EURO XXII
GAMS - Workshop

Jan-Hendrik Jagla

jhjagla@gams.com

GAMS Software GmbH
www.gams.de

July 8th 2007

Agenda

- GAMS Development / GAMS Software
- Working with GAMS – A Guided Tour
- GAMS Grid Computing
- Compressed and Encrypted Input Files
- Summary

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

*** Illustrative examples in the GAMS Model Library**

GAMS Solutions Specialists Network

TELEGYR SYSTEMS

UNIVERSITY APPS. INC.

Verbund

JK

OPTIENCE

ETSAP

EcoMod Net

Profit Point Inc.

PCS

VA TECH SAT

SAT AUTOMATION

COPENHAGEN ECONOMICS

BARKAWI

ECOPLAN

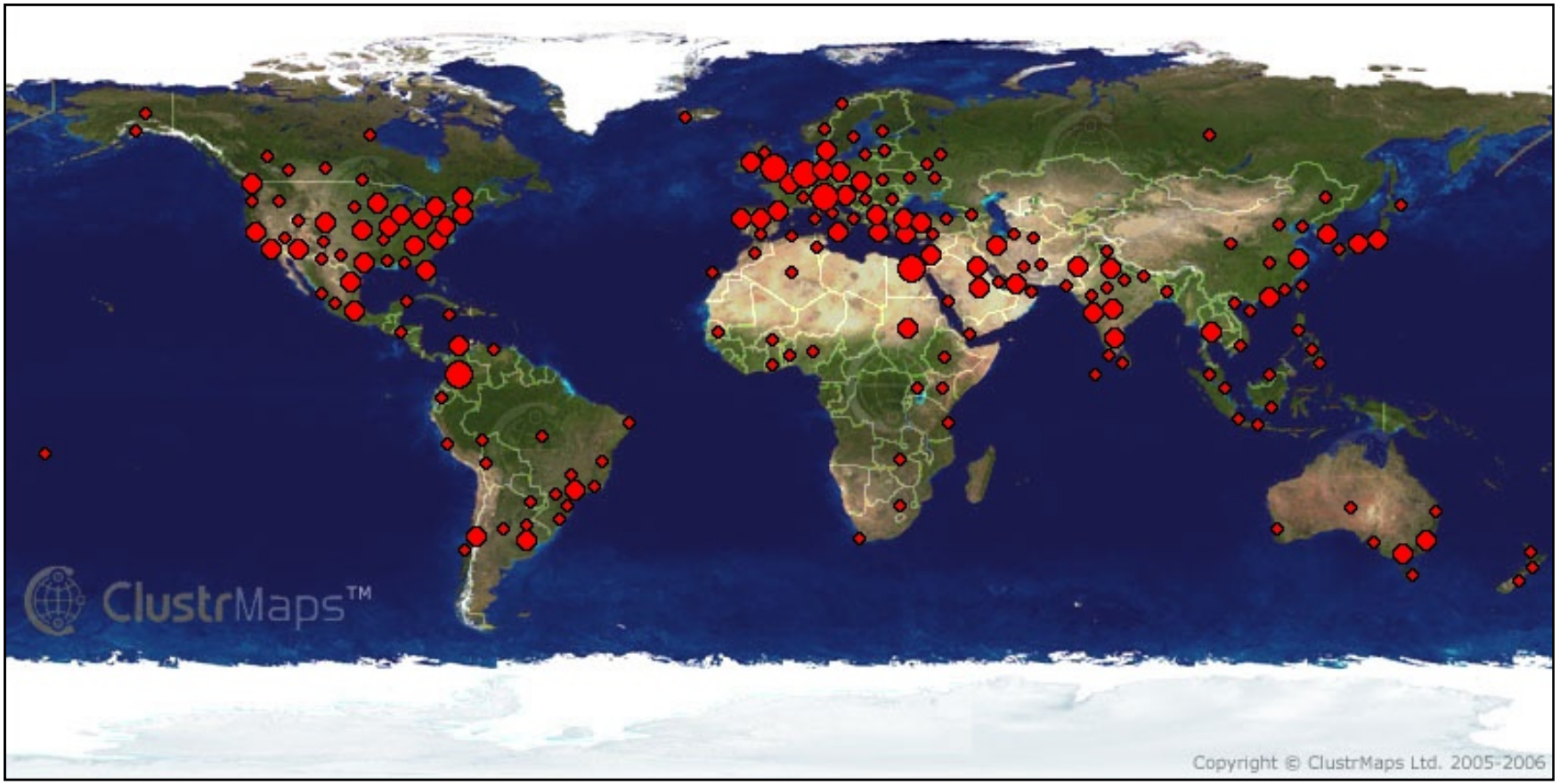
iiT

BALMOREL

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

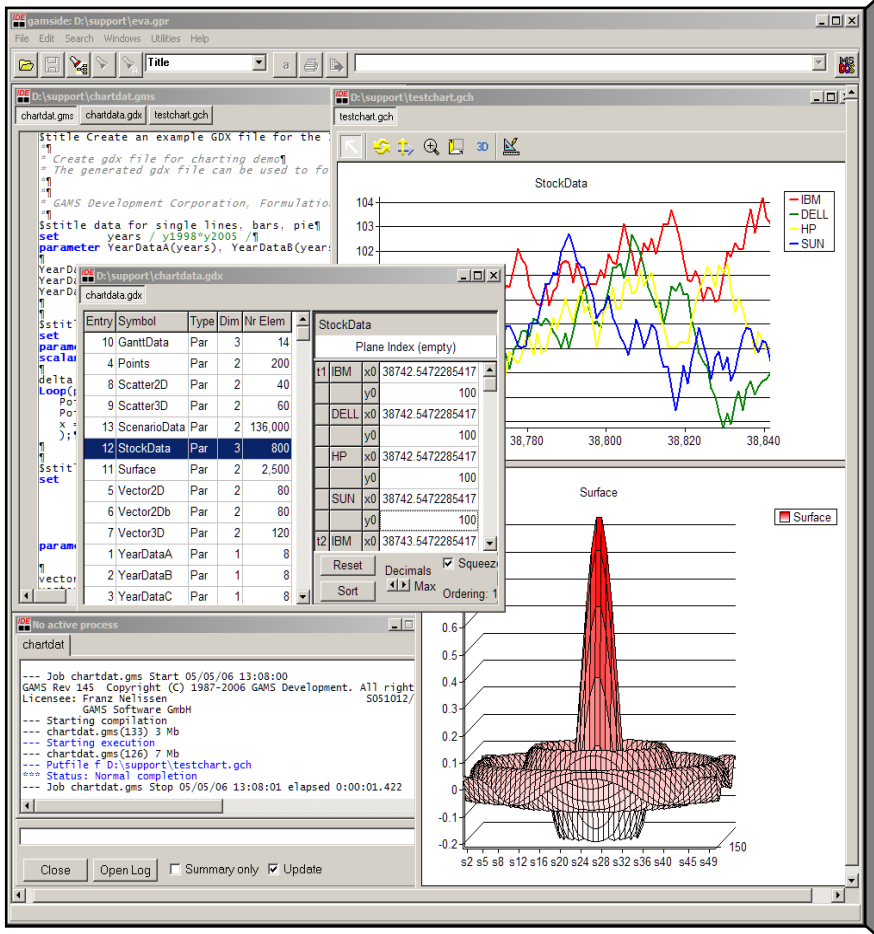
Algebraic Modeling Languages

- 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

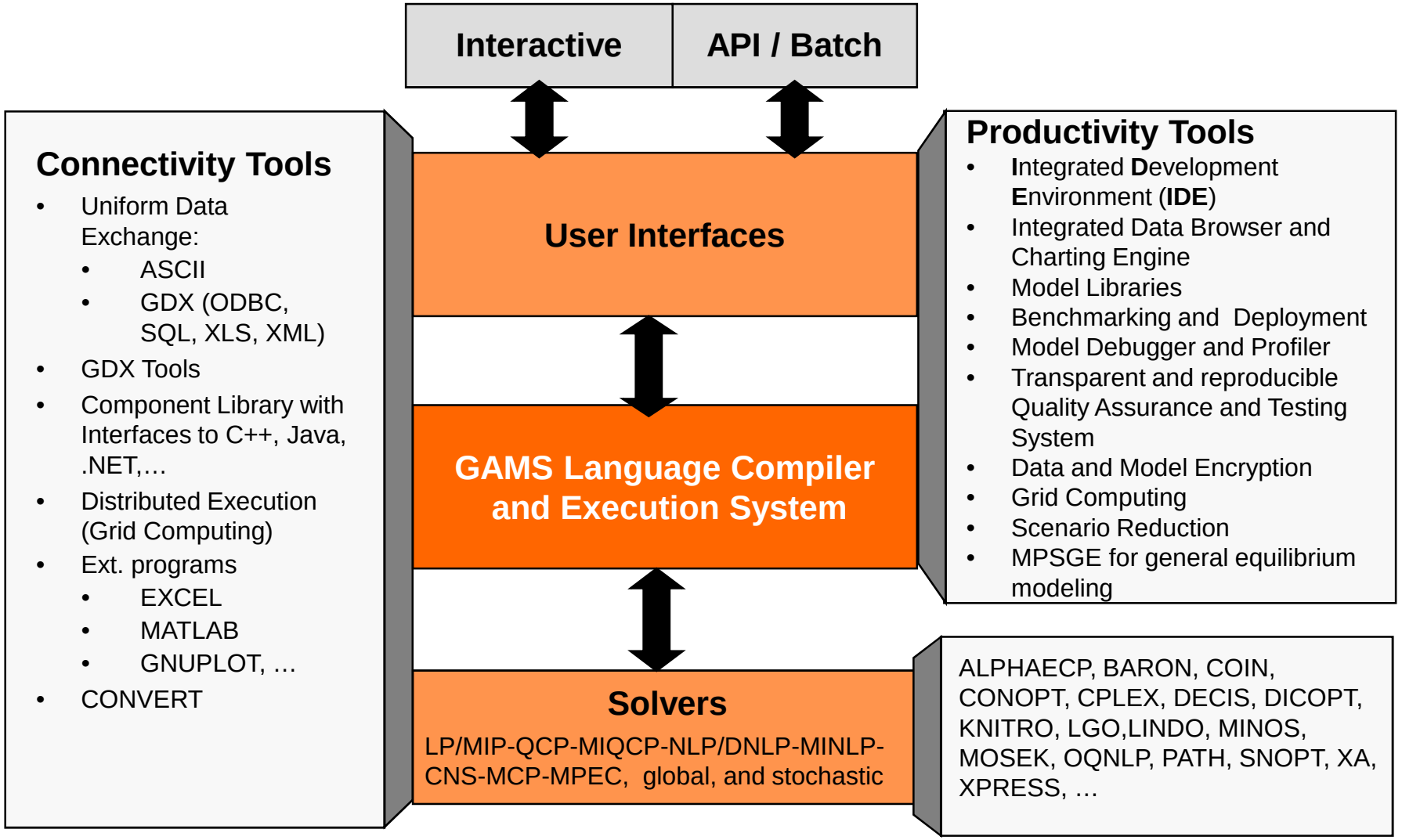


General **A**lgebraic **M**odeling **S**ystem:
Algebraic Modeling Language, Integrated Solver, Model Libraries, Connectivity- & Productivity Tools

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



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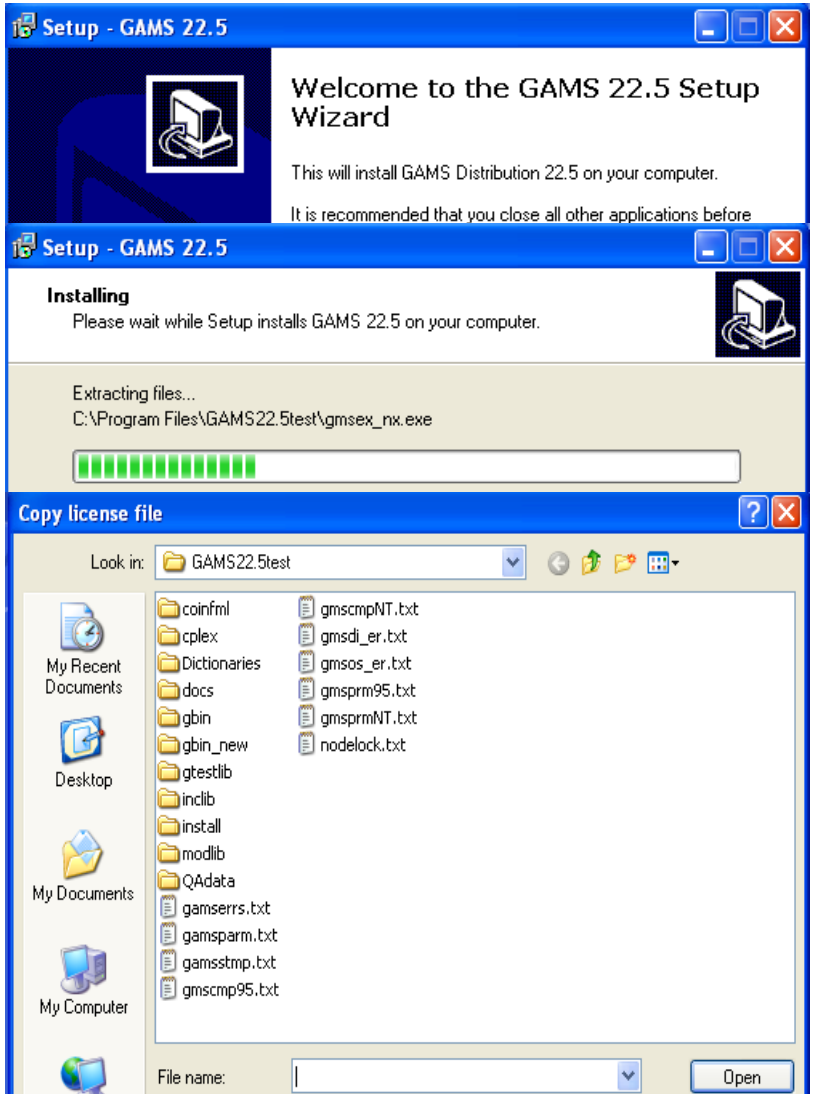
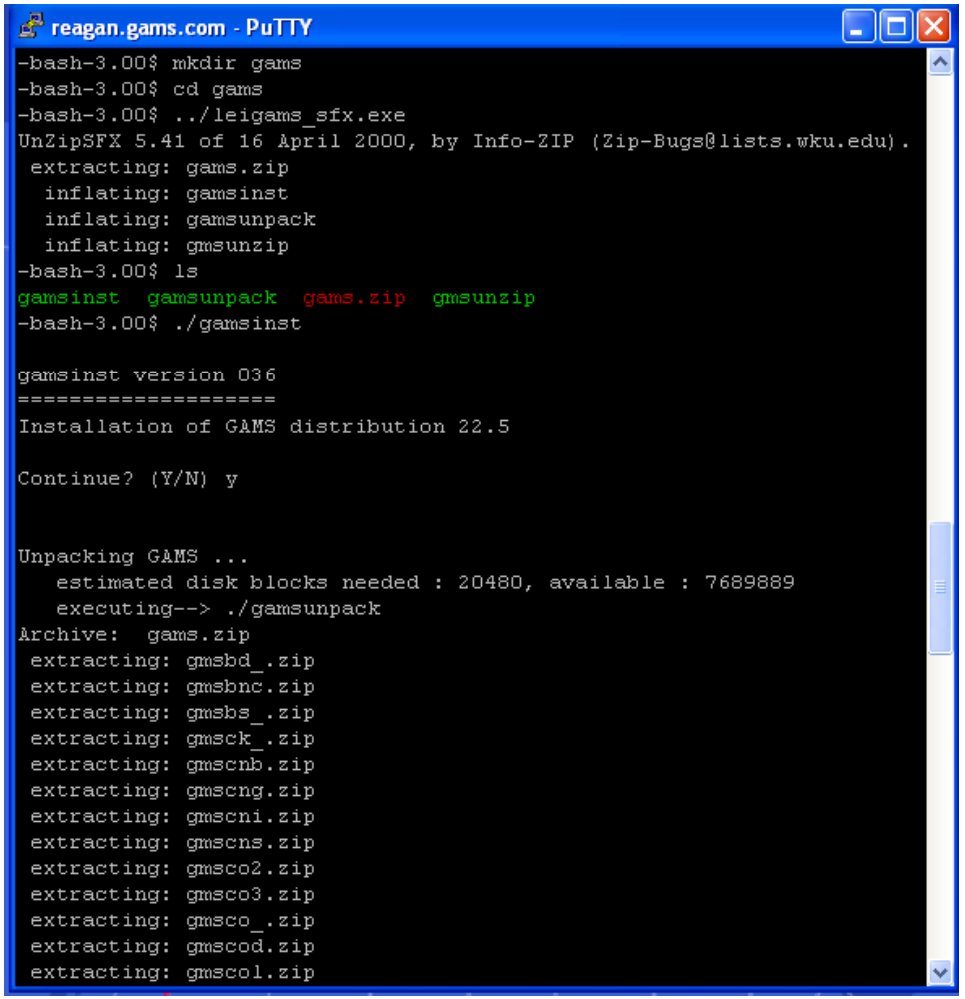
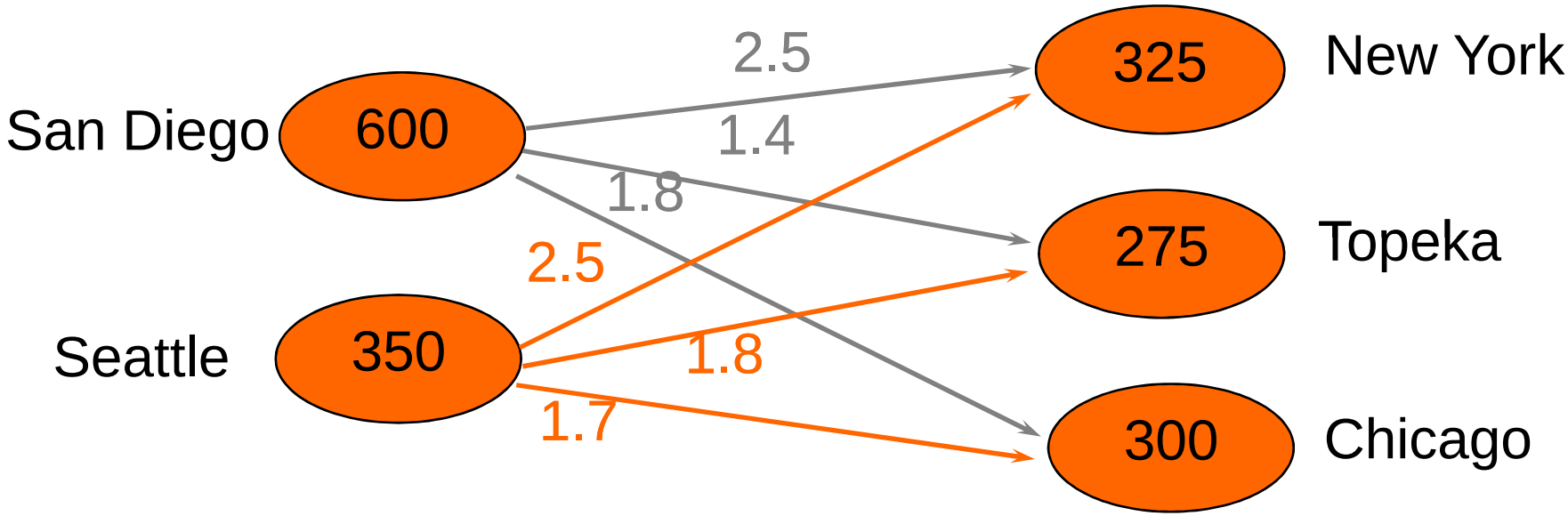
Hands-on! Installing GAMS





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

$$
\begin{aligned}
\sum_{\substack{c,p:\\(c,p)\in\mathcal{N}}} tcost \cdot dist(c,p) \cdot x_p^c &\rightarrow \min \\
\sum_{\substack{c,p:\\(c,p)\in\mathcal{N}}} x_p^c &\leq sup(c) \quad \forall c \\
\sum_{\substack{c,p:\\(c,p)\in\mathcal{N}}} x_p^c &\geq dem(p) \quad \forall p \\
x_p^c &\geq 0 \quad \forall c,p:\ (c,p)\in\mathcal{N}
\end{aligned}
$$

GAMS Algebra

gamside: C:\Documents and Settings\bussieck\My Documents\gamsdir\project.gpr - [c:\documents an...

File Edit Search Windows Utilities Help

call

trnsport.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/ ;
```

1: 1 Insert

GAMS Syntax

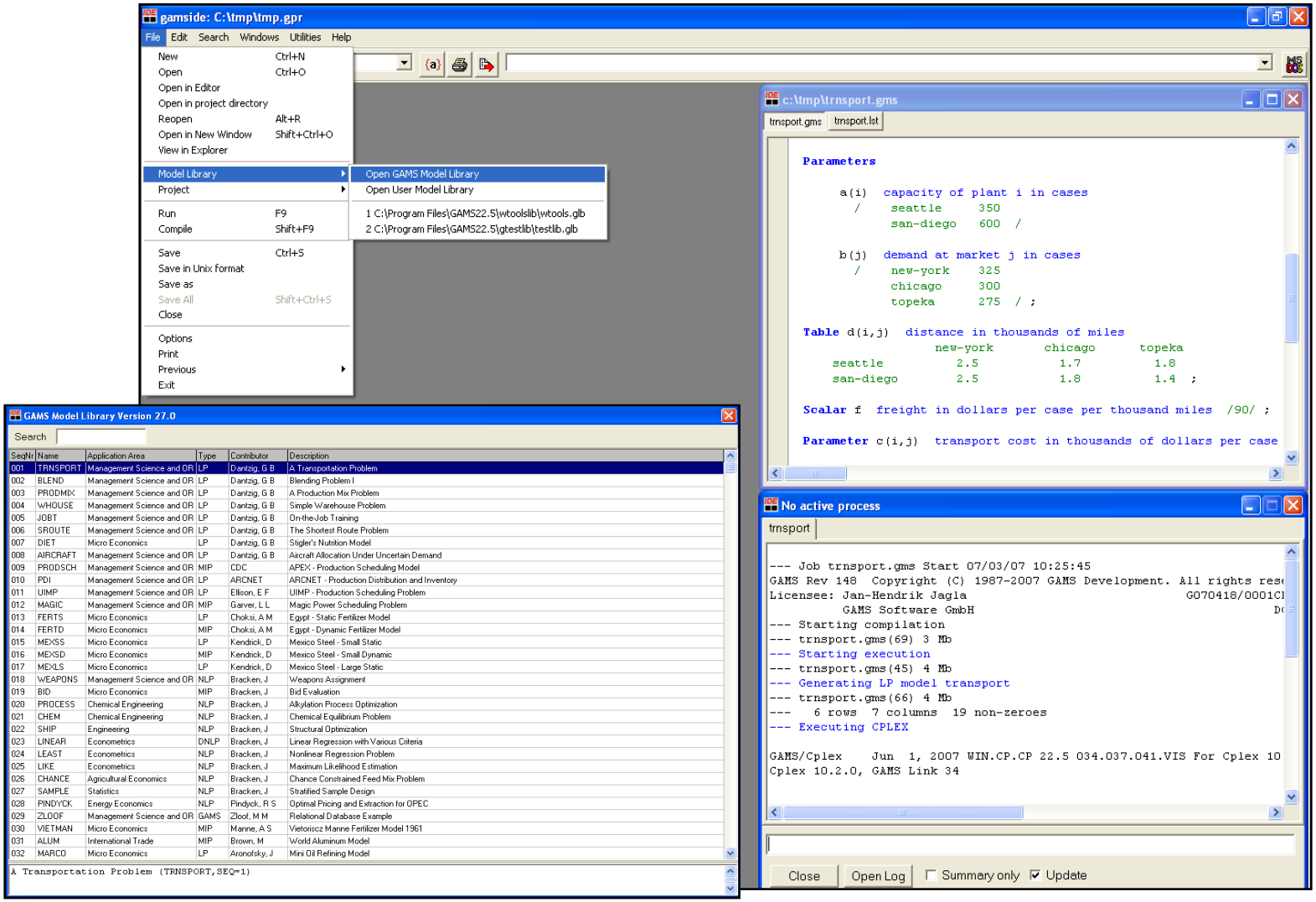
- Symbols:
  - Sets
  - Parameters
  - Variables
  - Equations
  - Models
  - ASCII Output Files

```
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.tl);
option reslim=10;
```

Hands-on! Testing the installation



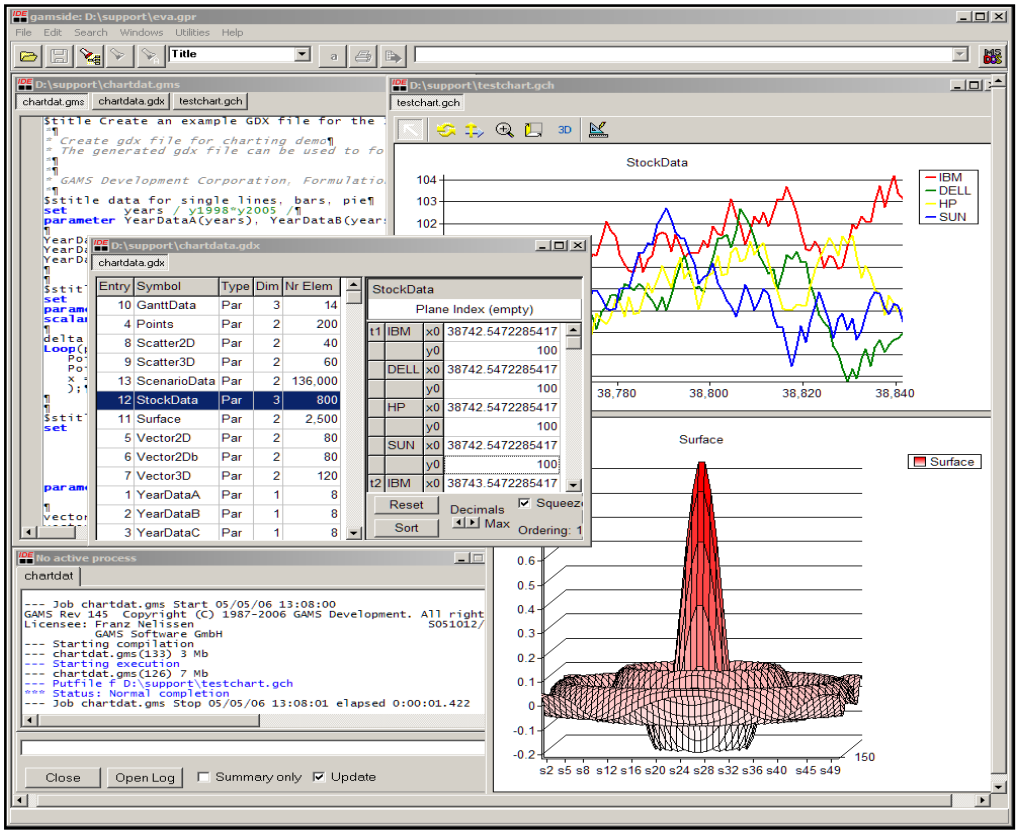
Hands-on! Testing the installation

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]
ALPHAECP	✔	✔	✔	✔	✔	✔		✔	✔	✔	
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

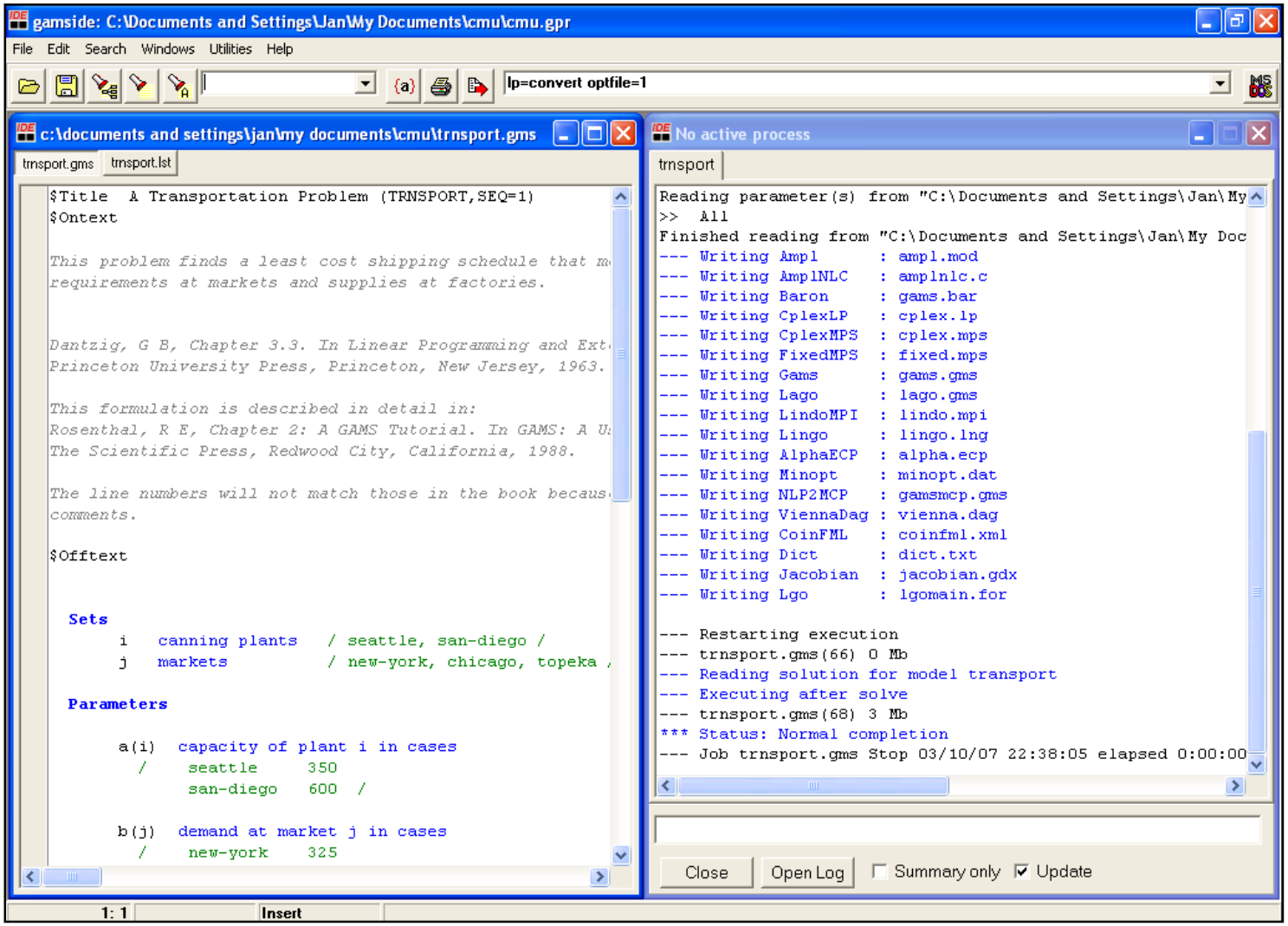
Solver/Model type availability - 22.5 June 1, 2007												
	LP	MIP	NLP	MCP	MPEC	CNS	DNLP	MINLP	QCP	MIQCP	*Stock.*	*Global*
ALPHAECP								✔		✔		
BARON 7.8	✔	✔	✔				✔	✔	✔	✔		✔
BDMLP	✔	✔										
COIN	✔	✔										
CONOPT 3	✔		✔			✔	✔		✔			
CPLEX 10.1	✔	✔							✔	✔		
DECIS	✔										✔	
DICOPT								✔				
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

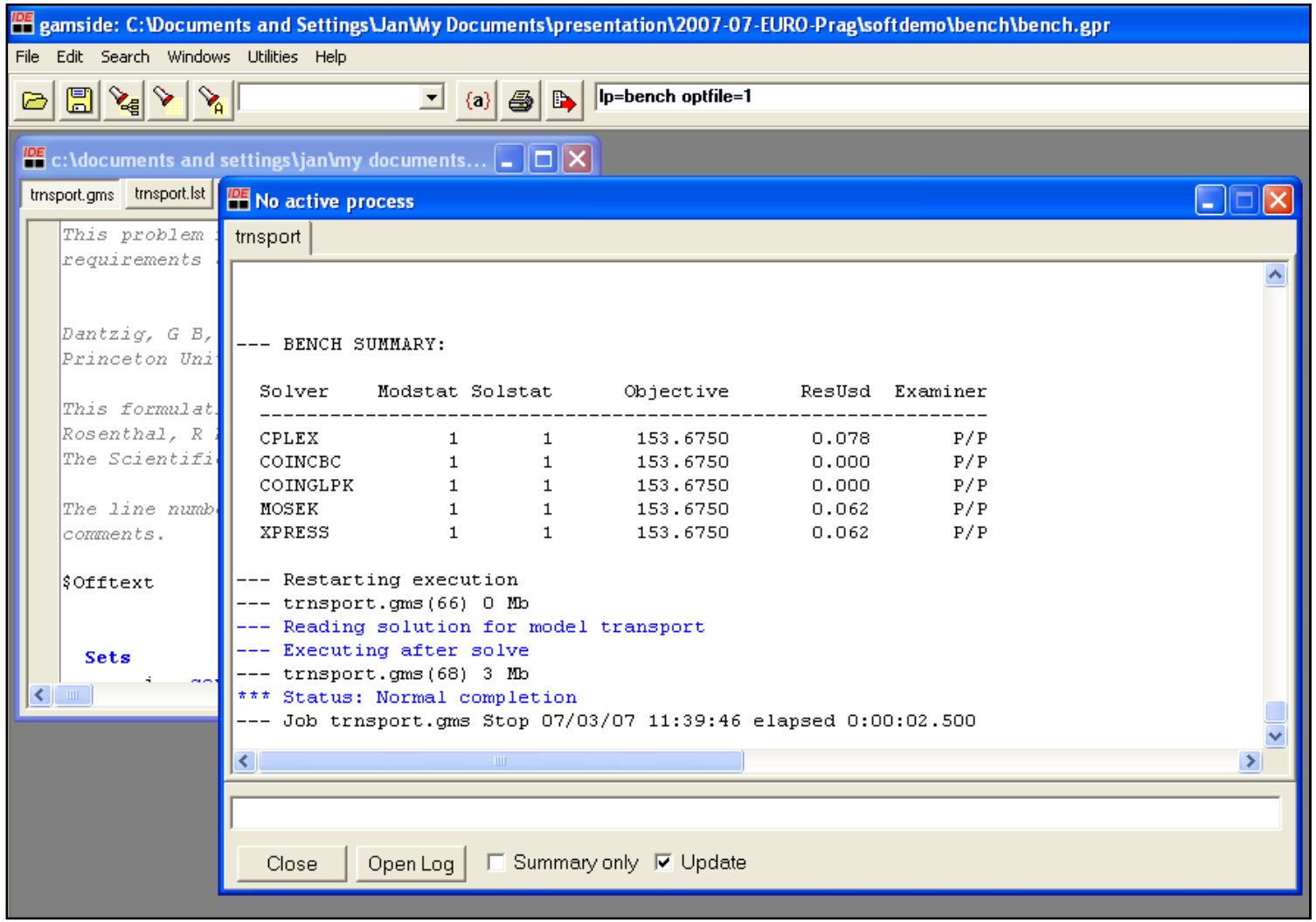
Solvers that do not *solve* the problem:

- **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

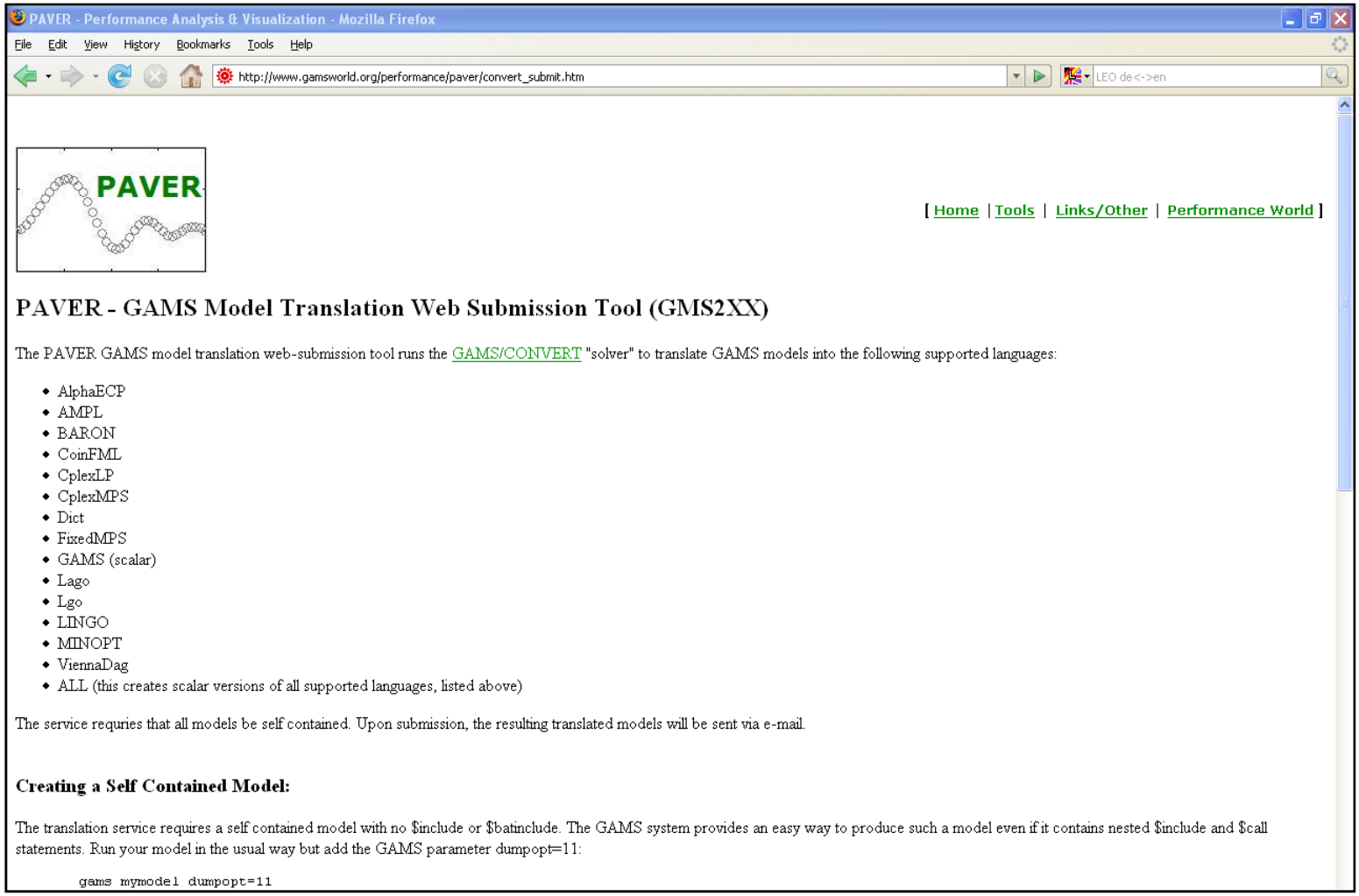
Hands-on! “Solver” Convert



Hands-on! ”Solver” Bench



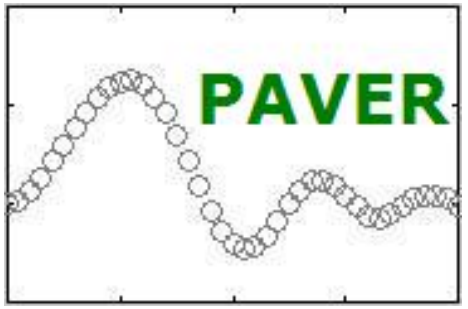
Convert online - www.gamsworld.org

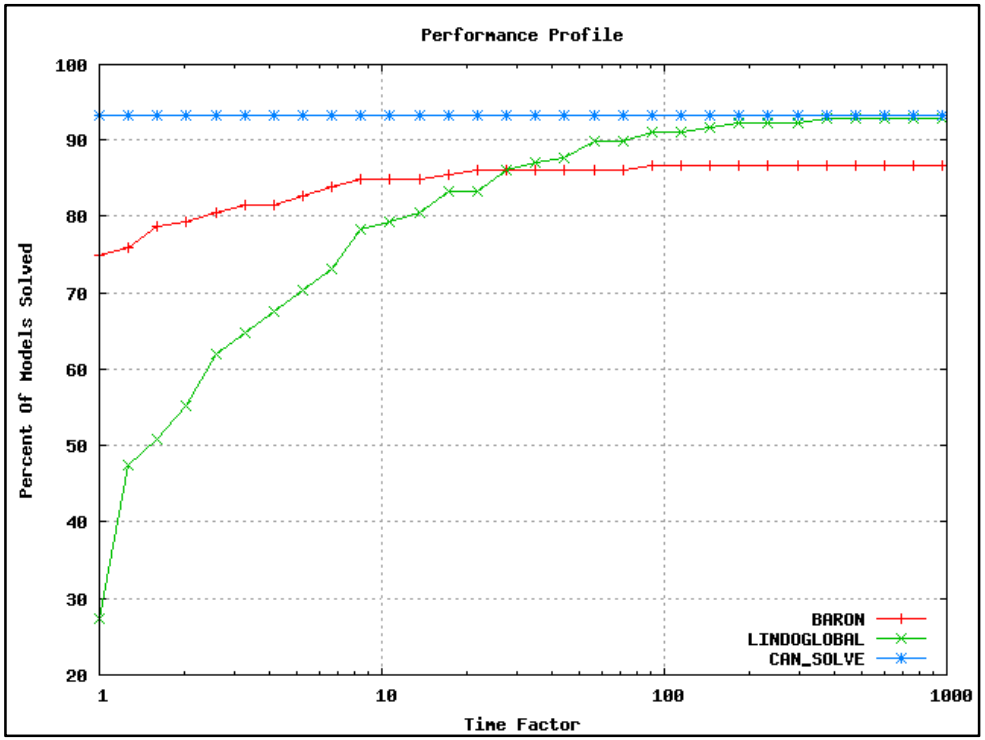


Benchmark online - www.gamsworld.org

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, …

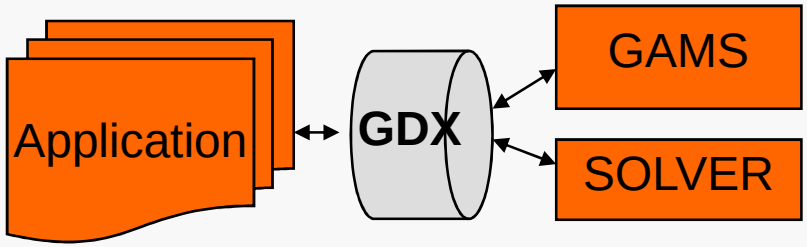
```
$call cut -d, -f1,3- file.txt > filenew.txt
```

- 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) /;
);
```

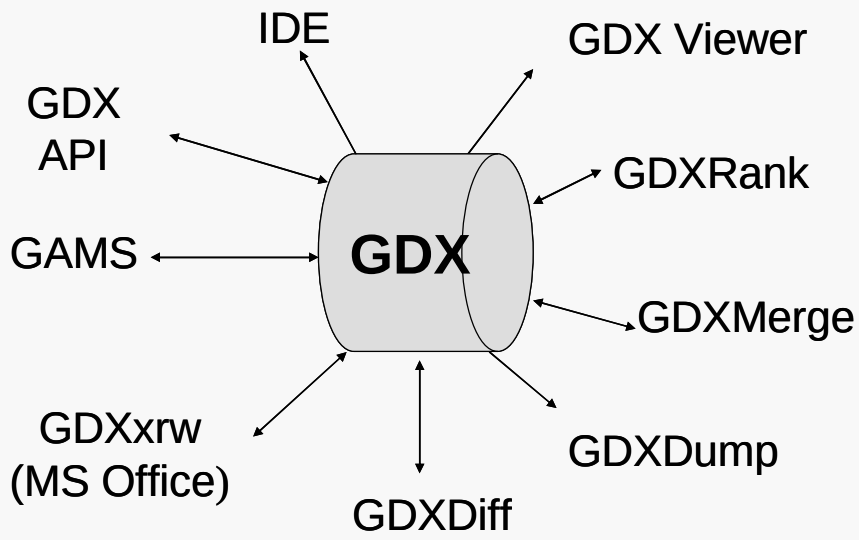
Gams Data eXchange

Binary Data Exchange

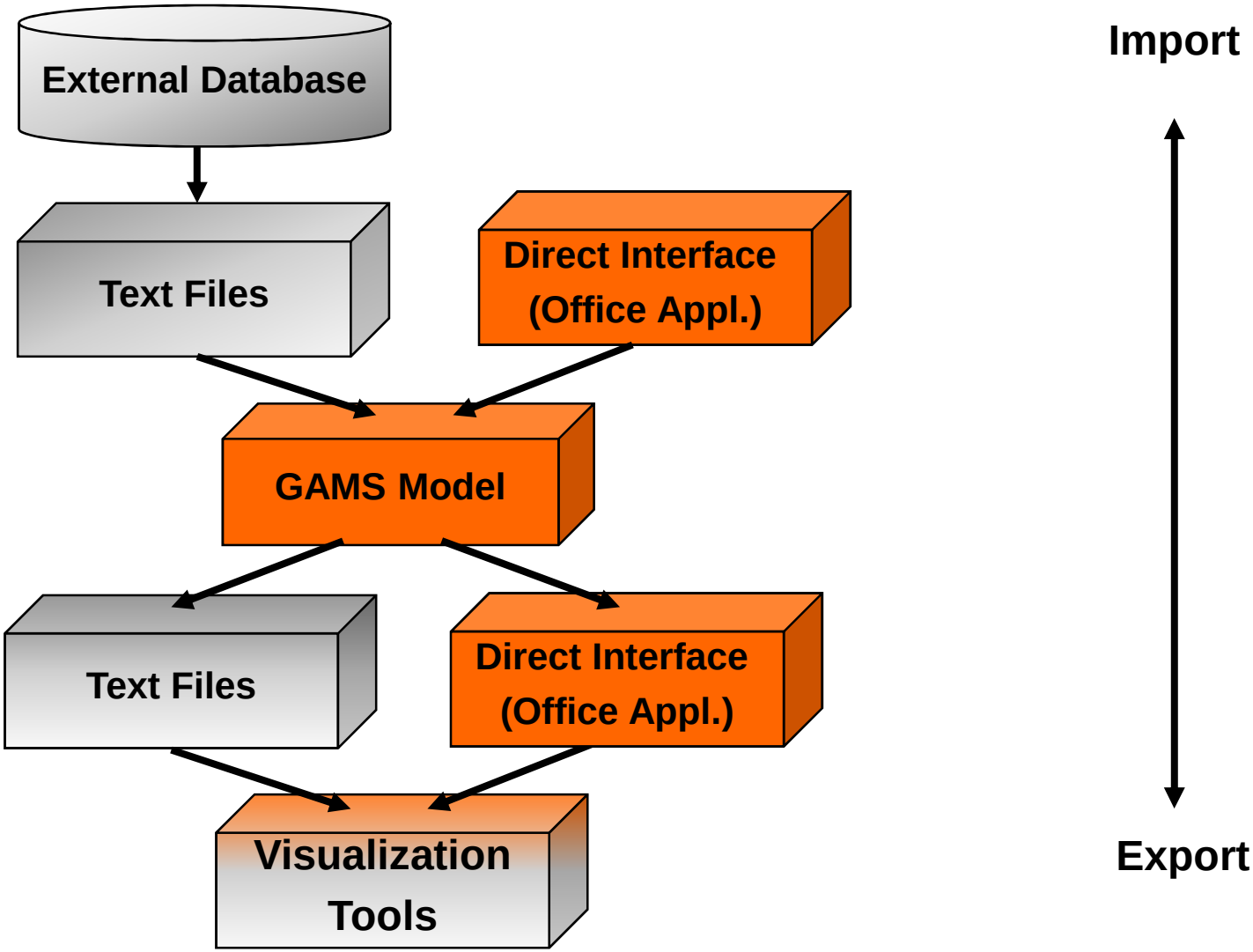


- Fast exchange of data
- Syntactical check on data before model starts
- Data Exchange at any stage (Compile and Run-time)
- Platform Independent
- Direct Excel connectivity
- General API
- Scenario Management Support
- Full Support of Batch Runs

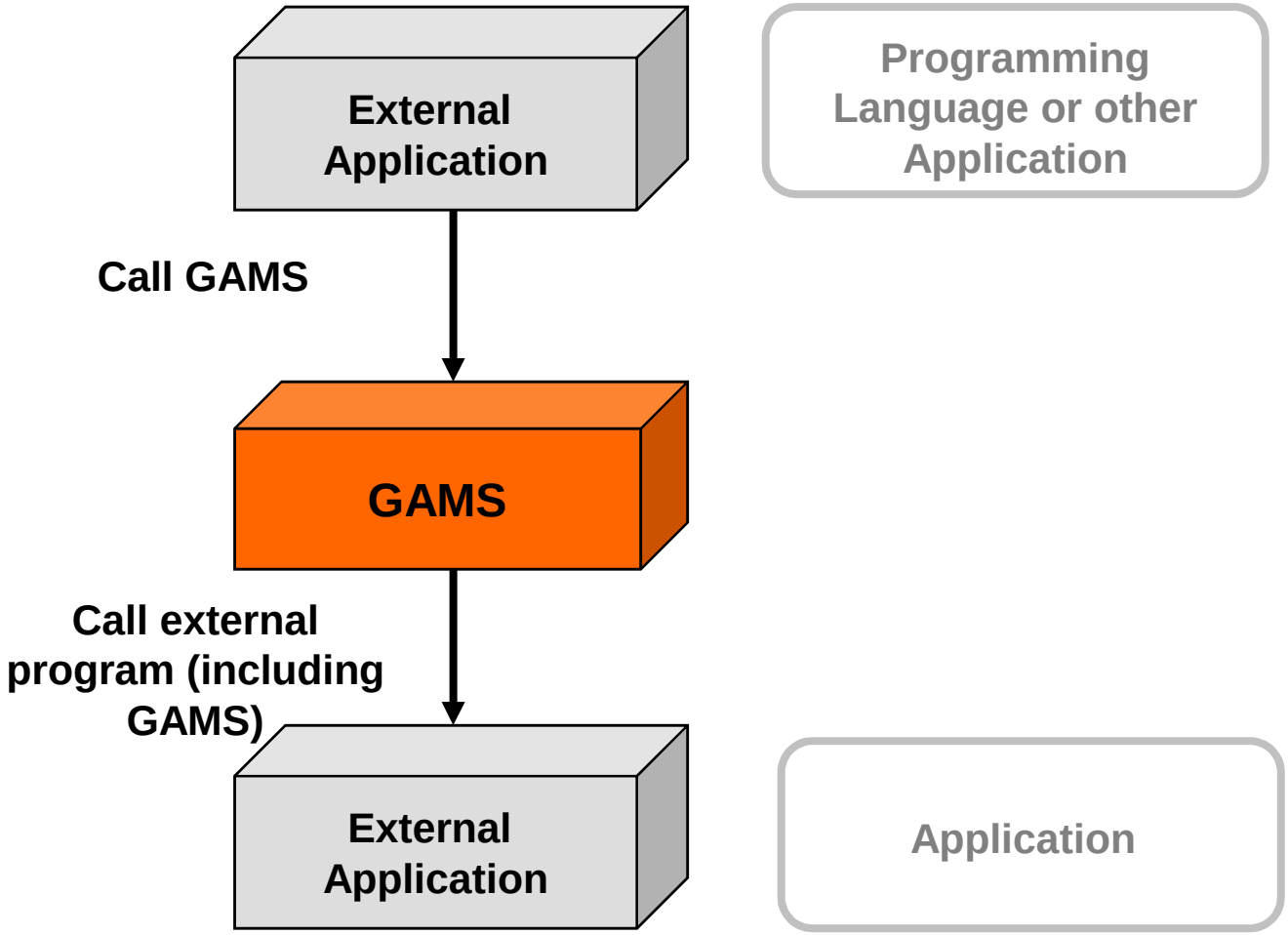
GDX Tools



GAMS in Control

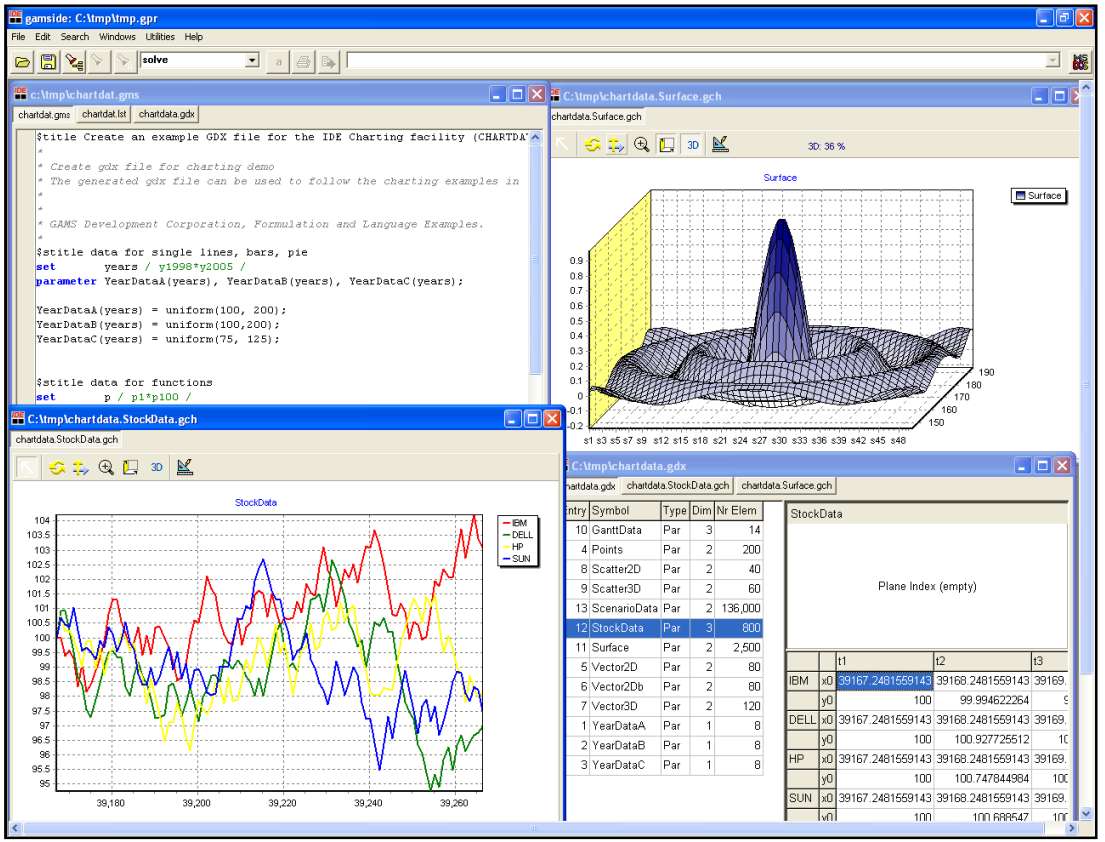


Application in Control

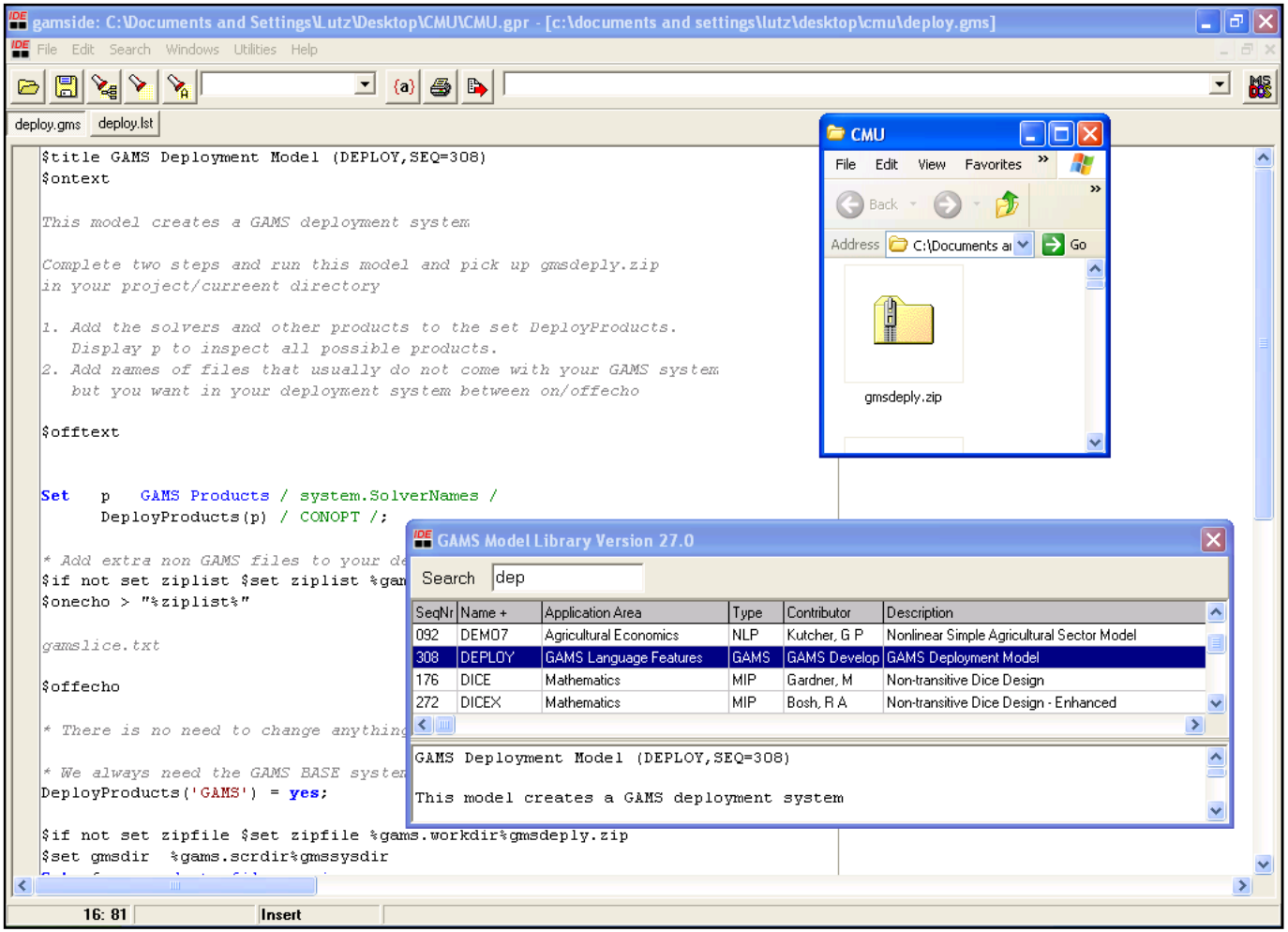


Hands-on! GDX and Tools

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



Hands-on! Deployment



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**

Agenda

- GAMS Development / GAMS Software
- Working with GAMS – A Guided Tour
- **GAMS Grid Computing**
- 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

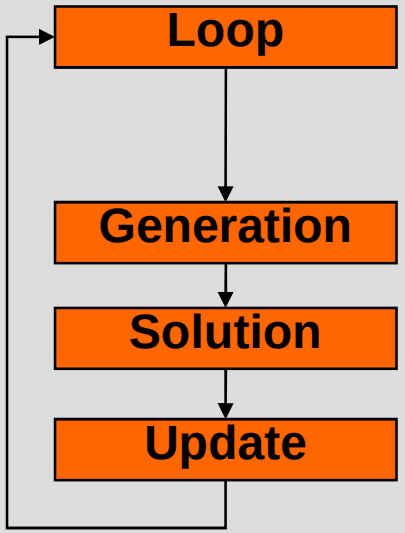
What is Grid Computing?

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

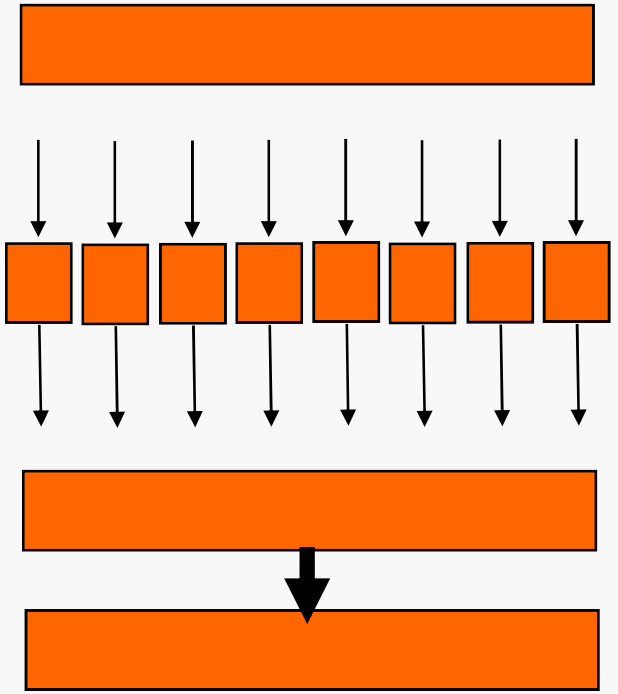
```
Loop(p(pp),
   v.fx = vmin + (vmax-vmin)
    /(card(pp)+1)*ord(pp) ;
   Solve var1 maximizing m using nlp ;
   xres(i,p)         = x.l(i);
   xres('mean',p)    = m.l;
   xres('var',p)     = v.l;
   xres('status',p) = var1.modelstat;
);
```



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\Jan\My Documents\presentation\2007-07-EURO-Prag\Workshop\meanvar_grid\meanvar.gpr

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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;
```

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meanvar.gms | 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.solvelink=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$sleep(card(handle)*0.2) 'sleep some tim
   until card(handle) = 0 or timeelapsed > 100;
   xres(i,p(pp))$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

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

Minimize variance *v* for a given target return *r*

Job Submission Loop

```
* turn on grid option
var1.solvelink=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 neeeded 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

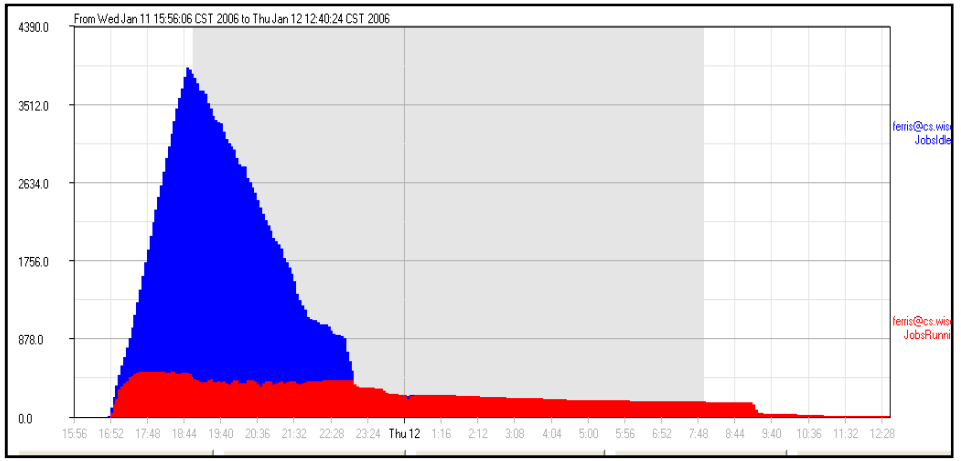
```
…
--- meanvar_edited.gms(161) 3 Mb
--- GDXin=C:\...\225a\grid133000004\gmsgrid.gdx
--- meanvar_edited.gms(161) 3 Mb
--- Removed handle grid133000004
…
```

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

Agenda

- GAMS Development / GAMS Software
- Working with GAMS – A Guided Tour
- 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

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cefiles.gms

```
$title Compressed Input Files (CEFILES,SEQ=317)

$ontext
This model demonstrates the use of compressed input f
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.nullfi
$if         errorlevel 1 $abort files trsnport 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
```

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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. Simila
compression, we offer an $encrypt utility to lock any
specific target license file. Once a file has been en
can only be read by a gams program that has the match
file.  There is no inverse operation possible: you ca
the original GAMS file from the encrypted version.

To create an encrypted file, we need a license file w
security option enabled. To allow easy testing and de
a special temporary demo license can be created inter
will be valid for a limited time only, usually one to

In the following example we will use the GAMS option
use a demo license with secure option instead of our
file. Also note that we use the same demo license fil
locked file by specifying the GAMS parameter plicence
$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.
$if   errorlevel 1     $abort encryption failed

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

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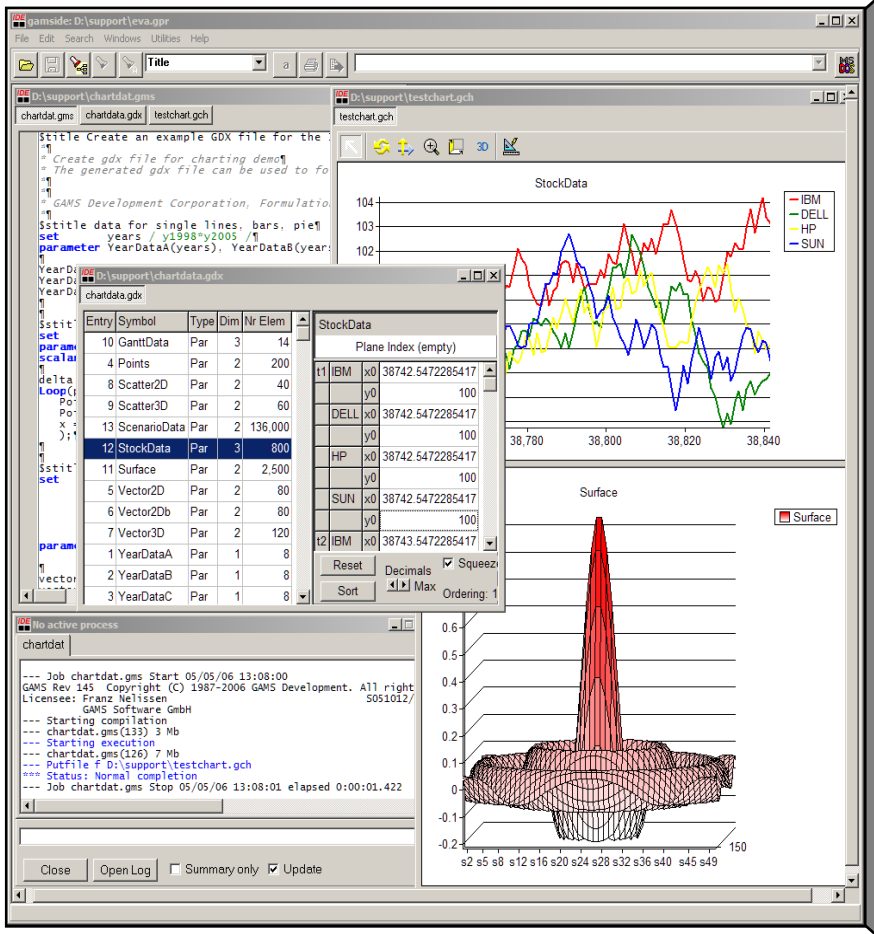
Benefits for Users



- 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_l.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