Cloud Strategies for Optimization Modeling Software

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WB-02, Modeling Systems I — Wednesday, 11:00-12:30

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

AMPL

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

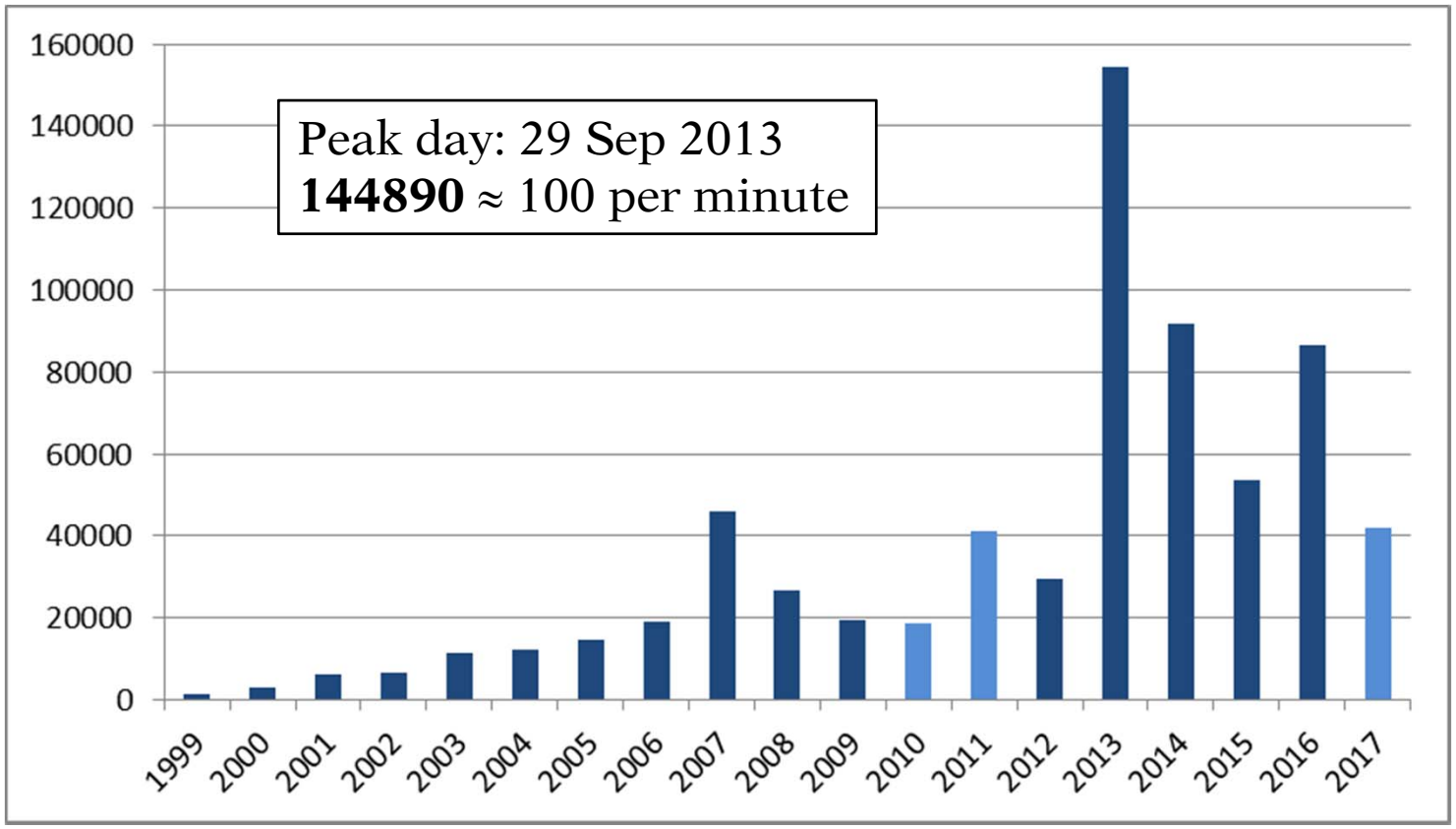
W. Gropp and J.J. Moré, 1997. **Optimization Environments and the NEOS Server**. *Approximation Theory and Optimization,* M. D. Buhmann and A. Iserles, eds., Cambridge University Press, 167-182.

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

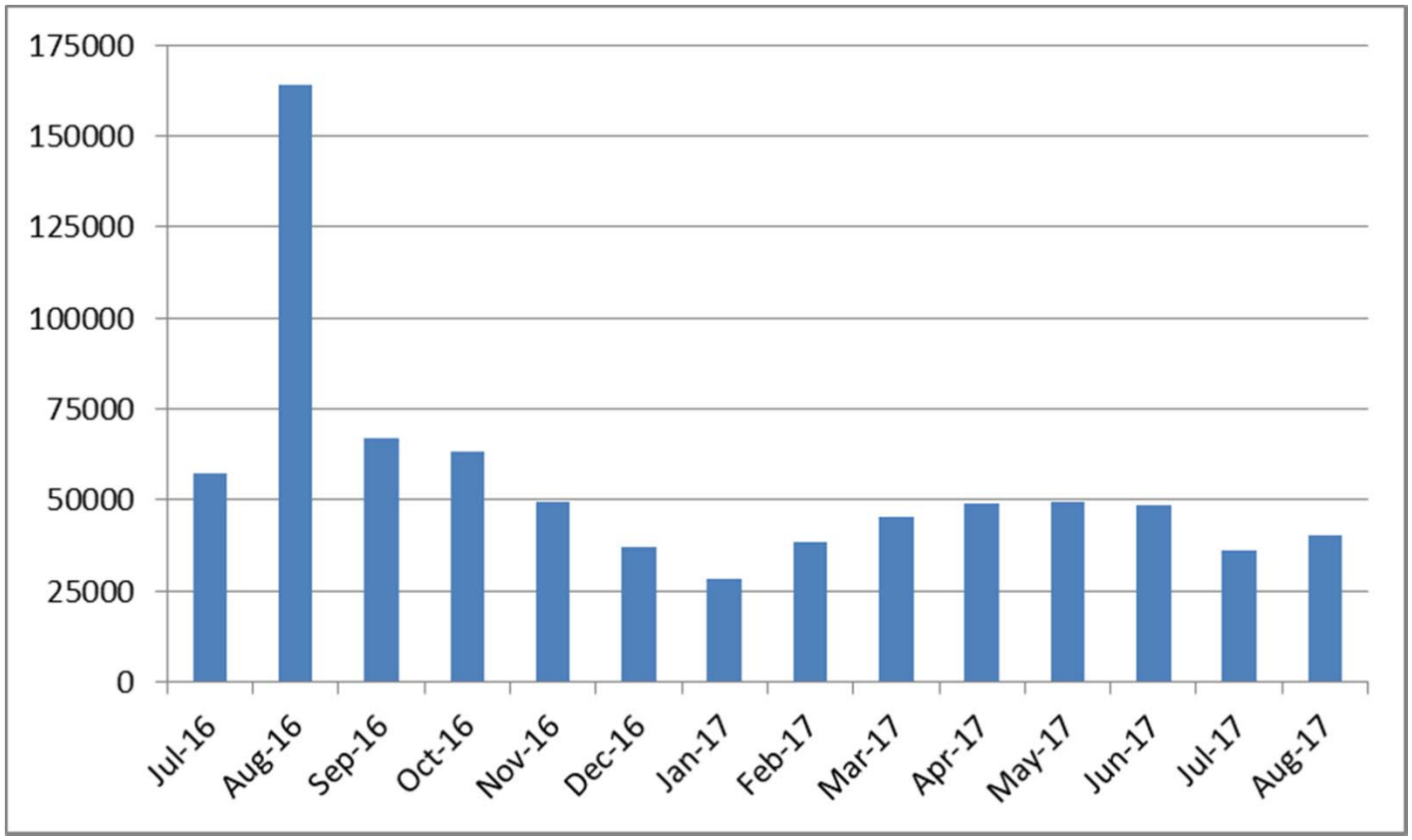


45000/month ≈ one per minute

NEOS Server

Impact: Recent Submissions

Monthly rates for past year



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

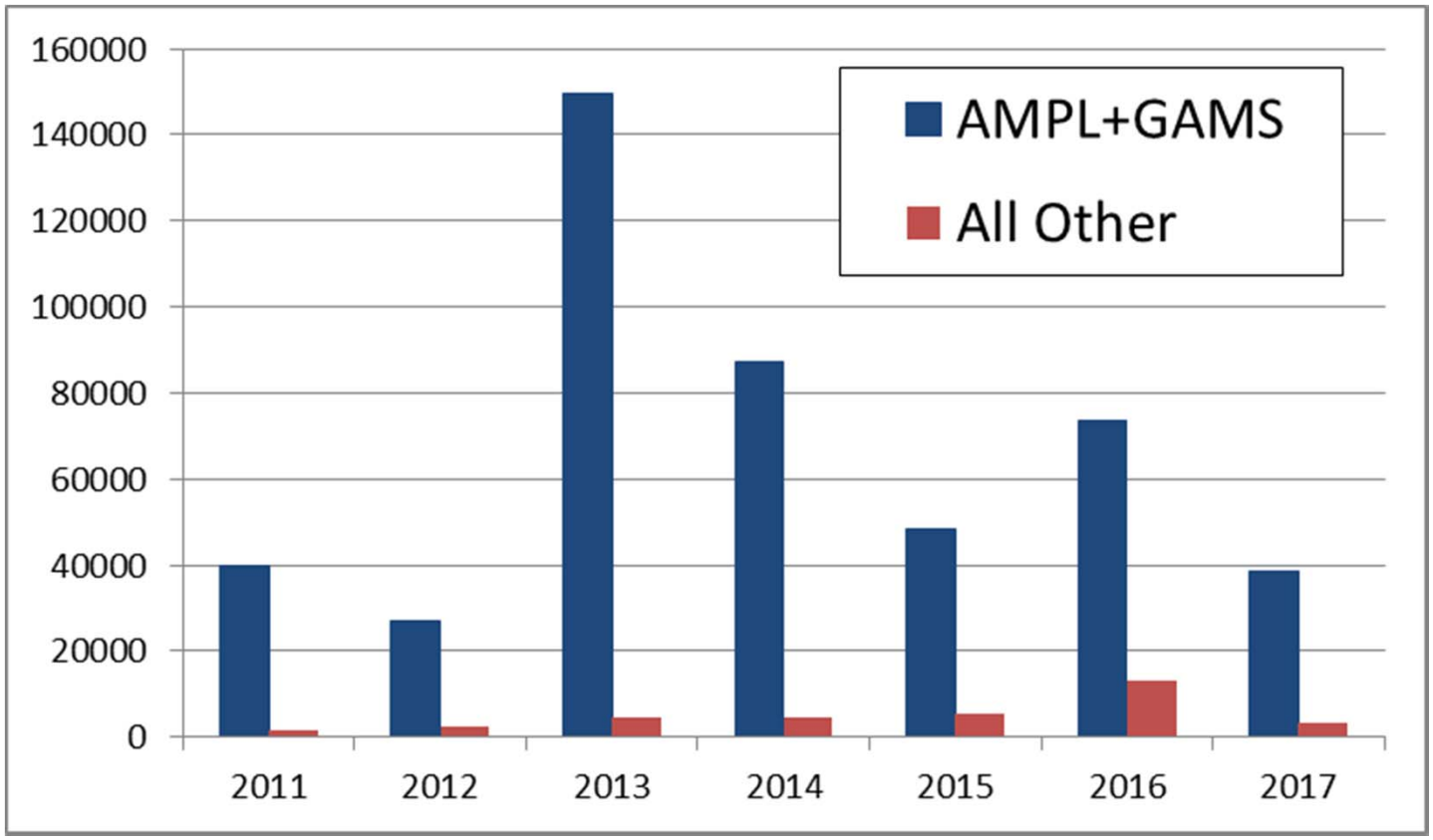
- User chooses a solver and a language
- NEOS scheduler finds a compatible workstation
- NEOS workstation invokes modeling language system with given inputs
- Modeling language system invokes solver

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

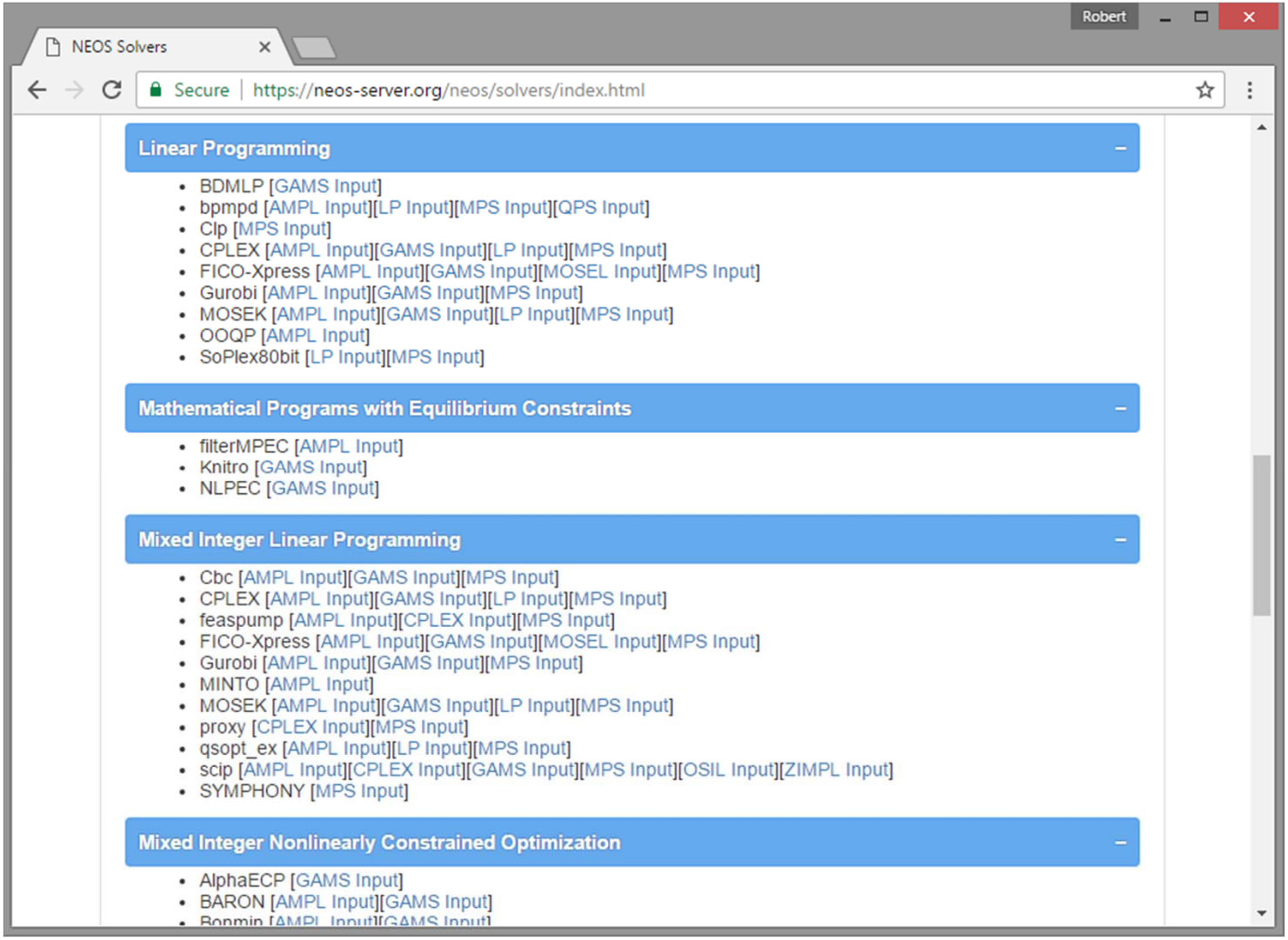
Impact: Modeling Languages

Monthly rates since 2011



NEOS Server

Solver & Language Listing

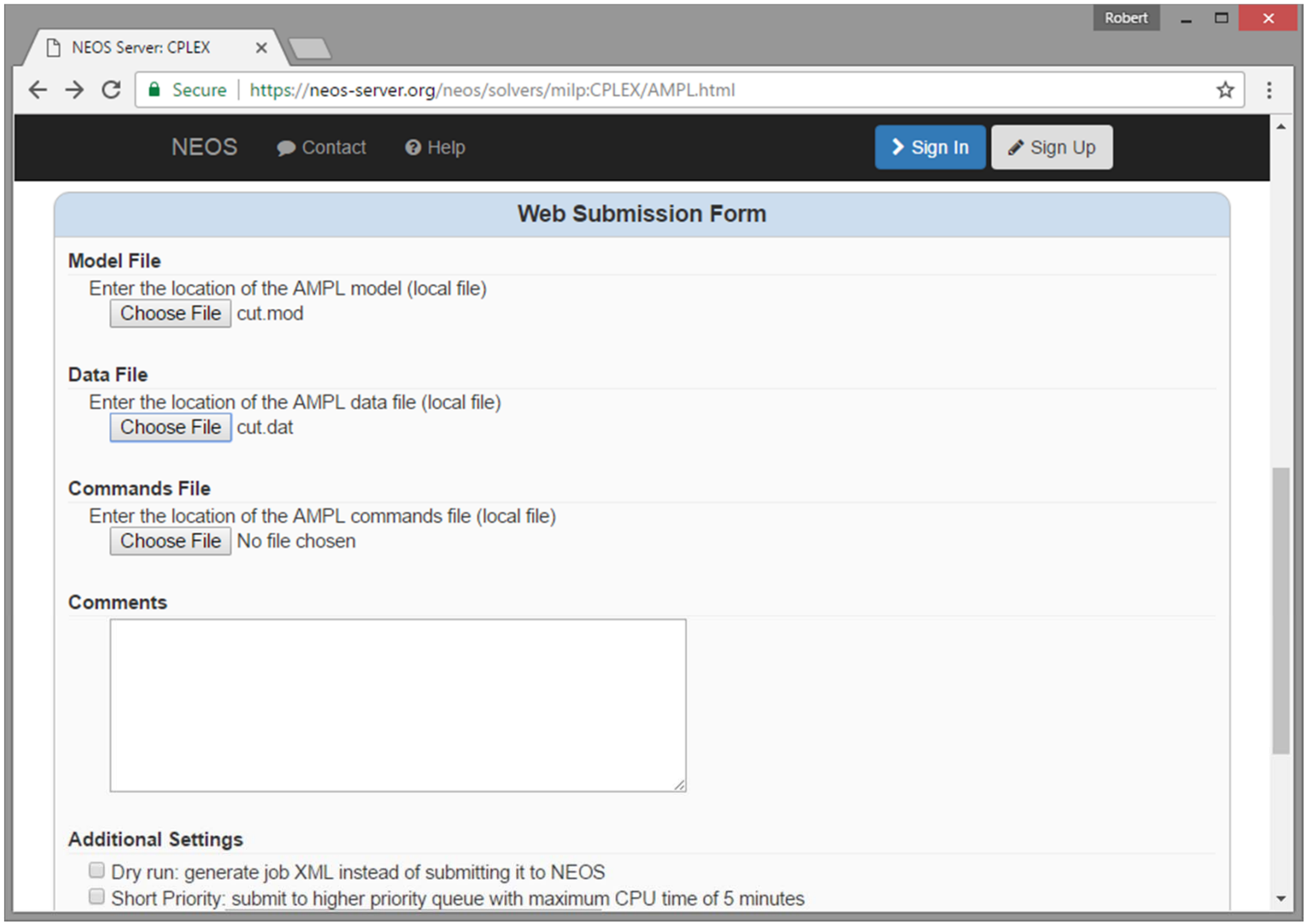


NEOS Server

AMPL Input Page

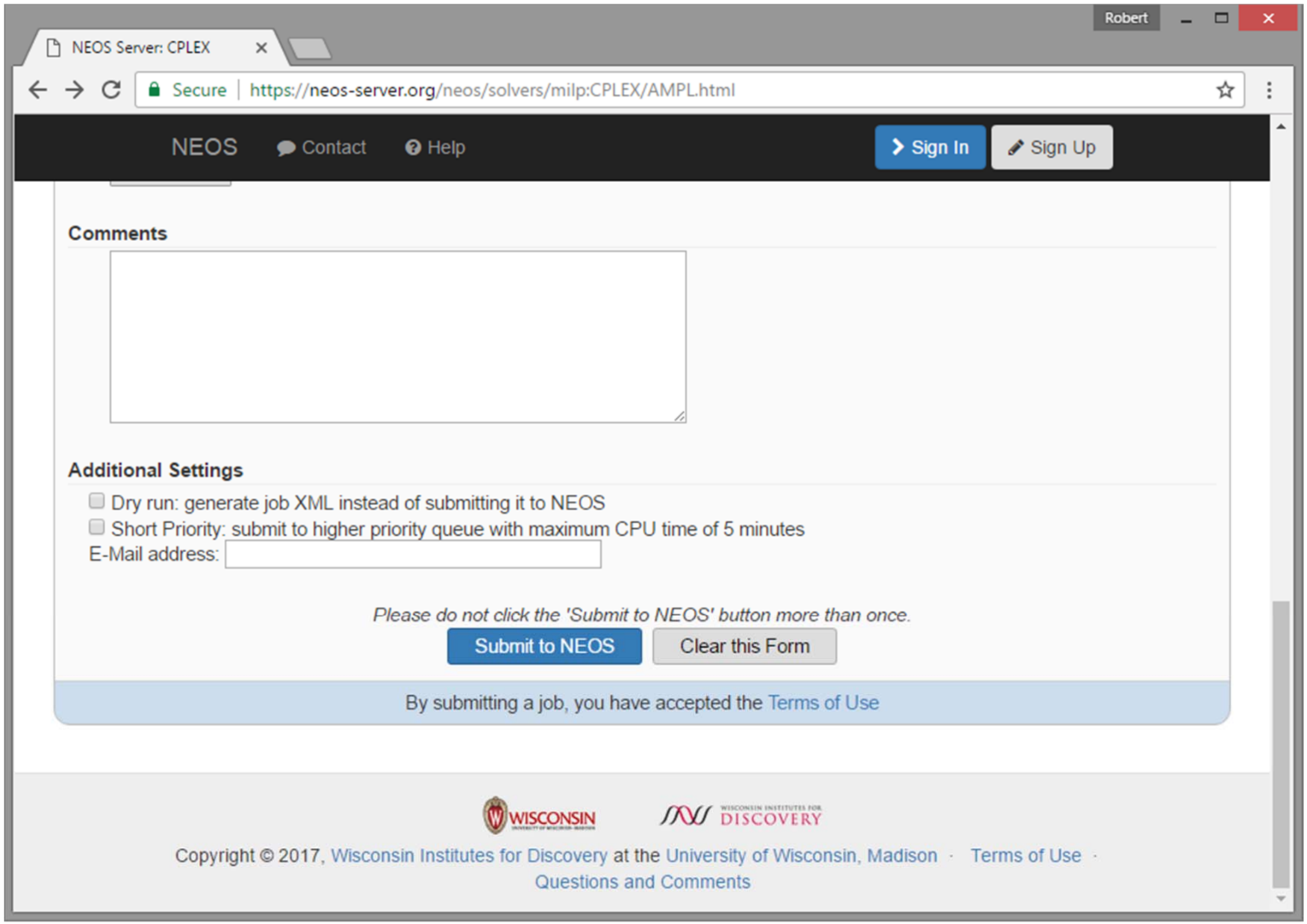
NEOS Server

AMPL Input Page



NEOS Server

AMPL Input Page



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

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

NEOS Server

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

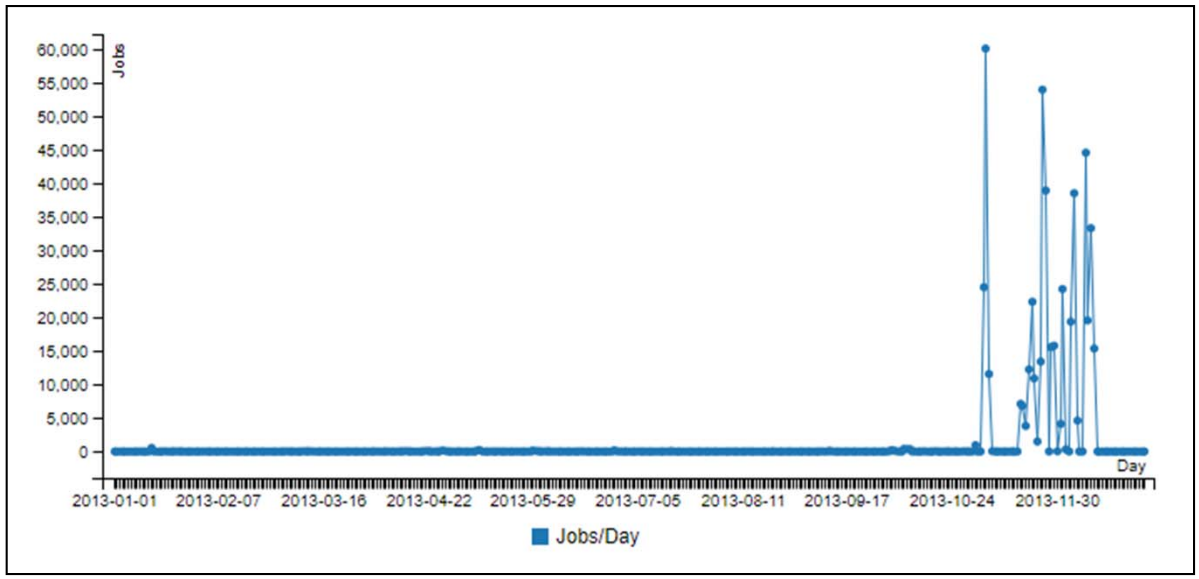
```
---------- Begin Solver Output -----------

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

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

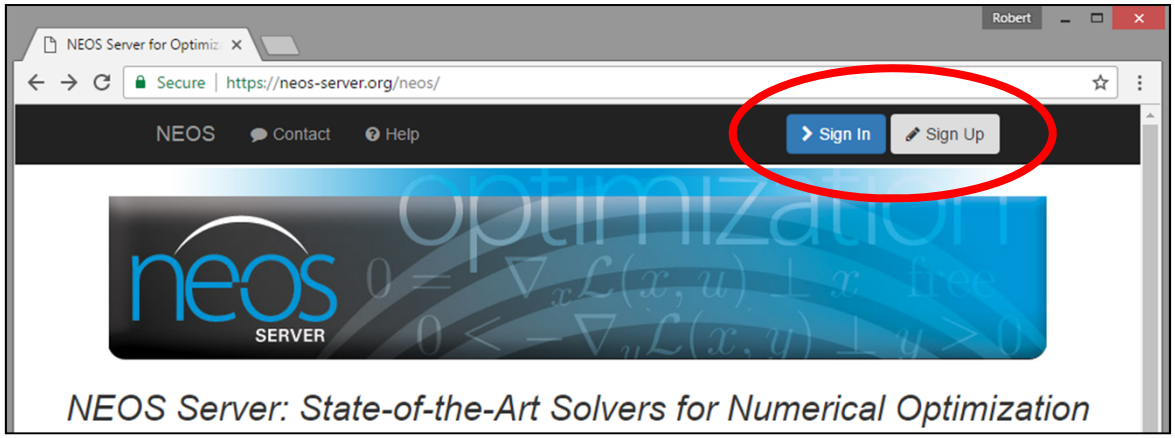
NEOS Server

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

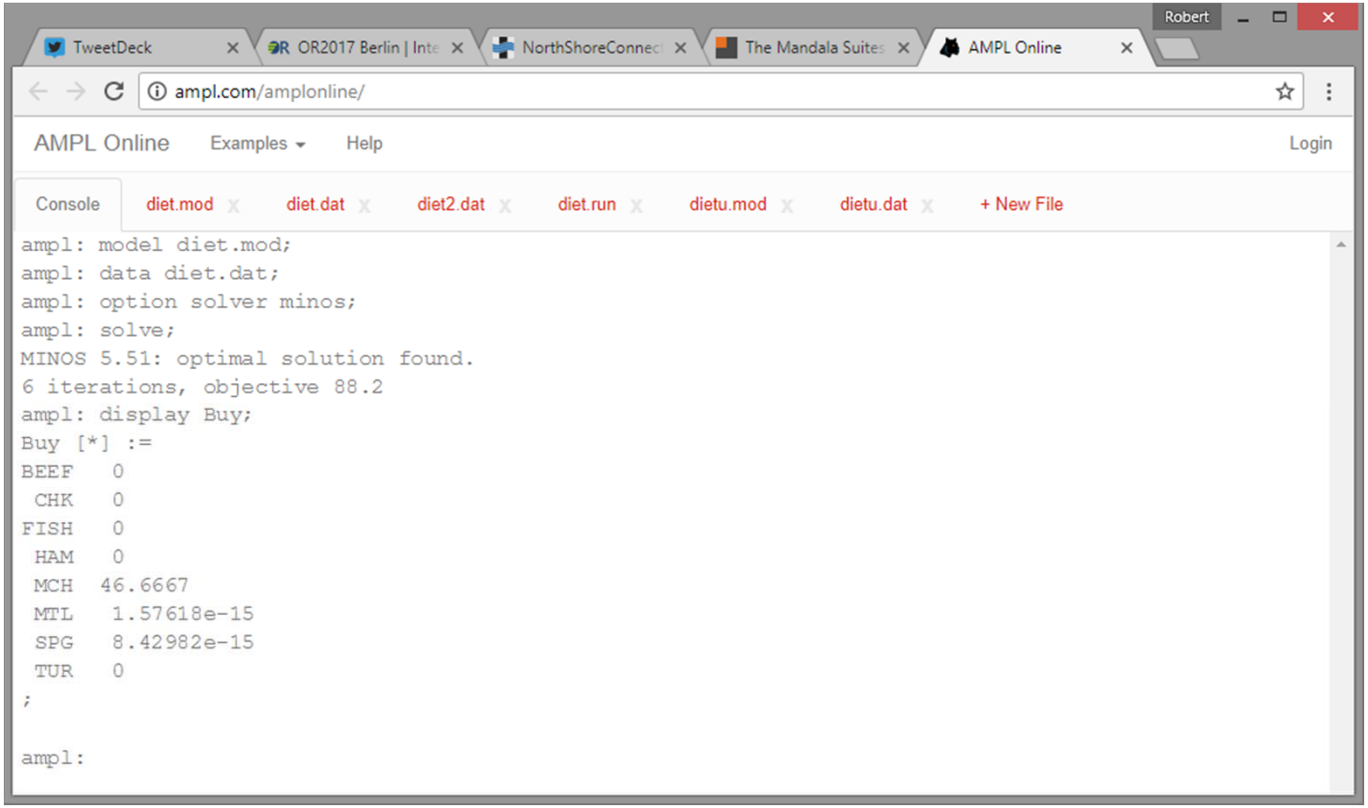
Like a commercial NEOS

- 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

www.ibm.com/us-en/marketplace/decision-optimization-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

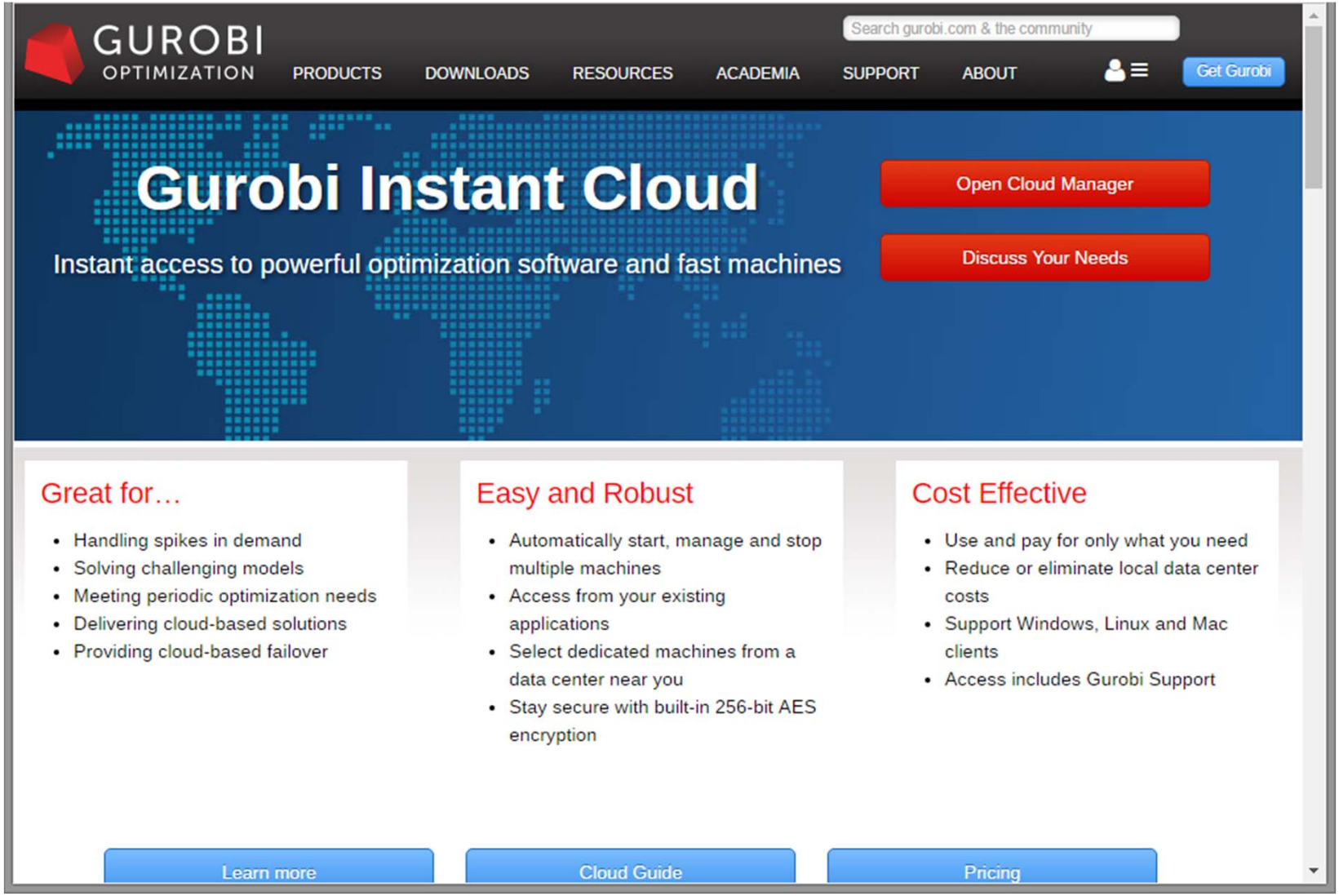
- AMPL installation (command-line or IDE)
- Standard Gurobi-for-AMPL installation

Server side

- Gurobi compute server
- Gurobi optimizer

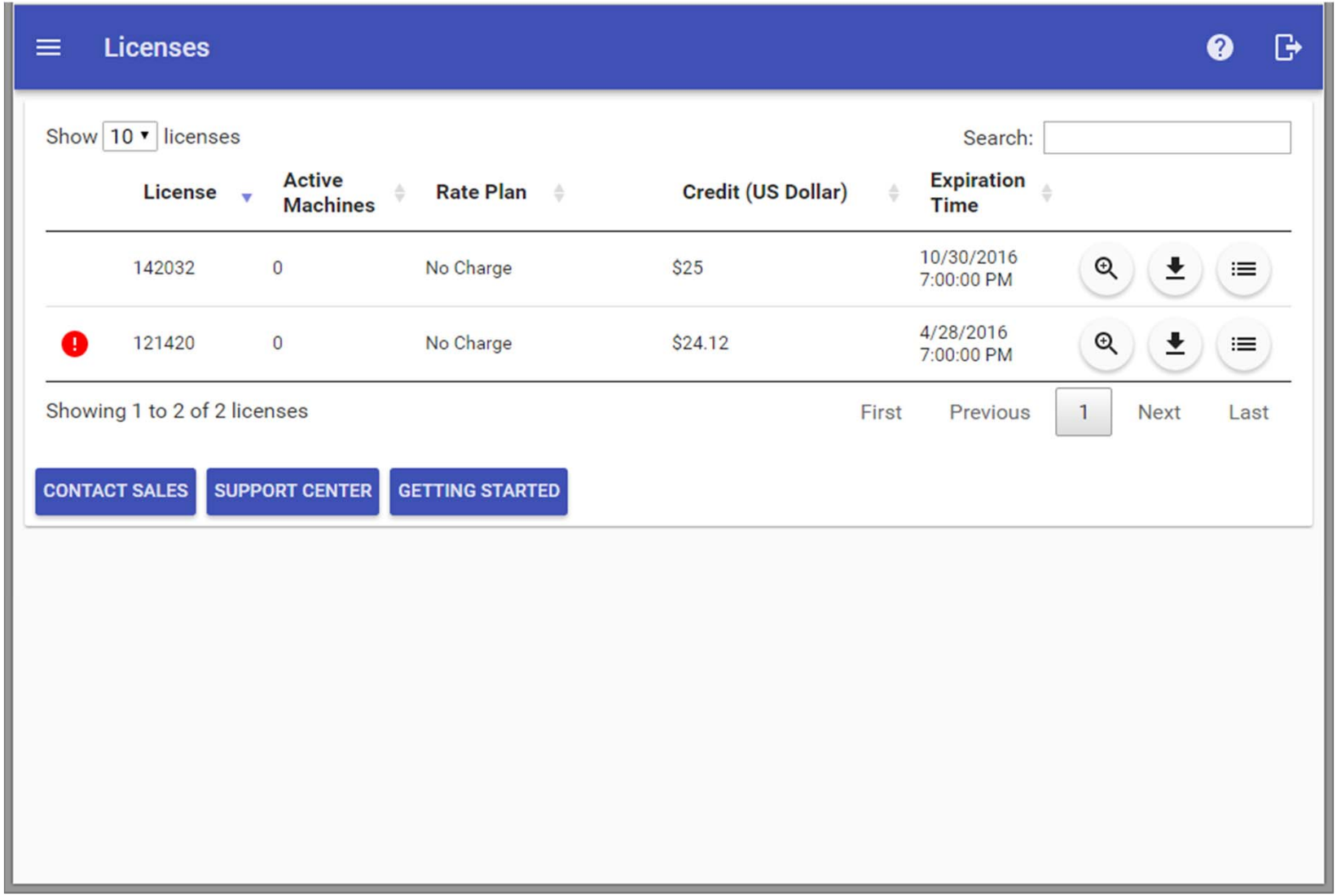
Gurobi Instant Cloud for AMPL

ngcloud.gurobi.com



Gurobi Instant Cloud for AMPL

View Available Licenses



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 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;
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ampl: option solver gurobi;

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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:
```

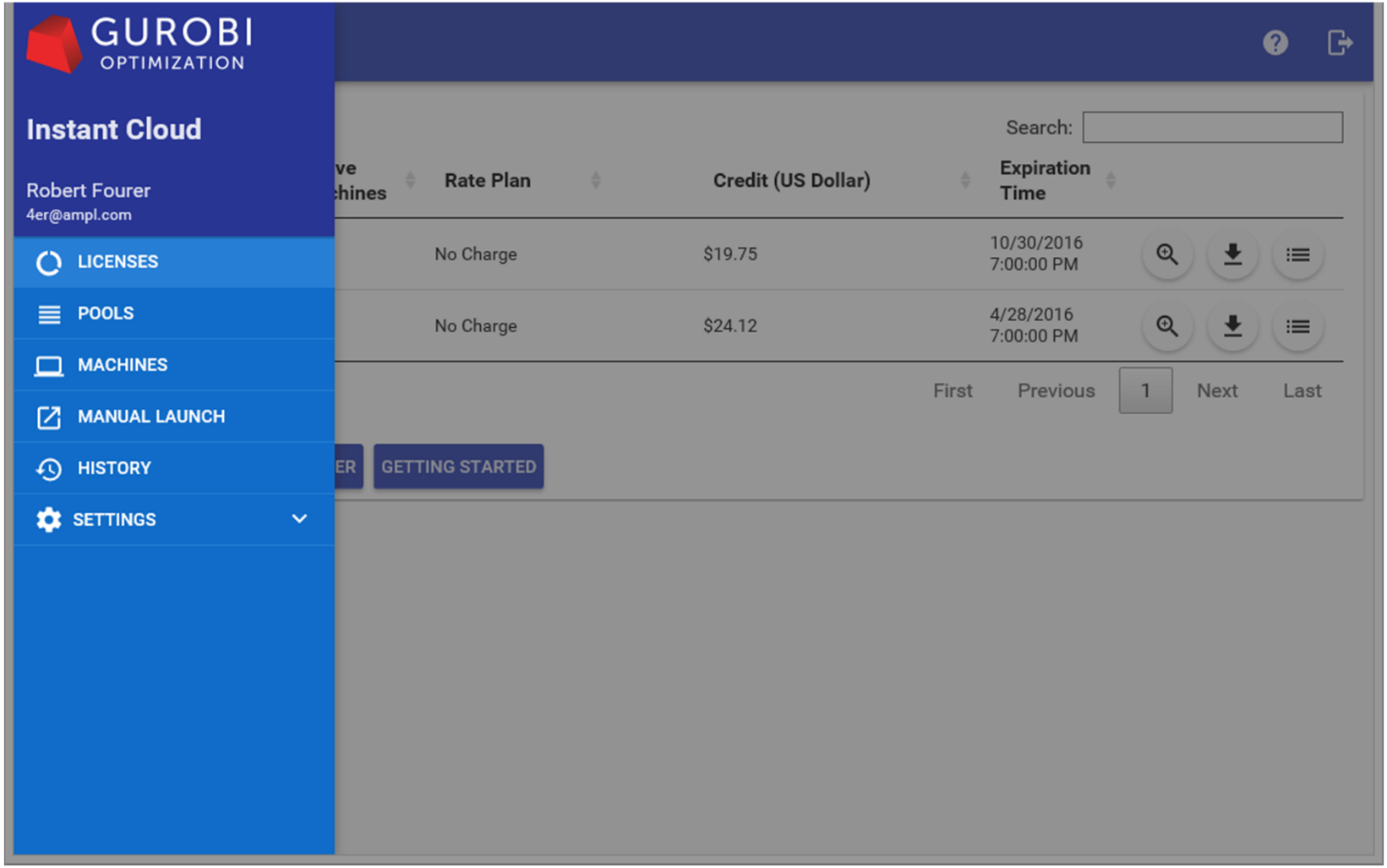
Gurobi Instant Cloud for AMPL

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:
```

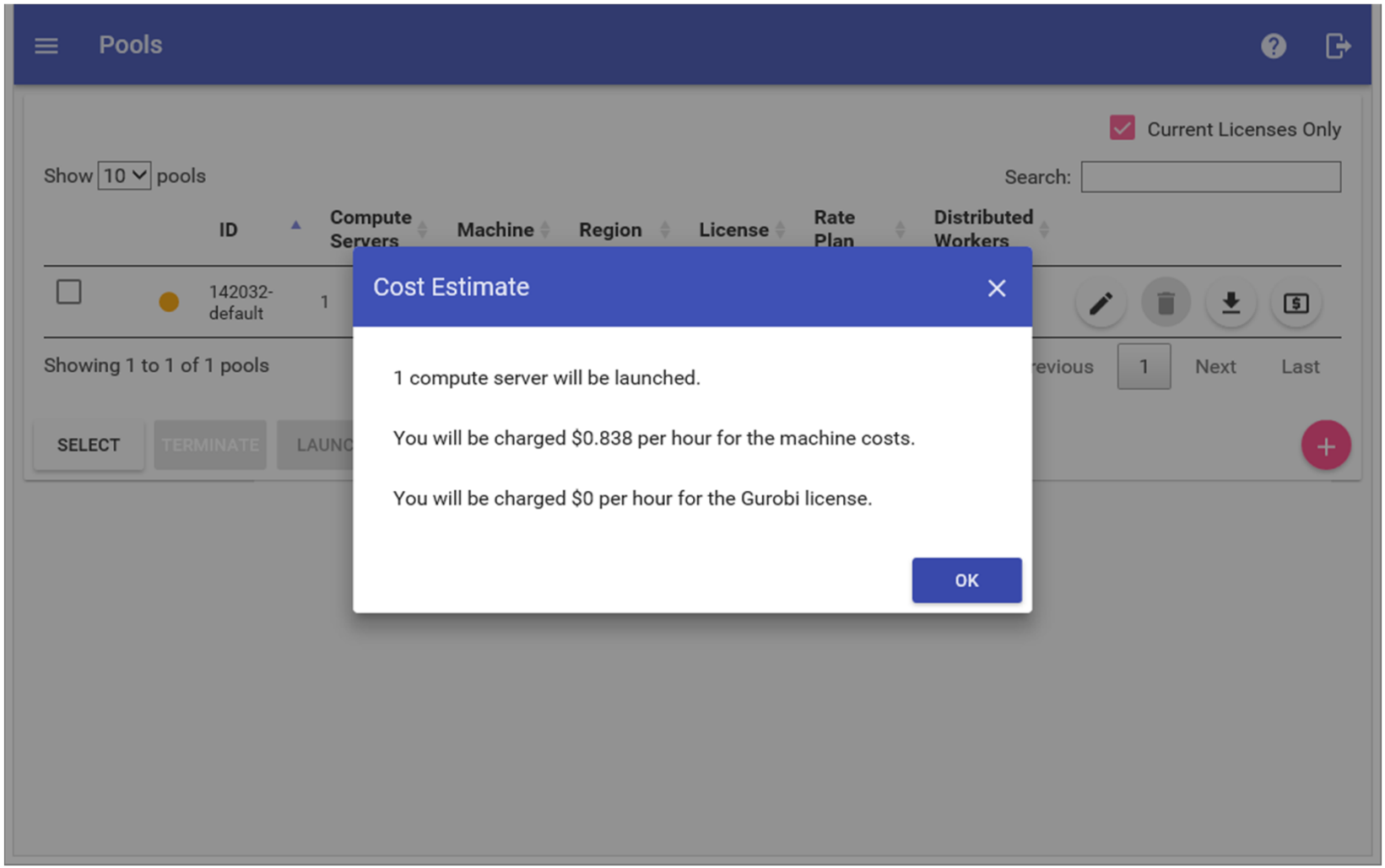
Gurobi Instant Cloud for AMPL

Manage Server Configuration



Gurobi Instant Cloud for AMPL

Check Costs



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

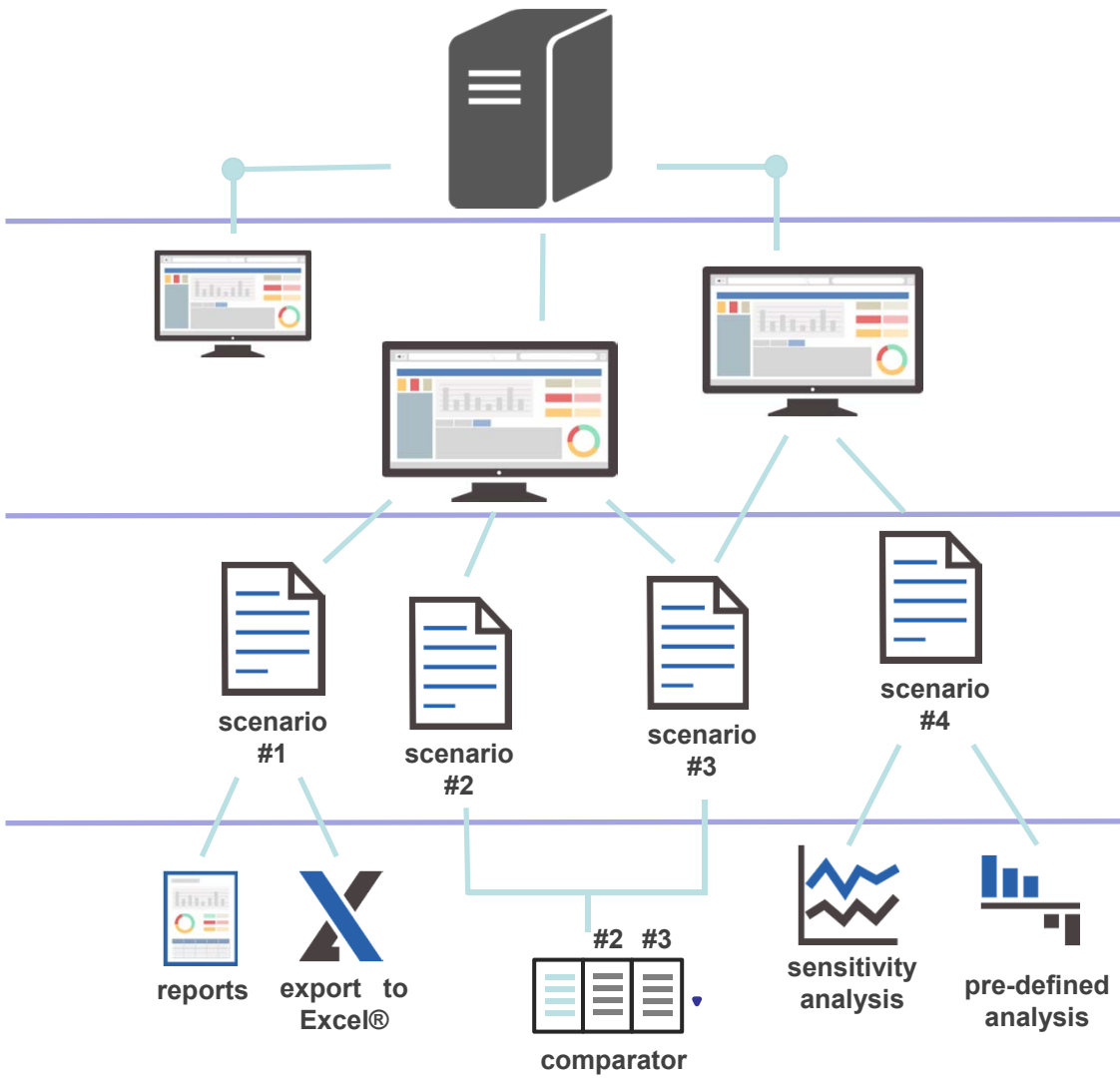
QuanΔec

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

CASSOTIS
consulting

AMPL

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)

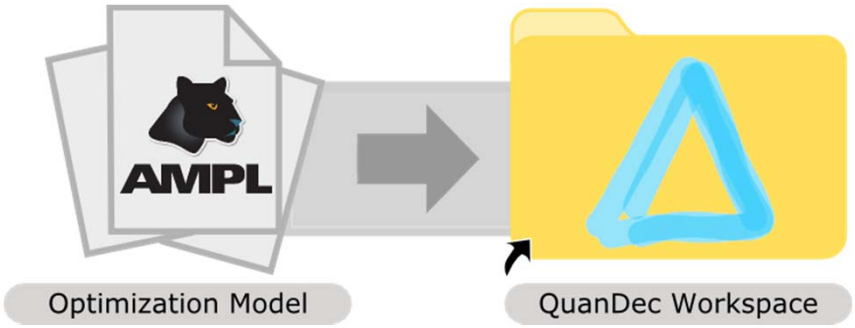
And much more…

Getting started

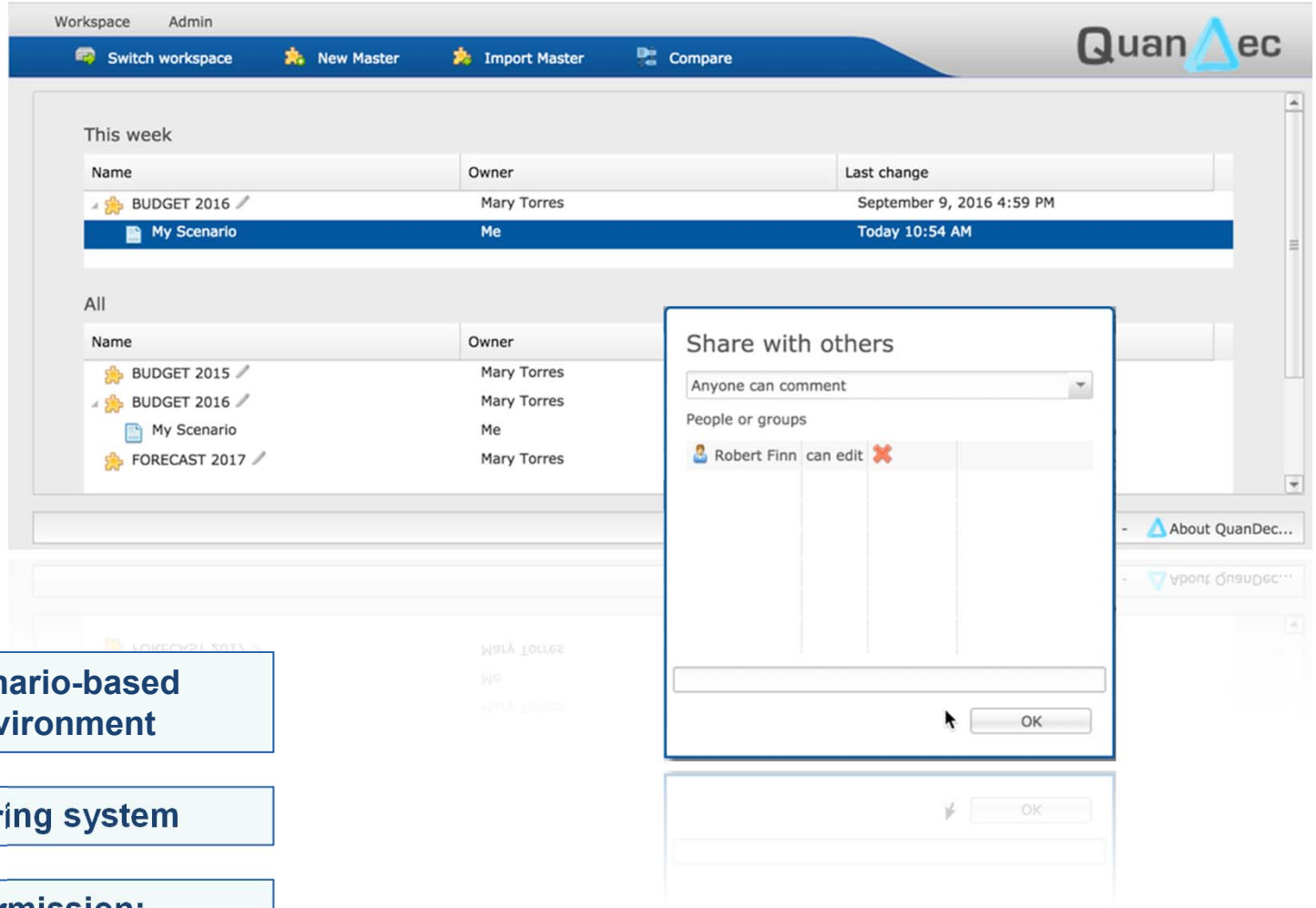
step 1: install QuanDec on a server

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

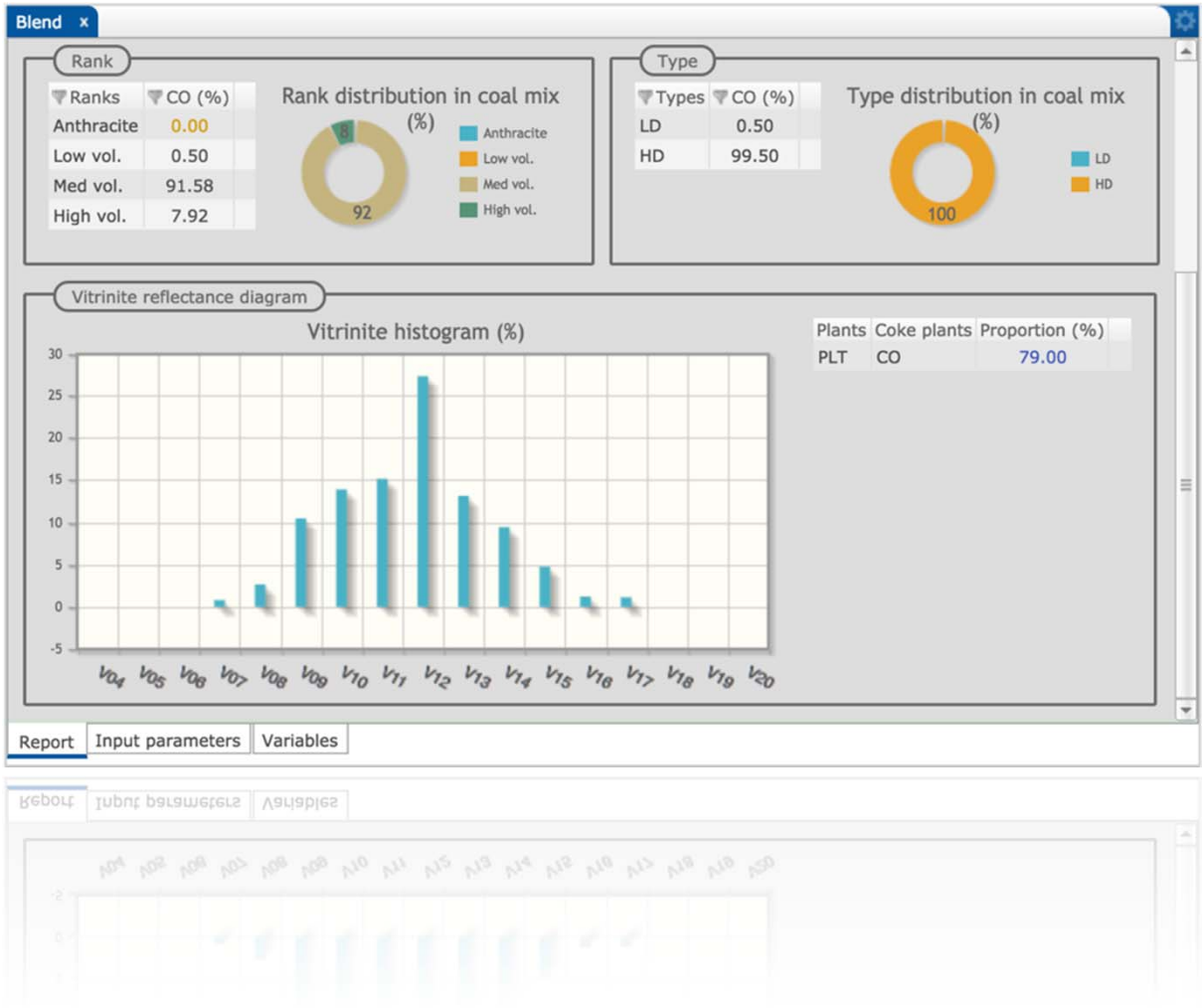
Permission: Edit – Comment - View

3 levels:
- **Report**
- **Input parameters**
- **Variables**

Chart and tables

Colored values for easier analysis

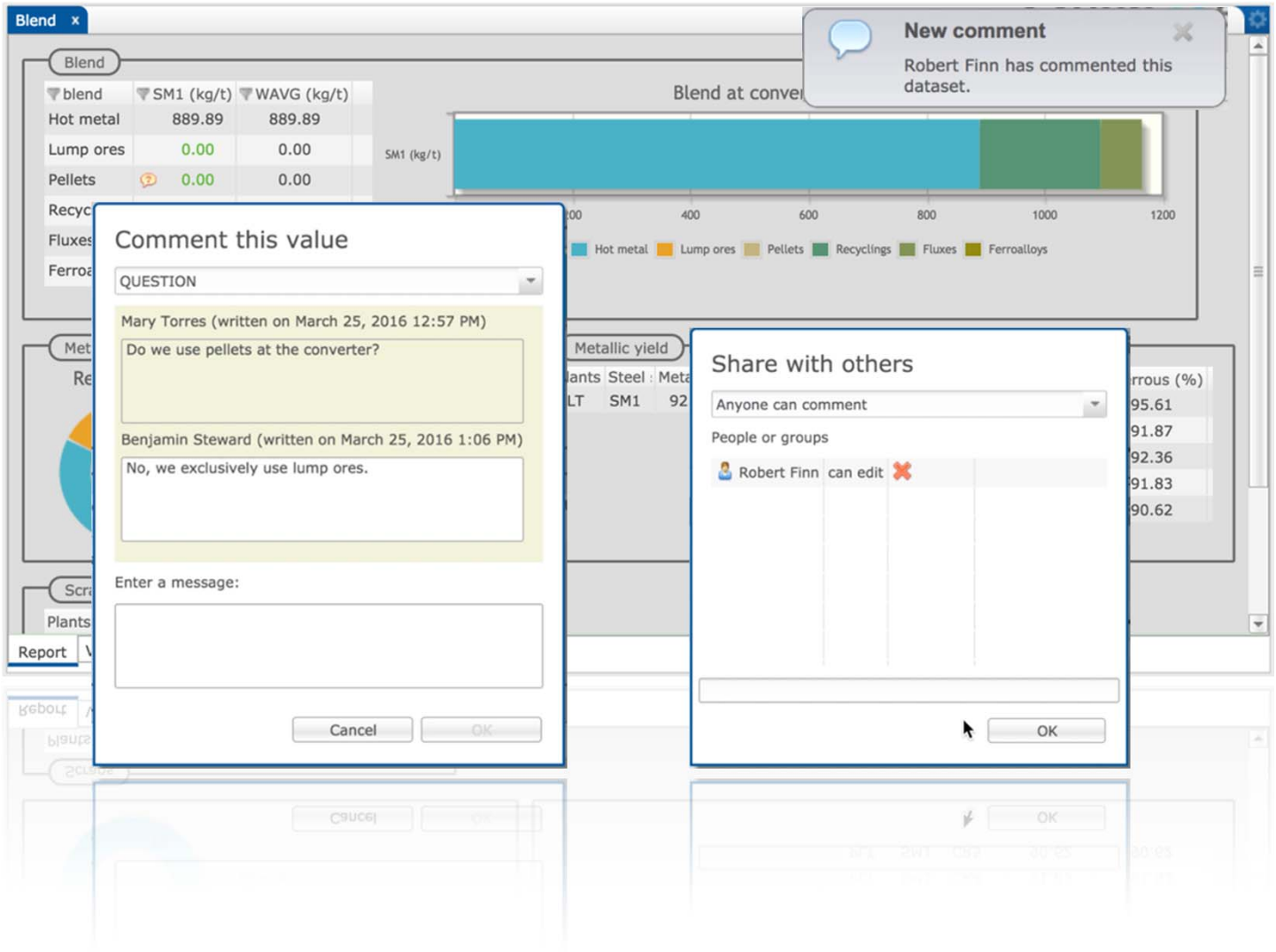
Constraint (min/max) on any variable

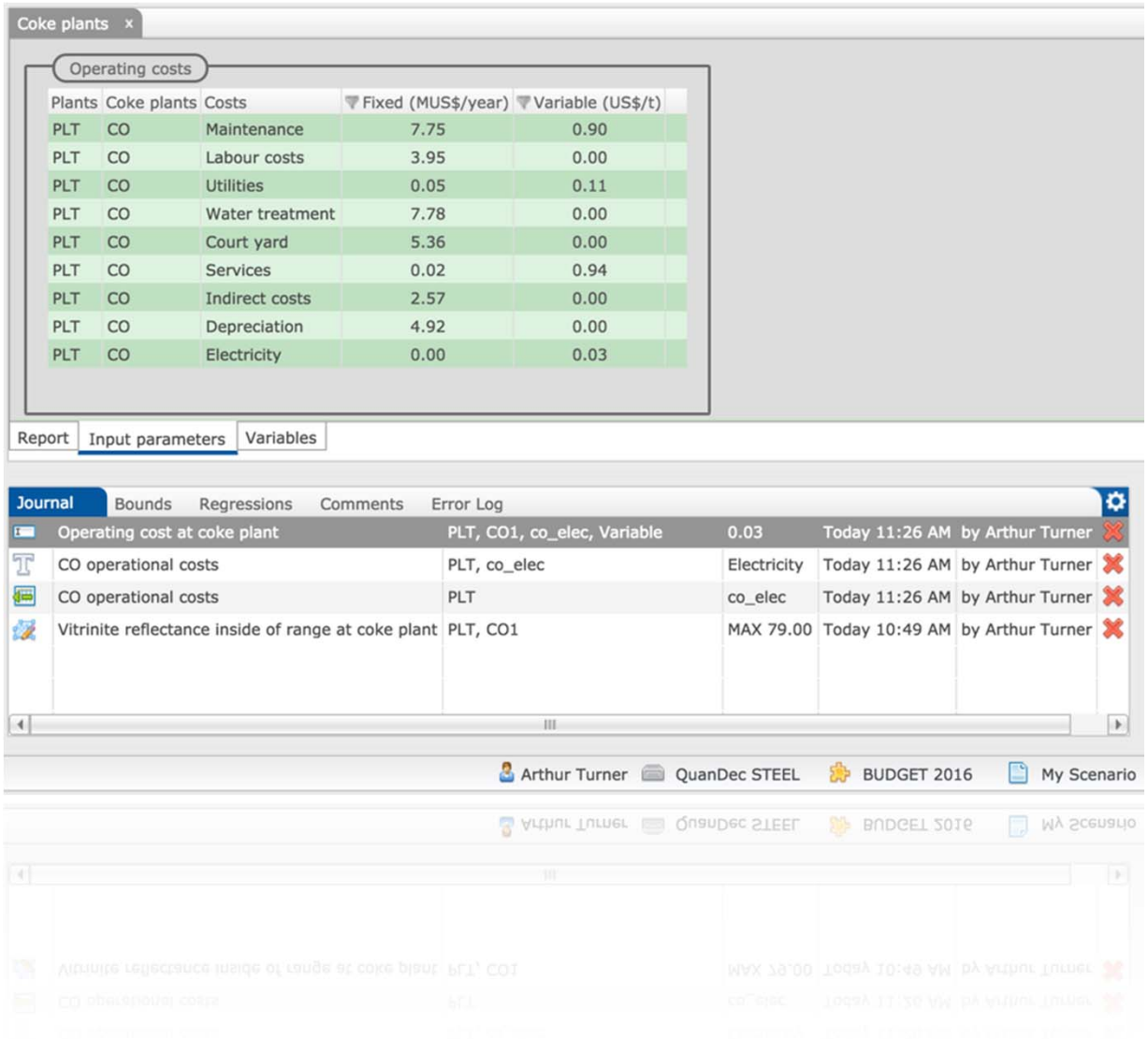


Collaborative work

Notification system

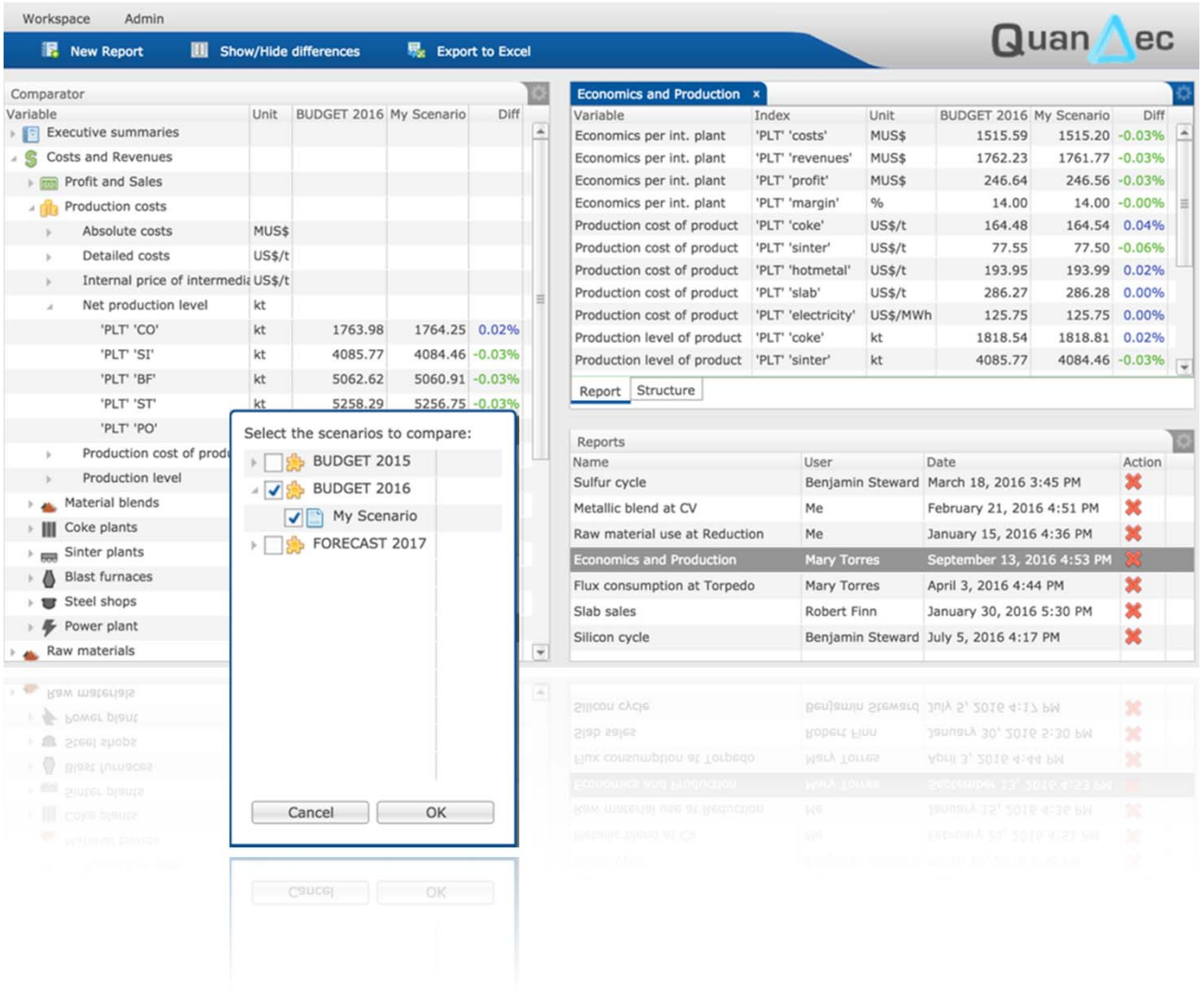
Comments between users





Scenarios with changes history

Traceability and undo system

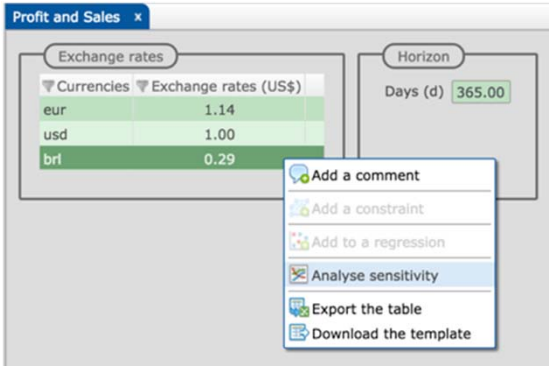


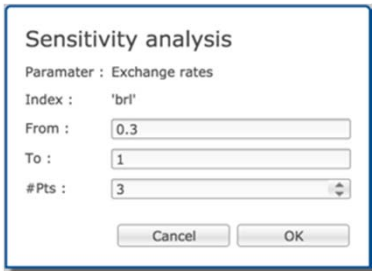
Scenario comparison

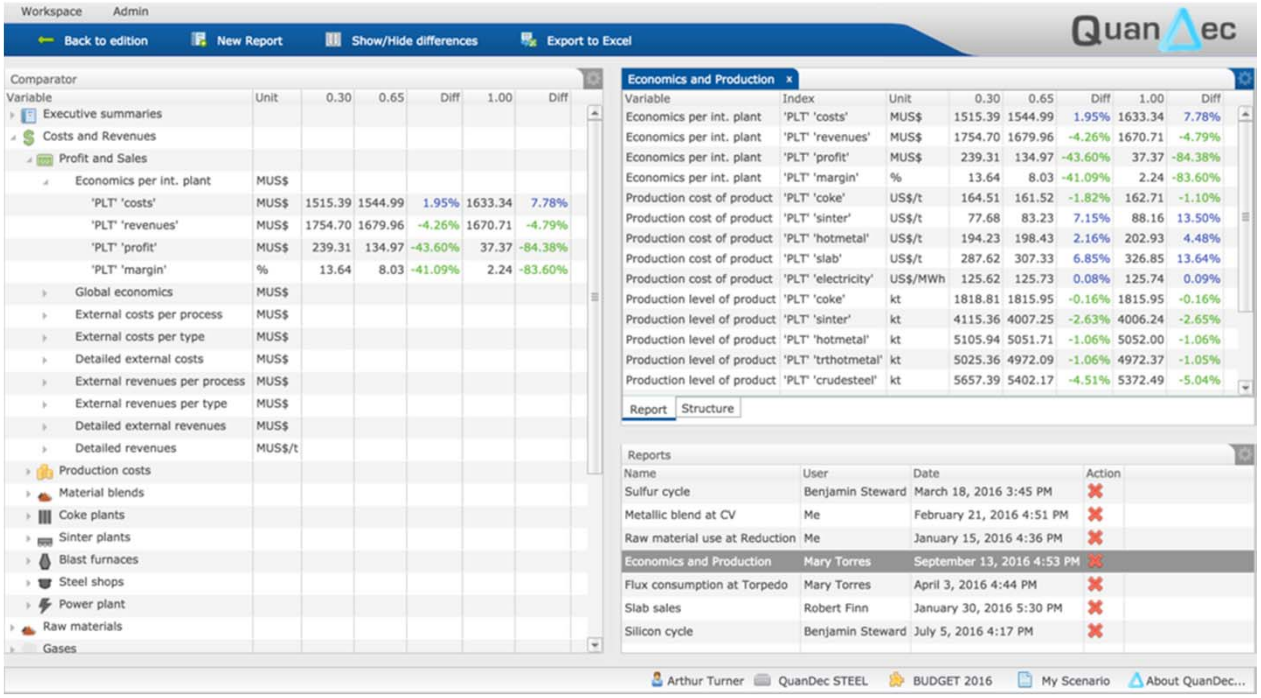
All variables can be compared

Display of relative difference

Custom reports







Sensitivity analysis

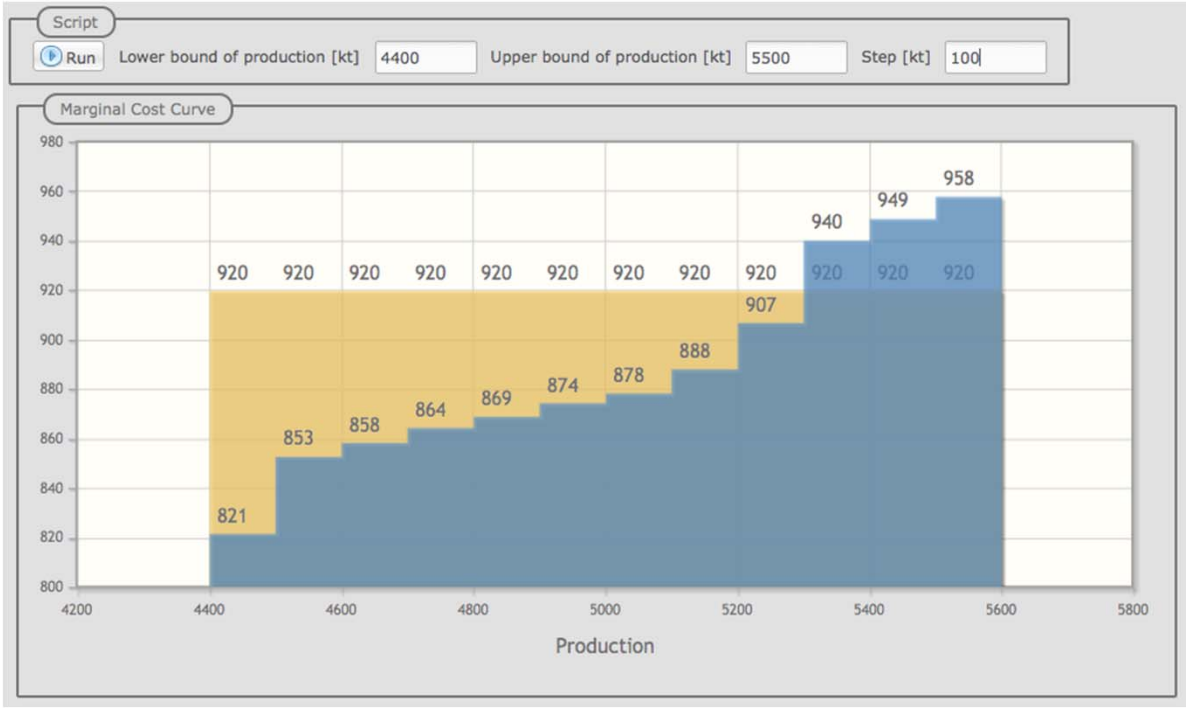
For both parameters AND variables

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