 22.3.											
Contributed Plug&Play solvers											
AMPLwrap	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
DEA	✓	✓	✓	✓	✓	✓		✓	✓		
Kestrel	✓	32bit	✓	32bit	✓						
For backward compatibility we maintain older versions of operating systems and solvers. Please call.											



Multiple Model Types

- LP Linear Programs
- MIP Mixed Integer Programs
- QCP Quadratically Constrained Programs
- MIQCP Quadratically Constrained MIPs
- NLP Nonlinear Programs
- DNLP NLP with Discontinuous Derivatives
- MINLP Mixed Integer Nonlinear Programs
- MCP Mixed Complementarity Programs
- MPEC NLP with Complementarity Constraints
- CNS Constrained Nonlinear Systems
- Stochastic Optimization
- Global Optimization



Multiple Solver & Model Types

Solver/Model type availability - 22.5 June 1, 2007												
	LP	MIP	NLP	MCP	MPEC	CNS	DNLP	MINLP	QCP	MIQCP	Stock.	Global
ALPHAECF								✓		✓		
BARON 7.8	✓	✓	✓				✓	✓	✓	✓		✓
BDMLP	✓	✓										
COIN	✓	✓										
CONOPT 3	✓		✓			✓	✓		✓			
CPLEX 10.1	✓	✓							✓	✓		
DECIS	✓										✓	
DICOPT								✓				
KNITRO 5.1	✓		✓				✓		✓			
LINDOGLOBAL 4.1	✓	✓	✓				✓	✓	✓	✓		
LGO	✓		✓				✓		✓			✓
MILES				✓								
MINOS	✓		✓				✓		✓			
MOSEK 4	✓	✓	✓				✓		✓	✓		
MPSGE												
MSNLP			✓				✓		✓			✓
NLPEC				✓	✓							
OQNLP			✓				✓	✓	✓	✓		✓
OSL V3	✓	✓										
OSLSE	✓										✓	
PATH				✓		✓						
SBB								✓		✓		
SNOPT	✓		✓				✓		✓			
XA	✓	✓										
XPRESS 17.10	✓	✓							✓			
Contributed Plug&Play solvers												
AMPLwrap	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DEA	✓	✓										
Kestrel	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓



Special Solvers

Solvers that do not solve the problem:

- **CONVERT**
 - Converts the model into different formats
- **BENCH**
 - Benchmarking solver
- **EXAMINER**
 - Checks quality of a solution found by different solver
- **AMPL/LINGO/AECPWRAP**
 - Converts model into AMPL/LINGO syntax and calls the other system to solve the problem



Hands-on! “Solver” Convert

The screenshot shows the GAMS IDE interface. The main window displays the GAMS model file `transport.gms`. The model includes a title, a description, and a list of sets and parameters. The sets are `canning plants` (seattle, san-diego) and `markets` (new-york, chicago, topeka). The parameters are `a(i)` (capacity of plant i in cases) and `b(j)` (demand at market j in cases).

The right-hand pane shows the output of the conversion process. It lists the files generated for each solver: `ampl.mod`, `amplnlp.c`, `gams.bar`, `cplex.lp`, `cplex.mps`, `fixed.mps`, `gams.gms`, `lago.gms`, `lindo.mpi`, `lingo.lng`, `alpha.ecp`, `minopt.dat`, `gams.mcp.gms`, `vienna.dag`, `coinfml.xml`, `dict.txt`, `jacobian.gdx`, and `lgomain.for`.

The bottom status bar indicates the job is complete: `*** Status: Normal completion` and `Job transport.gms Stop 03/10/07 22:38:05 elapsed 0:00:00`.



Hands-on! "Solver" Bench

gamside: C:\Documents and Settings\Jan\My Documents\presentation\2007-07-EURO-Prag\softdemo\bench\bench.gpr

File Edit Search Windows Utilities Help

lp=bench optfile=1

c:\documents and settings\jan\my documents...

transport.gms transport.lst

No active process

transport

--- BENCH SUMMARY:

Solver	Modstat	Solstat	Objective	ResUsd	Examiner
CPLEX	1	1	153.6750	0.078	P/P
COINCBC	1	1	153.6750	0.000	P/P
COINGLPK	1	1	153.6750	0.000	P/P
MOSEK	1	1	153.6750	0.062	P/P
XPRESS	1	1	153.6750	0.062	P/P

--- 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 07/03/07 11:39:46 elapsed 0:00:02.500

Close Open Log ☐ Summary only ☒ Update



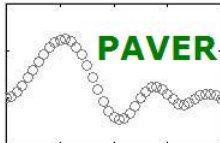
Convert online - www.gamsworld.org

PAVER - Performance Analysis & Visualization - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.gamsworld.org/performance/paver/convert_submit.htm

LEO de <-> en



[[Home](#) | [Tools](#) | [Links/Other](#) | [Performance World](#)]

PAVER - GAMS Model Translation Web Submission Tool (GMS2XX)

The PAVER GAMS model translation web-submission tool runs the [GAMS/CONVERT](#) "solver" to translate GAMS models into the following supported languages:

- AlphaECP
- AMPL
- BARON
- CoinFML
- CplexLP
- CplexMPS
- Dict
- FixedMPS
- GAMS (scalar)
- Lago
- Lgo
- LINGO
- MINOPT
- ViennaDag
- ALL (this creates scalar versions of all supported languages, listed above)

The service requires that all models be self contained. Upon submission, the resulting translated models will be sent via e-mail.

Creating a Self Contained Model:

The translation service requires a self contained model with no \$include or \$batinclude. The GAMS system provides an easy way to produce such a model even if it contains nested \$include and \$call statements. Run your model in the usual way but add the GAMS parameter dumpopt=11:

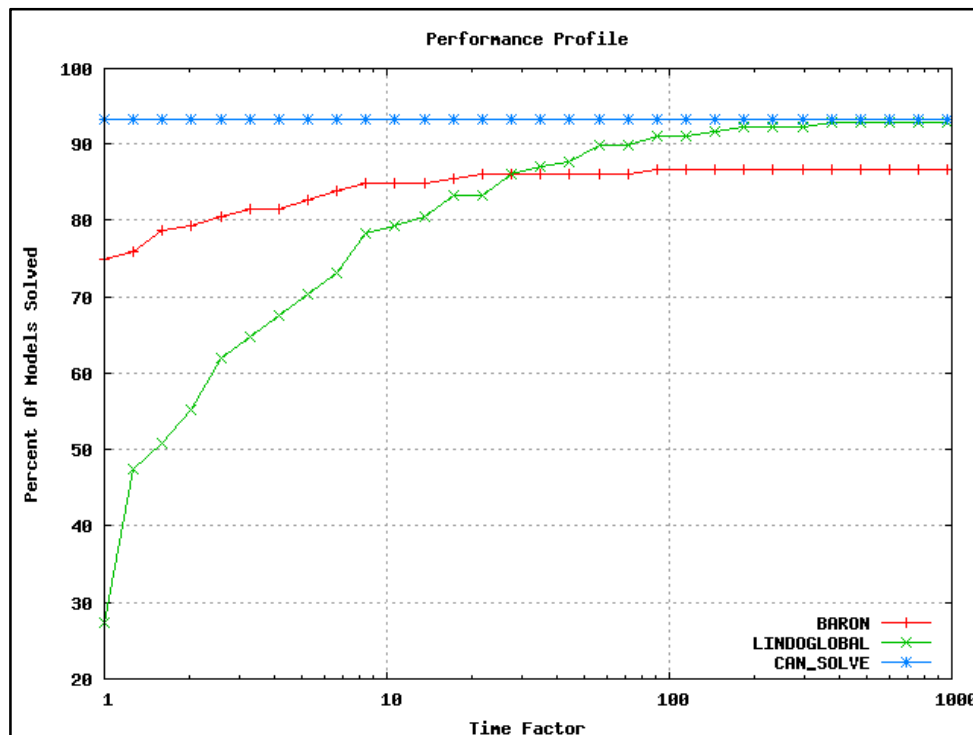
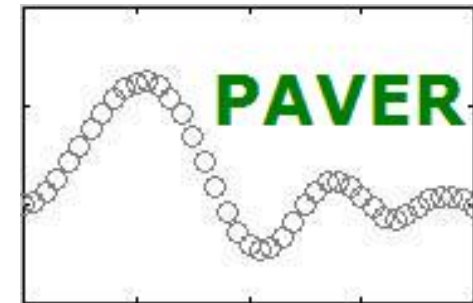
```
gams mymodel dumpopt=11
```



Benchmark online - www.gamsworld.org

PAVER – Server

Performance Analysis and Visualization
for Efficient Reproducibility





Excursus: Solver Links

- Standardized Solver Interface
 - Return Codes, Limits, Interrupts, ...
 - Common attributes (e.g. time) through GAMS options
 - Specific options through option file

à allows “hassle free” replacement of solvers:
`option nlp=conopt;`
- Open architecture assures seamless communication
 - IO Library (C, Fortran, Delphi) provides access to Matrix, Function/Derivative Evaluator, ...

à Linking your Solver to GAMS
THE COMPLETE NOTES Don't Panic !!



Input/Output through ASCII Files

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

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

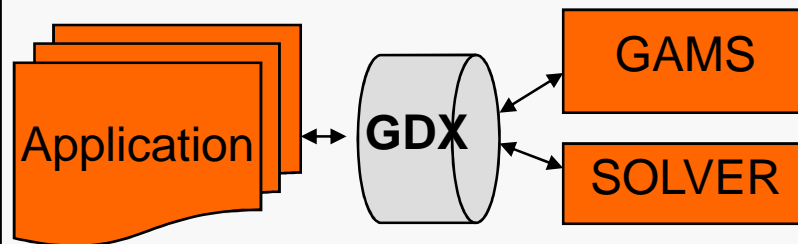
- ASCII File Output
 - GAMS Put Facilities

```
file fx / result.txt /;  
fx.pc=5; fx.lw=0; fx.nw=10; fx.nd=4;  
loop((i,j)$ (x.l(i,j)>0),  
    put fx i.tl j.tl x.l(i,j) /;  
);
```



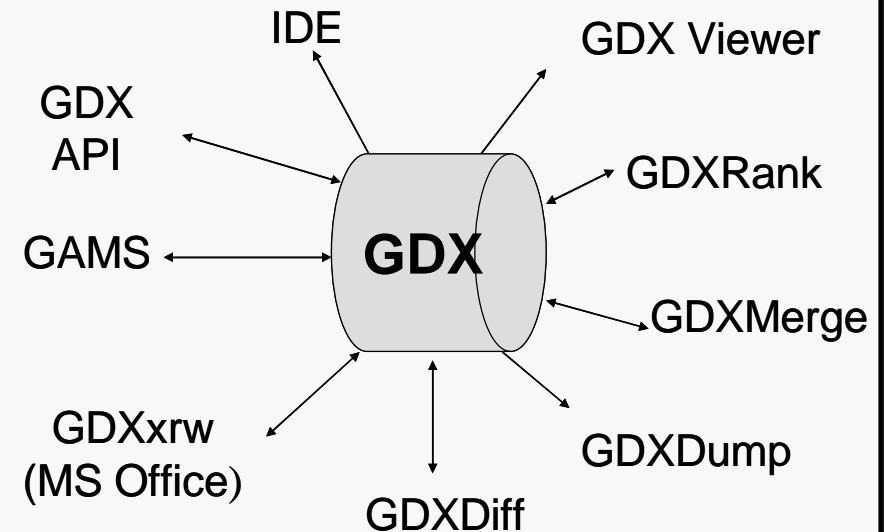
Gams Data eXchange

Binary Data Exchange



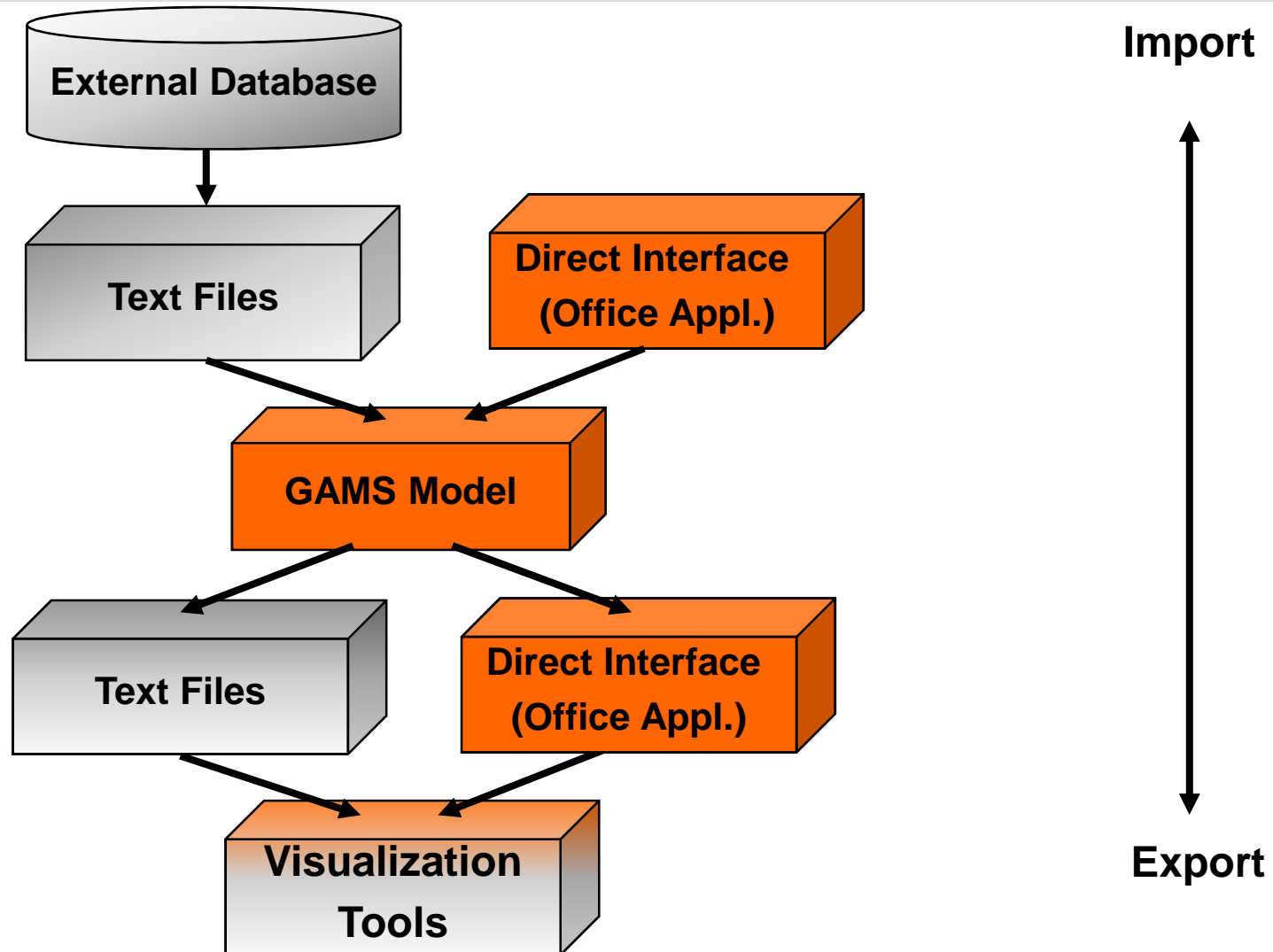
- Fast exchange of data
- Syntactical check on data before model starts
- Data Exchange at any stage (Compile and Run-time)
- Platform Independent
- Direct Excel connectivity
- General API
- Scenario Management Support
- Full Support of Batch Runs

GDX Tools



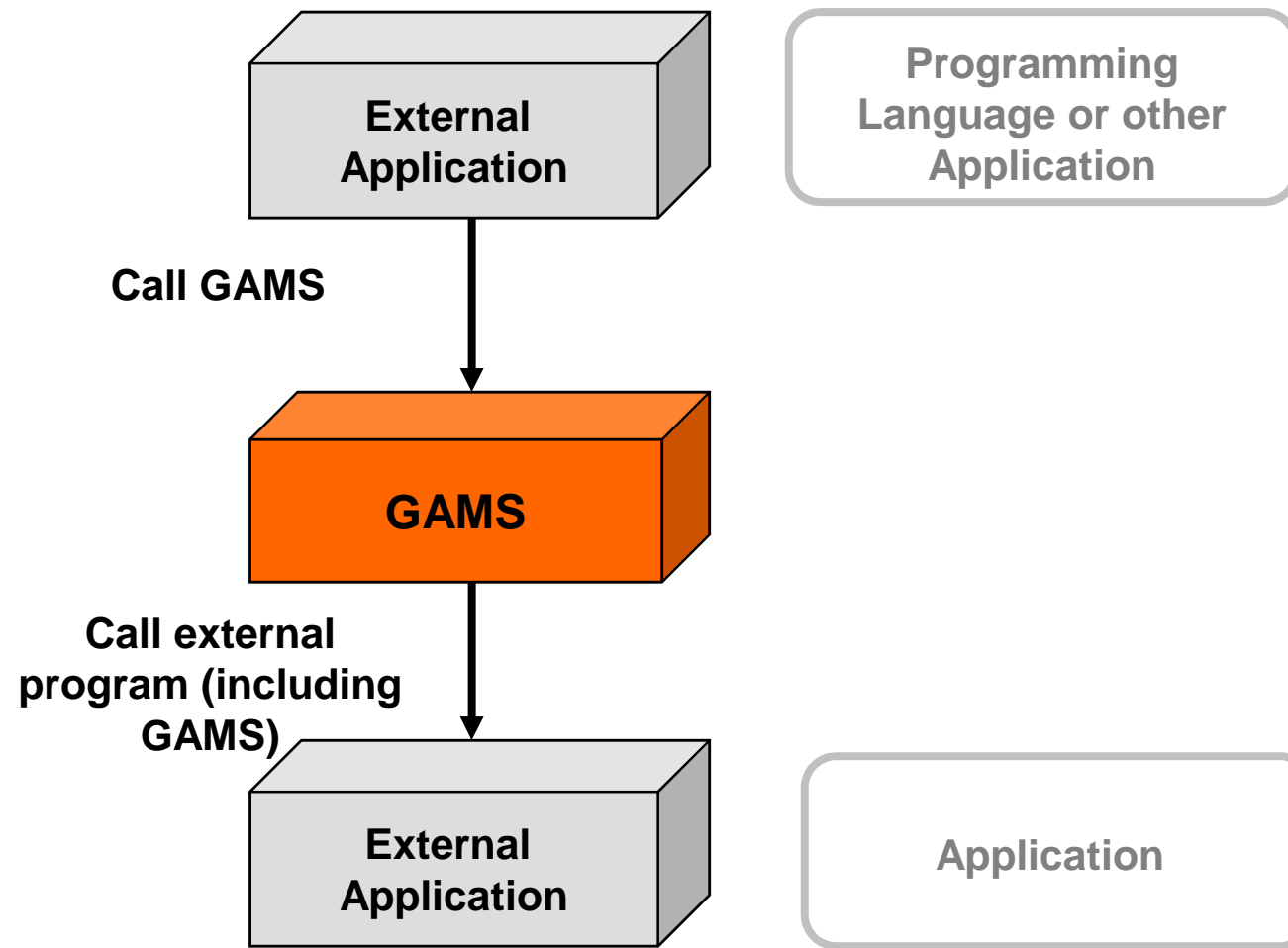


GAMS in Control





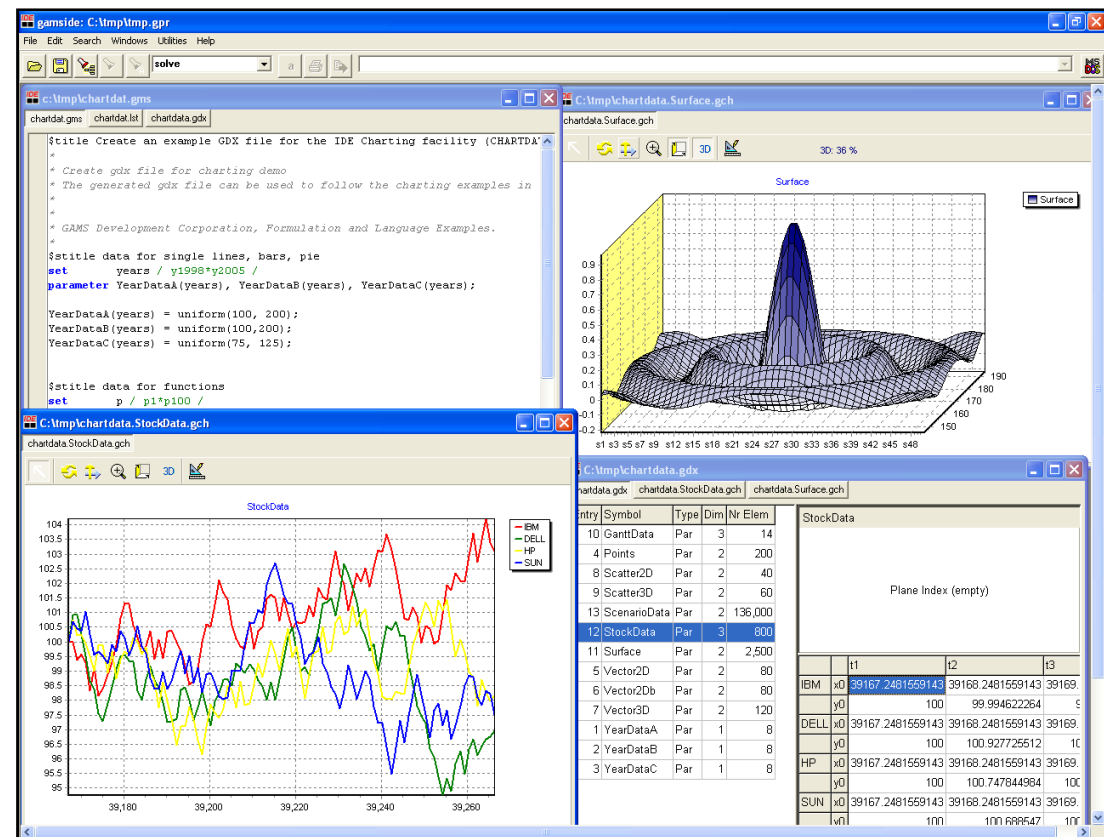
Application in Control





Hands-on! GDX and Tools

- Create GDX file
 - execute_unload
 - Gdx=filename
- GDX Viewer
 - Data cube
 - Export to Excel
- GDXdiff
- Charting Engine





Hands-on! Deployment

The screenshot displays the GAMS IDE interface. The main window shows a script titled 'deploy.gms' with the following content:

```

$title GAMS Deployment Model (DEPLOY,SEQ=308)
$ontext

This model creates a GAMS deployment system

Complete two steps and run this model and pick up gmsdeploy.zip
in your project/current directory

1. Add the solvers and other products to the set DeployProducts.
   Display p to inspect all possible products.
2. Add names of files that usually do not come with your GAMS system
   but you want in your deployment system between on/offecho

$offtext

Set p GAMS Products / system.SolverNames /
    DeployProducts(p) / CONOPT ;;

* Add extra non GAMS files to your deployment
$if not set ziplist $set ziplist %gams.workdir%gmsdeploy.zip
$onecho > "%ziplist%"

gmslice.txt

$offecho

* There is no need to change anything

* We always need the GAMS BASE system
DeployProducts('GAMS') = yes;

$if not set zipfile $set zipfile %gams.workdir%gmsdeploy.zip
$set gmsdir %gams.scrdir%gmssysdir
  
```

A file explorer window titled 'CMU' is open, showing the directory 'C:\Documents and Settings\lutz\Desktop\cmu\'. It contains a file named 'gmsdeploy.zip'.

A 'GAMS Model Library Version 27.0' window is also open, displaying a search result for 'dep'. The table below shows the search results:

SeqNr	Name +	Application Area	Type	Contributor	Description
092	DEM07	Agricultural Economics	NLP	Kutcher, G P	Nonlinear Simple Agricultural Sector Model
308	DEPLOY	GAMS Language Features	GAMS	GAMS Develop	GAMS Deployment Model
176	DICE	Mathematics	MIP	Gardner, M	Non-transitive Dice Design
272	DICEX	Mathematics	MIP	Bosh, R A	Non-transitive Dice Design - Enhanced

The 'DEPLOY' model is selected in the table. Below the table, the model's title and description are shown:

```

GAMS Deployment Model (DEPLOY,SEQ=308)

This model creates a GAMS deployment system
  
```



Model Maintenance

Optimization

- Takes Longer than one is willing to wait
- It will eventually fail

Application

- Real Time
- Always need a *Solution* to Problem

Keys for support/maintenance

- Catch problems before a model is solved
 - à Implement Data Error checks
- Reproduce the problem offline
 - à Get hold of Instance (`dumpopt=11`)
- Solver related problems in confidential models
 - à Get scalar Model using solver **CONVERT**



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Compressed and Encrypted Input Files

Summary



Release Notes

New Solvers

- **COIN-OR Solvers** (<http://www.coin-or.org/>)
 - MINLP solver: CoinBonmin
- **AlphaECP**
 - MINLP solver
 - Extended Cutting Plane method by T. Westerlund and T. Lastusilta (Abo Akademi University, Finland)
- **LINDOGLOBAL**
 - finds proven optimal solutions to non-convex MINLP
 - Global Optimization Solver from Lindo Systems, Inc.

New solver binaries

- **BARON, CONOPT, CPLEX, MOSEK, XPRESS,...**



Solver Technology

è Tremendous algorithmic and computational progress

- **LP** in fact only restricted by available memory
- **MIP**
 - Some small (academic) problems still unsolvable
 - Commercial problems in most case docile
- **NLP/MINLP**
 - Predictions are problem and data specific, global vs. local solutions

è Further progress using Multiple Threads / Grid Computing



Multiple Threads / SMP

- **CPLEX**

- **parallel extension** for B&B and interior point solver
- options *threads*, *barthreads*, *mipthreads*, *strongthreadlim*
- **concurrent optimizer** options *lpmethod*, *qpmethod*, *startalg*
- academic license includes 4 threads

- **MOSEK**

- **parallel extension** for the interior solver comes free of charge
- option *MSK_IPAR_INTPNT_NUM_THREADS*
- **concurrent optimizer** options *MSK_IPAR_CONCURRENT_**

- **XPRESS**

- **parallel extension** for B&B and interior point solver
- options *threads*, *barThreads*, *mipThreads*, *sbThreads*
- academic license includes 4 threads

- **XA (XAPAR)**



Grid Computing

Imagine...

*.. you have to solve 1.000's of
independent scenarios...
.. and you can do this very rapidly
for little additional money...
.. without having to do lots of
cumbersome programming work...*

Grid Computing



What is Grid Computing?



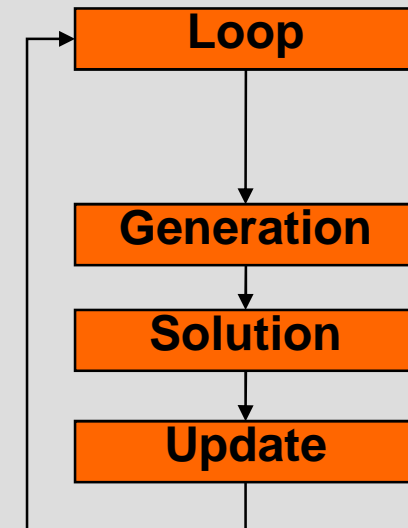
A pool of connected computers managed and available as a common computing resource

- Effective sharing of CPU power
- Massive parallel task execution
- Scheduler handles management tasks
- E.g. Condor, Sun Grid Engine, Globus
- Can be rented or owned in common
- Licensing & security issues



Simple Serial Solve Loop

```
Loop(p(pp),  
    v.fx = vmin + (vmax-vmin)  
    /(card(pp)+1)*ord(pp) ;  
    Solve var1 maximizing m using nlp ;  
    xres(i,p)      = x.l(i);  
    xres('mean',p) = m.l;  
    xres('var',p)   = v.l;  
    xres('status',p) = var1.modelstat;  
);
```

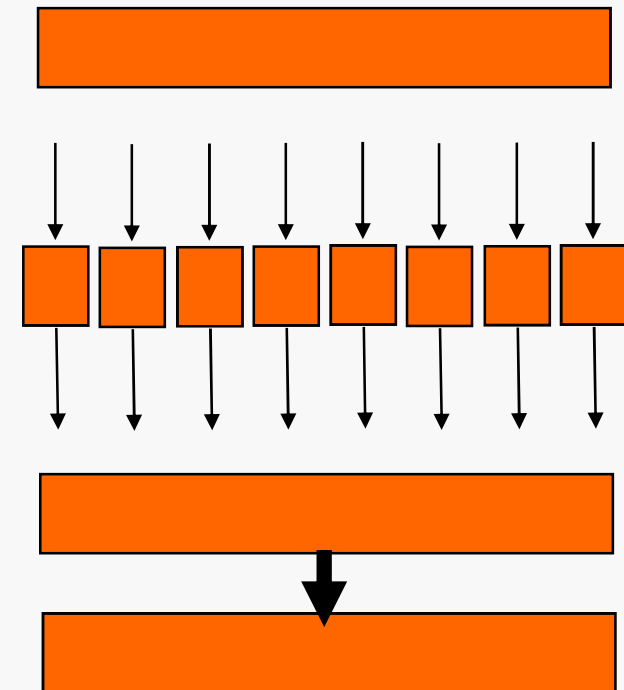


How do we get to parallel and distributed computing?



GRID Specific Enhancements

1. Submission of jobs
2. “Grid Middleware”
 - Distribution of jobs
 - Job execution
3. Collection of solutions
4. Processing of results





Hands-on! GAMS Grid Computing

```

gamside: C:\Documents and Settings\JanMy Documents\presentation\2007-07-EURO-Prag\Workshop\meanvar_grid\meanvar.gpr
File Edit Search Windows Utilities Help

meanvar.gms
xres('var',p)      = v.l;
xres('status',p)   = var1.modelstat;
vmin = v.l; );

Loop(p(pp),
  v.fx = vmin + (vmax-vmin)/(card(pp)+1)*ord(pp) ;
  Solve var1 maximizing m using nlp ;
  xres(i,p)      = x.l(i);
  xres('mean',p) = m.l;
  xres('var',p)   = v.l;
  xres('status',p) = var1.modelstat; );

Display xres;

meanvar_edited.gms
xres('var',p)      = v.l;
xres('status',p)   = var1.modelstat;
vmin = v.l; );

$if not set grid $set grid 0
parameter handle(p) Grid handle;

if(not %grid%,
  Loop(p(pp),
    v.fx = vmin + (vmax-vmin)/(card(pp)+1)*ord(pp)
    Solve var1 maximizing m using nlp ;
    xres(i,p)      = x.l(i);
    xres('mean',p) = m.l;
    xres('var',p)   = v.l;
    xres('status',p) = var1.modelstat; );
else
  var1.solverlink=3;
  Loop(p(pp),
    v.fx = vmin + (vmax-vmin)/(card(pp)+1)*ord(pp)
    Solve var1 maximizing m using nlp ;
    handle(p) = var1.handle );
  Repeat
    loop(p(pp)$handlecollect(handle(p)),
      xres(i,p)      = x.l(i);
      xres('mean',p) = m.l;
      xres('var',p)   = v.l;
      xres('status',p) = var1.modelstat;
      display$handledelete(handle(p)) 'trouble del
      handle(p) = 0 ) ;
      display$sleep(card(handle)*0.2) 'sleep some time
    until card(handle) = 0 or timeelapsed > 100;
    xres(i,p(pp))$handle(p) = na;
  );
Display xres;

execute_unload "portfolio.gdx" xres;

```



Hands-on! The Mean-Variance Model

Markowitz (1952), Nobel prize 1990

Given

- Some investments x_i with historical data
- **Rewards = Expected returns** of investments: μ_i (**Mean** of historical returns)
 - **Risk = Variance** of investments $Q_{i,j}$

Goal

Balance risk r of portfolio against expected returns of portfolio

Minimize variance v for a given target return r

Variance of Portfolio	$\text{Min} \sum_{i=1}^I \sum_{j=1}^J x_i Q_{i,j} x_j$
Target return	$\text{s.t.} \quad \sum_{i=1}^I \mu_i x_i \geq r$
Budget constraint	$\sum_{i=1}^I x_i = 1$
No short sales	$x_i \geq 0$



Job Submission Loop

```
* turn on grid option
var1.solverlink=3;
parameter handle(p) Grid handle;
Loop(p(pp),
    v.fx = vmin + (vmax-vmin)/(card(pp)+1)*ord(pp);
    Solve var1 maximizing m using nlp ;
* save instance handle
    handle(p) = var1.handle );
```

```
LOG      ...
        --- LOOPS pp = p1
        --- 3 rows 9 columns 23 non-zeroes
        --- 538 nl-code 7 nl-non-zeroes
        --- meanvar_edited.gms(174) 3 Mb
        --- Submitting model var1 with handle grid133000004
        ...
```



“Grid”- Middleware (PC)

```
@echo off
: gams grid submission script
: arg1 solver executable
:   2 control file
:   3 scratch directory
: gmscr_nx.exe processes the solution and produces 'gmsgrid.gdx'
: note: %3 will be the short name, this is needed because
:       the START command cannot handle spaces or '...'
:       before we use %~3 will strip surrounding '...'
:       makes the name short
: gmsrerun.cmd will resubmit runit.cmd

echo @echo off                > %3runit.cmd
echo %1 %2                    >> %3runit.cmd
echo gmscr_nx.exe %2          >> %3runit.cmd
echo echo OK ^> %3finished >> %3runit.cmd
echo exit                     >> %3runit.cmd

echo @start /b %3runit.cmd ^> nul > %3gmsrerun.cmd
start /b %3runit.cmd > nul

exit
```




Solution Collection Loop

Repeat

```
loop(p(pp)$handlecollect(handle(p)),  
xres(i,p)      = x.l(i); xres('mean',p)    = m.l;  
xres('var',p)   = v.l;    xres('status',p) = var1.modelstat;  
display$handledelete(handle(p)) 'trouble deleting handles';  
handle(p) = 0 ) ;  
display$sleep(card(handle)*0.2) 'sleep some time';  
until card(handle) = 0 or timeelapsed > 100;  
xres(i,p(pp))$handle(p) = na;
```

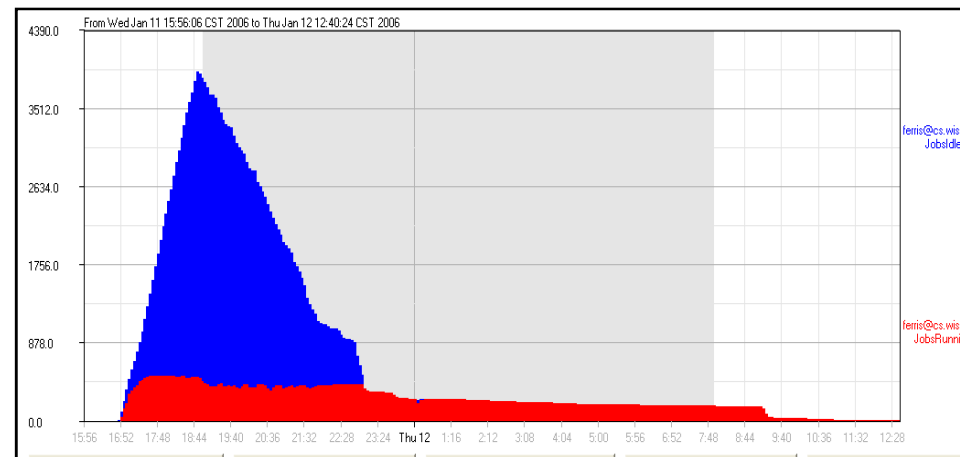
LOG

```
...  
--- meanvar_edited.gms(161) 3 Mb  
--- GDXin=C:\...\225a\grid133000004\gmsgrid.gdx  
--- meanvar_edited.gms(161) 3 Mb  
--- Removed handle grid133000004  
...
```



GAMS & Grid Computing

- **Scalable:**
 - support of massive grids, **but also**
 - multi-cpu / multiple cores desktop machines
 - “1 CPU - Grid”
- Platform **independent**
- Only **minor changes** to model required
- **Separation** of model and solution method
à Model stays **maintainable**





SUNgrid

www.network.com

- On-demand grid computing service operated by Sun Microsystems
- Access to enormous computing power over Internet
- Opteron-based servers with 4 GB of RAM per CPU
- Solaris 10 OS, and Sun Grid Engine 6 software.
- \$1 per CPU-hour
- **GAMS on the SUN Grid**
 - GAMS distribution 22.5 for Solaris 10
 - COIN-OR solvers will be available



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GAMS Grid Computing

Compressed and Encrypted Input Files

Summary



Compressed and Encrypted Input Files

Distribution of models to users/customers

- \$Compress
 - compresses into a GAMS system file
- \$Decompress
 - decompresses a GAMS system file

Issues of privacy, security, data integrity and ownership

- \$Encrypt
 - encrypts into a GAMS system file
 - requires special licensing



Hands-on! cefiles.gms + encrypt.gms

```

gamside: C:\Documents and Settings\Jan\My Documents\presentation\2007-07-EURO-Prag\Workshop\encrypt\encrypt.gpr
File Edit Search Windows Utilities Help

cefiles.gms
$title Compressed Input Files (CEFILES,SEQ=317)

$ontext
This model demonstrates the use of compressed input files.
Remember, if the file names contain spaces you need
to use single or double quotes around the file names.
$offtext

* --- get model
$ondollar
$call gamslib -q trnsport

* --- compress and run model
$compress trnsport.gms t1.gms
$decompress t1.gms t1.org
$call diff trnsport.gms t1.org > %system.nullfile
$if errorlevel 1 $abort files trnsport and t1

* --- check to see if we get the same result
$call gams trnsport gdx=trnsport lo=%gams.lo%
$if errorlevel 1 $abort model trnsport failed
$call gams t1 gdx=t1 lo=%gams.lo%
$if errorlevel 1 $abort model t1 failed
$call gdxdiff trnsport t1 %system.redirlog%
$if errorlevel 1 $abort results for trnsport and t1

* --- also works with include files
$echo $include t1.gms > t2.gms
$call gams t2 gdx=t2 lo=%gams.lo%
$if errorlevel 1 $abort model t2 failed
$call gdxdiff trnsport t2 %system.redirlog%
$if errorlevel 1 $abort results for trnsport and t2
$terminate

encrypt.gms
$title Input file encryption demo (ENCRYPT,SEQ=318)

$ontext
Input files can be encrypted and use the save/privacy
file mechanism for managing the user password. Similar
to file compression, we offer an $encrypt utility to lock any
specific target license file. Once a file has been encrypted,
it can only be read by a gams program that has the matching
license file. There is no inverse operation possible: you cannot
recover the original GAMS file from the encrypted version.

To create an encrypted file, we need a license file with the
security option enabled. To allow easy testing and development,
a special temporary demo license can be created internally. This
will be valid for a limited time only, usually one to two weeks.

In the following example we will use the GAMS option
$license=DEMO to use a demo license with secure option instead of our
own license file. Also note that we use the same demo license file
to lock the file by specifying the GAMS parameter plicense=DEMO.
$offtext

* --- get model
$ondollar
$call gamslib -q trnsport

* --- encrypt and try to decrypt
$call rm -f t1.gms
$echo $encrypt trnsport.gms t1.gms > s1.gms
$call gams s1 license=DEMO plicense=LICENSE lo=%gams.lo%
$if errorlevel 1 $abort encryption failed

$seolcom //
$if NOT errorfree $abort pending errors
$decompress t1.gms t1.org // this has to fail
$if errorfree $abort decompress did not fail
$clearerror
    
```



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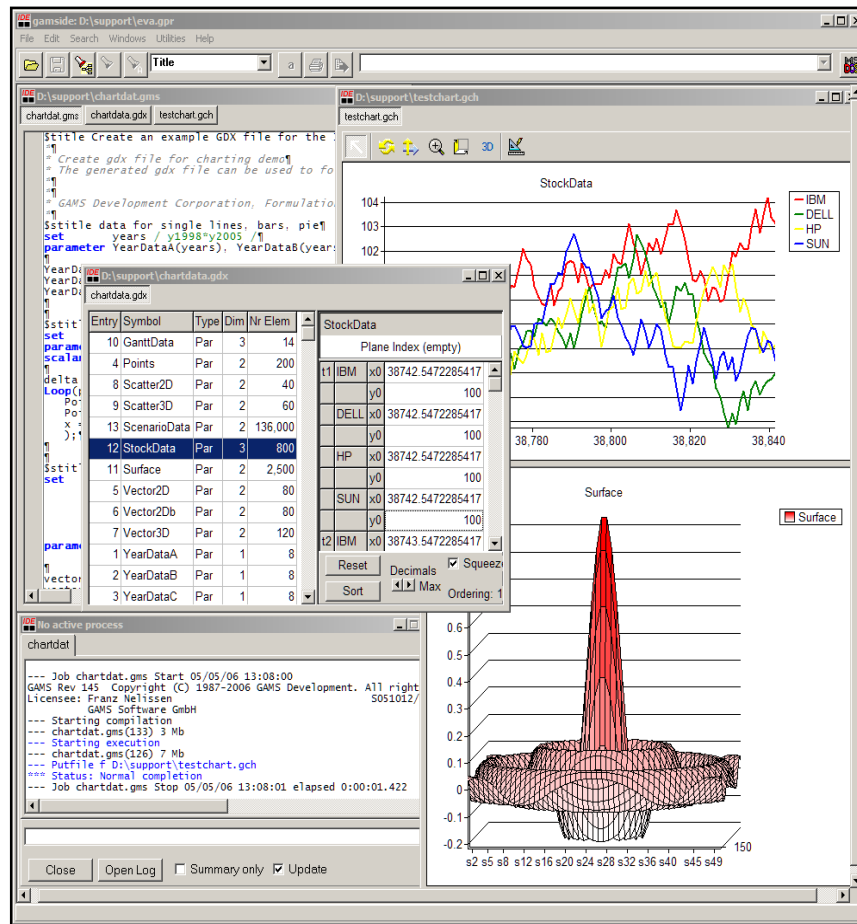
GAMS Grid Computing

Compressed and Encrypted Input Files

Summary



Benefits for Users



- Robust and scalable state-of-the-art modeling technology
- Tailored for complex, large-scale modeling applications
- Productivity gains through rapid development environment
- Broad academic and commercial network
- Proven reliability (30+ years of experience)
- Protection of investments through platform and solver independency



Benefits for Different User Groups

Researcher

- Projects
- Product maintenance
- Commercial network
- Quality assurance

Model Developer

- Rapid prototyping
- Higher productivity
- Robust & scalable solution
- Academic network

Consultants & Solution Provider

- Rapid prototyping
- Tailored solutions
- Benchmarking
- Extended support

Innocent User

- Works in different environments
- Lots of different interfaces
- Robust and reliable system

Management

- Protection of investments
- Low cost
- Maintainable applications
- Independence:
 - Solver
 - Platform
 - Interface



Sources of GAMS Information

Download: <http://download.gams-software.com/>

Release Notes: <http://www.gams.com/docs/release/release.htm>

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_1.htm

GAMS Google Group: <http://groups.google.de/group/gamsworld>

Other relevant sites on the Web: <http://www.gams.com/hotlinks.htm>



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