Cloud Strategies for Optimization Modeling Software

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Computing in the Cloud

Client side
- Local computing device owned by the user
  - Company, organization, university, individual
- Client application run by the user on the local device

Server side
- Remote computing facility owned by a provider
  - Company, organization, university
- Service running automatically at the remote facility

Client does not own the server
Optimization in the Cloud

Multiple solvers as a service
- NEOS Server
- Satalia SolveEngine

Modeling system + solvers as a service
- AMPL Online (*forthcoming*)

Dedicated solver as a service
- IBM Decision Optimization on Cloud
- Gurobi Instant Cloud

Distributed application development
- FICO Analytic Cloud
- IBM Data Science Experience
- QuanDec for AMPL
NEOS Server www.neos-server.org

Network Enabled Optimization System

- Originated 1995 at Argonne National Laboratory and Northwestern University
  - U.S. Department of Energy
  - National Science Foundation
- Since 2011 at University of Wisconsin, Madison
  - Wisconsin Institutes for Discovery

Free “optimization on demand”

- Over 40 solvers
- Several optimization modeling languages
**NEOS Server Architecture**

**Distributed workstations**
- Offer varied inputs & solvers
- Process submissions on demand
- Contributed by varied organizations

**Central scheduler**
- Receives and queues submissions
- Sends submissions to appropriate workstations
- Returns results

**Minimal hands-on management**
- *Distributed*: Install NEOS software on workstations
- *Central*: Update server database of workstation locations and abilities
NEOS Server

Original Facilities

Local submission clients

- Email
- Website
- NEOS submission tool

Problem description formats

- Linear: MPS and other solver files
- Nonlinear: Fortran or C programs
  - automatic differentiation of programs


Impact: Total Submissions

Monthly rates since 1999

Peak day: 29 Sep 2013
144890 ≈ 100 per minute

45000/month ≈ one per minute
**NEOS Server**

**Impact: Recent Submissions**

*Monthly rates for past year*

![Bar Chart]

45000/month ≈ one per minute
NEOS Server

Assessment

Strengths

➢ Free
➢ Choice of solvers
   ¦ Every popular solver available
➢ Easy to use
   ¦ No account setup
   ¦ No advance scheduling

Weaknesses

➢ Stand-alone focus: submission of “solve jobs”
➢ Non-profit management
   ¦ Limited support & development
   ¦ No guarantee of confidentiality
   ¦ No guarantee of performance
NEOS Server

Modeling Languages in NEOS

Modeling language inputs
- AMPL model, data, commands files
- GAMS model, options, gdx files

Modeling language operation
- User chooses a solver and a language
- NEOS scheduler finds a compatible workstation
- NEOS workstation invokes modeling language system with given inputs
- Modeling language system invokes solver

NEOS Server

Impact: Modeling Languages

Monthly rates since 2011

![Bar chart showing monthly rates for AMPL+GAMS and All Other from 2011 to 2017.](chart.png)
NEOS Server

Solver & Language Listing

**Linear Programming**
- BDMLP [GAMS Input]
- bpmip [AMPL Input][LP Input][MPS Input][QPS Input]
- Clp [MPS Input]
- CPLEX [AMPL Input][GAMS Input][LP Input][MPS Input]
- FICO-Xpress [AMPL Input][GAMS Input][MOSEL Input][MPS Input]
- Gurobi [AMPL Input][GAMS Input][MPS Input]
- MOSEK [AMPL Input][GAMS Input][LP Input][MPS Input]
- OOOQ [AMPL Input]
- SoPlex68bit [LP Input][MPS Input]

**Mathematical Programs with Equilibrium Constraints**
- filterMPEC [AMPL Input]
- Knitro [GAMS Input]
- NLPEC [GAMS Input]

**Mixed Integer Linear Programming**
- Cbc [AMPL Input][GAMS Input][MPS Input]
- CPLEX [AMPL Input][GAMS Input][LP Input][MPS Input]
- feaspump [AMPL Input][CPLEX Input][MPS Input]
- FICO-Xpress [AMPL Input][GAMS Input][MOSEL Input][MPS Input]
- Gurobi [AMPL Input][GAMS Input][MPS Input]
- MINTO [AMPL Input]
- MOSEK [AMPL Input][GAMS Input][LP Input][MPS Input]
- proxy [CPLEX Input][MPS Input]
- qsopt_ex [AMPL Input][LP Input][MPS Input]
- scip [AMPL Input][CPLEX Input][GAMS Input][MPS Input][COSIL Input][ZIMPL Input]
- SYMPHONY [MPS Input]

**Mixed Integer Nonlinearly Constrained Optimization**
- AlphaECP [GAMS Input]
- BARON [AMPL Input][GAMS Input]
- Bonmin [AMPL Input][GAMS Input]
NEOS Server
AMPL Input Page

NEOS Interface to CPLEX
WWW Form & Sample Submissions Email XML-RPC

CPLEX
The NEOS Server offers the IBM ILOG CPLEX Optimizer for the solution of mixed-integer linear programming (MILP) problems that can be modeled in AMPL format.
For information on IBM Decision Optimization products, including the CPLEX Optimizer, visit IBM Decision Optimization.
For information on all IBM software available to academics, visit the IBM Academic Initiative.

Using the NEOS Server with AMPL/CPLEX
The user must submit a model in AMPL format to solve a mixed-integer linear program. The examples section of the AMPL website provides examples of models in AMPL format.
The MILP problem must be specified by a model file with the options of a data file and a commands file. If the commands file is specified, it must contain the AMPL solve command. However, the command file must not contain the model or data commands. The model and data files are renamed internally by NEOS.
The commands file may include option settings for CPLEX. To specify solver options, add
NEOS Server

AMPL Input Page

Web Submission Form

Model File
Enter the location of the AMPL model (local file)
Choose File cut.mod

Data File
Enter the location of the AMPL data file (local file)
Choose File cut.dat

Commands File
Enter the location of the AMPL commands file (local file)
Choose File No file chosen

Comments

Additional Settings
- Dry run: generate job XML instead of submitting it to NEOS
- Short Priority: submit to higher priority queue with maximum CPU time of 5 minutes
NEOS Server

AMPL Input Page

Please do not click the 'Submit to NEOS' button more than once.

Submit to NEOS  Clear this Form

By submitting a job, you have accepted the Terms of Use
APIs

Application programming interfaces
  ➢ Access NEOS from a local program

Implementations
  ➢ Version 1: XML-RPC remote procedure call
  ➢ Version 5: full Python API

Uses
  ➢ NEOS submission tool
  ➢ NEOS option in Solver Studio for Excel
  ➢ NEOS as a “solver” for modeling systems
Modeling Systems as NEOS Clients

New “solvers”
- Kestrel for AMPL
- Kestrel for GAMS

Familiar operation
- Choose Kestrel as the local “solver”
- Set an option to choose a real solver on NEOS
- Initiate a solve and wait for results

**NEOS Server**

**AMPL Interactive Session**

```ampl
ampl: model sched1.mod;
ampl: data sched.dat;
ampl: let least_assign := 16;
ampl: option solver kestrel;
ampl: option kestrel_options 'solver=cplex';
ampl: solve;
```

Connecting to: neos-server.org:3332
Job 4679195 submitted to NEOS, password='JMNRQoTD'

Check the following URL for progress report:
http://neos-server.org/neos/cgi-bin/nph-neos-solver.cgi?admin=results&jobnumber=4679195&pass=JMNRQoTD

Job 4679195 dispatched
password: JMNRQoTD

---------- Begin Solver Output ----------

Job submitted to NEOS HTCondor pool.
**NEOS Server**

**AMPL Interactive Session**

------------- Begin Solver Output -------------

Job submitted to NEOS HTCondor pool.

CPLEX 12.6.2.0: optimal integer solution; objective 265.9999999999943
135348 MIP simplex iterations
17430 branch-and-bound nodes

ampl: option omit_zero_rows 1, display_1col 0;
ampl: display Work;

Work [*] :=

```
[          ]
1 16 11 16 36 19 72 20 82 20 106 16 114 20 125 20
3 16 29 16 66 17 79 19 104 19 112 16 121 16
```

ampl:
NEOS Server

Kestrel Impact

Some success

- Intensive use in short bursts
  - Peaks of 10,000-60,000 per day
- Modest use on average
  - Average of 1,750 per month
  - Mostly AMPL/CPLEX
NEOS Server

Kestrel Assessment

Strengths

➢ Powerful local client for modeling
➢ NEOS facilities for solving

Weaknesses

➢ Not all NEOS solvers available
➢ Local solver software is strong competition . . .
   ✴ Bundled with modeling languages
   ✴ Free for trial use
   ✴ Free for course and academic use
➢ Limited support & development

. . . Kestrel for AMPL new release forthcoming
NEOS Server

Recent Developments

**Intensified support**
- Shift to HTCondor “high-throughput” platforms
- Updated Kestrel client
- Updated solver offerings

**User accounts**
- Higher priority for job scheduling
- “My Jobs” tab listing recent jobs & links to results
Satalia SolveEngine www.satalia.com

Like a commercial NEOS

- Range of inputs and solvers
- Royalties to clients and to solvers
  * Planned Kestrel-like support of AMPL, GAMS
- Automated solver choice
- Free, pay-as-you-go, and subscription services
**AMPL Online** *(forthcoming)*

**AMPL command line in a browser**

- Interactive AMPL + solvers as a service
- User’s files saved between sessions
IBM Decision Optimization on Cloud

Commercial NEOS-like functions for CPLEX

- “DropSolve” service similar to NEOS
  * .lp files and OPL model/data files
- “DOcplexcloud API” like NEOS API
- Pay-as-you-go, committed hours, “flex tier” services
Gurobi 7.5 Instant Cloud cloud.gurobi.com

Client side
- Standard Gurobi installation
- Cloud license

Server side
- Compute server for Gurobi solver
  * Single-machine solves
  * Distributed MIP solves
  * Distributed tuning
- Server pools with load balancing

. . . hosted on Amazon Web Services

“Cloud computing technology is changing quickly. Please check these documents periodically to ensure you have the latest instructions for the Gurobi Cloud.”
Gurobi Instant Cloud for AMPL

*Client side*
- AMPL installation (command-line or IDE)
- Standard Gurobi-for-AMPL installation

*Server side*
- Gurobi compute server
- Gurobi optimizer
Gurobi Instant Cloud for AMPL
ngcloud.gurobi.com
**Gurobi Instant Cloud for AMPL**

**View Available Licenses**

<table>
<thead>
<tr>
<th>License</th>
<th>Active Machines</th>
<th>Rate Plan</th>
<th>Credit (US Dollar)</th>
<th>Expiration Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>142032</td>
<td>0</td>
<td>No Charge</td>
<td>$25</td>
<td>10/30/2016 7:00:00 PM</td>
</tr>
<tr>
<td>121420</td>
<td>0</td>
<td>No Charge</td>
<td>$24.12</td>
<td>4/28/2016 7:00:00 PM</td>
</tr>
</tbody>
</table>

Showing 1 to 2 of 2 licenses
Gurobi Instant Cloud for AMPL

Get Gurobi License File

```
# This is a license file created by the Gurobi Instant Cloud
# Created on Mon, 17 Oct 2016 20:46:26 GMT
# License Id: 142032
# Place this file in your home directory or one of the following
# locations where XXX is the Gurobi Optimizer version you are using:
#   * C:\gurobi\ or C:\gurobiXXX\ on Windows
#   * /opt/gurobi/ or /opt/gurobiXXX/ on Linux
#   * /Library/gurobi/ or /Library/gurobiXXX/ on Mac OS X
# Or set environment variable GRB_LICENSE_FILE to point to this file
# Do not share this license file because it contains your secret key

CLOUDACCESSID=fedf3901-04f1-44d7-9725-e36c1c3f70f6
CLOUDKEY=0v9XdWrDQLiE3EiAAEKtFw
CLOUDHOST=ngcloud.gurobi.com
```
Gurobi Instant Cloud for AMPL

Use with AMPL: Setup

ampl: model multip3.mod;
ampl: data multip3.dat;
ampl: option solver gurobi;
ampl: option gurobi_options
ampl? 'cloudid=fedf3901-04f1-44d7-9725-e36c1c3f70f6 \
ampl? cloudkey=0v9XdWrDQLiE3EiAAEKtFw';
ampl:
Use with AMPL: Startup

ampl: model multmip3.mod;
ampl: data multmip3.dat;
ampl: option solver gurobi;
ampl: option gurobi_options
ampl? 'cloudid=fedf3901-04f1-44d7-9725-e36c1c3f70f6 \\ampl? cloudkey=0v9XdWrDQLiE3EiAAEKFw';
ampl: solve;

Gurobi 7.0.0: cloudid=fedf3901-04f1-44d7-9725-e36c1c3f70f6
cloudkey=0v9XdWrDQLiE3EiAAEKFw

Waiting for cloud server to start...........
Gurobi Instant Cloud for AMPL

Use with AMPL: Solve

ampl: model multmip3.mod;
ampl: data multmip3.dat;
ampl: option solver gurobi;
ampl: option gurobi_options
ampl?  'cluid=0v9XdWrDQLiE3EiAAEKtFW' 
ampl?  cloudkey=0v9XdWrDQLiE3EiAAEKtFW';
ampl: solve;
Gurobi 7.0.0: cluid=fedf3901-04f1-44d7-9725-e36c1c3f70f6
cloudkey=0v9XdWrDQLiE3EiAAEKtFW
Waiting for cloud server to start............
Capacity available on 'default' cloud pool - connecting...
Established 256-bit AES encrypted connection
Gurobi 7.0.0: optimal solution; objective 235625
289 simplex iterations
25 branch-and-cut nodes
plus 35 simplex iterations for intbasis
ampl:
Use with AMPL: Continue

```
ampl: display {i in ORIG, j in DEST} sum {p in PROD} Trans[i,j,p];
: DET FRA FRE LAF LAN STL WIN :=
CLEV    625  375   550   0  500  550  0
GARY     0   0    0  400  0    625  375
PITT     525  525  625  600  0    625   0
;

ampl: reset data;
ampl: data multmip3a.dat;
ampl: solve;

Gurobi 7.0.0: cloudid=fedf3901-04f1-44d7-9725-e36c1c3f70f6
cloudkey=0v9XdWrDQLiE3EiAAEkFw
Capacity available on 'default' cloud pool - connecting...
Established 256-bit AES encrypted connection

Gurobi 7.0.0: optimal solution; objective 238450
163 simplex iterations
plus 33 simplex iterations for intbasis
```

Gurobi Instant Cloud for AMPL
Gurobi Instant Cloud for AMPL

Manage Server Configuration

![Gurobi Instant Cloud for AMPL interface](image)
Gurobi Instant Cloud for AMPL

Check Costs

1 compute server will be launched.

You will be charged $0.838 per hour for the machine costs.

You will be charged $0 per hour for the Gurobi license.
Gurobi Cloud Costs

Commercial plans

- Annual subscription fee, *plus*
- Hourly rates for use:
  - Gurobi rate for compute servers
  - Amazon rate for distributed workers

Trials, academic use, special grants

- Amazon rate only

... *set up through sales rep*
Gurobi Cloud for AMPL: Assessment

**Strengths**

- Security
- Reliability (via Amazon)
- Support for multi-server and/or multi-worker pools
- Support for local modeling clients

**Drawbacks (compared to NEOS)**

- Not free
  - Budgeting can be complicated
- Solver-specific
- Not quite “optimization on demand”
**QuanDec** ampl.com/products/quandec

**Server side**
- AMPL model and data
- Standard AMPL-solver installations

**Client side**
- Interactive tool for collaboration & decision-making
- Runs on any recent web browser
- Java-based implementation
  - AMPL API for Java
  - Eclipse Remote Application Platform

... *developed / supported by Cassotis Consulting*
The web-based graphical interface that turns optimization models written in AMPL into decision-making tools.
Features

Server application
Centralized data
Several models on a single server

Web-based
Multi-users
Concurrent access
Secure access

Scenario-based
Sharing between users
Sharing rights
(edit / comment / view)

And much more…
Getting started

**step 1:** install QuanDec on a server

**step 2:** copy & paste your model files (.mod and .dat) into QuanDec’s workspace

**step 3:** create AMPL tables and link them to QuanDec explorer
Web-application
Multi-user
Secure access
Concurrent access
Scenario-based environment

Sharing system

Permission: Edit – Comment - View
3 levels:
- Report
- Input parameters
- Variables

Chart and tables

Colored values for easier analysis

Constraint (min/max) on any variable
Collaborative work

Notification system

Comments between users
Scenarios with changes history

Traceability and undo system
Scenario comparison

All variables can be compared

Display of relative difference

Custom reports
Sensitivity analysis

For both parameters AND variables

All variables can be compared

Display of relative difference
Predefined analyses

Script parameters
QuanDec Availability

*Ready now for commercial applications*
- Free trials available
- Pricing keyed to number of models & users

*First year’s support included*
- Tailored setup support from Cassotis Consulting
- Customizations possible

... contact sales@ampl.com for details