Setting Up and Hosting Your Solver as Web Services via Optimization Services (OS)

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Outline

• Motivation
• OS Framework
• OS Library
• OS Server
• Conclusion/User Experience
Motivation

Future of Computing
OS Framework
Optimization Services System

Model/Data
Parse to OSiL

Agent
OSP/OSxL

Solver

Registry

Servlet

Web Server

CGI

OS Server

Database/App Service

OS Framework
Optimization Services System

Modeler

html form

browser

socket

http/html

Web address

Web page

OS Server

Model/Data

Modeler

OR Library
OR Application, Software, Library

Optimization Services Framework

System
**OS Library**

- **OSCommon**
  - representationParser
    - OSiL Reader/Writer
    - OSrL result
    - OSoL option
    - Etc.
  - util
    - data structure
    - io
    - xml
    - etc
  - communicationInterface
    - OShL (hook up to solvers/analyzers: solve, send, retrieve)
    - OScL (call to simulations)
    - OSdL (discover in registries)
- **localInterface**
  - OSInstance
    - etc.
  - nonlinear: defines all the nonlinear operator/operands/functions

```java
OSiLReader reader = new OSiLReader();
reader.read(example.osil);
reader.getLinearConstraintCoefficients();
reader.calculateNonlinearFunction(5, x); // x is double[]
```
OS Library

- **OSAgent**
  - Solver agent
  - Simulation agent
  - Solver agent
- **OSSolver**
  - Utility and implementation of os-compatible solvers
- **OSSimulation**
  - Utility and implementation of os-compatible simulation.
- **OSRegistry**
  - Allows os developers to register their services
  - Lets os users discover os services
  - Let os users/developers validate instances
- **OSAnalyzer**
  - Utility and implementation of os-compatible analyzers.
- **OSScheduler**
  - Schedules optimization jobs over the distributed system
  - Takes care of all the non-optimization related chores.

```java
OSSolverAgent agent = new OSSolverAgent();
agent.solverAddress = "http://1.2.3.6/CbcSolverService";
String osrIResult = agent.solve(osilInstance, osolOption);
```
OS Framework
Optimization Services Protocol (OSP)

The 7-layer OSI Model
- Application
- Presentation
- Session
- Transport
- Network
- Link
- Physical

The 4-layer Internet Model
- Application
- Presentation
- Transport
- Network
- Link
- Physical

GET /xt/services/ColorRequest HTTP/1.0
Content Length: 442
Host: localhost
Content-type: text/xml; charset=utf-8
SOAPAction: "/getColor"

<soap:Envelope>
  <soap:Body>
  </soap:Body>
</soap:Envelope>

OSP – specifies soap content

Communication Interface Representation
- e.g. hook ("<OSiL> ... </OSiL>")
OS Server

- Networking Protocols: HTTP, SOAP, OSP
  (OS server: Tomcat, Axis, OS library)

OSServer =

http parser

<table>
<thead>
<tr>
<th>soap parser</th>
</tr>
</thead>
<tbody>
<tr>
<td>osp handler</td>
</tr>
</tbody>
</table>

CbcSolverService
OS Server

OS Communication Methods

solve() Method
OSIL and OSoL

knock() Method
OSPIL and OSoL

send() Method
OSIL and OSoL
true or false

retrieve() Method
OSoL

getJobID() Method
OSPIL
string - JobID

kill() Method
OSPIL
Download the OSServer

- Download the binary distribution: os-distribution-release_number.zip. The server side of the Java distribution is based on the Tomcat 5.5 implementation.
- After unpacking os-distribution-release_number.zip there is a directory os-server-1.0 and a single file os.war.
- For users that have not installed the Tomcat server, os-server-1.0 contains all of the necessary files for a OS Solver Service. If you do not have a Tomcat server running do the following to setup a Tomcat server with the OS Solver Service:
Setting up the OSServer

- **Step 1.** Put the folder os-server-1.0 in the desired location for the OS Solver Service on the server machine.
- **Step 2.** Connect to the Tomcat bin directory in the os-server-1.0 root and execute ./startup.sh (Linux) or ./start.bat (Windows).
- **Step 3.** Test to see if the server is running the OSSolverService. Open a browser on the server and enter the URL:
  - or
  - http://127.0.0.1:8080/os/OSSolverService.jws

  You should see a message Click to see the WSDL. Click on the link and you should see an XML description of the various methods available from the OSSolverService.
- **Step 4.** On a client machine, create the file testremote.config with the following lines of text:

  - `serviceLocation http://***.***.***.***:8080/os/OSSolverService.jws`
  - `osil parincLinear.osil`

  where ***.***.***.*** is the IP address of the Tomcat server machine. Then, assuming the files testremote.config and parincLinear.osil are in the same directory on the client machine as the OSSolverService execute:

  - `./OSSolverService -config testremote.config`

  You should get back an OSrL message saying the problem was optimized.
Connect to the OSServer with OSSolverService

- At present, the OSSolverService takes the following parameters. The order of the parameters is irrelevant. Not all the parameters are required. However, if the solve or send service methods are invoked a problem instance location must be specified.
- \texttt{-osil xxx.osil} this is the name of the file that contains the optimization instance in OSiL format. It is assumed that this file is available in a directory on the machine that is running OSSolverService. If this option is not specified then the instance location must be specified in the OSoL solver options file.
- \texttt{-osol xxx.osol} this is the name of the file that contains the solver options. It is assumed that this file is available in a directory on the machine that is running OSSolverService. It is not necessary to specify this option.
- \texttt{-osrl xxx.osrl} this is the name of the file that contains the solver solution. A valid file path must be given on the machine that is running OSSolverService. It is not necessary to specify this option.
Connect to the OSServer with OSSolverService

- **-serviceLocation url** is the URL of the solver service. This is not required, and if not specified it is assumed that the problem is solved locally.

- **-serviceMethod methodName** this is the method on the solver service to be invoked. The options are `solve`, `send`, `kill`, `knock`, `getJobID`, and `retrieve`. The use of these options is illustrated in the examples below. This option is not required, and the default value is `solve`.

- **-solver solverName** Possible values for default OS installation are `clp` (COIN-OR Clp), `cbc` (COIN-OR Cbc), `dylp` (COIN-OR DyLP), and `symphony` (COIN-OR SYMPHONY). Other solvers supported (if the necessary libraries are present) are `cplex` (Cplex through COIN-OR Osi), `glpk` (glpk through COIN-OR Osi), `ipopt` (COIN-OR Ipopt), `knitro` (Knitro), and `lindo` LINDO. If no value is specified for this parameter, then `cbc` is the default value of this parameter if the solve or send service methods are used.
Connect to the OSServer with OSSolverService

• **-mps xxx.mps** this is the name of the mps file if the problem instance is in mps format. It is assumed that this file is available in a directory on the machine that is running OSSolverService. The default file format is OSiL so this option is not required.

• **-nl xxx.nl** this is the name of the AMPL nl file if the problem instance is in AMPL nl format. It is assumed that this file is available in a directory on the machine that is

• **-browser browserName** this parameter is a path to the browser on the local machine. If this optional parameter is specified then the solver result in OSrL format is transformed using XSLT into HTML and displayed in the browser.

• **-config pathToConfigureFile** this parameter specifies a path on the local machine to a text file containing values for the input parameters. This is convenient for the user not wishing to constantly retype parameter values.
Examples (1)

• `./OSSolverService -solver clp -osil ./parincLinear.osil`
• `./OSSolverService –config ./testlocalclp.config`

where testlocalclp.config looks like:
- `osil ./parincLinear.osil`
- `solver clp`

• `./OSSolverService –config ./testlocal.config`

where testlocalclp.config looks like:
- `osil ../data/osilFiles/parincQuadratic.osil`
- `solver ipopt`
- `serviceMethod solve`
- `browser /Applications/`
- `osrl ./test.osrl`

• `./OSSolverService –config ./testlocalclp.config`

where testlocalclp.config looks like:
- `osol ./demo.osol`
- `solver clp`
Examples (2)

- ./OSSolverService –config ./testremote.config
  where testlocalclp.config looks like:
  -osil ./parincLinear.osil
  -serviceLocation http://gsbkip.chicagogsb.edu/os/OSSolverService.jws
  -serviceMethod send
- ./OSSolverService -config .testremote.config -solver clp
- or by adding the line -solver clp to the testremote.config file.
- ./OSSolverService -osol ./remoteSolve1.osol -serviceLocation
  http://gsbkip.chicagogsb.edu/os/OSSolverService.jws
  where remoteSolve1.osol looks like:

  <?xml version="1.0" encoding="UTF-8"?>
  <osol xmlns="os.optimizationservices.org">
    <general>
      <instanceLocation locationType="local">c:\parincLinear.osil</instanceLocation>
      <contact transportType="smtp">maj@northwestern.edu</contact>
    </general>
    <optimization>
      <other name="os_solver">ipopt</other>
    </optimization>
  </osol>
Usage Summary

• `solve(osil, osol)`:
  – Inputs: a string with the instance in OSiL format and an optional string with the solver options in OSoL format
  – Returns: a string with the solver solution in OSrL format
  – Synchronous call, blocking request/response

• `send(osil, osol)`:
  – Inputs: a string with the instance in OSiL format and a string with the solver options in OSoL format (same as in `solve`)
  – Returns: a boolean, true if the problem was successfully submitted, false otherwise
  – Has the same signature as `solve`
  – Asynchronous (server side), non-blocking call
  – The `osol` string should have a JobID in the `<jobID>` element
Usage Summary

• `getJobID(osol)`
  – Inputs: a string with the solver options in OSoL format (in this case, the string may be empty because no options are required to get the JobID)
  – Returns: a string which is the unique job id generated by the solver service
  – Used to maintain session and state on a distributed system

• `knock(ospl, osol)`
  – Inputs: a string in OSpL format and an optional string with the solver options in OSoL format
  – Returns: process and job status information from the remote server in OSpL format

• `retrieve(osol)`
  – Inputs: a string with the solver options in OSoL format
  – Returns: a string with the solver solution in OSrL format
  – The osol string should have a JobID in the `<jobID>` element

• `kill(osol)`
  – Inputs: a string with the solver options in OSoL format
  – Returns: process and job status information from the remote server in OSpL format
  – Critical in long running optimization jobs
Conclusion/User Experience

• Open Environment
• Convenience just like Using Utility Services
• No High Computing Power Needed
• No Knowledge in Optimization Algorithms and Software (solvers, options, etc.)
• Better and More Choices of Modeling Languages
• More Solver Choices
• Solve More Types of Problems
• Automatic Optimization Services Discovery
• Decentralized Optimization Services Development and Registration
• More Types of Optimization Services Components Integrated (Analyzers/Preprocessors, Problem Providers, Bench Markers)
• Smooth Flow and Coordination of Various Optimization Services Components.
• A Universal, Scalable and Standard Infrastructure that promotes Collaboration and Other Related Researches
• Concentration on Good Modeling