

**GAMS**



# **GAMS**

## **Grid Computing**

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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

## Improvements

- **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



## Multiple Threads / SMP

- **CPLEX**
  - **parallel extension** for B&B and interior point solver
  - **concurrent optimizer**
  - academic license includes 4 threads
- **MOSEK**
  - **parallel extension** for the interior solver comes free of charge
  - **concurrent optimizer**
- **XPRESS**
  - **parallel extension** for B&B and interior point solver
  - 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?



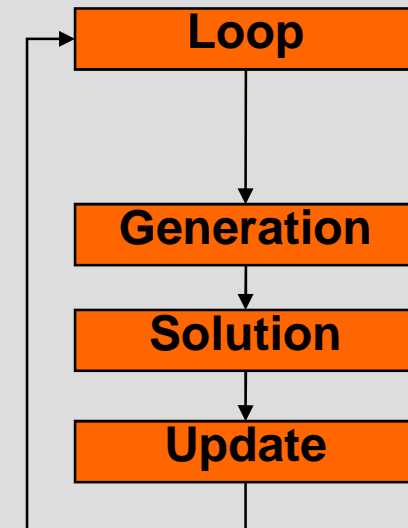
**A pool of connected computers managed and available as a common computing resource**

- 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;  
);
```

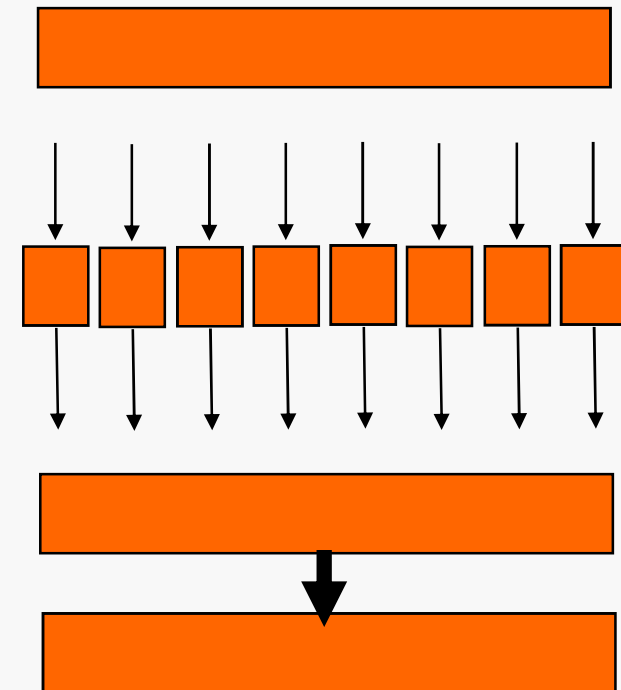


**How do we get to parallel and distributed computing?**



## 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! 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  $v$  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         | $\text{st.} \sum_{i=1}^I \mu_i x_i \geq r$             |
| 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;
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
...
```



# Hands-on! GAMS Grid Computing

```

gamside: C:\Documents and Settings\JanMy Documents\presentation\2007-07-EURO-PragWorkshop\meanvar_grid\meanvar_gpr
File Edit Search Windows Utilities Help
h
c:\documents and settings\janmy documents\presentation\2007-07-euro-pragwor... meanvar.gms
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;

c:\documents and settings\janmy documents\presentation\2007-07-euro-pragwo... meanvar.gms | meanvar_edited.gms
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.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$sleep(card(handle)*0.2) 'sleep some tim
    until card(handle) = 0 or timeelapsed > 100;
  xres(i,p(pp))$handle(p) = na;
);
Display xres;

execute_unload "portfolio.gdx" xres;

```

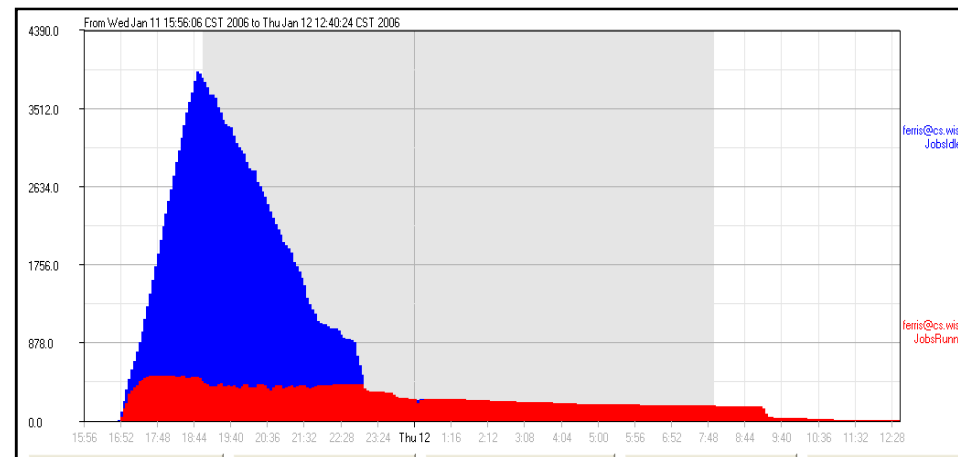


# GAMS & Grid Computing

- **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](http://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 Distribution 22.5 available**
- **250 free CPU hours to new users**

[www.gams.com/sungrid](http://www.gams.com/sungrid)



## 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](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>





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