
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

Optimization modeling systems first appeared online almost 20 years ago, not long after web browsers came into widespread use. This presentation describes the evolution of optimization alternatives in what has come to be known as cloud computing, with emphasis on the role of the AMPL modeling language in making models easy to develop and deploy. We start with the pioneering free NEOS Server, and then compare more recent commercial offerings such as Gurobi Instant Cloud; the benefits of these solver services are readily leveraged through their use with the AMPL modeling tools. We conclude by introducing QuanDec, which creates web-based collaborative applications from an AMPL models.

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!***

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
- ❖ Algorithm'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

3 ways to use . . .

3 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

Example: Roll Cutting

Motivation

- ❖ Fill orders for rolls of various widths
 - * by cutting raw rolls of one (large) fixed width
 - * using a variety of cutting patterns

Optimization model

- ❖ Decision variables
 - * number of raw rolls to cut according to each pattern
- ❖ Objective
 - * minimize number of raw rolls used
- ❖ Constraints
 - * meet demands for each ordered width

Roll cutting

Mathematical Formulation

Given

W set of ordered widths

n number of patterns considered

and

a_{ij} occurrences of width i in pattern j ,
for each $i \in W$ and $j = 1, \dots, n$

b_i orders for width i , for each $i \in W$

Roll cutting

Mathematical Formulation (*cont'd*)

Determine

X_j number of rolls to cut using pattern j ,
for each $j = 1, \dots, n$

to minimize

$$\sum_{j=1}^n X_j$$

total number of rolls cut

subject to

$$\sum_{j=1}^n a_{ij} X_j \geq b_i, \text{ for all } i \in W$$

number of rolls of width i cut
must be at least the number ordered

Roll Cutting

AMPL Formulation

Symbolic model

```
set WIDTHS;  
param orders {WIDTHS} > 0;  
param nPAT integer >= 0;  
param nbr {WIDTHS,1..nPAT} integer >= 0;  
  
var Cut {1..nPAT} integer >= 0;  
  
minimize Number:  
    sum {j in 1..nPAT} Cut[j];  
  
subj to Fulfill {i in WIDTHS}:  
    sum {j in 1..nPAT} nbr[i,j] * Cut[j] >= orders[i];
```

$$\sum_{j=1}^n a_{ij} X_j \geq b_i$$

Roll Cutting

AMPL Formulation (*cont'd*)

Explicit data (independent of model)

```
param: WIDTHS: orders :=
    6.77    10
    7.56    40
    17.46   33
    18.76   10 ;

param nPAT := 9 ;

param nbr:  1  2  3  4  5  6  7  8  9 :=
    6.77    0  1  1  0  3  2  0  1  4
    7.56    1  0  2  1  1  4  6  5  2
    17.46   0  1  0  2  1  0  1  1  1
    18.76   3  2  2  1  1  1  0  0  0 ;
```

Command Language

Model + data = problem instance to be solved

```
ampl: model cut.mod;
ampl: data cut.dat;
ampl: option solver cplex;
ampl: solve;
CPLEX 12.6.3.0: optimal integer solution; objective 20
3 MIP simplex iterations
ampl: option omit_zero_rows 1;
ampl: option display_1col 0;
ampl: display Cut;
4 13 7 4 9 3
```

Command Language (*cont'd*)

Solver choice independent of model and data

```
ampl: model cut.mod;
ampl: data cut.dat;
ampl: option solver gurobi;
ampl: solve;
Gurobi 6.5.0: optimal solution; objective 20
3 simplex iterations
ampl: option omit_zero_rows 1;
ampl: option display_1col 0;
ampl: display Cut;
4 13 7 4 9 3
```

Command Language (*cont'd*)

Results available for browsing

```
ampl: display {j in 1..nPAT, i in WIDTHS: Cut[j] > 0} nbr[i,j];
:      4   7   9   :=                                # patterns used
6.77   0   0   4
7.56   1   6   2
17.46  2   1   1
18.76  1   0   0

ampl: display {j in 1..nPAT} sum {i in WIDTHS} i * nbr[i,j];
1 63.84   3 59.41   5 64.09   7 62.82   9 59.66      # pattern
2 61.75   4 61.24   6 62.54   8 62.0          # total widths

ampl: display Fulfill.slack;
6.77  2                                # overruns
7.56  3
17.46 0
18.76 3
```


IDE for Command Language

The screenshot displays the AMPL IDE interface. On the left is a file explorer showing the current directory: C:\Users\Robert\Desktop\FILES\T. The central console window shows the execution of an AMPL model, including the command 'ampl: solve;' and the output 'Gurobi 6.0.4: optimal solution; objective 20'. The console also displays the results of a 'display' command, showing a matrix of values for 'Cut' and 'nbr[i,j]'. On the right, two code editors are open: 'cut.mod' and 'cut.dat'. The 'cut.mod' editor contains the AMPL model code, including parameter declarations, variable declarations, and objective and constraint functions. The 'cut.dat' editor contains the data for the model, including parameter values for 'WIDTHS', 'nPAT', and 'nbr'.

```
File Edit Window Help
Current Directory
C:\Users\Robert\Desktop\FILES\T
ChvatalD.dat
cut.dat
cut.mod
cutPat.mod
cutPatEnum.run
cutPatEnum100.run
cutSENS.run
HaesslerB.dat
Schrage19.dat
Sorrentino.dat

Console
AMPL
ampl: model cut.mod;
ampl: data cut.dat;
ampl: option solver gurobi;
ampl: solve;
Gurobi 6.0.4: optimal solution; objective 20
3 simplex iterations
ampl: option omit_zero_rows 1;
ampl: option display_1col 0;
ampl: option display_transpose 100;
ampl: display Cut;
Cut [*] :=
4 13 7 4 9 3
;

ampl: display {j in 1..nPAT, i in WIDTHS: Cut[j] > 0} nbr[i,j];
nbr[i,j] [*,*] (tr)
:=
6.77 0 0 4
7.56 1 6 2
17.46 2 1 1
18.76 1 0 0
;

ampl: |

cut.mod
set WIDTHS;
param orders {WIDTHS} > 0;

param nPAT integer >= 0;
param nbr {WIDTHS,1..nPAT} integer >= 0;

var Cut {1..nPAT} integer >= 0;

minimize Number:
sum {j in 1..nPAT} Cut[j];

subj to Fulfill {i in WIDTHS}:
sum {j in 1..nPAT} nbr[i,j] * Cut[j] >= orders[i];

cut.dat
param: WIDTHS: orders :=
6.77 10
7.56 40
17.46 33
18.76 10 ;

param nPAT := 9 ;

param nbr: 1 2 3 4 5 6 7 8 9 :=
6.77 0 1 1 0 3 2 0 1 4
7.56 1 0 2 1 1 4 6 5 2
17.46 0 1 0 2 1 0 1 1 1
18.76 3 2 2 1 1 1 0 0 0 ;
```

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

AMPL

^ *Optimization in the Cloud*

Local modeling system, remote solver

- NEOS Server
- Gurobi Instant Cloud

Local analysis tools, remote model

- QuanDec

... a variety of AMPL interface alternatives

NEOS Server www.neos-server.org

Network Enabled Optimization System

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

Free “optimization on demand”

- Over 40 solvers
- Several optimization modeling languages

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

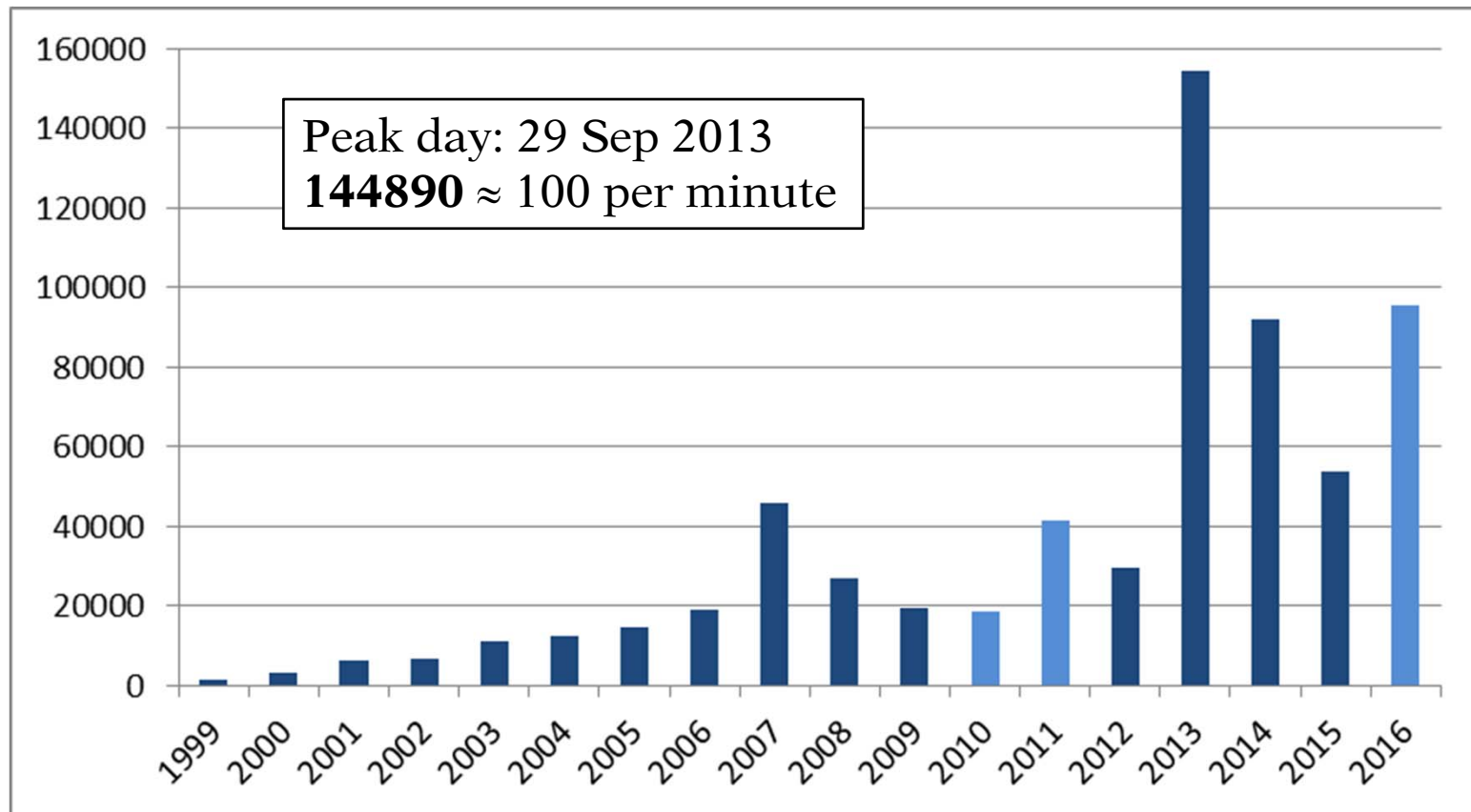
W. Gropp and J.J. Moré, 1997. **Optimization Environments and the NEOS Server**. *Approximation Theory and Optimization*, M. D. Buhmann and A. Iserles, eds., Cambridge University Press, 167-182.

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

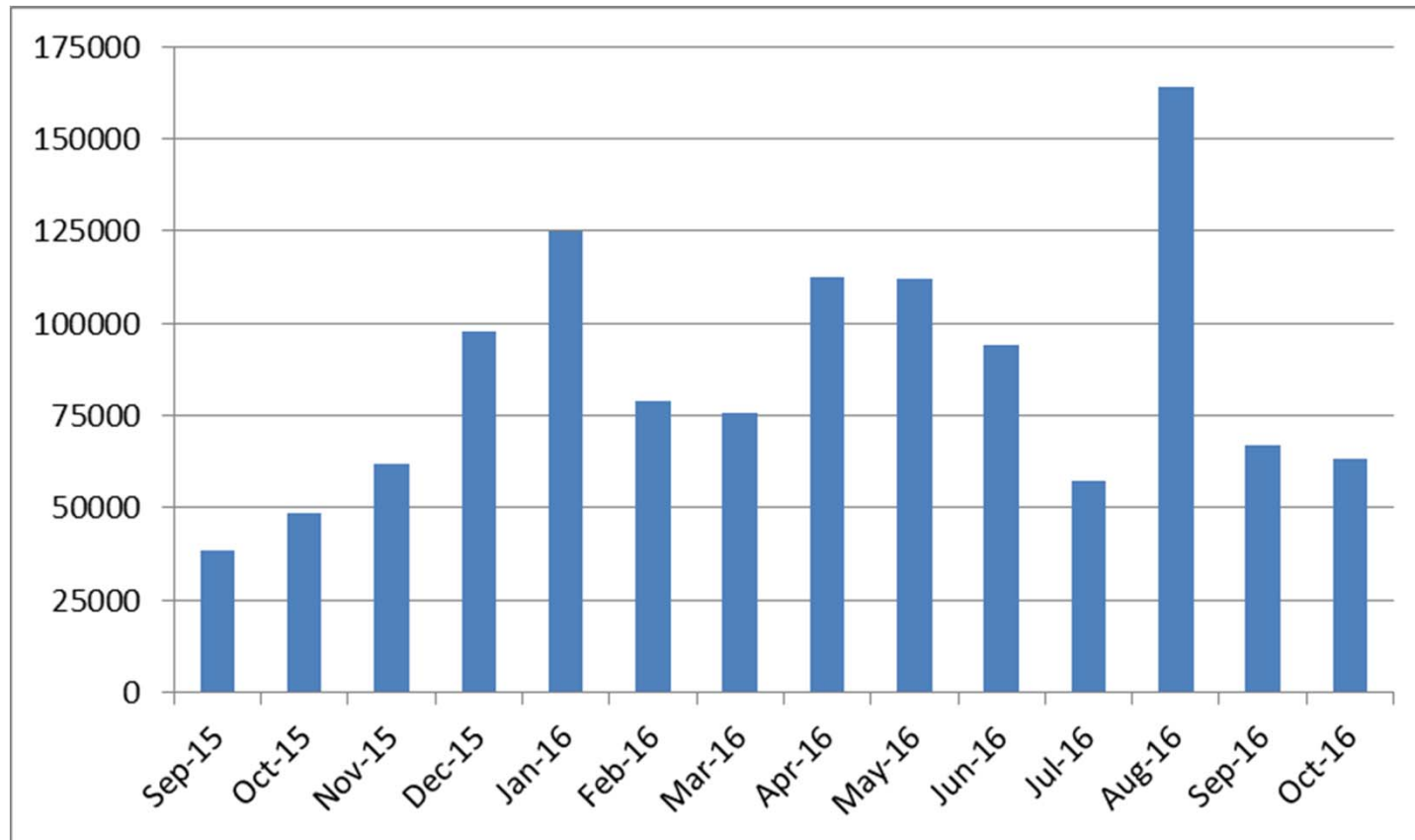


45000/month \approx one per minute

NEOS Server

Impact: Recent Submissions

Monthly rates for past year



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

NEOS Server

Recent Enhancements

More flexible server infrastructure

- Based on HTCondor “high-throughput computing”

Secure user authentication

- Option to register and sign in when submitting
- Potential advantages for registered clients
 - * priority job execution
 - * data security
 - * “more services and better customized experiences”

Modeling Languages in NEOS

Modeling language inputs

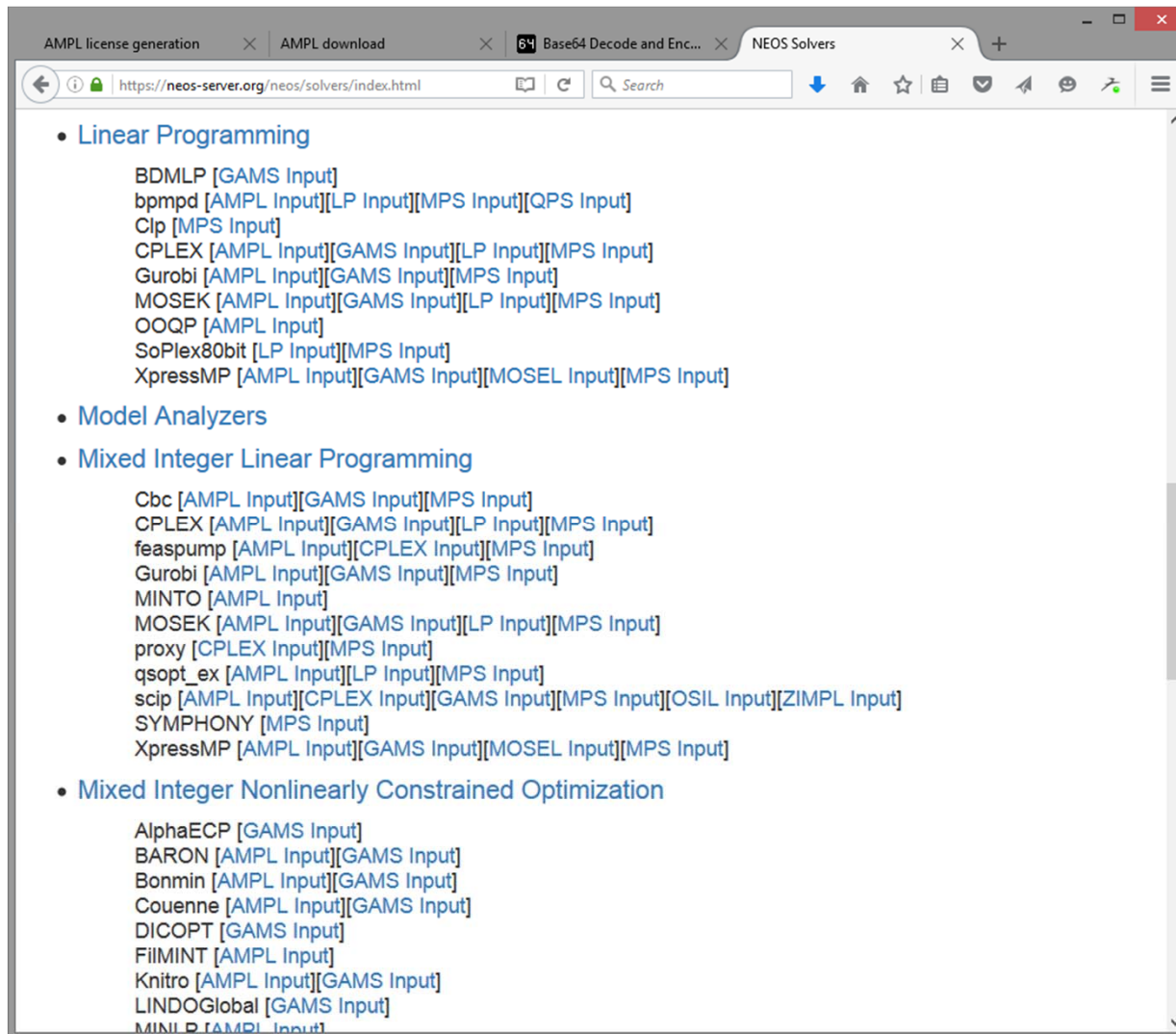
- AMPL model, data, commands files
- GAMS model, options,.gdx files

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

Solver & Language Listing



NEOS Server

AMPL Input Page



The screenshot shows a web browser window with the URL <https://neos-server.org/neos/solv>. The browser's address bar shows the page title "NEOS Server: CPLEX". The page features a navigation bar with "NEOS", "Contact", and "Help" links, along with "Sign In" and "Sign Up" buttons. A large banner image displays the "neos SOLVERS" logo and the word "Optimization" in a stylized font. A text box on the right side of the banner reads "NEOS Interfaces to CPLEX" and lists "WWW Form & Sample Submissions", "Email", and "XML-RPC" as options. Below the banner, the "CPLEX" section is titled in blue. The text explains that the NEOS Server offers the IBM ILOG CPLEX Optimizer for solving linear programming (LP) problems in AMPL format. It provides links for more information on IBM Decision Optimization products and the IBM Academic Initiative. The "Using the NEOS Server with AMPL/CPLEX" section details the submission process, including the requirement for a model file, data file, and commands file. A note specifies that an email address is required for submissions and that the XML-RPC interface requires a specific line in the XML file.

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

CPLEX

The NEOS Server offers the IBM ILOG [CPLEX Optimizer](#) for the solution of linear programming (LP) 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 linear program. The [examples section](#) of the AMPL website provides examples of models in AMPL format. The LP 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.

Note: An email address is required for any submissions that use CPLEX. This email address will be forwarded to IBM and may be used by IBM for promotional purposes. If using the XML-RPC interface, you must add the line `<email>your.address@email.edu</email>` into the XML file that is sent to NEOS.

NEOS Server

AMPL Input Page

The screenshot shows a web browser window with the URL <https://neos-server.org/neos/solv>. The browser's address bar shows several tabs, including "NEOS Server: CPLEX". The page has a dark header with the "NEOS" logo, "Contact", and "Help" links, and "Sign In" and "Sign Up" buttons. The main content area contains three file selection sections and a comments box:

- Model File:** "Enter the location of the AMPL model file (local file)" with a text input field and a "Browse..." button.
- Data File:** "Enter the location of the AMPL data file (local file)" with a text input field and a "Browse..." button.
- Commands File:** "Enter the location of the AMPL commands file (local file)" with a text input field and a "Browse..." button.
- Comments:** A large empty text area for user comments.

NEOS Server

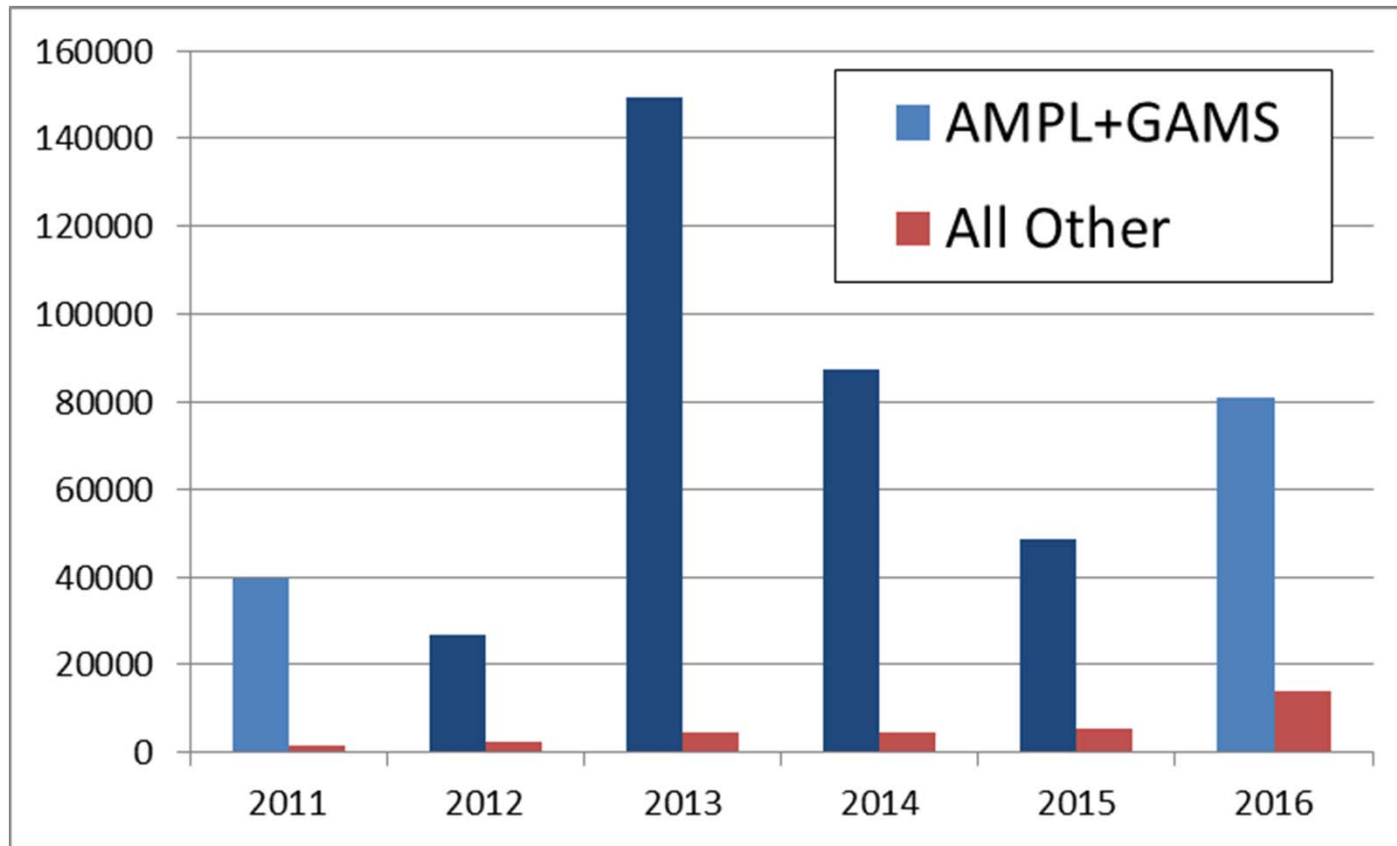
AMPL Input Page

The screenshot shows a web browser window with the URL <https://neos-server.org/neos/solv>. The browser's address bar shows several tabs, including "NEOS Server: CPLEX". The page header includes "NEOS", "Contact", and "Help" links, along with "Sign In" and "Sign Up" buttons. A "Comments:" section contains a large text input area. Below this, there are two checkboxes: "Dry run: generate job XML instead of submitting it to NEOS" and "Short Priority: submit to higher priority queue with maximum CPU time of 5 minutes". An "e-mail address:" label is followed by an input field. A message states: "By submitting a job, you have accepted the [Terms of Use](#)". Below this are "Submit to NEOS" and "Clear this Form" buttons. A warning says: "Please do not click the 'Submit to NEOS' button more than once." The footer contains "Comments and Questions · Terms of Use", the "WISCONSIN INSTITUTE FOR DISCOVERY" logo, and a copyright notice: "Copyright © 2016, Wisconsin Institutes for Discovery at the University of Wisconsin, Madison · Terms of Use".

NEOS Server

Impact: Modeling Languages

Monthly rates since 2011



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.
```

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

- 2013 and 2014:
Peaked at over 500,000 submissions
- 2015:
Dropped to only about 30,000 submissions
- 2016:
Up to over 100,000 submissions so far

Kestrel Assessment

Strengths

- Powerful local client for modeling
- NEOS facilities for solving

Weaknesses

- Limited support & development
- 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

More Recently . . .

NEOS in Solver Studio

- Excel add-in using
AMPL/GAMS models, NEOS solvers

Optimization Services

- Fully distributed, decentralized alternative to NEOS

IBM Decision Optimization on Cloud

- “DropSolve” service similar to NEOS
- “DOcplexcloud API” like NEOS API

Gurobi Cloud Services for Optimization

- Gurobi cloud for Amazon Web Services
- *Gurobi instant cloud*

NEW

Gurobi 7.0 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
www.gurobi.com

The screenshot shows the Gurobi Optimization website homepage. The browser window title is "Gurobi Optimization - Th x" and the address bar shows "www.gurobi.com". The page features a dark blue header with the Gurobi logo and navigation links: PRODUCTS, DOWNLOADS, RESOURCES, ACADEMIA, SUPPORT, and ABOUT. There are also "Login" and "Register" buttons. A search bar is present with the text "Search gurobi.com & the community". The main content area has a blue background with a world map made of dots. The headline reads "An easier way to make better decisions" and the sub-headline says "The state-of-the-art mathematical programming solver for prescriptive analytics". To the right, there is a section for "Gurobi Optimizer 6.5" with a list of features: "Faster times to feasibility and optimality", "No-surprises pricing", "Intuitive interfaces", and "Easy-to-reach technical support". Below this are two red buttons: "Get Started Today!" and "See what's new in v6.5!". The page is divided into three columns with icons: a magnifying glass for "Learn About", a hand for "Get Gurobi", and a wrench for "Use Gurobi". Each column has a short paragraph of text. At the bottom, there is a section for training events with a list of bullet points.

GUROBI
OPTIMIZATION

PRODUCTS DOWNLOADS RESOURCES ACADEMIA SUPPORT ABOUT

Login Register

Search gurobi.com & the community

An easier way to make better decisions

The state-of-the-art mathematical programming solver for prescriptive analytics

Gurobi Optimizer 6.5

- Faster times to feasibility and optimality
- No-surprises pricing
- Intuitive interfaces
- Easy-to-reach technical support

Get Started Today!

See what's new in v6.5!

Learn About

Gurobi builds and supports the best math programming solvers available for all major problem types. It's all we do...

Get Gurobi

We offer versions designed specifically for the needs of commercial, ISV, and academic users...

Use Gurobi

We've worked hard to make it easier to get started with or switch to Gurobi than you may have thought possible...

Join us for your choice of free, two-day, in-person training events

We are offering two free training events for commercial users, one presented in English and another presented in German.

In these hands-on and interactive training events you will:

- build your modeling skills across three modeling workshops ranging from beginner to advanced

Gurobi Instant Cloud for AMPL

www.gurobi.com

GUROBI
OPTIMIZATION

PRODUCTS DOWNLOADS RESOURCES ACADEMIA SUPPORT ABOUT

Search gurobi.com & the community

Login Register

An easier way to make better decisions

The state-of-the-art mathematical programming solver for prescriptive analytics

Gurobi Optimizer 6.5

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Learn About

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Get Gurobi

We offer versions designed specifically for the needs of commercial, ISV, and academic users...

Use Gurobi

We've worked hard to make it easier to get started with or switch to Gurobi than you may have thought possible...

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We are offering two free training events for commercial users, one presented in English and another presented in German.

In these hands-on and interactive training events you will:

- build your modeling skills across three modeling workshops ranging from beginner to advanced

Gurobi Instant Cloud for AMPL

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 USA, Germany, and Japan. Further right are links for "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 tabs: "Home" and "Login". The main content area contains the text: "Please login below to access protected content, or [register here](#) (for free).". Below this text 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:

- Product Overviews
- Features and Benefits
- Modeling Languages
- Use in Industry
- Licensing and Pricing

- Download Center
- Gurobi Software
- AMPL Software
- Licenses

- Resources Center
- Documentation
- Code Examples
- Getting Started
- Switching To Gurobi

- Academia Center
- For Universities
- For Online Courses

- Support Center
- Consulting Services
- Training Resources
- User Community
- FAQs

- 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).

Gurobi Instant Cloud for AMPL
ngcloud.gurobi.com

The screenshot shows the homepage of the Gurobi Instant Cloud service. 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 menu items: PRODUCTS, DOWNLOADS, RESOURCES, ACADEMIA, SUPPORT, and ABOUT. Further right is a search bar with the placeholder text 'Search gurobi.com & the community', a user profile icon, and a 'Get Gurobi' button. The main banner features a world map composed of small blue squares. Overlaid on the map is the text 'Gurobi Instant Cloud' in large white font, followed by 'Instant access to powerful optimization software and fast machines' in a smaller white font. 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 white boxes with red headers and bulleted lists of features. The first box is titled 'Great for...' and lists five benefits. The second box is titled 'Easy and Robust' and lists four benefits. The third box is titled 'Cost Effective' and lists four benefits. At the bottom of the page, there are three blue buttons: 'Learn more', 'Cloud Guide', and 'Pricing'.

GUROBI
OPTIMIZATION

PRODUCTS DOWNLOADS RESOURCES ACADEMIA SUPPORT ABOUT

Search gurobi.com & the community

Get Gurobi

Gurobi Instant Cloud

Instant access to powerful optimization software and fast machines

Open Cloud Manager

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

Learn more Cloud Guide Pricing

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☰ 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
```

Gurobi Instant Cloud for AMPL

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>
```


Gurobi Instant Cloud for 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.....
```


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?   '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: Instant Cloud, Robert Fourer (4er@ampl.com), LICENSES, POOLS, MACHINES, MANUAL LAUNCH, HISTORY, and SETTINGS. The main content area features a search bar and a table of server configurations. The table has columns for Name, Rate Plan, Credit (US Dollar), and Expiration Time. Two rows are visible, both with a 'No Charge' rate plan. The first row has a credit of \$19.75 and an expiration time of 10/30/2016 7:00:00 PM. The second row has a credit of \$24.12 and an expiration time of 4/28/2016 7:00:00 PM. Below the table is a pagination control showing '1' of 1 items. A 'GETTING STARTED' button is also visible.

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

Check Costs

The screenshot displays the Gurobi Instant Cloud interface. A modal dialog box titled "Cost Estimate" is open, 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 "Pools" table with the following columns: ID, Compute Servers, Machine, Region, License, Rate Plan, and Distributed Workers. A search bar and a "Current Licenses Only" checkbox are also visible.

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

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

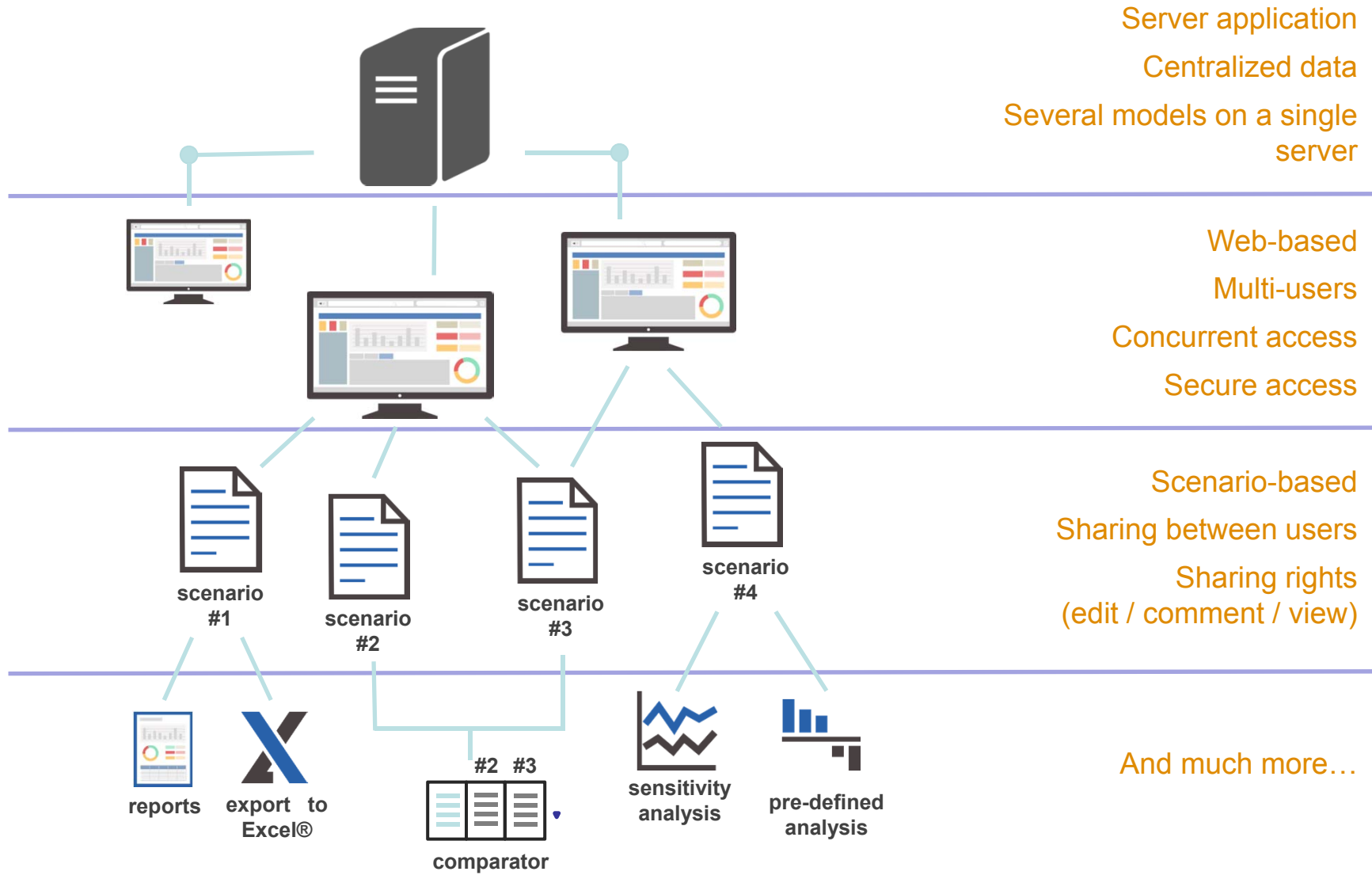
Quan Δ ec



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



Features

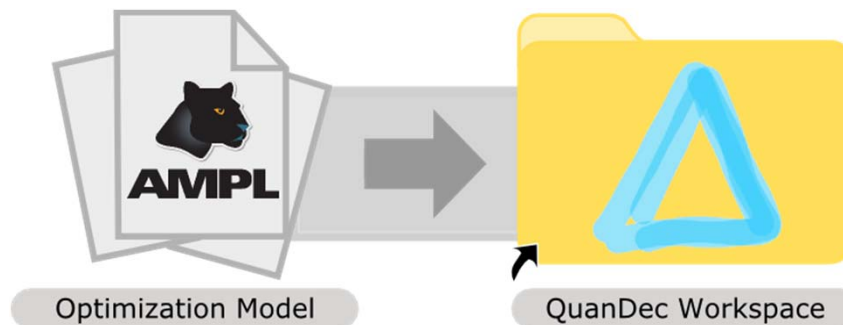


Getting started

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





E-mail :

Password :

[Forgot?](#)

Enter your email to login

Version 2.3.1

CASSOTIS consulting

Login

Web-application

Multi-user

Secure access

Concurrent access

The screenshot shows the QuanDec software interface. At the top, there is a navigation bar with 'Workspace' and 'Admin' tabs, and buttons for 'Switch workspace', 'New Master', 'Import Master', and 'Compare'. The main area displays a list of scenarios under 'This week' and 'All' sections. A 'Share with others' dialog box is open, showing a dropdown menu set to 'Anyone can comment', a list of people or groups with 'Robert Finn' selected and 'can edit' permission, and an 'OK' button.

Name	Owner	Last change
BUDGET 2016	Mary Torres	September 9, 2016 4:59 PM
My Scenario	Me	Today 10:54 AM

Name	Owner
BUDGET 2015	Mary Torres
BUDGET 2016	Mary Torres
My Scenario	Me
FORECAST 2017	Mary Torres

Scenario-based environment

Sharing system

**Permission:
Edit – Comment - View**

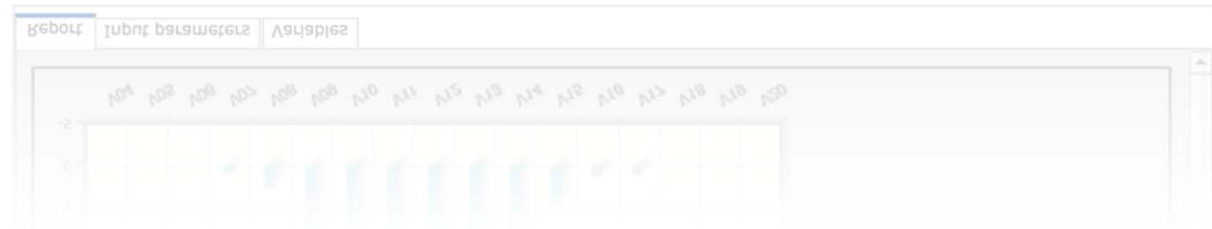
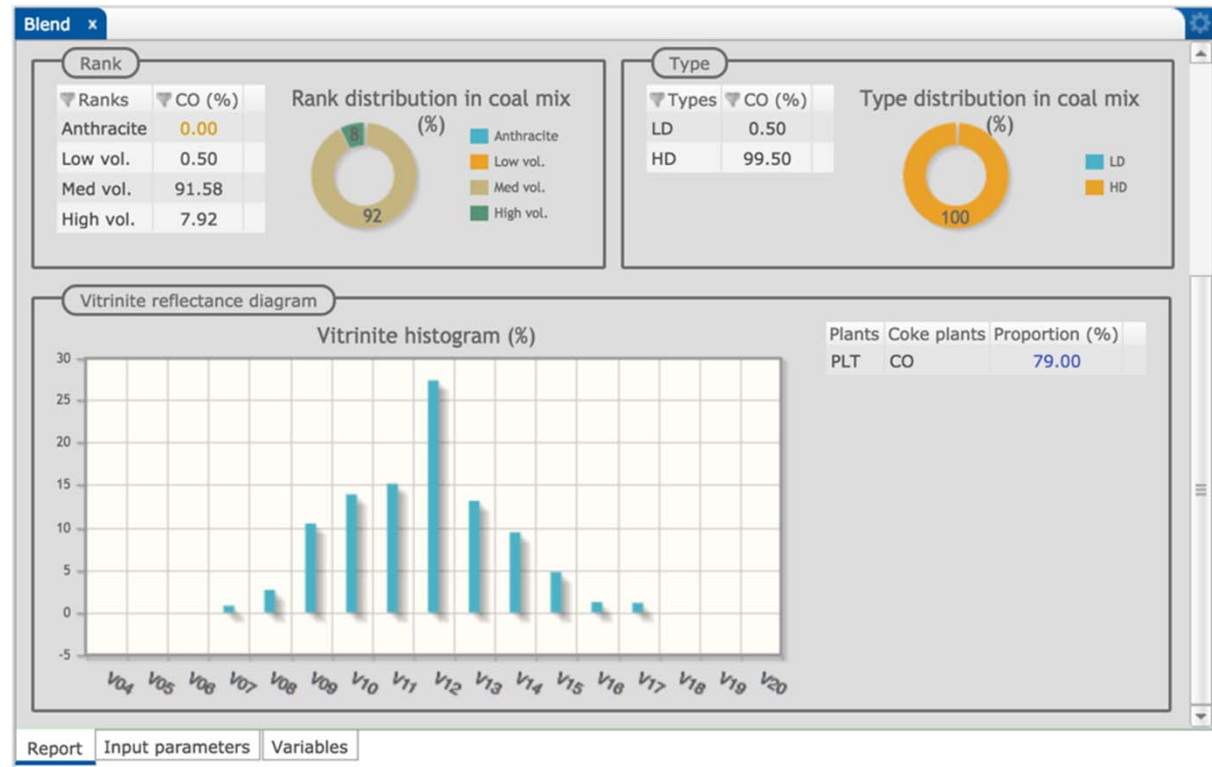
3 levels:

- 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

The screenshot displays a software interface with several components:

- Table:** A table with columns for 'blend', 'SM1 (kg/t)', and 'WAVG (kg/t)'.

blend	SM1 (kg/t)	WAVG (kg/t)
Hot metal	889.89	889.89
Lump ores	0.00	0.00
Pellets	0.00	0.00
- Chart:** A horizontal bar chart titled 'Blend at conver' showing the composition of materials. The legend includes Hot metal (blue), Lump ores (orange), Pellets (yellow), Recyclings (green), Fluxes (light green), and Ferroalloys (dark green).
- Pop-up Windows:**
 - Comment this value:** A dialog box with a dropdown menu set to 'QUESTION'. It shows two comments: one from Mary Torres asking 'Do we use pellets at the converter?' and one from Benjamin Steward replying 'No, we exclusively use lump ores.' There is an 'Enter a message:' field and 'Cancel'/'OK' buttons.
 - Share with others:** A dialog box with a dropdown menu set to 'Anyone can comment'. It lists 'Robert Finn' with 'can edit' and a red 'X' icon. There is an 'OK' button.
 - New comment:** A notification bubble in the top right corner stating 'Robert Finn has commented this dataset.'

Coke plants x

Operating costs

Plants	Coke plants	Costs	Fixed (MUS\$/year)	Variable (US\$/t)
PLT	CO	Maintenance	7.75	0.90
PLT	CO	Labour costs	3.95	0.00
PLT	CO	Utilities	0.05	0.11
PLT	CO	Water treatment	7.78	0.00
PLT	CO	Court yard	5.36	0.00
PLT	CO	Services	0.02	0.94
PLT	CO	Indirect costs	2.57	0.00
PLT	CO	Depreciation	4.92	0.00
PLT	CO	Electricity	0.00	0.03

Report Input parameters Variables

Journal Bounds Regressions Comments Error Log

Journal	Bounds	Regressions	Comments	Error Log
Operating cost at coke plant	PLT, CO1, co_elec, Variable	0.03	Today 11:26 AM	by Arthur Turner
CO operational costs	PLT, co_elec	Electricity	Today 11:26 AM	by Arthur Turner
CO operational costs	PLT	co_elec	Today 11:26 AM	by Arthur Turner
Vitrinite reflectance inside of range at coke plant	PLT, CO1	MAX 79.00	Today 10:49 AM	by Arthur Turner

Arthur Turner QuanDec STEEL BUDGET 2016 My Scenario

Arthur Turner QuanDec STEEL BUDGET 2016 My Scenario

Vitrinite reflectance inside of range at coke plant	PLT, CO1	MAX 79.00	Today 10:49 AM	by Arthur Turner
CO operational costs	PLT, co_elec	Electricity	Today 11:26 AM	by Arthur Turner
CO operational costs	PLT	co_elec	Today 11:26 AM	by Arthur Turner

Scenarios with changes history

Traceability and undo system

Workspace Admin

New Report Show/Hide differences Export to Excel

Quan^Δec

Comparator

Variable	Unit	BUDGET 2016	My Scenario	Diff
Executive summaries				
Costs and Revenues				
Profit and Sales				
Production costs				
Absolute costs	MUS\$			
Detailed costs	US\$/t			
Internal price of intermediates	US\$/t			
Net production level	kt			
'PLT' 'CO'	kt	1763.98	1764.25	0.02%
'PLT' 'SI'	kt	4085.77	4084.46	-0.03%
'PLT' 'BF'	kt	5062.62	5060.91	-0.03%
'PLT' 'ST'				
'PLT' 'PO'				
Production cost of product				
Production level				
Material blends				
Coke plants				
Sinter plants				
Blast furnaces				
Steel shops				
Power plant				
Raw materials				

Select the scenarios to compare:

BUDGET 2015

BUDGET 2016

My Scenario

FORECAST 2017

Cancel OK

Economics and Production

Variable	Index	Unit	BUDGET 2016	My Scenario	Diff
Economics per int. plant	'PLT' 'costs'	MUS\$	1515.59	1515.20	-0.03%
Economics per int. plant	'PLT' 'revenues'	MUS\$	1762.23	1761.77	-0.03%
Economics per int. plant	'PLT' 'profit'	MUS\$	246.64	246.56	-0.03%
Economics per int. plant	'PLT' 'margin'	%	14.00	14.00	-0.00%
Production cost of product	'PLT' 'coke'	US\$/t	164.48	164.54	0.04%
Production cost of product	'PLT' 'sinter'	US\$/t	77.55	77.50	-0.06%
Production cost of product	'PLT' 'hotmetal'	US\$/t	193.95	193.99	0.02%
Production cost of product	'PLT' 'slab'	US\$/t	286.27	286.28	0.00%
Production cost of product	'PLT' 'electricity'	US\$/MWh	125.75	125.75	0.00%
Production level of product	'PLT' 'coke'	kt	1818.54	1818.81	0.02%
Production level of product	'PLT' 'sinter'	kt	4085.77	4084.46	-0.03%

Report Structure

Reports

Name	User	Date	Action
Sulfur cycle	Benjamin Steward	March 18, 2016 3:45 PM	✖
Metallic blend at CV	Me	February 21, 2016 4:51 PM	✖
Raw material use at Reduction	Me	January 15, 2016 4:36 PM	✖
Economics and Production	Mary Torres	September 13, 2016 4:53 PM	✖
Flux consumption at Torpedo	Mary Torres	April 3, 2016 4:44 PM	✖
Slab sales	Robert Finn	January 30, 2016 5:30 PM	✖
Silicon cycle	Benjamin Steward	July 5, 2016 4:17 PM	✖

Scenarios comparison

All variables can be compared

Display of relative difference

Custom reports

Profit and Sales

Exchange rates

Currencies	Exchange rates (US\$)
eur	1.14
usd	1.00
brl	0.29

Horizon

Days (d) 365.00

- Add a comment
- Add a constraint
- Add to a regression
- Analyse sensitivity
- Export the table
- Download the template

Sensitivity analysis

Parameter : Exchange rates

Index : 'brl'

From : 0.3

To : 1

#Pts : 3

Cancel OK

Sensitivity analysis

For both parameters AND variables

All variables can be compared

Display of relative difference

Workspace Admin

Back to edition New Report Show/Hide differences Export to Excel

QuanDec

Comparator

Variable	Unit	0.30	0.65	Diff	1.00	Diff
Executive summaries						
Costs and Revenues						
Profit and Sales						
Economics per int. plant	MUS\$					
'PLT' 'costs'	MUS\$	1515.39	1544.99	1.95%	1633.34	7.78%
'PLT' 'revenues'	MUS\$	1754.70	1679.96	-4.26%	1670.71	-4.79%
'PLT' 'profit'	MUS\$	239.31	134.97	-43.60%	37.37	-84.38%
'PLT' 'margin'	%	13.64	8.03	-41.09%	2.24	-83.60%
Global economics	MUS\$					
External costs per process	MUS\$					
External costs per type	MUS\$					
Detailed external costs	MUS\$					
External revenues per process	MUS\$					
External revenues per type	MUS\$					
Detailed external revenues	MUS\$					
Detailed revenues	MUS\$/t					
Production costs						
Material blends						
Coke plants						
Sinter plants						
Blast furnaces						
Steel shops						
Power plant						
Raw materials						
Gases						

Economics and Production

Variable	Index	Unit	0.30	0.65	Diff	1.00	Diff
Economics per int. plant	'PLT' 'costs'	MUS\$	1515.39	1544.99	1.95%	1633.34	7.78%
Economics per int. plant	'PLT' 'revenues'	MUS\$	1754.70	1679.96	-4.26%	1670.71	-4.79%
Economics per int. plant	'PLT' 'profit'	MUS\$	239.31	134.97	-43.60%	37.37	-84.38%
Economics per int. plant	'PLT' 'margin'	%	13.64	8.03	-41.09%	2.24	-83.60%
Production cost of product	'PLT' 'coke'	US\$/t	164.51	161.52	-1.82%	162.71	-1.10%
Production cost of product	'PLT' 'sinter'	US\$/t	77.68	83.23	7.15%	88.16	13.50%
Production cost of product	'PLT' 'hotmetal'	US\$/t	194.23	198.43	2.16%	202.93	4.48%
Production cost of product	'PLT' 'slab'	US\$/t	287.62	307.33	6.85%	326.85	13.64%
Production cost of product	'PLT' 'electricity'	US\$/MWh	125.62	125.73	0.08%	125.74	0.09%
Production level of product	'PLT' 'coke'	kt	1818.81	1815.95	-0.16%	1815.95	-0.16%
Production level of product	'PLT' 'sinter'	kt	4115.36	4007.25	-2.63%	4006.24	-2.65%
Production level of product	'PLT' 'hotmetal'	kt	5105.94	5051.71	-1.06%	5052.00	-1.06%
Production level of product	'PLT' 'trhotmetal'	kt	5025.36	4972.09	-1.06%	4972.37	-1.05%
Production level of product	'PLT' 'crudesteel'	kt	5657.39	5402.17	-4.51%	5372.49	-5.04%

Report Structure

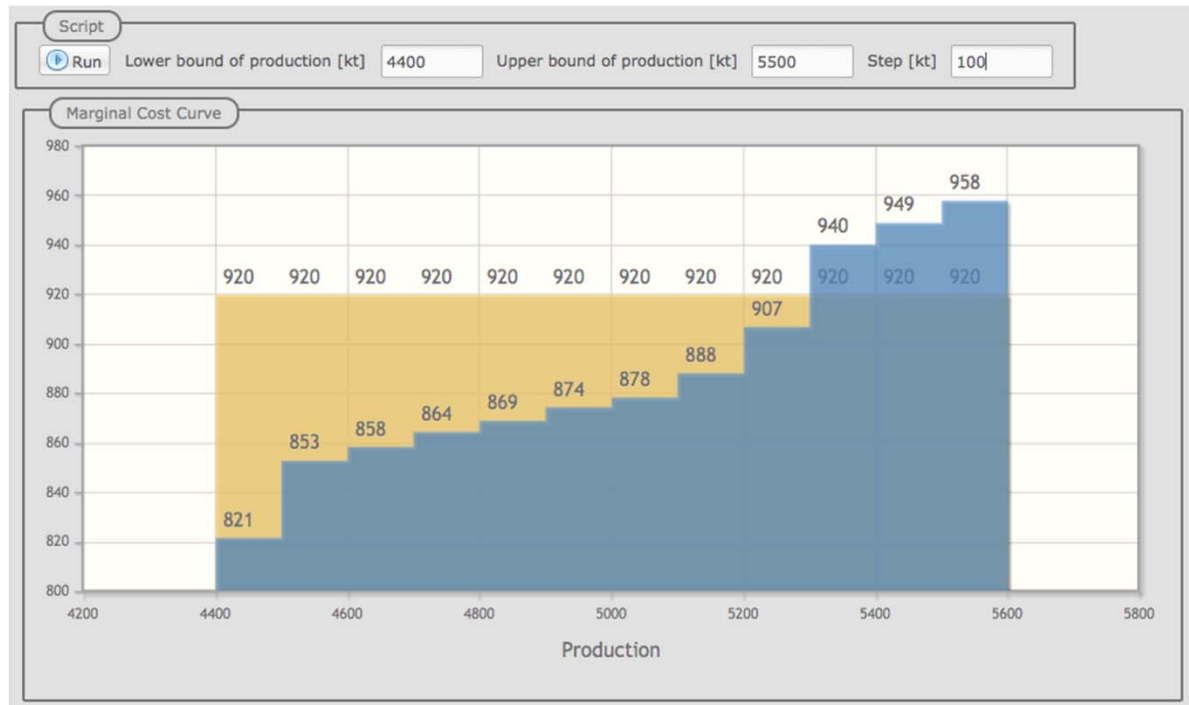
Reports

Name	User	Date	Action
Sulfur cycle	Benjamin Steward	March 18, 2016 3:45 PM	✗
Metallic blend at CV	Me	February 21, 2016 4:51 PM	✗
Raw material use at Reduction	Me	January 15, 2016 4:36 PM	✗
Economics and Production	Mary Torres	September 13, 2016 4:53 PM	✗
Flux consumption at Torpedo	Mary Torres	April 3, 2016 4:44 PM	✗
Slab sales	Robert Finn	January 30, 2016 5:30 PM	✗
Silicon cycle	Benjamin Steward	July 5, 2016 4:17 PM	✗

Arthur Turner QuanDec STEEL BUDGET 2016 My Scenario About QuanDec...

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