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The NEOS Server

Optimization, Environments, and Network Computing

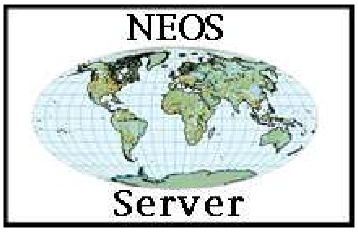
Jorge Moré

Mathematics and Computer Science Division
Argonne National Laboratory
`http://www.mcs.anl.gov/home/more/`

NEOS (Network-Enabled-Optimization-System) Server

A novel environment for solving optimization problems.

- Internet-based access to a library of optimization software.
- Submissions via email, a browser, or the `neos-submit` tool.
- Users only need to submit a specification of the problem.
- The Server provides all the information required by solver.



History

- September 1994 – Email version of the Server, based on netlib.
- October 1994 – Contacted Eric Grosse re security.
- November 1994 – Demo at SC94, Washington D.C.
- January 1995 – Begin re-writing Server with Perl.
- May 1995 – Beta version available.
- September 1995 – Version 1.0 of the NEOS Server.
- March 1996 – Submission tool (version 1.3) released.
- May 1996 – PATH solver works with Condor.
- December 1996 – Redesign of Web interface.
- May 1997 – Version 2.0 of the NEOS Server.
- August 1997 – PDS added. Execution on an IBM SP.
- September 1997 – SDPpack (Matlab version) added.
- October 1997 – LOQO with AMPL input added.

NEOS (Network-Enabled-Optimization-System) Server

Optimization software

Software tools

- Perl
- Tcl/Tk

Automatic differentiation

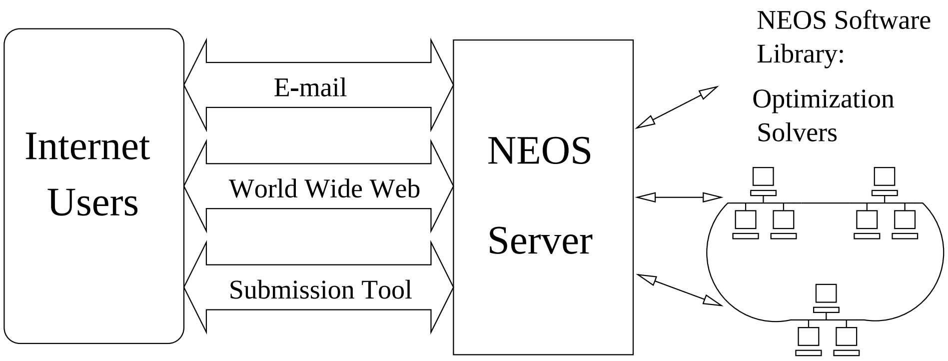
- ADIFOR
- ADOL-C

Heterogeneous distributed computing

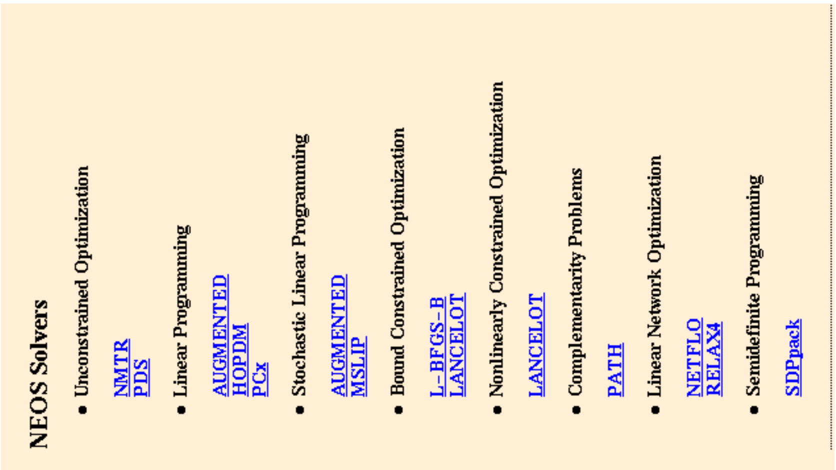
- Condor
- Globus

Design of the NEOS Server

Usable, Scalable, Fault-Tolerant



NEOS Server Web Interface: Solvers



NEOS Server Web Interface: LANCELOT

NEOS

Server

Background

Sample Submission

LANCELOT

The NEOS Server offers LANCELOT for the solution of nonlinearly constrained optimization problem in n variables, where the variables may be constrained by general constraints. Both the variables and the constraints may be restricted by lower and upper bounds. It provides information on the optimization problem, the solution process, and the solution. The NEOS Server for LANCELOT uses the ADIFOR automatic differentiation tool.

To learn more about LANCELOT, click the "Background" button

Typical Environment for Nonlinear Optimization

$$\min \{ f(x) : x_l \leq x \leq x_u, \; c_l \leq c(x) \leq c_u \}$$

Tasks

- Develop code to evaluate the objective function $f : \mathbb{R}^n \mapsto \mathbb{R}$ and constraint $c : \mathbb{R}^n \mapsto \mathbb{R}^m$
- Decide on the software
- Retrieve the software
- Hand-code the gradients, Hessians, sparsity patterns.
- Compile, debug, compile, debug, ... run
- Interpret the results
- Repeat the process

The NEOS Way

- Develop code to evaluate the objective function $f : \mathbb{R}^n \mapsto \mathbb{R}$ and constraint $c : \mathbb{R}^n \mapsto \mathbb{R}^m$
- Submit problem to the **NEOS** Server
- Interpret the results
- Repeat the process

Advantages

⋆ Easy to use
⋆ No need to choose or retrieve software
⋆ No need to compute derivatives or sparsity patterns
⋆ Independent of computing resources

NEOS

A research effort of the Optimization Technology Center, initiated by Argonne National Laboratory and Northwestern University.

NEOS Guide: A Web-based guide to optimization theory and practice.

NEOS Server: An Internet-based client/server application that provides access to a library of optimization software.

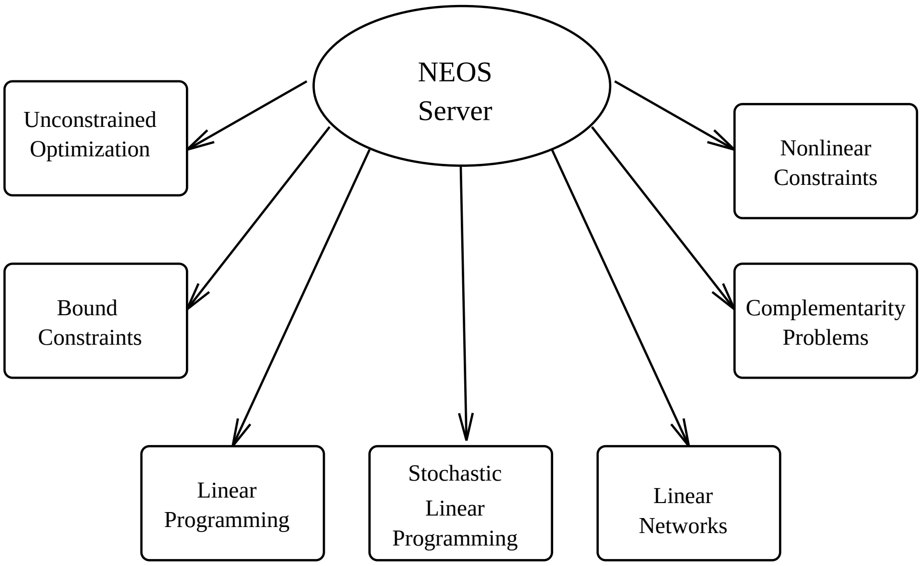
NEOS Guide

- Optimization Software Guide
- Optimization Tree
- Case Studies
- Frequently Asked Questions

NEOS Collaborations

- ⋆ Michael Ferris, University of Wisconsin
- ⋆ Nick Gould, Rutherford Appleton Laboratory
- ⋆ David Serafini, Rice University
- ⋆ Madhu Nayakkankuppam, New York University
- ⋆ Jorge Nocedal, Jon Owen, Ciyou Zhu, NWU
- ⋆ Joe Czyzyk, Jorge Moré, Steve Wright, Zhijun Wu, ANL
- Dan Bienstock, Columbia University
- Phil Gill, University of California, San Diego
- Bob Vanderbei, Princeton University

NEOS Software Library



Specifying Constrained Optimization Problems

$$\min\{f(x) : x_l \le x \le x_u,\ c_l \le c(x) \le c_u\}$$

$$f(x) = \sum_{i=1}^{n_f} f_i(x)$$

Dimensions: `n, m`

Number of element functions: `nf`

Initial point: `initpt(n,x)`

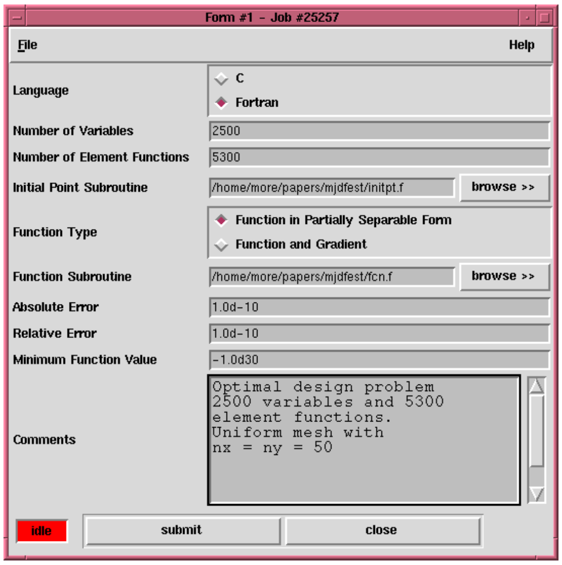
Objective function: `fcn(n,x,nf,fvec)`

Constraint function: `cfcn(n,x,m,c)`

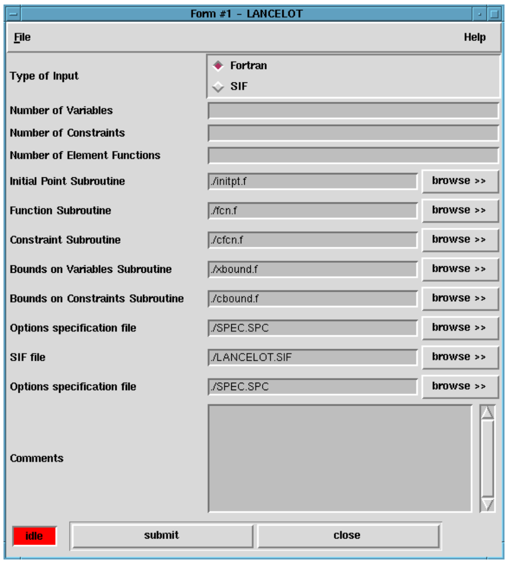
Bounds on the variables: `xbound(n,xl,xu)`

Bounds on the general constraints: `cbound(m,cl,cu)`

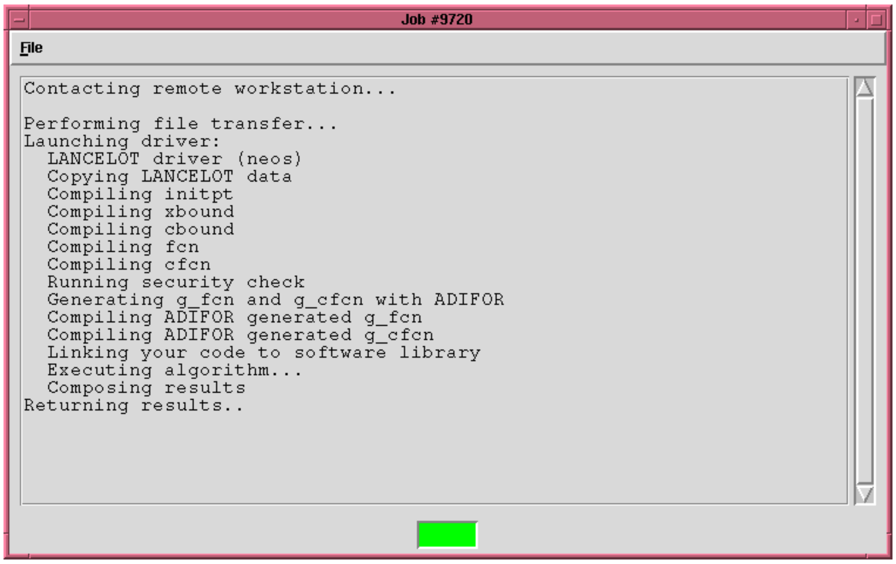
NEOS Submission Tool – VMLM



NEOS Submission Tool – LANCELOT



Output from the NEOS Submission Tool



Solve Script for LANCELOT

- Set environment variables.
- Check that problem dimensions have appropriate values.
- Check that fcn, cfcn, initpt, xbound, and cbound exist. Check that they reference the appropriate subroutine.
- Copy script and composition files needed by ADIFOR.
- Compile user functions and run security check.
- Generate gradients and Jacobians with ADIFOR.
- Execute algorithm.
- Compose results. Return error messages, if any.
- Collect information.

Error messages: ADIFOR

```
Errors in program...
Procedure fcn undefined: required by procedure
fcn_sample in module /local.beaner/testneos/
neos-communications-2.9/jobs/13238/fcn_sample.f.


ADIFOR exiting after error:
*     File Adifor.cpp
*     Line 382
**********
Errors or warnings encountered in program.
**********
make: *** [adifor] Error 255

Please correct and resubmit.
```

Errors Messages

What if ...

- A subroutine does not compile?
- The calling sequence is wrong?
- The function evaluation blows up at the starting point?
- The function evaluation blows up at an iterate?
- The function evaluation is garbage?
- The function is non-differentiable?
- The user wants to write or read information?

ADIFOR: Performance of the NEOS Solver vmlm

Minimal surface problem: `dmsa(nx,ny,x,nf,fvec)`

$$f(x) = \sum_{i=1}^{m} f_i(x),$$

	Function			Function and Gradient		
n	`niters`	`nfgev`	`time`	`niters`	`nfgev`	`time`
2,500	260	266	85	256	260	15
10,000	554	563	676	516	530	135

ADOL-C: Performance of the NEOS Solver vmlm

Minimal surface problem: `dmsa(nx,ny,x,nf,fvec)`

$$f(x) = \sum_{i=1}^{m} f_i(x),$$

	Function				Function and Gradient		
n	`niters`	`nfgev`	`time`	`mem`	`niters`	`nfgev`	`time`
2,500	258	264	125	1.8MB	256	260	20
10,000	551	564	1274	7.1MB	516	530	168

Users of the NEOS Server: May 1997

Number of jobs – 684
Date distribution:
  05/06/97 – 71
Solver distribution:
  NCO:LANCELOT – 154
  BCO:L-BFGS-B – 115
Username distribution:
  derk@ei.ele.tue.nl – 95
  cscook@acsu.buffalo.edu – 21
Domain distribution:
  US Educational (edu) – 182
  Netherlands (nl) – 164
  US Government (gov) – 121

Uses of the NEOS Server

- Solving large optimization problems
- Education and information on optimization technology
- Classroom exercises
- Testing optimization software
- Comparing optimization software
- Prototype problem solving environment

Future Directions for the NEOS Server

- Handling C-programs (ADIC)
- metaNEOS
  - NEOS/NEXUS – Todd Munson, University of Wisconsin
  - Distributed computing
  - Global optimization
  - Integer programming
- Problem-solving environment

Additional Information

J. Czyzyk, M. Mesnier, and J. Moré,
The Network-Enabled Optimization System (NEOS) Server, Preprint MCS-P615-0996, September 1996.

W. Gropp and J. Moré,
Optimization environments and the NEOS Server, Preprint MCS-P654-0397, March 1997.

NEOS Server `http://www.mcs.anl.gov/otc/Server/`
NEOS Guide `http://www.mcs.anl.gov/otc/Guide/`