
AMPL in the Cloud

Using Online Services to Develop and Deploy Optimization Applications through Algebraic Modeling

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AMPL in the Cloud

Using Online Services to Develop and Deploy Optimization Applications through Algebraic Modeling

Cloud services promising “optimization on demand” have become steadily more numerous and more powerful in recent years. This presentation offers a user-oriented survey, with a focus on the role of the AMPL modeling language in streamlining development and deployment of optimization models using online tools. Starting with the pioneering free NEOS Server, we compare more recent commercial offerings such as Gurobi Instant Cloud and the Satalia SolveEngine; the benefits of these solver services are enhanced through their use with AMPL’s algebraic modeling facilities. We conclude by introducing QuanDec, which turns AMPL models into web-based collaborative decision-making tools.

Outline

AMPL Introduction

- Concept of a modeling language
- Example in the AMPL language

AMPL in the cloud

- Optimization on demand
 - * NEOS Server
 - * Satalia SolveEngine
 - * IBM Decision Optimization on Cloud
- Optimization to order
 - * Gurobi Instant Cloud
- Collaborative optimization
 - * QuanDec

The Optimization Modeling Cycle

Steps

- Communicate with problem owner
- Build model
- Prepare data
- Generate optimization problem
- Submit problem to solver
 - * Gurobi, Knitro, CPLEX, Xpress, CONOPT, MINOS, . . .
- Report & analyze results
- *Repeat until you get it right!*

Goals for optimization software

- Do this quickly and reliably
- Get results before client loses interest
- Deploy for application

Optimization Modeling Languages

Two forms of an optimization problem

- Modeler's form
 - * Mathematical description, easy for people to work with
- Solver's form
 - * Explicit data structure, easy for solvers to compute with

Idea of a modeling language

- *A computer-readable modeler's form*
 - * You write optimization problems in a modeling language
 - * Computers translate to algorithm's form for solution

Advantages of a modeling language

- Faster modeling cycles
- More reliable modeling
- More maintainable applications

Algebraic Modeling Languages

Formulation concept

- Define data in terms of sets & parameters
 - * Analogous to database keys & records
- Define decision variables
- Minimize or maximize a function of decision variables
- Subject to equations or inequalities that constrain the values of the variables

Advantages

- Familiar
- Powerful
- Proven



Features

- Algebraic modeling language
- Built specially for optimization
- Designed to support many solvers

Design goals

- Powerful, general expressions
- Natural, easy-to-learn modeling principles
- Efficient processing that scales well with problem size

Many ways to use . . .

Many Ways to Use AMPL

Command language

- Browse results & debug model interactively
- Make changes and re-run

Scripting language

- Bring the programmer to the modeling language

Programming interface (API)

- Bring the modeling language to the programmer

Deployment tool

- Turn models into collaboration environments

Example (1st cycle)

Multicommodity transportation . . .

- Products available at factories
- Products needed at stores
- Plan shipments at lowest cost

Mathematical Formulation

Given

O Set of origins (factories)

D Set of destinations (stores)

P Set of products

and

a_{ip} Amount available, for each $i \in O$ and $p \in P$

b_{jp} Amount required, for each $j \in D$ and $p \in P$

l_{ij} Limit on total shipments, for each $i \in O$ and $j \in D$

c_{ijp} Shipping cost per unit, for each $i \in O, j \in D, p \in P$

Multicommodity Transportation

Mathematical Formulation

Determine

X_{ijp} Amount of each product $p \in P$
to be shipped from origin $i \in O$ to destination $j \in D$

to minimize

$$\sum_{i \in O} \sum_{j \in D} \sum_{p \in P} c_{ijp} X_{ijp}$$

Total shipping cost

Mathematical Formulation

Subject to

$$\sum_{j \in D} X_{ijp} \leq a_{ip} \quad \text{for all } i \in O, p \in P$$

Total shipments of product p out of origin i
must not exceed availability

$$\sum_{i \in O} X_{ijp} = b_{jp} \quad \text{for all } j \in D, p \in P$$

Total shipments of product p into destination j
must satisfy requirements

$$\sum_{p \in P} X_{ijp} \leq l_{ij} \quad \text{for all } i \in O, j \in D$$

Total shipments from origin i to destination j
must not exceed the limit

AMPL Formulation

Symbolic data

```
set ORIG;    # origins
set DEST;    # destinations
set PROD;    # products

param supply {ORIG,PROD} >= 0; # availabilities at origins
param demand {DEST,PROD} >= 0; # requirements at destinations
param limit  {ORIG,DEST} >= 0; # capacities of links
param cost   {ORIG,DEST,PROD} >= 0; # shipment cost
```

AMPL Formulation

Symbolic model: variables and objective

```
var Trans {ORIG,DEST,PROD} >= 0;  # actual units to be shipped

minimize Total_Cost:
    sum {i in ORIG, j in DEST, p in PROD} cost[i,j,p] * Trans[i,j,p];
```

$$\sum_{i \in O} \sum_{j \in D} \sum_{p \in P} c_{ijp} X_{ijp}$$

Multicommodity Transportation

AMPL Formulation

Symbolic model: constraint

```
subject to Supply {i in ORIG, p in PROD}:  
    sum {j in DEST} Trans[i,j,p] <= supply[i,p];
```

$$\sum_{j \in D} X_{ijp} \leq a_{ip}, \text{ for all } i \in O, p \in P$$

AMPL Formulation

Symbolic model: constraints

```
subject to Supply {i in ORIG, p in PROD}:  
    sum {j in DEST} Trans[i,j,p] <= supply[i,p];  
  
subject to Demand {j in DEST, p in PROD}:  
    sum {i in ORIG} Trans[i,j,p] = demand[j,p];  
  
subject to Multi {i in ORIG, j in DEST}:  
    sum {p in PROD} Trans[i,j,p] <= limit[i,j];
```


AMPL Formulation

Explicit data independent of symbolic model

```
set ORIG := GARY CLEV PITT ;
set DEST := FRA DET LAN WIN STL FRE LAF ;
set PROD := bands coils plate ;

param supply (tr):  GARY    CLEV    PITT :=
                    bands   400    700    800
                    coils   800    1600   1800
                    plate   200    300    300 ;

param demand (tr):
                    FRA    DET    LAN    WIN    STL    FRE    LAF :=
bands   300    300    100    75    650    225    250
coils   500    750    400    250    950    850    500
plate   100    100     0    50    200    100    250 ;

param limit default 625 ;
```

Multicommodity Transportation

AMPL Formulation

Explicit data (continued)

```
param cost :=  
  [*,*,bands]: FRA DET LAN WIN STL FRE LAF :=  
    GARY 30 10 8 10 11 71 6  
    CLEV 22 7 10 7 21 82 13  
    PITT 19 11 12 10 25 83 15  
  [*,*,coils]: FRA DET LAN WIN STL FRE LAF :=  
    GARY 39 14 11 14 16 82 8  
    CLEV 27 9 12 9 26 95 17  
    PITT 24 14 17 13 28 99 20  
  [*,*,plate]: FRA DET LAN WIN STL FRE LAF :=  
    GARY 41 15 12 16 17 86 8  
    CLEV 29 9 13 9 28 99 18  
    PITT 26 14 17 13 31 104 20 ;
```

Multicommodity Transportation

AMPL Solution

Model + data = problem instance to be solved

```
ampl: model multi.mod;
ampl: data multi.dat;
ampl: option solver minos;

ampl: solve;
MINOS 5.51: optimal solution found.
53 iterations, objective 199500

ampl: display Trans;
Trans [CLEV,*,*] (tr)
:      DET  FRA  FRE  LAF  LAN  STL  WIN  :=
bands   0  225   0  150   0  250  75
coils  525   0  225   75  400  300  75
plate  100   50  100   0   0   0   50
...
```

Multicommodity Transportation

AMPL Solution

Solver choice independent of model and data

```
ampl: model multi.mod;
ampl: data multi.dat;
ampl: option solver snopt;

ampl: solve;
SNOPT 7.5-1.2 : Optimal solution found.
60 iterations, objective 199500

ampl: display Trans;
Trans [CLEV,*,*] (tr)
:      DET   FRA   FRE   LAF   LAN   STL   WIN   :=
bands  150   225    0    0    0   250   75
coils  375    0   225  225  400  300   75
plate  100   50   100    0    0    0   50
...
```

Example (4th cycle)

Multicommodity transportation . . .

- Products available at factories
- Products needed at stores
- Plan shipments at lowest cost

. . . revised in light of practical considerations

- Using an origin-destination pair incurs some fixed cost
- Shipments cannot be too small
- Factories cannot serve too many stores

Mathematical Formulation

Given

- O Set of origins (factories)
- D Set of destinations (stores)
- P Set of products

and

- a_{ip} Amount available, for each $i \in O$ and $p \in P$
- b_{jp} Amount required, for each $j \in D$ and $p \in P$
- l_{ij} Limit on total shipments, for each $i \in O$ and $j \in D$
- c_{ijp} Shipping cost per unit, for each $i \in O, j \in D, p \in P$
- d_{ij} Fixed cost for shipping any amount from $i \in O$ to $j \in D$
- s Minimum total size of any shipment
- n Maximum number of destinations served by any origin

Mathematical Formulation

Determine

X_{ijp} Amount of each $p \in P$ to be shipped from $i \in O$ to $j \in D$

Y_{ij} 1 if any product is shipped from $i \in O$ to $j \in D$
0 otherwise

to minimize

$$\sum_{i \in O} \sum_{j \in D} \sum_{p \in P} c_{ijp} X_{ijp} + \sum_{i \in O} \sum_{j \in D} d_{ij} Y_{ij}$$

Total variable cost plus total fixed cost

Mathematical Formulation

Subject to

$$\sum_{j \in D} X_{ijp} \leq a_{ip} \quad \text{for all } i \in O, p \in P$$

Total shipments of product p out of origin i
must not exceed availability

$$\sum_{i \in O} X_{ijp} = b_{jp} \quad \text{for all } j \in D, p \in P$$

Total shipments of product p into destination j
must satisfy requirements

$$\sum_{p \in P} X_{ijp} \leq l_{ij} Y_{ij} \quad \text{for all } i \in O, j \in D$$

When there are shipments from origin i to destination j ,
the total may not exceed the limit, and Y_{ij} must be 1

Mathematical Formulation

Subject to

$$\sum_{p \in P} X_{ijp} \geq sY_{ij} \quad \text{for all } i \in O, j \in D$$

When there are shipments from origin i to destination j , the total amount of shipments must be at least s

$$\sum_{j \in D} Y_{ij} \leq n \quad \text{for all } i \in O$$

Number of destinations served by origin i must be at most n

AMPL Formulation

Symbolic data

```
set ORIG;    # origins
set DEST;    # destinations
set PROD;    # products

param supply {ORIG,PROD} >= 0; # availabilities at origins
param demand {DEST,PROD} >= 0; # requirements at destinations
param limit  {ORIG,DEST} >= 0; # capacities of links

param vcost {ORIG,DEST,PROD} >= 0; # variable shipment cost
param fcost {ORIG,DEST} > 0;      # fixed usage cost

param minload >= 0;                # minimum shipment size
param maxserve integer > 0;       # maximum destinations served
```

AMPL Formulation

Symbolic model: variables and objective

```
var Trans {ORIG,DEST,PROD} >= 0;    # actual units to be shipped
var Use {ORIG, DEST} binary;        # 1 if link used, 0 otherwise

minimize Total_Cost:
    sum {i in ORIG, j in DEST, p in PROD} vcost[i,j,p] * Trans[i,j,p]
+ sum {i in ORIG, j in DEST} fcost[i,j] * Use[i,j];
```

$$\sum_{i \in O} \sum_{j \in D} \sum_{p \in P} c_{ijp} X_{ijp} + \sum_{i \in O} \sum_{j \in D} d_{ij} Y_{ij}$$

AMPL Formulation

Symbolic model: constraints

```
subject to Supply {i in ORIG, p in PROD}:  
    sum {j in DEST} Trans[i,j,p] <= supply[i,p];  
  
subject to Demand {j in DEST, p in PROD}:  
    sum {i in ORIG} Trans[i,j,p] = demand[j,p];  
  
subject to Multi {i in ORIG, j in DEST}:  
    sum {p in PROD} Trans[i,j,p] <= limit[i,j] * Use[i,j];  
  
subject to Min_Ship {i in ORIG, j in DEST}:  
    sum {p in PROD} Trans[i,j,p] >= minload * Use[i,j];  
  
subject to Max_Serve {i in ORIG}:  
    sum {j in DEST} Use[i,j] <= maxserve;
```

AMPL Formulation

Explicit data independent of symbolic model

```
set ORIG := GARY CLEV PITT ;
set DEST := FRA DET LAN WIN STL FRE LAF ;
set PROD := bands coils plate ;

param supply (tr):  GARY    CLEV    PITT :=
                    bands   400     700     800
                    coils   800    1600    1800
                    plate   200     300     300 ;

param demand (tr):
                    FRA    DET    LAN    WIN    STL    FRE    LAF :=
bands   300    300    100    75    650    225    250
coils   500    750    400    250    950    850    500
plate   100    100     0     50    200    100    250 ;

param limit default 625 ;

param minload := 375 ;
param maxserve := 5 ;
```

Multicommodity Transportation

AMPL Formulation

Explicit data (continued)

```
param vcost :=
  [*,*,bands]: FRA DET LAN WIN STL FRE LAF :=
    GARY 30 10 8 10 11 71 6
    CLEV 22 7 10 7 21 82 13
    PITT 19 11 12 10 25 83 15
  [*,*,coils]: FRA DET LAN WIN STL FRE LAF :=
    GARY 39 14 11 14 16 82 8
    CLEV 27 9 12 9 26 95 17
    PITT 24 14 17 13 28 99 20
  [*,*,plate]: FRA DET LAN WIN STL FRE LAF :=
    GARY 41 15 12 16 17 86 8
    CLEV 29 9 13 9 28 99 18
    PITT 26 14 17 13 31 104 20 ;
param fcost: FRA DET LAN WIN STL FRE LAF :=
  GARY 3000 1200 1200 1200 2500 3500 2500
  CLEV 2000 1000 1500 1200 2500 3000 2200
  PITT 2000 1200 1500 1500 2500 3500 2200 ;
```

Multicommodity Transportation

AMPL Solution

Model + data = problem instance to be solved

```
ampl: model multmip3.mod;
ampl: data multmip3.dat;
ampl: option solver gurobi;
ampl: solve;
Gurobi 7.0.0: optimal solution; objective 235625
332 simplex iterations
23 branch-and-cut nodes
ampl: display Use;
Use [*,*]
:      DET FRA FRE LAF LAN STL WIN  :=
CLEV   1   1   1   0   1   1   0
GARY   0   0   0   1   0   1   1
PITT   1   1   1   1   0   1   0
;
```

Multicommodity Transportation

AMPL Solution

Solver choice independent of model and data

```
ampl: model multmip3.mod;
ampl: data multmip3.dat;
ampl: option solver cplex;
ampl: solve;
CPLEX 12.7.0.0: optimal integer solution; objective 235625
135 MIP simplex iterations
0 branch-and-bound nodes
ampl: display Use;
Use [*,*]
:      DET FRA FRE LAF LAN STL WIN  :=
CLEV   1   1   1   0   1   1   0
GARY   0   0   0   1   0   1   1
PITT   1   1   1   1   0   1   0
;
```


AMPL Solution

Solver choice independent of model and data

```
ampl: model multmip3.mod;
ampl: data multmip3.dat;
ampl: option solver xpress;
ampl: solve;
XPRESS 29.01: Global search complete
Best integer solution found 235625
4 integer solutions have been found, 7 branch and bound nodes
ampl: display Use;
Use [*,*]
:      DET FRA FRE LAF LAN STL WIN  :=
CLEV   1   1   1   0   1   1   0
GARY   0   0   0   1   0   1   1
PITT   1   1   1   1   0   1   0
;
```

Multicommodity Transportation

AMPL Solution

Examine results

```
AMPL: display {i in ORIG, j in DEST}
AMPL?   sum {p in PROD} Trans[i,j,p] / limit[i,j];

:      DET    FRA    FRE    LAF    LAN    STL    WIN    :=
CLEV   1      0.6    0.88   0     0.8    0.88   0
GARY   0      0      0     0.64   0     1      0.6
PITT   0.84    0.84   1     0.96   0     1      0
;

AMPL: display Max_Serve.body;

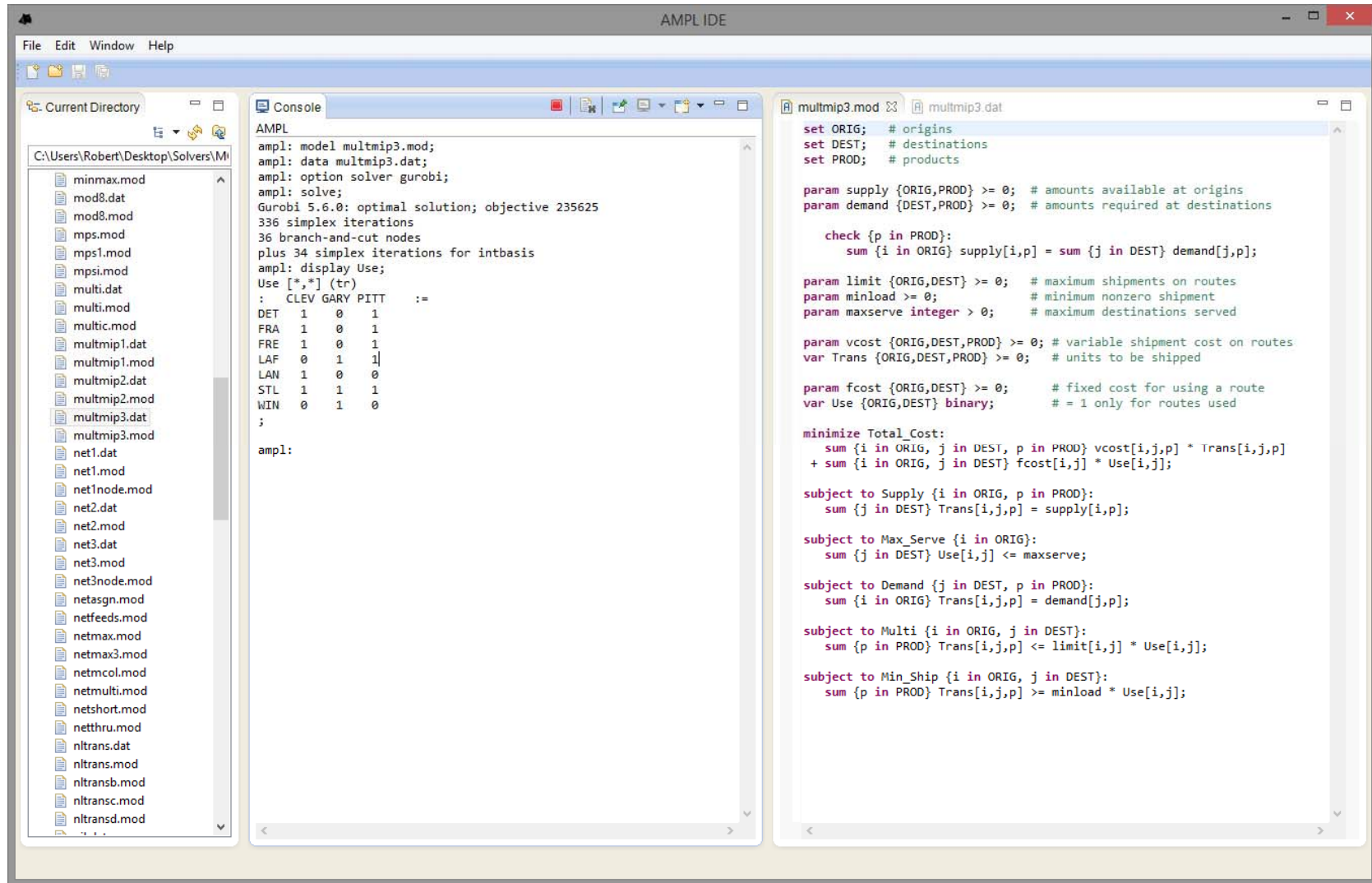
CLEV   5
GARY   3
PITT   5
;

AMPL: display TotalCost,
AMPL?   sum {i in ORIG, j in DEST} fcost[i,j] * Use[i,j];

TotalCost = 235625
sum {i in ORIG, j in DEST} fcost[i,j]*Use[i,j] = 27600
```

Multicommodity Transportation

AMPL IDE



Scripting

Extend modeling language syntax . . .

- Algebraic expressions
- Set indexing expressions
- Interactive commands

. . . with programming concepts

- Loops of various kinds
- If-then and If-then-else conditionals
- Assignments

APIs

Run AMPL from your programs

- Transfer data to and from AMPL
- Execute AMPL commands within your application
 - * Access all available solvers

Use popular programming languages

- C++, C#, Java, MATLAB, Python, R
 - * Use Python dictionaries, R dataframes, MATLAB matrices, etc.

AMPL

^ *Optimization in the Cloud*

Optimization on demand

- NEOS Server
- Satalia SolveEngine
- IBM Decision Optimization on Cloud

Optimization to order

- Gurobi Instant Cloud

Collaborative optimization

- QuanDec

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

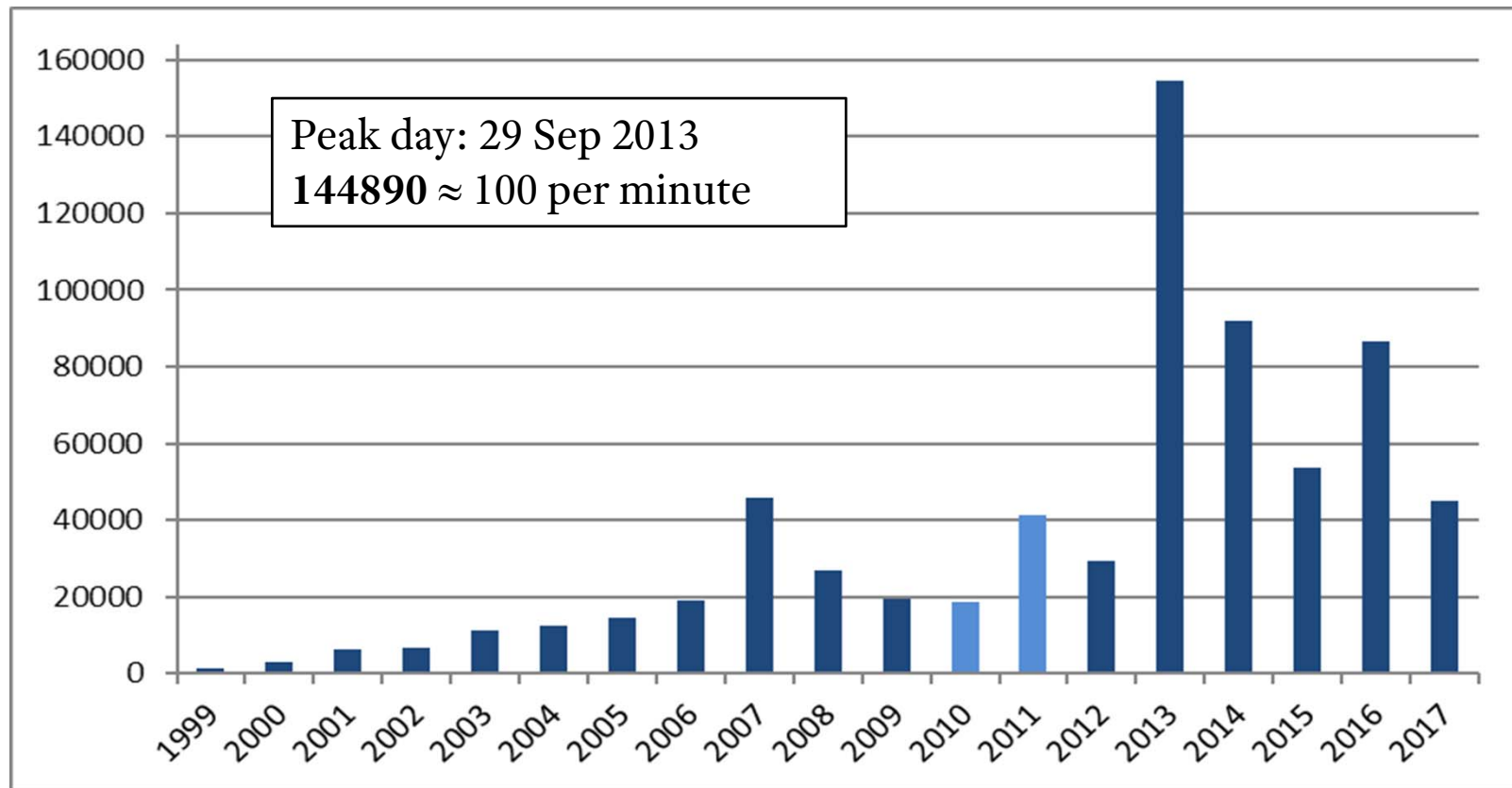
W. Gropp and J.J. Moré, 1997. **Optimization Environments and the NEOS Server.** *Approximation Theory and Optimization*, M. D. Buhmann and A. Iserles, eds., Cambridge University Press, 167-182.

J. Czyzyk, M.P. Mesnier and J.J. Moré, 1998. **The NEOS Server.** *IEEE Journal on Computational Science and Engineering* 5(3), 68-75.

NEOS Server

Impact: Total Submissions

Monthly rates since 1999

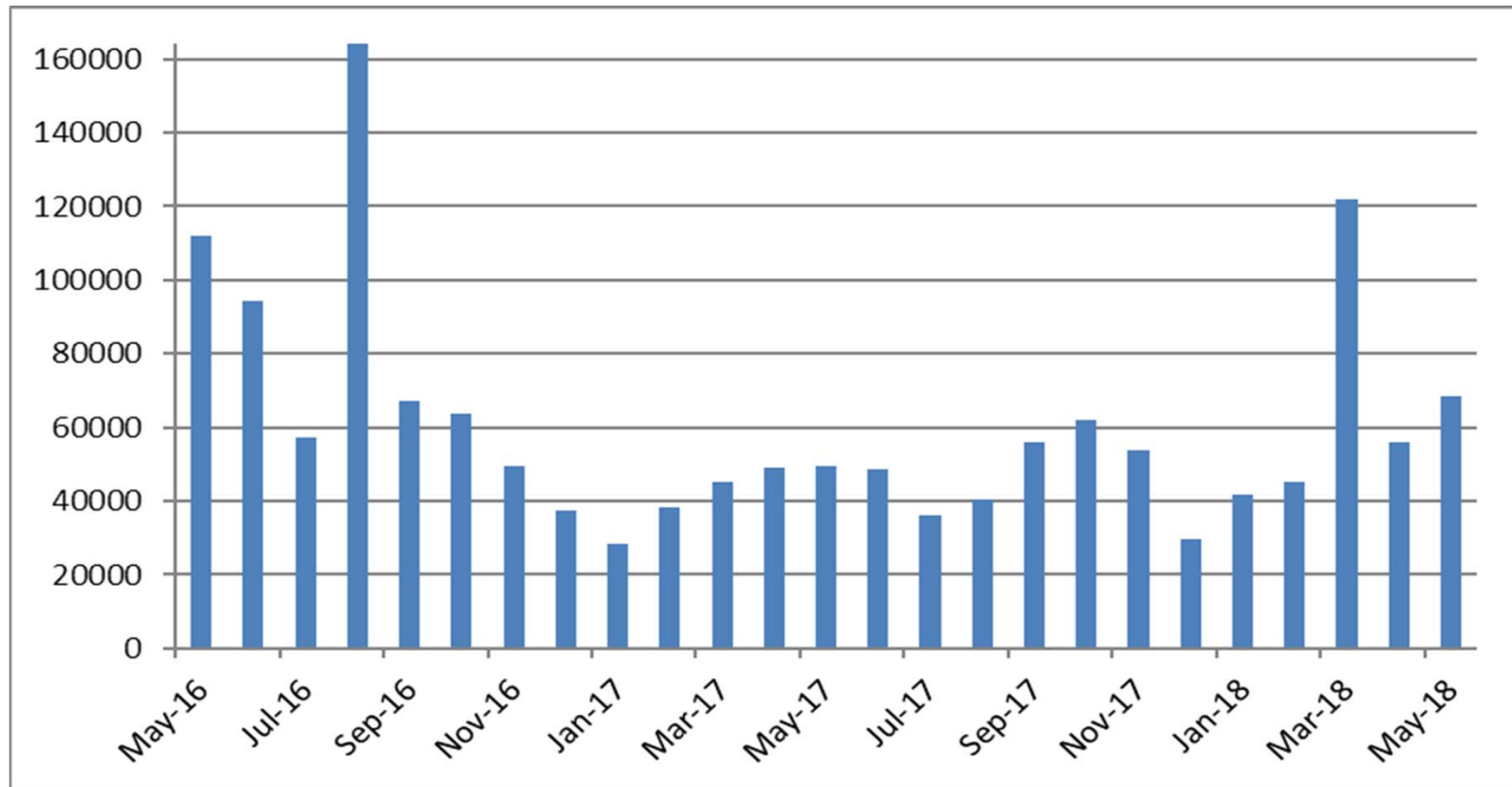


45000/month \approx one per minute

NEOS Server

Impact: Recent Submissions

Monthly rates for past two years



45000/month \approx one per minute

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

Modeling Languages in NEOS

Modeling language inputs

- AMPL model, data, commands files
- GAMS model, options,.gdx files

Modeling language operation

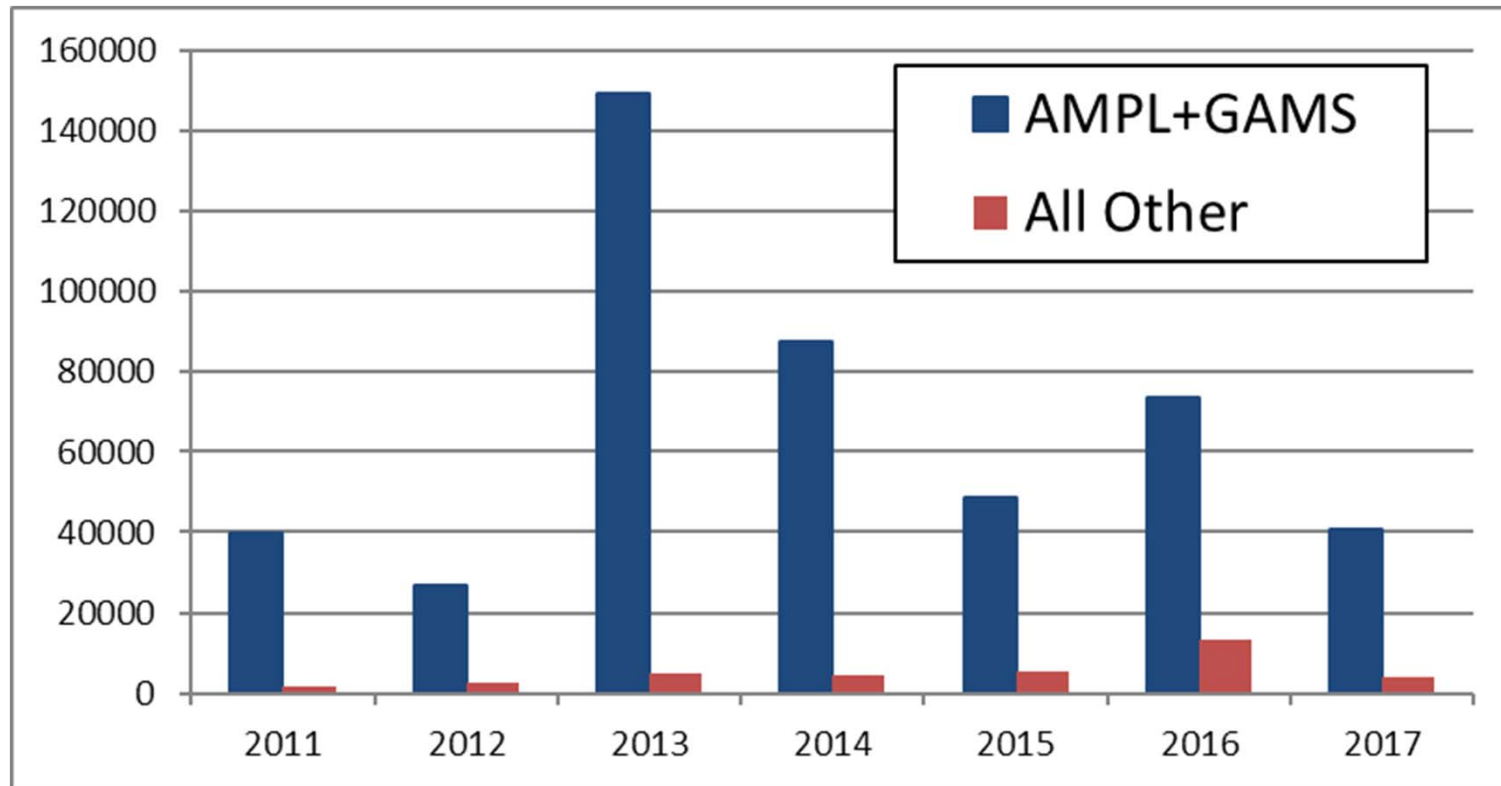
- User chooses a solver and a language
- NEOS scheduler finds a compatible workstation
- NEOS workstation invokes modeling language system with given inputs
- Modeling language system invokes solver

E.D. Dolan, R. Fourer, J.J. Moré and T.S. Munson,
Optimization on the NEOS Server. *SIAM News* 35:6
(July/August 2002) 4, 8–9. www.siam.org/pdf/news/457.pdf

NEOS Server

Impact: Modeling Languages

Monthly rates since 2011



Solver & Language Listing

The screenshot shows a web browser window with the URL <https://neos-server.org/neos/solvers/index.html>. The page features a navigation bar with 'NEOS', 'Contact', 'Help', 'Sign In', and 'Sign Up' buttons. The main content is a list of optimization categories, each with a plus or minus sign to expand or collapse the list of solvers and languages. The 'Mixed Integer Linear Programming' category is expanded, showing a list of solvers and their supported input languages.

- Linear Programming +
- Mathematical Programs with Equilibrium Constraints +
- Mixed Integer Linear Programming -**
 - Cbc [AMPL Input][GAMS Input][MPS Input]
 - CPLEX [AMPL Input][GAMS Input][LP Input][MPS Input][NL Input]
 - feasumpump [AMPL Input][CPLEX Input][MPS Input]
 - FICO-Xpress [AMPL Input][GAMS Input][MOSEL Input][MPS Input][NL Input]
 - Gurobi [AMPL Input][GAMS Input][LP Input][MPS Input][NL Input]
 - MINTO [AMPL Input]
 - MOSEK [AMPL Input][GAMS Input][LP Input][MPS Input][NL Input]
 - proxy [CPLEX Input][MPS Input]
 - qsopt_ex [AMPL Input][LP Input][MPS Input]
 - scip [AMPL Input][CPLEX Input][GAMS Input][MPS Input][OSIL Input][ZIMPL Input]
 - SYMPHONY [MPS Input]
- Mixed Integer Nonlinearly Constrained Optimization +
- Mixed-Integer Optimal Control Problems +
- Nondifferentiable Optimization +
- Nonlinearly Constrained Optimization -**
 - ANTIGONE [GAMS Input]
 - CONOPT [AMPL Input][GAMS Input]
 - filter [AMPL Input]
 - Ipopt [AMPL Input][GAMS Input][NL Input]
 - Knitro [AMPL Input][GAMS Input]
 - LANCELOT [AMPL Input]

Input Page for CPLEX using AMPL



The screenshot shows a web browser window with the URL <https://neos-server.org/neos/solvers/milp:CPLEX/AMPL.html>. The page features a navigation bar with "NEOS", "Contact", and "Help" links, along with "Sign In" and "Sign Up" buttons. A banner image displays the "neos SOLVERS" logo and the word "Optimization" in a stylized font. Below the banner, a box titled "NEOS Interfaces to CPLEX" contains links for "Sample Submissions", "WWW Form", "Email", and "XML-RPC". The main content area has a section titled "CPLEX" with a description of the solver's capabilities and supported input formats. A sub-section titled "Using the NEOS Server for CPLEX/AMPL" provides instructions on how to submit a model file and what commands should be included in the commands file.

NEOS SOLVERS

Optimization

NEOS Interfaces to CPLEX

[Sample Submissions](#)
[WWW Form](#) - [Email](#) - [XML-RPC](#)

CPLEX

The NEOS Server offers the IBM ILOG CPLEX Optimizer for the solution of linear programming (LP), mixed-integer linear programming (MILP), and second-order conic programming (SOCP) problems. Acceptable input formats for CPLEX on the NEOS server include AMPL, GAMS, LP, MPS, and NL formats.

Details on CPLEX can be found on the [IBM CPLEX](#) website. Additional information on all IBM software available to academics can be found on the [IBM Academic Resources](#) webpage.

Using the NEOS Server for CPLEX/AMPL

The user must submit a model in AMPL format. Examples are provided in the [examples](#) section of the [AMPL website](#).

The problem must be specified in a model file. A data file and commands files may also be provided. If the commands file is specified, it must contain the AMPL `solve` command; however, it must not contain the `model` or `data` commands. The model and data files are renamed internally by NEOS.

Input Page (*cont'd*)

Web Submission Form

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

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

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

Comments

Additional Settings

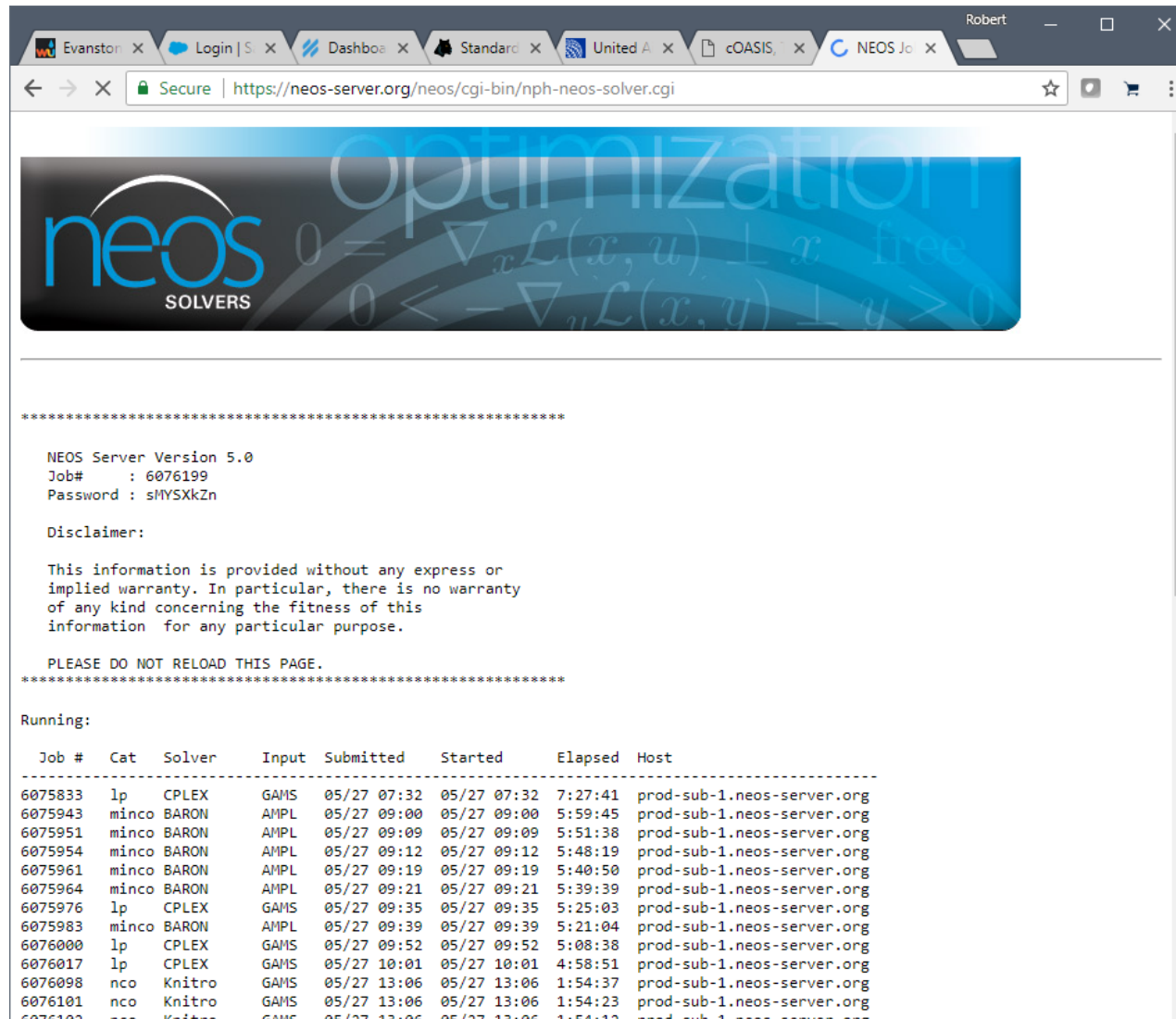
Dry run: generate job XML instead of submitting it to NEOS

Short Priority: submit to higher priority queue with maximum CPU time of 5 minutes

E-Mail address:

NEOS Server

Queue Page



NEOS Server Version 5.0
Job# : 6076199
Password : sHYSXkZn

Disclaimer:

This information is provided without any express or implied warranty. In particular, there is no warranty of any kind concerning the fitness of this information for any particular purpose.

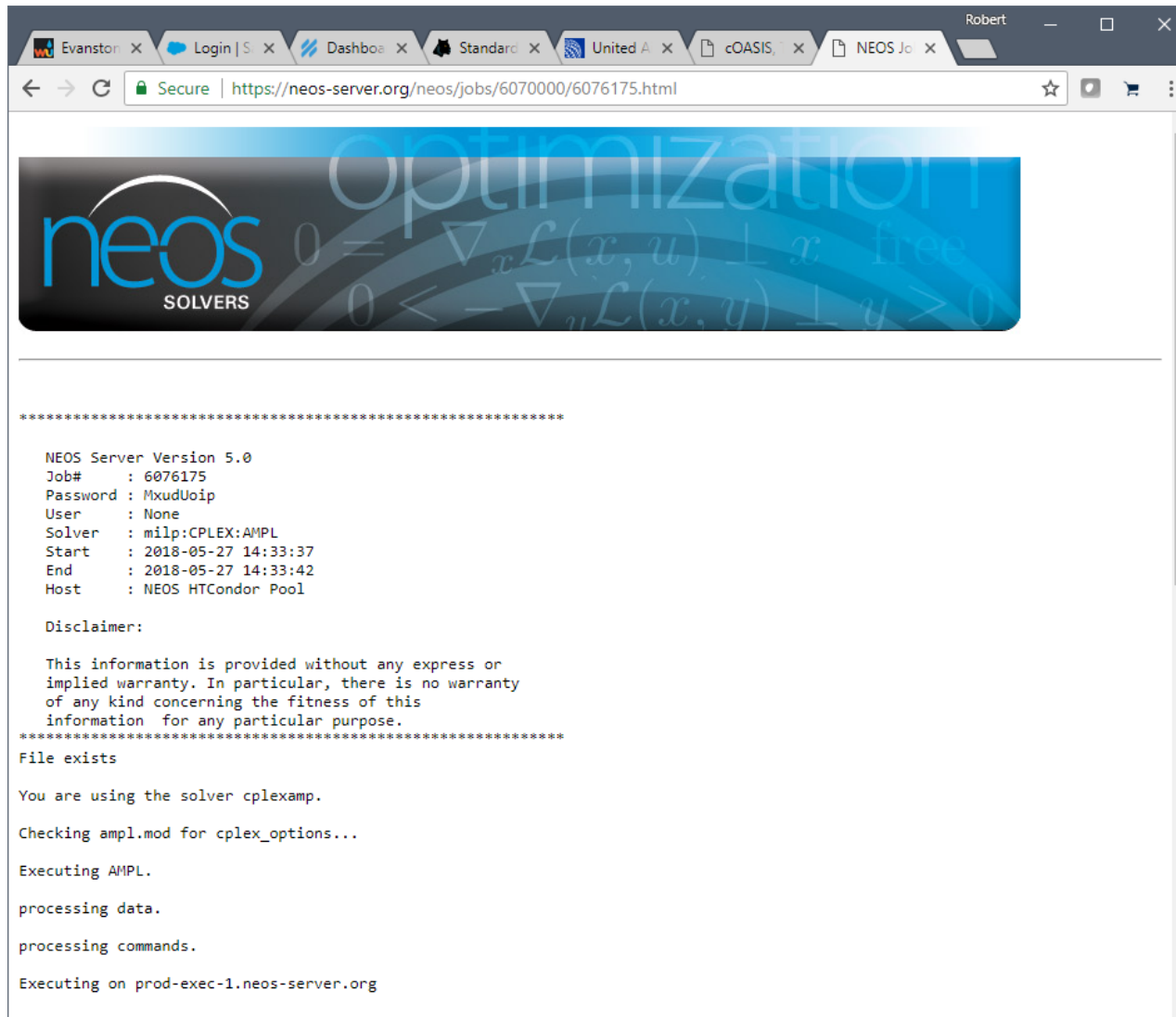
PLEASE DO NOT RELOAD THIS PAGE.

Running:

Job #	Cat	Solver	Input	Submitted	Started	Elapsed	Host
6075833	lp	CPLEX	GAMS	05/27 07:32	05/27 07:32	7:27:41	prod-sub-1.neos-server.org
6075943	minco	BARON	AMPL	05/27 09:00	05/27 09:00	5:59:45	prod-sub-1.neos-server.org
6075951	minco	BARON	AMPL	05/27 09:09	05/27 09:09	5:51:38	prod-sub-1.neos-server.org
6075954	minco	BARON	AMPL	05/27 09:12	05/27 09:12	5:48:19	prod-sub-1.neos-server.org
6075961	minco	BARON	AMPL	05/27 09:19	05/27 09:19	5:40:50	prod-sub-1.neos-server.org
6075964	minco	BARON	AMPL	05/27 09:21	05/27 09:21	5:39:39	prod-sub-1.neos-server.org
6075976	lp	CPLEX	GAMS	05/27 09:35	05/27 09:35	5:25:03	prod-sub-1.neos-server.org
6075983	minco	BARON	AMPL	05/27 09:39	05/27 09:39	5:21:04	prod-sub-1.neos-server.org
6076000	lp	CPLEX	GAMS	05/27 09:52	05/27 09:52	5:08:38	prod-sub-1.neos-server.org
6076017	lp	CPLEX	GAMS	05/27 10:01	05/27 10:01	4:58:51	prod-sub-1.neos-server.org
6076098	nco	Knitro	GAMS	05/27 13:06	05/27 13:06	1:54:37	prod-sub-1.neos-server.org
6076101	nco	Knitro	GAMS	05/27 13:06	05/27 13:06	1:54:23	prod-sub-1.neos-server.org
6076102	nco	Knitro	GAMS	05/27 13:06	05/27 13:06	1:54:12	prod-sub-1.neos-server.org

NEOS Server

Output Page



```
*****
NEOS Server Version 5.0
Job#      : 6076175
Password  : MxudUoip
User      : None
Solver    : milp:CPLEX:AMPL
Start     : 2018-05-27 14:33:37
End       : 2018-05-27 14:33:42
Host      : NEOS HTCondor Pool

Disclaimer:

This information is provided without any express or
implied warranty. In particular, there is no warranty
of any kind concerning the fitness of this
information for any particular purpose.
*****
File exists

You are using the solver cplexamp.

Checking ampl.mod for cplex_options...

Executing AMPL.

processing data.

processing commands.

Executing on prod-exec-1.neos-server.org
```

NEOS Server

Output Page (*cont'd*)

```
processing commands.  
Executing on prod-exec-1.neos-server.org  
  
Presolve eliminates 72 constraints.  
Adjusted problem:  
2556 variables:  
    2520 binary variables  
    36 linear variables  
582 constraints, all linear; 25224 nonzeros  
    210 equality constraints  
    360 inequality constraints  
    12 range constraints  
1 linear objective; 36 nonzeros.  
  
CPLEX 12.7.0.0: timelimit=300  
threads=4  
CPLEX 12.7.0.0: optimal integer solution; objective 16  
530 MIP simplex iterations  
0 branch-and-bound nodes  
No basis.
```

neos
HOME

NEOS Server

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**

NEOS Server

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

E.D. Dolan, R. Fourer, J.-P. Goux, T.S. Munson and J. Sarich,
**Kestrel: An Interface from Optimization Modeling Systems
to the NEOS Server.** *INFORMS Journal on Computing* **20**
(2008) 525–538. [dx.doi.org/10.1287/ijoc.1080.0264](https://doi.org/10.1287/ijoc.1080.0264)

AMPL Interactive Session

```
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

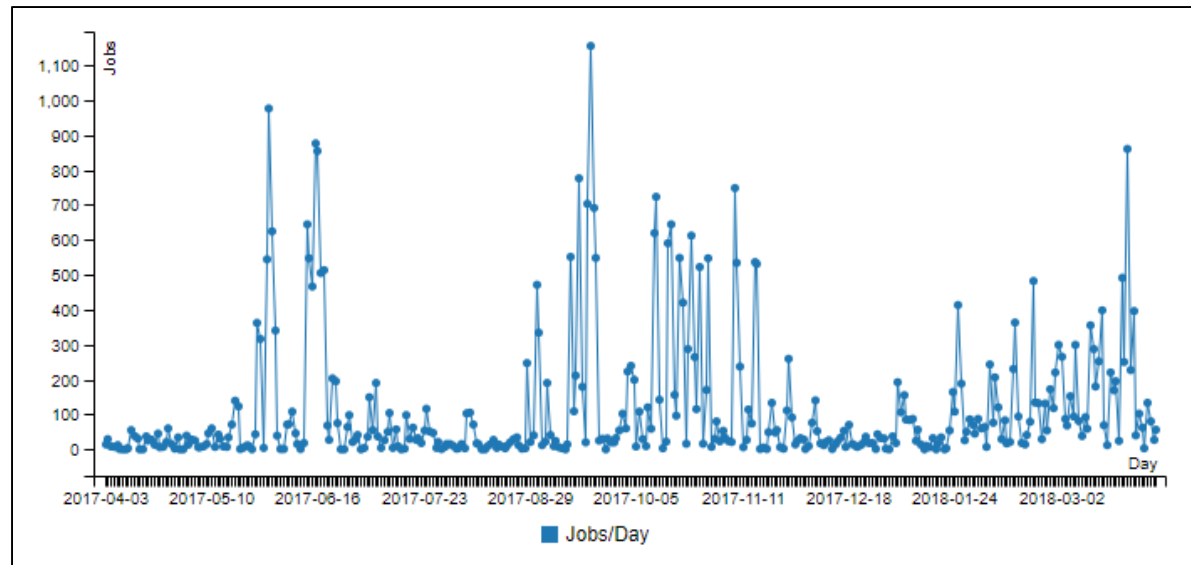
Kestrel Impact

Intensive use in short bursts

- Peaks of 10,000-60,000 per day

Modest use on average

- Average of 3,570 per month over past year
- Mostly AMPL/CPLEX



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
 - * Solver logs not currently returned

. . . we provide support for Kestrel/AMPL

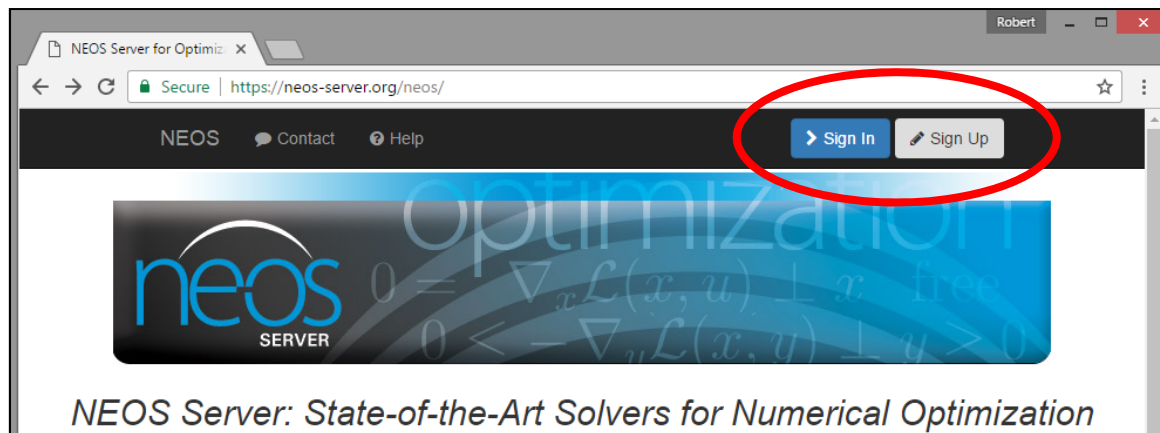
NEOS Server

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

A Commercial NEOS?

The screenshot shows a web browser window with the URL <https://solve.satalia.com>. The page features the SATALIA logo in the top left and navigation links for FAQ, PROVIDERS, REGISTER, and LOGIN in the top right. The main heading is "The SolveEngine" followed by a yellow "BETA" badge. Below this, a paragraph states: "We built the SolveEngine. It aggregates thousands of optimisation algorithms and uses artificial intelligence to choose the best ones to solve your problem. Whilst we are making it awesome, the SolveEngine Beta is free to use." A blue "START SOLVING" button is positioned at the bottom center. A vertical "Provide feedback" button is on the right side. The browser's address bar shows the URL, and the page footer contains the text <https://solve.satalia.com/login>.

Satalia SolveEngine

The screenshot shows a web browser window with the URL <https://solve.satalia.com>. The page title is "Modelling Languages". Below the title, there are three columns of information:

MiniZinc	AMPL	GAMS
High-level open-source modelling language for optimisation and satisfaction problems	Modelling language for mathematical programming and optimisation	Modelling language for mathematical programming and optimisation
September 2017	Coming early 2018	Coming early 2018

A "Provide feedback" button is visible on the right side of the page.

Satalia SolveEngine

The screenshot shows a web browser window with the URL <https://solve.satalia.com>. The page features the following content:

- Header:** "Smart Solving, Smart Pricing" with a blue horizontal line underneath.
- Text:** "Access a portfolio of state-of-the-art commercial and academic optimisation algorithms, and only pay for the time it takes to solve your problems."
- Buttons:** Three blue buttons labeled "PAY AS YOU GO", "ACADEMICS", and "ENTERPRISE".
- Text:** "All Pay As You Go tiers are licence free!"
- Feedback:** A vertical blue button on the right side labeled "Provide feedback".

Satalia SolveEngine

The screenshot shows a web browser window with the URL <https://solve.satalia.com>. The page displays three pricing tiers for the Satalia SolveEngine service. The browser tabs include 'Evanston, IL Foreca', 'Login | Salesforce', '#4373 Re: for Mas', 'Home - AMPLAMP', and 'Satalia SolveEngine'. The user's name 'Robert' is visible in the top right corner of the browser window.

Tier	Price	Features	Availability
Tier 0	Free	30 minutes of SolveTime each month 1 problem running Queue up to 2 problems 4GB maximum problem size Public queue	Available
Tier 1	£10 per hour	No minimum contract 1 problem running Queue up to 5 problems No maximum problem size Public queue	COMING SOON
Tier 2	£25 per hour	No minimum contract Run up to 5 problems concurrently Queue up to 50 problems No maximum problem size Private queue	COMING SOON

A vertical 'Provide feedback' button is located on the right side of the pricing cards.

A Solver-Specific NEOS?

The screenshot shows a web browser window with the URL <https://www.ibm.com/us-en/marketplace/decision-optimization-cloud>. The page features the IBM logo and a search bar. The main heading is "IBM Decision Optimization on Cloud" with sub-navigation for "Overview", "Purchase", and "Resources". The text below the heading reads: "Leverage advanced analytics and decision making optimization software on cloud to solve your planning and scheduling challenges". Below this, it states "Starting at \$10.60 USD per hour". There are two buttons: "Watch the demo" and "Start your free trial". At the bottom, there is a yellow button labeled "Let's talk" and a preview of the DropSolve software interface on a tablet.

IBM Decision Optimization on Cloud

DOplexcloud API

- Analogous to NEOS Python API

DropSolve service

- *Similar to NEOS web services*
- Matrix formats: LP, SAV, and MPS files
- OPL modeling language: MOD and DAT files
- Python programs using the API

IBM solvers

- CPLEX
- CP optimizer

See also FICO Analytic Cloud for Xpress solver

Gurobi 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

cloud.gurobi.com

The screenshot shows the Gurobi Instant Cloud website homepage. The browser window title is "Gurobi Instant Cloud" and the URL is "https://cloud.gurobi.com". The page features a dark blue header with the Gurobi logo and navigation links: PRODUCTS, DOWNLOADS, RESOURCES, ACADEMIA, SUPPORT, ABOUT, and a "Get Gurobi" button. A search bar is also present. The main content area has a blue background with a world map made of dots. The text "Gurobi Instant Cloud" is prominently displayed, followed by the tagline "Instant access to powerful optimization software and fast machines". Three red buttons are stacked vertically: "Open Cloud Manager", "Check Service Status", and "Discuss Your Needs". Below this, three white boxes highlight key benefits: "Great for...", "Easy and Robust", and "Cost Effective", each with a bulleted list of features.

GUROBI
OPTIMIZATION

PRODUCTS DOWNLOADS RESOURCES ACADEMIA SUPPORT ABOUT

Enter search text here...

Gurobi Instant Cloud
Instant access to powerful optimization software and fast machines

Open Cloud Manager

Check Service Status

Discuss Your Needs

Great for...

- Handling spikes in demand
- Solving challenging models
- Meeting periodic optimization needs
- Delivering cloud-based solutions
- Providing cloud-based failover

Easy and Robust

- Automatically start, manage and stop multiple machines
- Access from your existing applications
- Select dedicated machines from a data center near you
- Stay secure with built-in 256-bit AES encryption

Cost Effective

- Use and pay for only what you need
- Reduce or eliminate local data center costs
- Support Windows, Linux and Mac clients
- Access includes Gurobi Support

Gurobi Instant Cloud

cloud.gurobi.com

The screenshot shows the Gurobi Instant Cloud website homepage. At the top, there is a navigation bar with the Gurobi logo (a red cube) and the text "GUROBI OPTIMIZATION". To the right of the logo are links for "PRODUCTS", "DOWNLOADS", "RESOURCES", "ACADEMIA", "SUPPORT", and "ABOUT". A search bar is located in the top right corner with the placeholder text "Search gurobi.com & the community". A user profile icon and a "Get Gurobi" button are also present in the top right.

The main content area features a large blue banner with a world map made of small squares. The text "Gurobi Instant Cloud" is prominently displayed in white, with the subtitle "Instant access to powerful optimization software and fast machines" below it. Two red buttons are positioned on the right side of the banner: "Open Cloud Manager" and "Discuss Your Needs".

Below the banner, there are three columns of text, each with a red heading and a list of bullet points:

- Great for...**
 - Handling spikes in demand
 - Solving challenging models
 - Meeting periodic optimization needs
 - Delivering cloud-based solutions
 - Providing cloud-based failover
- Easy and Robust**
 - Automatically start, manage and stop multiple machines
 - Access from your existing applications
 - Select dedicated machines from a data center near you
 - Stay secure with built-in 256-bit AES encryption
- Cost Effective**
 - Use and pay for only what you need
 - Reduce or eliminate local data center costs
 - Support Windows, Linux and Mac clients
 - Access includes Gurobi Support

At the bottom of the page, there are three blue buttons: "Learn more", "Cloud Guide", and "Pricing".

Gurobi Instant Cloud

www.gurobi.com

The screenshot shows the Gurobi website's login page. At the top, there is a dark navigation bar with the Gurobi logo (a red cube) and the text "GUROBI OPTIMIZATION". To the right of the logo is a search bar with the placeholder text "Search gurobi.com & the community" and flags for the United States, Germany, and Korea. Further right are navigation links: "PRODUCTS", "DOWNLOADS", "RESOURCES", "ACADEMIA", "SUPPORT", and "ABOUT". On the far right of the navigation bar are "Login" and "Register" buttons.

Below the navigation bar, there are two breadcrumb links: "Home" and "Login". The main content area features a message: "Please login below to access protected content, or [register here](#) (for free)." Below this message are three input fields: "Email", "Password", and a "Login" button.

Below the login form, there is a link: "If you have forgotten or would like to reset your password, please [click here](#)." A horizontal dotted line separates this section from the footer.

The footer is a dark grey area with a grid of links. The links are organized into six columns:

- Column 1: Product Overviews, Features and Benefits, Modeling Languages, Use in Industry, Licensing and Pricing
- Column 2: Download Center, Gurobi Software, AMPL Software, Licenses
- Column 3: Resources Center, Documentation, Code Examples, Getting Started, Switching To Gurobi
- Column 4: Academia Center, For Universities, For Online Courses
- Column 5: Support Center, Consulting Services, Training Resources, User Community, FAQs
- Column 6: About Gurobi, Management Team, Example Customers, News, Events

On the right side of the footer, there are two buttons: "Contact Us to Learn More" (blue) and "Try For Free" (red).

View Available Licenses

☰ Licenses ⓘ ↗

Show licenses Search:

License	Active Machines	Rate Plan	Credit (US Dollar)	Expiration Time	
142032	0	No Charge	\$25	10/30/2016 7:00:00 PM	🔍 ⬇️ ☰
! 121420	0	No Charge	\$24.12	4/28/2016 7:00:00 PM	🔍 ⬇️ ☰

Showing 1 to 2 of 2 licenses First Previous **1** Next Last

[CONTACT SALES](#) [SUPPORT CENTER](#) [GETTING STARTED](#)

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
```


Use with AMPL: *Setup*

```
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=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=0v9XdWrDQLiE3EiAAEKtFw';

ampl: solve;

Gurobi 7.0.0: cloudid=fedf3901-04f1-44d7-9725-e36c1c3f70f6
cloudkey=0v9XdWrDQLiE3EiAAEKtFw

Waiting for cloud server to start.....
```

Use with AMPL: *Solve*

```
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=0v9XdWrDQLiE3EiAAEKtFw';

ampl: solve;

Gurobi 7.0.0: cloudid=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=0v9XdWrDQLiE3EiAAEKtFw  
  
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  
  
ampl:
```

Manage Server Configuration

The screenshot displays the Gurobi Instant Cloud management interface. On the left is a blue sidebar with the Gurobi logo and navigation options: LICENSES, POOLS, MACHINES, MANUAL LAUNCH, HISTORY, and SETTINGS. The main content area shows a table of server configurations with columns for Name, Rate Plan, Credit (US Dollar), and Expiration Time. A search bar is located at the top right of the table. Below the table, there are pagination controls (First, Previous, 1, Next, Last) and a 'GETTING STARTED' button.

Name	Rate Plan	Credit (US Dollar)	Expiration Time
...	No Charge	\$19.75	10/30/2016 7:00:00 PM
...	No Charge	\$24.12	4/28/2016 7:00:00 PM

Gurobi Instant Cloud

Check Costs

The screenshot displays the Gurobi Instant Cloud 'Pools' management interface. A modal dialog box titled 'Cost Estimate' is centered on the screen, providing the following information:

- 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.

The background interface shows a table with columns for ID, Compute Servers, Machine, Region, License, Rate Plan, and Distributed Workers. A single pool with ID '142032-default' and 1 compute server is visible. The interface also includes a search bar, a 'Current Licenses Only' checkbox, and navigation controls.

Gurobi Cloud Costs

Commercial plans

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

Pick the Gurobi Instant Cloud plan that best meets your needs:

Plan	Cost	Best For...
Starter	\$1,500 for three months of access, incl. Support, + \$20/hr. per machine	...situations where you want a short-term introduction to the Instant Cloud. Includes a Compute Server license. Note that the Starter Plan is not renewable.
Bronze	\$4,000 for one year of access, incl. Support, + \$10/hr. per machine	...situations where you just want to solve one model at a time and don't need the features or flexibility of Compute Server. Includes a Single-Use license.
Silver	\$10,000 for one year of access, incl. Support, + \$8/hr. per machine	...more active development and deployment situations where the hourly charge is more of a factor. Includes a Compute Server license.
Gold	\$20,000 for one year of access, incl. Support, + \$5/hr. per machine	...heavy usage situations where the features of Compute Server and getting the lowest hourly charge are important.

We recommend starting with our default instance size, c4.4xlarge, and then experimenting from there depending on your needs and budget. Instances with more than 16 vCPUs (such as the c4.8xlarge and r3.8xlarge instances) are charged at 2X the stated hourly price.

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

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

QuanDec

Initialization

Prepare the model and data

- Add reporting variables to the model
- Select initial data in AMPL .dat format

Import to QuanDec

- Install on a server
- Read zipfile of model and data
- Create new application and first master problem

Configure displays

- Create data tables
- Adjust views

... mostly done automatically



CASSOTIS
CONSULTING & SOLUTIONS IN OPTIMIZATION

The web-based graphical interface that
turns optimization models written in
AMPL into decision-making tools



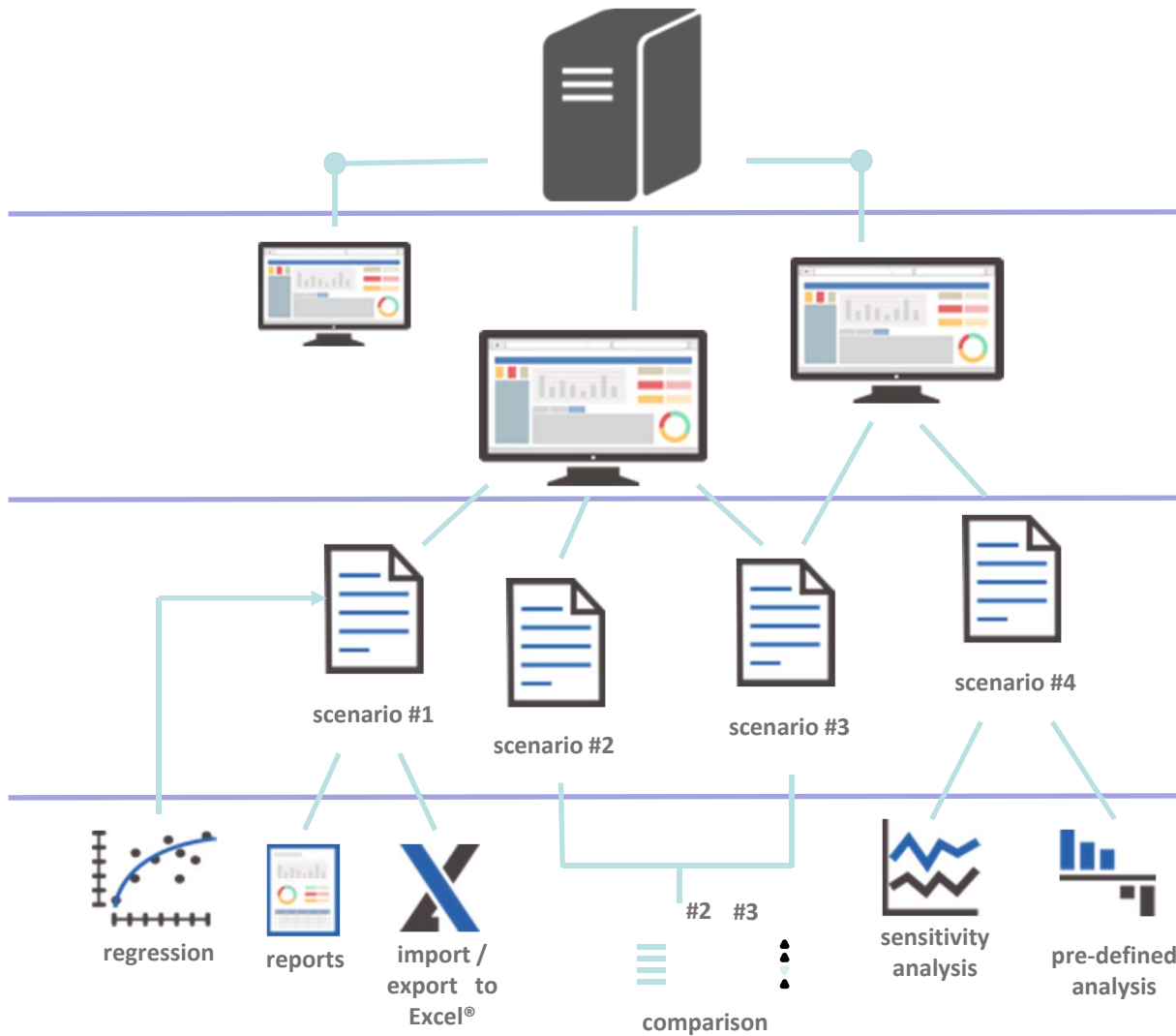
Features

Server application
 Centralized data
 Several apps on a single instance



Web-based
 Multi-users
 Concurrent access
 Secure access


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


And much more...



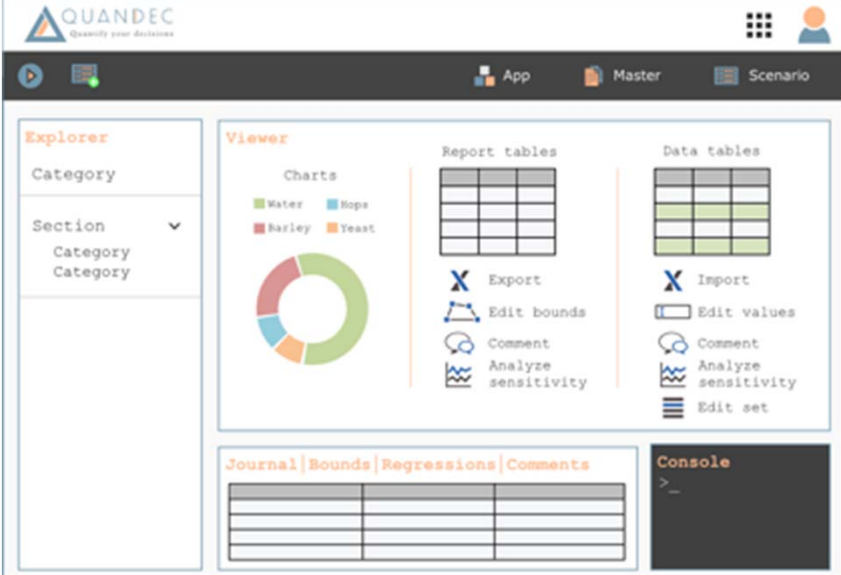
Getting started

Your AMPL model  +  Configure how you want to display your parameters and variables (many options of tables and charts)

Zip and upload configuration and AMPL model files into 



Quantify your decisions!



The interface shows a sidebar with 'Explorer' containing 'Category' and 'Section' dropdowns. The main 'Viewer' area includes a 'Charts' section with a donut chart for 'Water', 'Rops', 'Barley', and 'Yeast'. It also features 'Report tables' and 'Data tables' with grid icons. A bottom section contains 'Journal | Bounds | Regressions | Comments' and a 'Console' window.

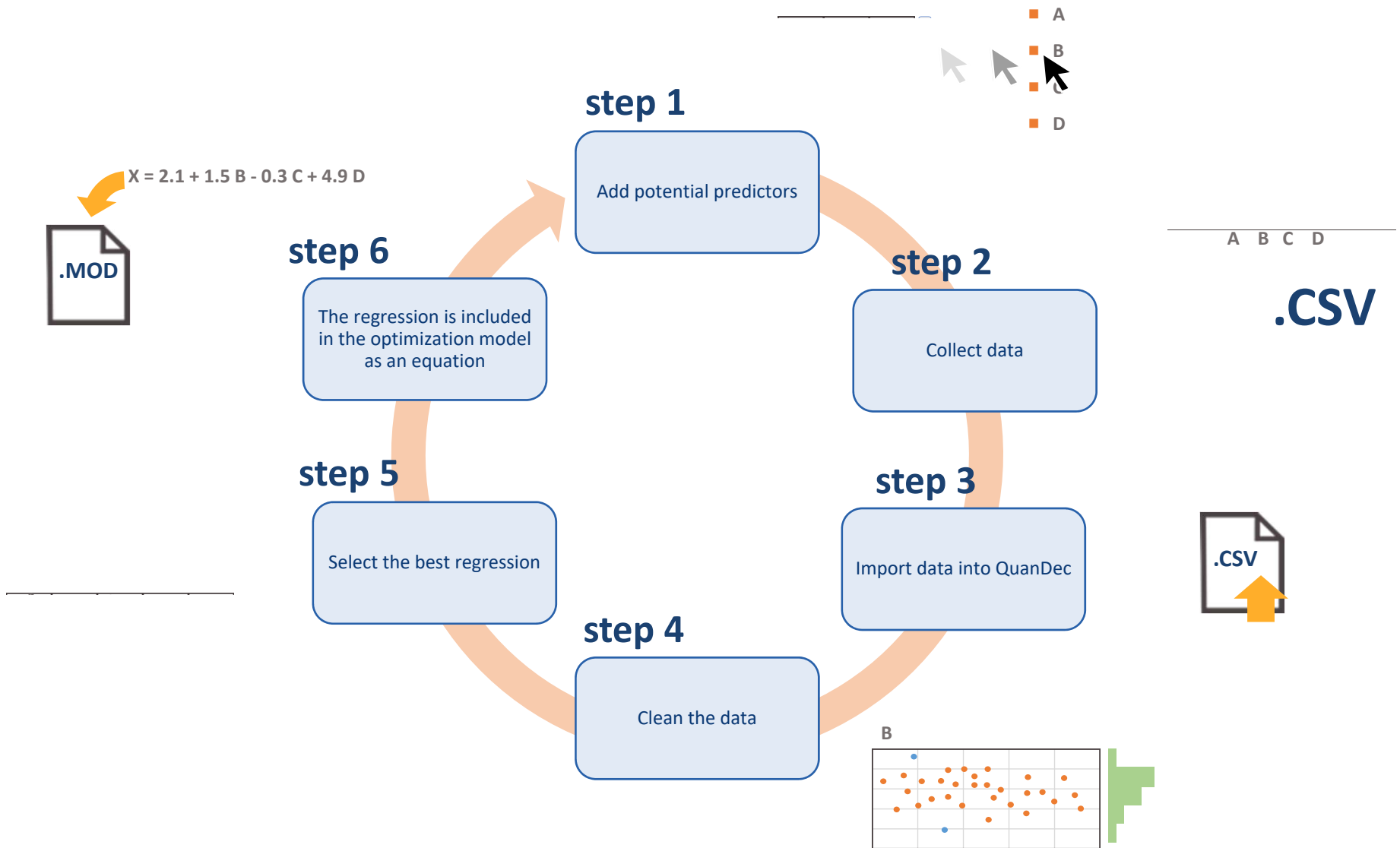
Workbench

The screenshot displays the QUANDEC Workbench interface. At the top left is the QUANDEC logo with the tagline "Quantify your decisions". On the top right, there is a grid icon and a user profile icon. Below the header is a dark navigation bar with icons for "App", "Master", and "Scenario".

The main workspace is divided into several panels:

- Explorer:** A sidebar on the left with a "Category" section and a "Section" dropdown menu. Below the dropdown, the text "Category" and "Category" is visible.
- Viewer:** The central panel containing a "Charts" section with a donut chart. The chart is divided into four segments: Water (green), Hops (blue), Barley (red), and Yeast (orange). Below the chart are icons for "Export", "Edit bounds", "Comment", and "Analyze sensitivity".
- Report tables:** A table with 5 rows and 3 columns, with the top row shaded grey.
- Data tables:** A table with 5 rows and 3 columns, with the second, third, and fourth rows shaded green.
- Journal | Bounds | Regressions | Comments:** A table with 5 rows and 3 columns, with the top row shaded grey.
- Console:** A dark grey terminal window at the bottom right with the text "> _".

Regression tool



Quandec's value proposition

GUI creation in less than 2 days, without any programming

No need of knowledge in Operations Research to be an end user

No proprietary format: use your preferred editor and use any good versioning system

Run optimization in various conditions (scenarios)

Benefit from all AMPL language features

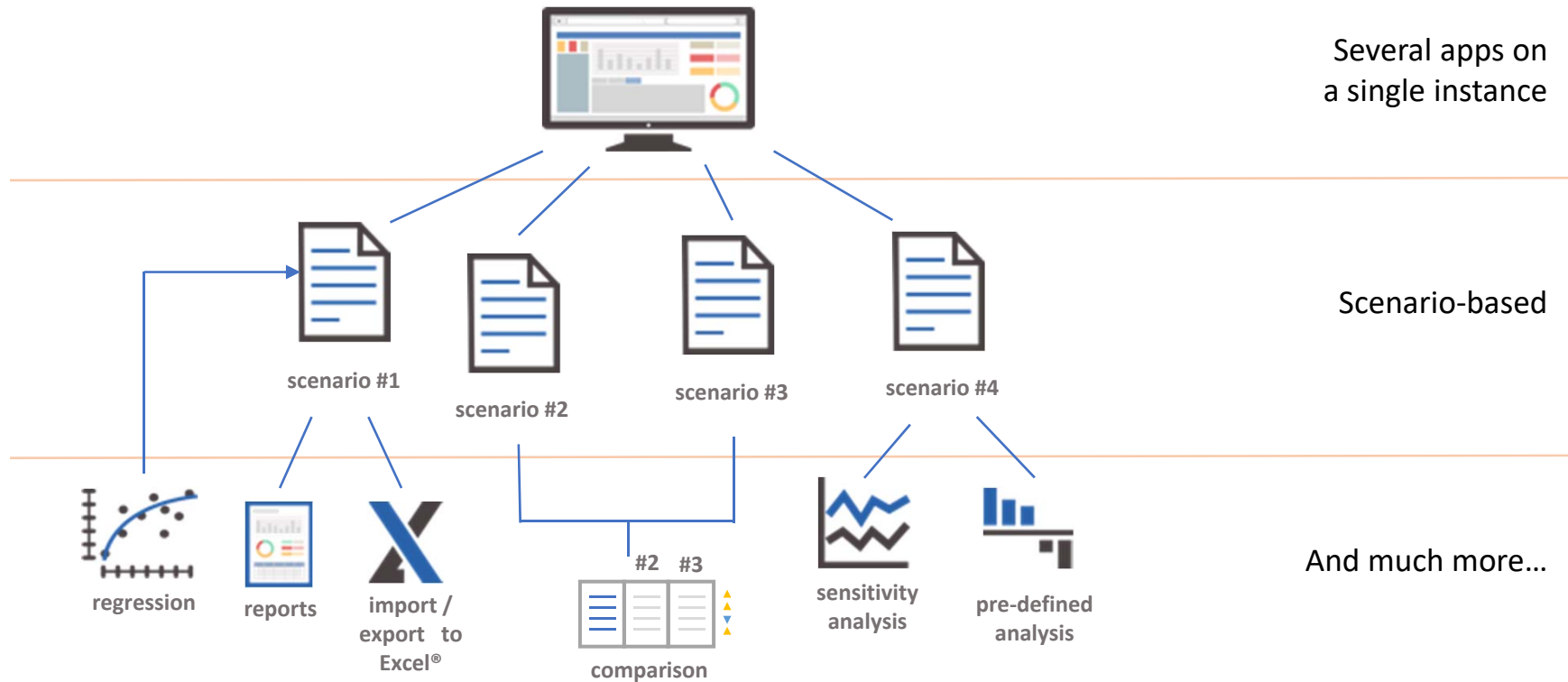
Intuitive & user-friendly

Recurrent decisions based on the result of analyses (scripts)



Standalone Quandec Version

Available in 2018 Q3



QuanDec Availability

Contact sales@ampl.com

- Free trials available
- Pricing keyed to number of models & users

First year's support included

- Tailored setup support from Cassotis Consulting
- Customizations possible