EURO XXII
GAMS - Workshop

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Agenda

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

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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 *

<table>
<thead>
<tr>
<th>Agricultural Economics</th>
<th>Applied General Equilibrium</th>
</tr>
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<tbody>
<tr>
<td>Chemical Engineering</td>
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<tr>
<td>Econometrics</td>
<td>Energy</td>
</tr>
<tr>
<td>Environmental Economics</td>
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<tr>
<td>Finance</td>
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<tr>
<td>International Trade</td>
<td>Logistics</td>
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<tr>
<td>Macro Economics</td>
<td>Military</td>
</tr>
<tr>
<td>Management Science/OR</td>
<td>Mathematics</td>
</tr>
<tr>
<td>Micro Economics</td>
<td>Physics</td>
</tr>
</tbody>
</table>

* Illustrative examples in the GAMS Model Library
GAMS Solutions Specialists Network

Companies with wide experience in GAMS modeling

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:**

**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

Connectivity Tools
- Uniform Data Exchange:
  - ASCII
  - GDX (ODBC, SQL, XLS, XML)
- GDX Tools
- Component Library with Interfaces to C++, Java, .NET,…
- Distributed Execution (Grid Computing)
- Ext. programs
  - EXCEL
  - MATLAB
  - GNUPLOT, …
- CONVERT

Productivity Tools
- Integrated Development Environment (IDE)
- Integrated Data Browser and Charting Engine
- Model Libraries
- Benchmarking and Deployment
- Model Debugger and Profiler
- Transparent and reproducible Quality Assurance and Testing System
- Data and Model Encryption
- Grid Computing
- Scenario Reduction
- MPSGE for general equilibrium modeling

Solvers
LP/MIP-QCP-MIQCP-NLP/DNLP-MINLP-CNS-MCP-MPEC, global, and stochastic

User Interfaces

Interactive

API / Batch

GAMS Language Compiler and Execution System

ALPHAEC, BARON, COIN, CONOPT, CPLEX, DECIS, DICOPT, KNITRO, LGO, LINDO, MINOS, MOSEK, OQNLP, PATH, SNOPT, XA, XPRESS, …
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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

San Diego 600
          2.5 1.4
          1.8
Seattle 350
          2.5 1.8
          1.7
            
New York 325
Topeka 275
Chicago 300
\[ \sum_{(c,p) \in \mathcal{N}} t_{\text{cost}} \cdot \text{dist}(c, p) \cdot x_{p}^{c} \rightarrow \min \]

\[ \sum_{(c,p) \in \mathcal{N}} x_{p}^{c} \leq \sup(c) \quad \forall c \]

\[ \sum_{(c,p) \in \mathcal{N}} x_{p}^{c} \geq \text{dem}(p) \quad \forall p \]

\[ x_{p}^{c} \geq 0 \quad \forall c, p : (c, p) \in \mathcal{N} \]
GAMS Algebra

```plaintext
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

```gams
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

```gams
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

![Image of a computer screen with a GAMS model open, showing a model library and a CPLEX interface with a table and parameters. The model includes variables such as demand and capacity, and parameters like transport costs and distances between cities.]
Hands-on! Testing the installation

```
reagan.gams.com - PuTTY

$ gamslib transport
Model transport.gms retrieved
$ gams transport

--- Job transport Start 07/03/07 10:33:00
--- 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-zeros
--- Executing CPLEX

GAMS/Cplex Jun 1, 2007 LEX.CF.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.

<table>
<thead>
<tr>
<th>Iteration</th>
<th>Dual Objective</th>
<th>In Variable</th>
<th>Out Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>79.135000</td>
<td>x(seattle,new-york)</td>
<td>demand(new-york)</td>
</tr>
<tr>
<td>2</td>
<td>119.025000</td>
<td>x(seattle,chicago)</td>
<td>demand(chicago)</td>
</tr>
<tr>
<td>3</td>
<td>153.675000</td>
<td>x(san-diego, topeka)</td>
<td>demand(topeka)</td>
</tr>
<tr>
<td>4</td>
<td>153.675000</td>
<td>x(san-diego, new-york)</td>
<td>supply(seattle)</td>
</tr>
</tbody>
</table>
```
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 \texttt{solver.opt} e.g. \texttt{cplex.opt} with solver specific options (one per line)

• Activate solver option file
  – \texttt{optfile=1} on command line/parameter window
  – \texttt{<modelname>.optfile=1}; before solve

• Multiple option files:
  – \texttt{solver.opt} \texttt{optfile=1}
  – \texttt{solver.op2} \texttt{optfile=2}
  – \texttt{...}
  – \texttt{solver.999} \texttt{optfile=999}
# Multiple Solvers & Platforms

<table>
<thead>
<tr>
<th>Solver/Platform availability - 22.5</th>
<th>June 1, 2007</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Platform</strong></td>
<td><strong>Solver</strong></td>
</tr>
<tr>
<td><strong>x86</strong></td>
<td><strong>x86_64</strong></td>
</tr>
<tr>
<td>MS Windows</td>
<td>Linux</td>
</tr>
<tr>
<td>-----------------</td>
<td>----------------</td>
</tr>
<tr>
<td>ALPHAEC [✓]</td>
<td>[✓]</td>
</tr>
<tr>
<td>BARON 7.0</td>
<td>[✓]</td>
</tr>
<tr>
<td>BSDL [✓]</td>
<td>[✓]</td>
</tr>
<tr>
<td>CPLEX 12.1</td>
<td>[✓]</td>
</tr>
<tr>
<td>CPLEX 11</td>
<td>[✓]</td>
</tr>
<tr>
<td>DICOPT</td>
<td>[✓]</td>
</tr>
<tr>
<td>GRTOPT 5.1</td>
<td>[✓]</td>
</tr>
<tr>
<td>LINDO/Global 4.1</td>
<td>[✓]</td>
</tr>
<tr>
<td>LOQO</td>
<td>[✓]</td>
</tr>
<tr>
<td>MPS [✓]</td>
<td>[✓]</td>
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<td>NLPEC</td>
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<tr>
<td>ODHLP</td>
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<tr>
<td>QSL [✓]</td>
<td>[✓]</td>
</tr>
<tr>
<td>SLP [✓]</td>
<td>[✓]</td>
</tr>
<tr>
<td>PATH</td>
<td>[✓]</td>
</tr>
<tr>
<td>SBB</td>
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</tr>
<tr>
<td>SNOPT</td>
<td>[✓]</td>
</tr>
<tr>
<td>SLP</td>
<td>[✓]</td>
</tr>
<tr>
<td>XPRESS 17.10</td>
<td>[✓]</td>
</tr>
</tbody>
</table>

Note: For backwards compatibility we maintain older versions of operating systems and solvers. Please check.

Contributed Plug & Play solvers:

- AMPL: [✓] [✓]
- CPLEX: [✓] [✓]
- DSA: [✓] [✓]
- Keel: [✓] [✓]

1. GAMS distribution for HP 9000/HP-UX is 22.1.
2. GAMS distribution for SGI IRIX is 22.3.
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

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<tr>
<td></td>
<td>LP</td>
</tr>
<tr>
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<td>-----</td>
</tr>
<tr>
<td>ALPHAECP</td>
<td>✓</td>
</tr>
<tr>
<td>BARON 7.8</td>
<td>✓</td>
</tr>
<tr>
<td>BB</td>
<td>✓</td>
</tr>
<tr>
<td>CPLEX 3.0</td>
<td>✓</td>
</tr>
<tr>
<td>CPLEX 10.1</td>
<td>✓</td>
</tr>
<tr>
<td>DICOPT</td>
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</tr>
<tr>
<td>DICOPT</td>
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<td>ENZIG</td>
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<td>LINDO/Global 4.1</td>
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<td>LGO</td>
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</tr>
<tr>
<td>MIME</td>
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<tr>
<td>MINOS</td>
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</tr>
<tr>
<td>Mosek 4</td>
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</tr>
<tr>
<td>MPSger</td>
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<td>BB</td>
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<tr>
<td>SNOPT</td>
<td>✓</td>
</tr>
<tr>
<td>ZAP</td>
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<tr>
<td>EXPRESS 17.0</td>
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<tr>
<td>AMPL</td>
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<tr>
<td>DSA</td>
<td>✓</td>
</tr>
<tr>
<td>Excel</td>
<td>✓</td>
</tr>
</tbody>
</table>

*Contributed Plug&Play solvers*
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
PAVER - GAMS Model Translation Web Submission Tool (GMS2XX)

The PAVER GAMS model translation web-submission tool runs the \texttt{GAMS/CONVERT} "solvers" to translate GAMS models into the following supported languages:

- AlphaECP
- AMPL
- BARON
- CcmFML
- CplexLP
- CplexMPS
- Dst
- FiniMPS
- GAMS (scalar)
- Lapo
- Lep
- LINGO
- MINOPT
- Vensim

\texttt{ALL} (that 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 email.

Creating a Self Contained Model:

The translation service requires a self-contained model with no \texttt{Include} or \texttt{BReference}. The GAMS system provides an easy way to produce such a model even if it contains nested \texttt{Include} and \texttt{Set} statements. Run your model in the usual way but add the GAMS parameter \texttt{dumpopt=11}:

\begin{verbatim}
solve wmodel using lp min costs
dumpmodel dumpopt=11
\end{verbatim}
PAVER – Server
Performance Analysis and Visualization for Efficient Reproducibility

Benchmark online - www.gamsworld.org
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
Application in Control

Call GAMS

GAMS

Call external program (including GAMS)

External Application

Programming Language or other Application

External Application

Application
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

This model creates a GAMS deployment system.
Complete two steps and run this model and pick up gamsdeploy.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/off/echo

```
Set  p GAMS Products / system.SolverNames /
    DeployProducts[p] / CONOPT /

* Add extra new GAMS files to your deployment set
  if not set ziplist set ziplist name
  using echo "ziplist"

* There is no need to change anything
* We always need the GAMS BASE system
deployproducts('GAMS') = yes;
```

```
This model creates a GAMS deployment system
Not set zipline set zipline "gamsmodel/gamsdeploy.zip"
set gamsdir gamsmodel/gamsdeploy.zip
```
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
  - Implement Data Error checks
- Reproduce the problem offline
  - Get hold of Instance (dumpopt=11)
- Solver related problems in confidential models
  - Get scalar Model using solver CONVERT
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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

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

```gams
execute_unload "portfolio.gdx" xres;
```
The Mean-Variance Model

Markowitz (1952), Nobel prize 1990

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

**Goal**
- Balance risk $r$ of portfolio against expected returns of portfolio
- Minimize variance $\nu$ for a given target return $r$

**Mathematical Formulation**

Variance of Portfolio

\[ \text{Minimize} \sum_{i=1}^{I} \sum_{j=1}^{J} x_i Q_{i,j} x_j \]

Target return

\[ s.t. \sum_{i=1}^{I} \mu_i x_i \geq r \]

Budget constraint

\[ \sum_{i=1}^{I} x_i = 1 \]

No short sales

\[ x_i \geq 0 \]
**Job Submission Loop**

* turn on grid option
var1.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  
...
@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                     >> %3runit.cmd
echo exit                  >> %3runit.cmd
echo @start /b %3runit.cmd ^> nul
start /b  %3runit.cmd > nul

exit
Solution Collection Loop

Repeat

\[
\begin{align*}
\text{loop}(p(pp) \& handlecollect(handle(p)), \\
xres(i,p) &= x.l(i); \ xres('mean',p) = m.l; \\
xres('var',p) &= v.l; \ xres('status',p) = var1.modelstat; \\
display$handledelete(handle(p)) \ 'trouble\ deleting\ handles'; \\
handle(p) &= 0;
\end{align*}
\]

display$sleep(card(handle)\times0.2) \ '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 grid13300004
...
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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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

```plaintext
$Title Compressed Input Files (CEFILES,SEQ=317)
$Context
This model demonstrates the use of compressed input: Remember, if the file names contain spaces you need to use single or double quotes around the file names.
$Offtext

* --- get model
Sondollar
$call gamslib -q transport

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

* --- check to see if we get the same result
$call gams transport.gdx=transport lo=$gams.lo
$if $errorlevel 1 $abort model transport failed
$call gams t1.gdx=tl lo=$gams.lo
$if $errorlevel 1 $abort model t1 failed
$call gmsdiff transport t1 $system Redirlog
$if $errorlevel 1 $abort results for transport 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 gmsdiff transport t2 $system Redirlog
$if $errorlevel 1 $abort results for transport and t1
$terminate

$Title Input file encryption demo (ENCRYPT,SEQ=318)
$Context
Input files can be encrypted and use the save/privacy file mechanism for managing the user password. Similar 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 key.
There is no inverse operation to get you the original GAMS file from the encrypted version.

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

In the following example, we will use the GAMS option --el to use a demo license with secure option instead of our default. Also note that we use the same demo license file that is locked file by specifying the GAMS parameter license.

$Offtext

* --- get model
Sondollar
$call gamslib -q transport

* --- encrypt and try to decrypt
$call rm -f t1.gms
$echo $encrypt transport.gms t1.gms > s1.gms
$call gams s1 license=$gams license=LICENSE lo=$gams
$if $errorlevel 1 $abort encryption failed
$call gams s1.gms t1.gms // this has to fail
$if not errorfree $abort decompress did not fail
```

Agenda

- GAMS Development / GAMS Software
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- 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

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<td>• Robust &amp; scalable solution</td>
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<td>• Lots of different interfaces</td>
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<td>- Interface</td>
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Sources of GAMS Information

Download: http://download.gams-software.com/
Contributed Documentation: http://www.gams.com/docs/contributed
Contributed Software: http://www.gams.com/contri/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
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