Recent Developments in Optimization Services

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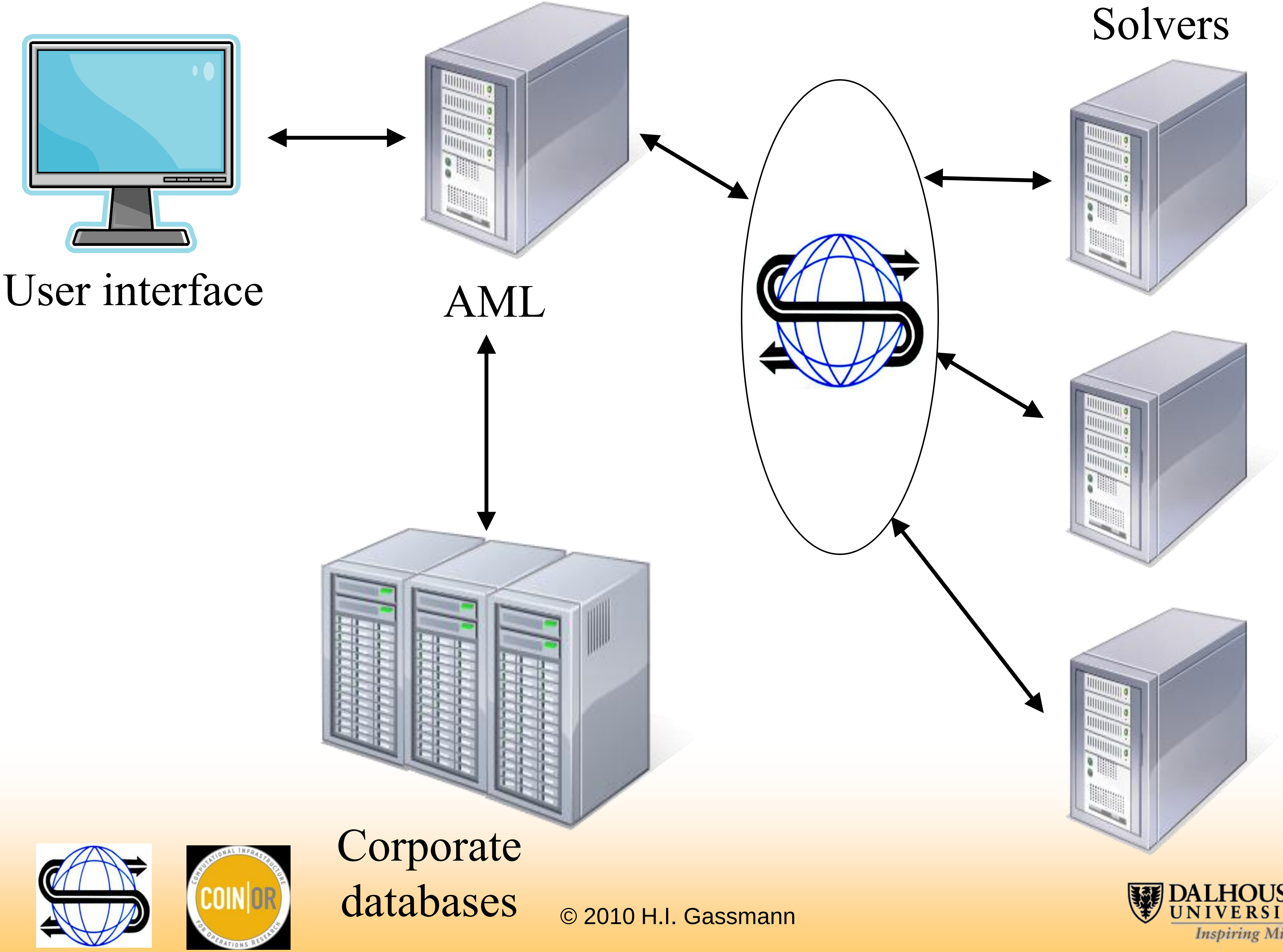
Outline

- Distributed computing and OR
- Optimization Services
- Solver options
- OSoL – OS option language
- Solver results
- OSrL – OS result language
- Availability

OR development cycle

- Model building
- Data collection
- Instance generation
- Problem solution
- Result analysis
- …potentially all on different computers


Solvers
User interface
AML
Corporate
databases

What Is Optimization Services (OS)?

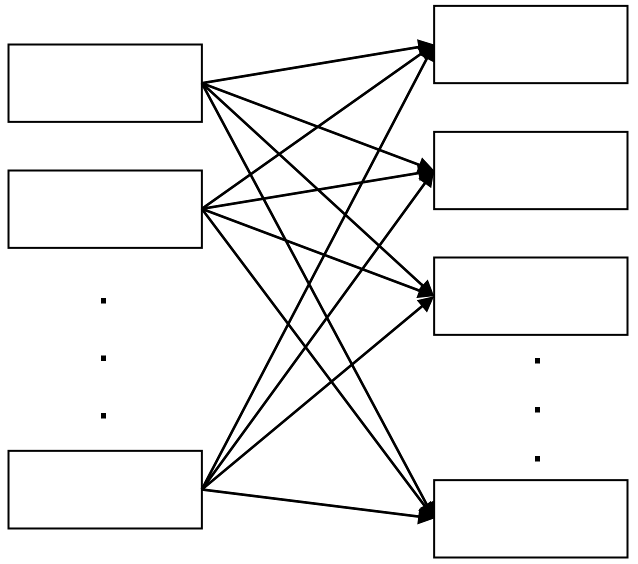
- Web-aware framework that connects algebraic modelling languages and optimization solvers
- XML-based standards for representing optimization instances (OSiL), optimization results (OSrL), optimization solver options (OSoL), etc.
- Open source libraries that implement the standards (under COIN-OR)
- A robust API for both solver algorithms and modeling systems
- A command line executable OSSolverService
- OSAmplClient, an executable to work with the AMPL modeling language
- Utilities that convert MPS files and AMPL nl files into OSiL
- Server software that works with Apache Tomcat and Apache Axis

Why Optimization Services?

Optimization services is needed because there is/are:

- Numerous modeling languages each with their own format for storing the underlying model.
- Numerous solvers each with their own application program interface (API).
- Numerous operating system, hardware, and programming language combinations.
- No standard for representing problem instances, especially nonlinear optimization instances.
- No real standard for registry and discovery services.

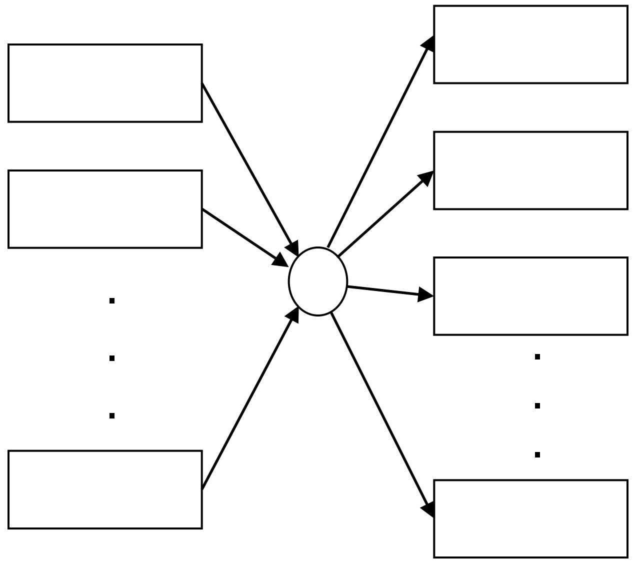
Why a standard interface?



Modelling systems

Solvers

*n***m* hook-ups



Modelling systems

Solvers

n+*m* hook-ups

Solver support

- All versions of OS download with COIN-OR solvers
  - Clp
  - Cbc
  - Ipopt
  - Bonmin
  - Couenne
  - Symphony
- Additional support
  - Cplex
  - GLPK
  - Lindo

OSSolverService capabilities

- OSSolverService can be run
  - locally or remotely
  - synchronously or asynchronously
  - with data local or remote relative to solver machine
  - as standalone application
  - from AMPL and GAMS

Running OSSolverService locally

-
```
OSSolverService –config                     \
     ../data/configFiles/testlocal.config
```

- testlocal.config contains:

```
-osil ../data/osilfiles/parincLinear.osil
-osol ../data/osolfiles/parincLinear_ipopt.osol
-solver ipopt
-serviceMethod solve
```

- It is assumed that input files exist on the local host

OSSolverService on a remote server

-
  ```
  OSSolverService -config                     \
       ../data/configFiles/testremote.config
  ```
- testremote.config contains:

  ```
  -osil ../data/osilfiles/parincLinear.osil
  -osol ../data/osolfiles/parincLinear_ipopt.osol
  -solver ipopt
  -serviceMethod send
  -serviceLocation <url>
  ```
- It is assumed that input files exist on the remote server —otherwise they need to be uploaded first

Using OSAmplClient

Start **ampl.exe** at the command line. Inside **ampl.exe**, do the following

```
# open the AMPL model file
model hs71.mod;

# tell AMPL to use OSAmplClient as the solver
option solver OSAmplClient;

# now tell OSAmplClient to use Ipopt
option OSAmplClient_options "solver ipopt";

# tell ipopt to use a remote server (optional)
option ipopt_options
   "service http://gsbkip.uchicago.edu/os/OSSolverService.jws";

# solve the problem
solve;

# display the solution
display {j in 1.._nvars} (_varname[j], _var[j]);
```

GAMSlinks

- Implemented as a separate COIN-OR project

```
gams trnsport lp=os optfile=1
```

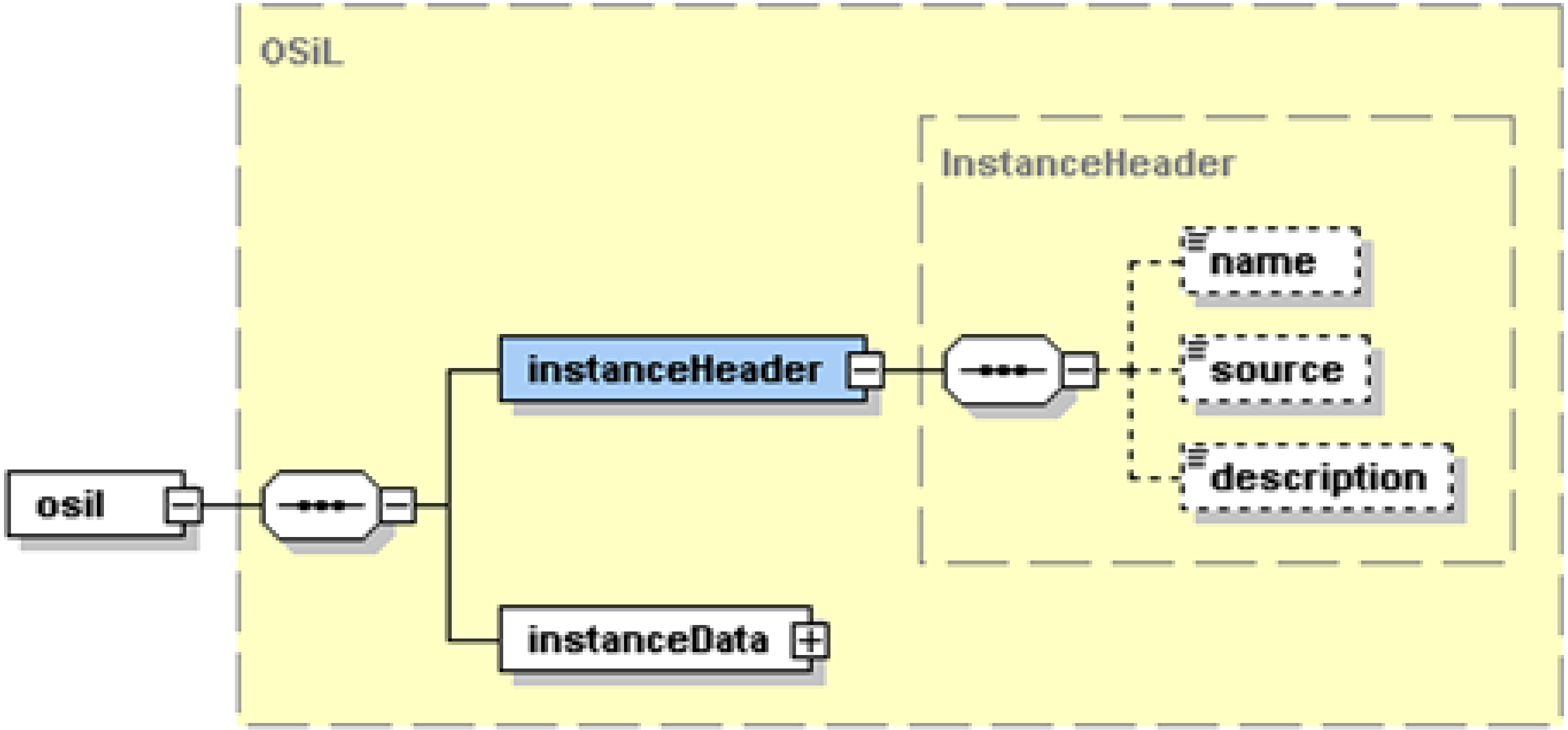
- This tells GAMS to read `os.opt` for more information
- `os.opt` looks like this

```
writeosil osil.xml
writeosrl osrl.xml
service
   http://gsbkip.uchicago.edu/os/OSSolverService.jws
solver clp
```

OSiL

- XML schema for mathematical programs
  - Linear
  - Integer
  - Nonlinear
  - Stochastic
  - Multiobjective
  - Semidefinite
  - …

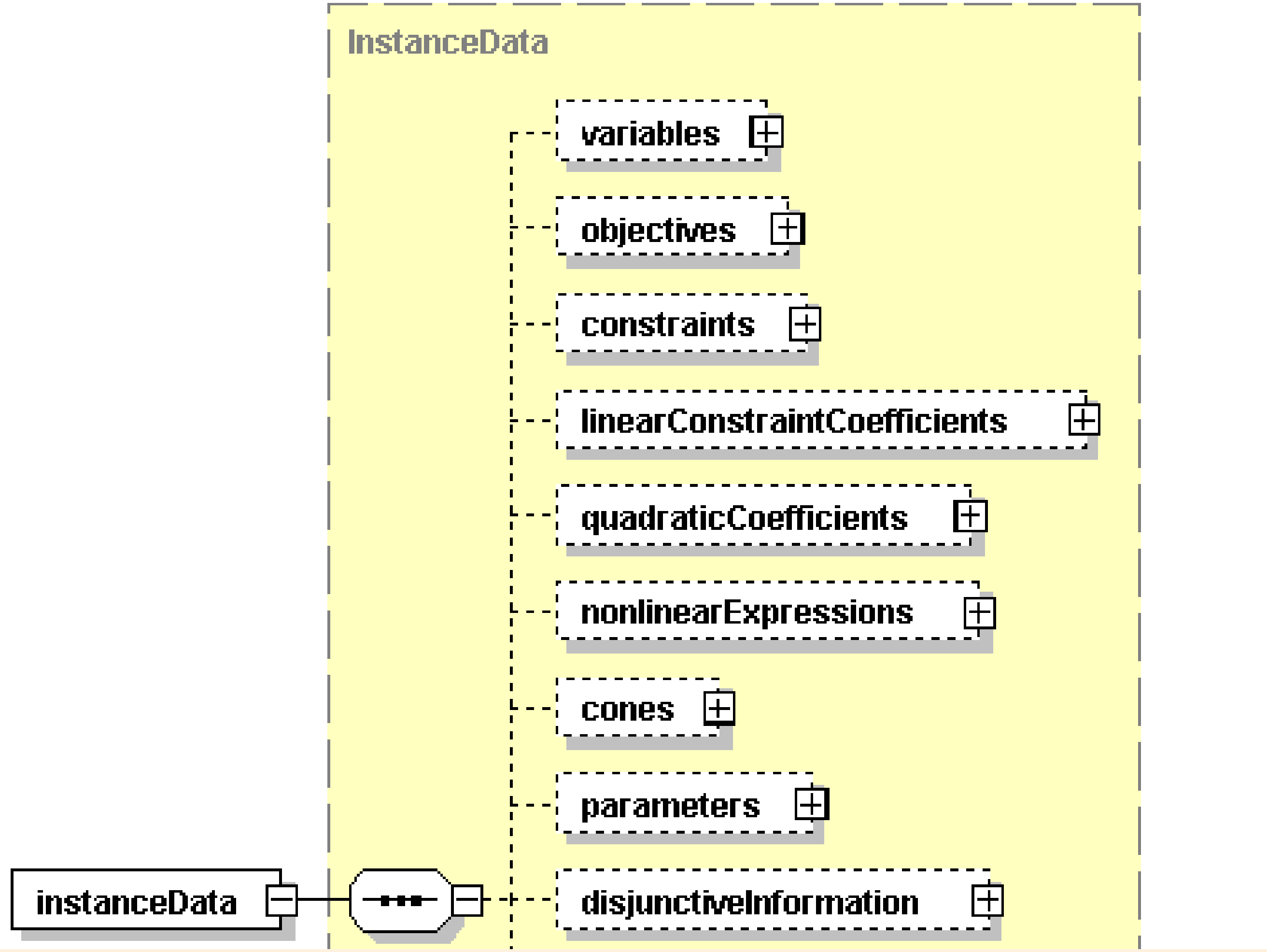
OSiL Schema – Header information



Header information – Example

```
<?xmlversion="1.0"encoding="UTF8"?>
    <osil xmlns="os.optimizationservices.org"
        xmlns:xsi=http://www.w3.org/2001/XMLSchemainstance
        xsi:schemaLocation="OSiL.xsd">
      <instanceHeader>
        <name>FinPlan</name>
          <source>
              Birge and Louveaux, Stochastic Programming
          </source>
          <description>
               Three-stage stochastic investment problem
          </description>
      </instanceHeader >
      <instanceData>
         ...
      </instanceData>
    </osil>
```

OSiL Schema – Deterministic data



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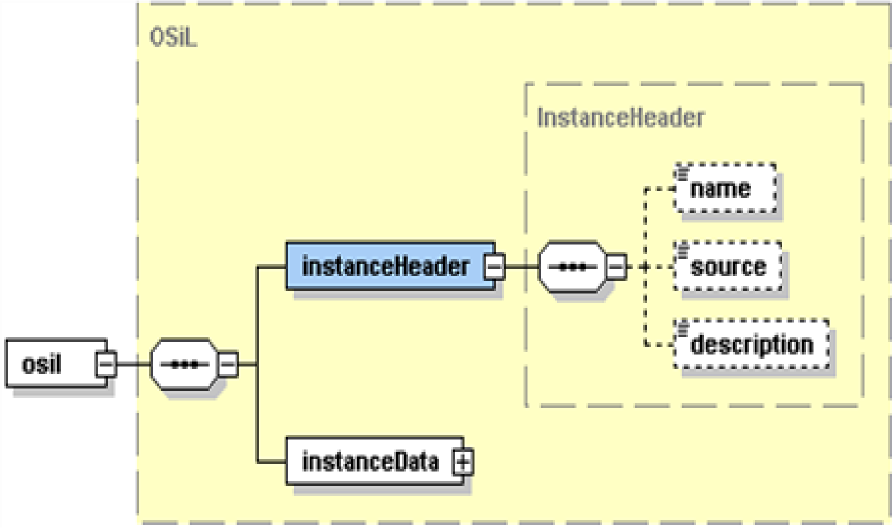
OSInstance: In-memory representation

- XML elements correspond to C++ classes
- Child elements mapped as member classes



```
class OSInstance{
public:
   OSInstance();
   InstanceHeader *instanceHeader;
   InstanceData *instanceData;
}; // class OSInstance
```

- set(), get() and calculate() methods

Instance vs. options

- Instance describes what is to be solved
  - Variables, objectives, relationships
- Options explain how to solve it
  - Algorithm tuning
    - e.g., tolerances, pricing and branching rules, starting point
  - Job performance
    - e.g., iteration limits, CPU limits
  - System requirements
  - Other, e.g., control of output levels

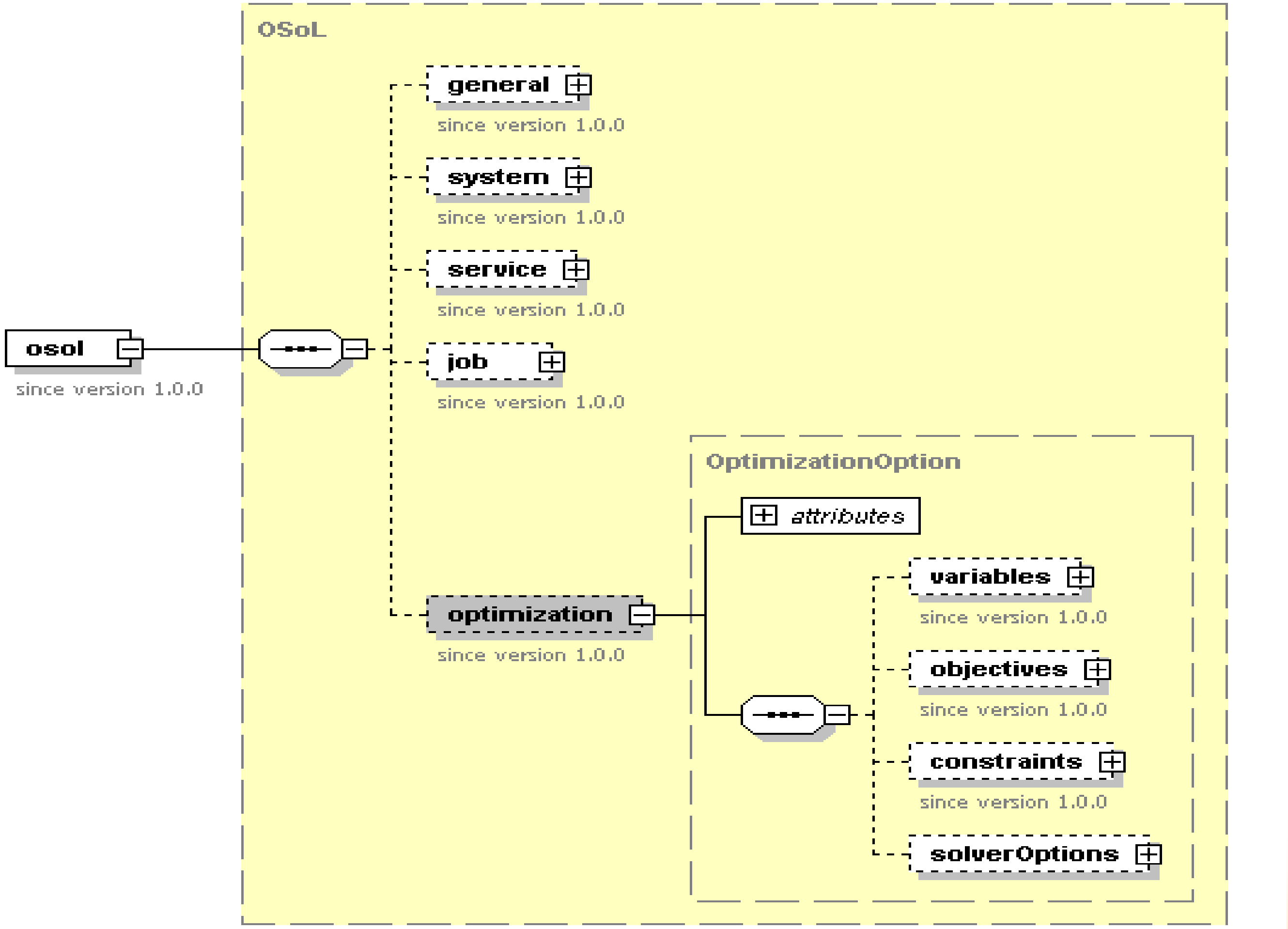
Solver option characteristics

- Different classes of options
- Many options shared among solvers
- Some options unique to one solver
- Syntax and meaning may vary

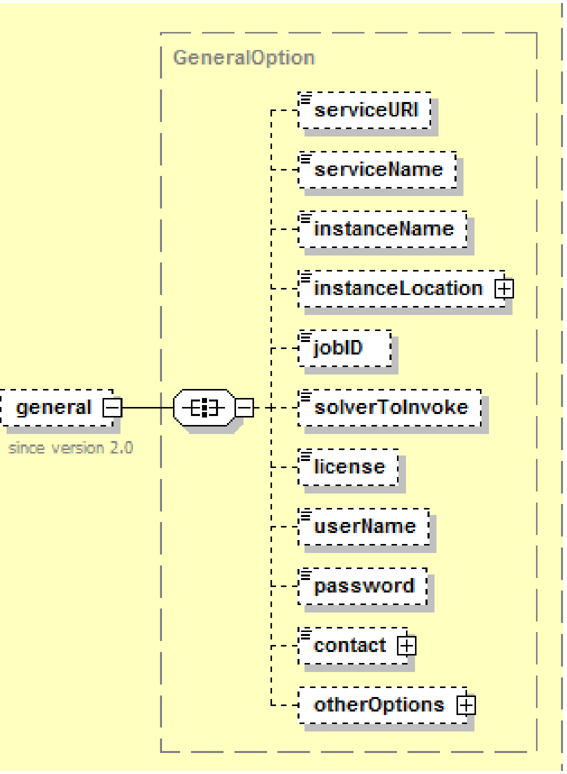
OSoL – OS option language

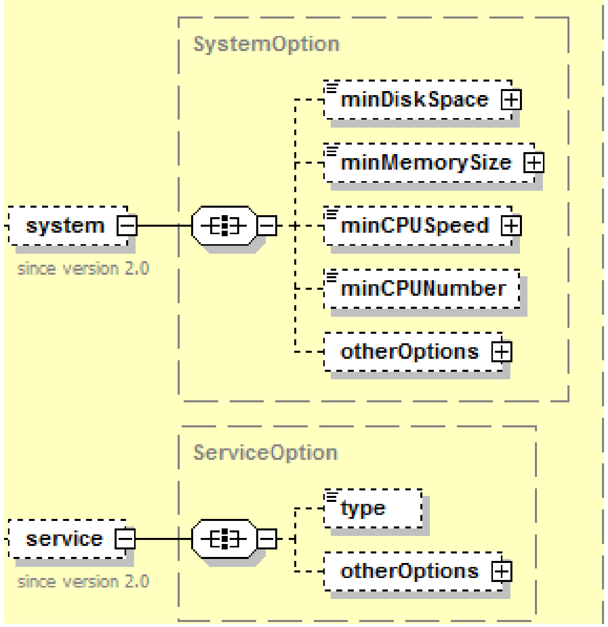
- Common syntax
- Solver-specific semantics
- Standard representation for common options
- Flexibility to allow extensions
- Solver driver translates options into form understandable by the solver
- In-memory representation: `OSOption`
- API: `get()`, `set()`, `add()` methods

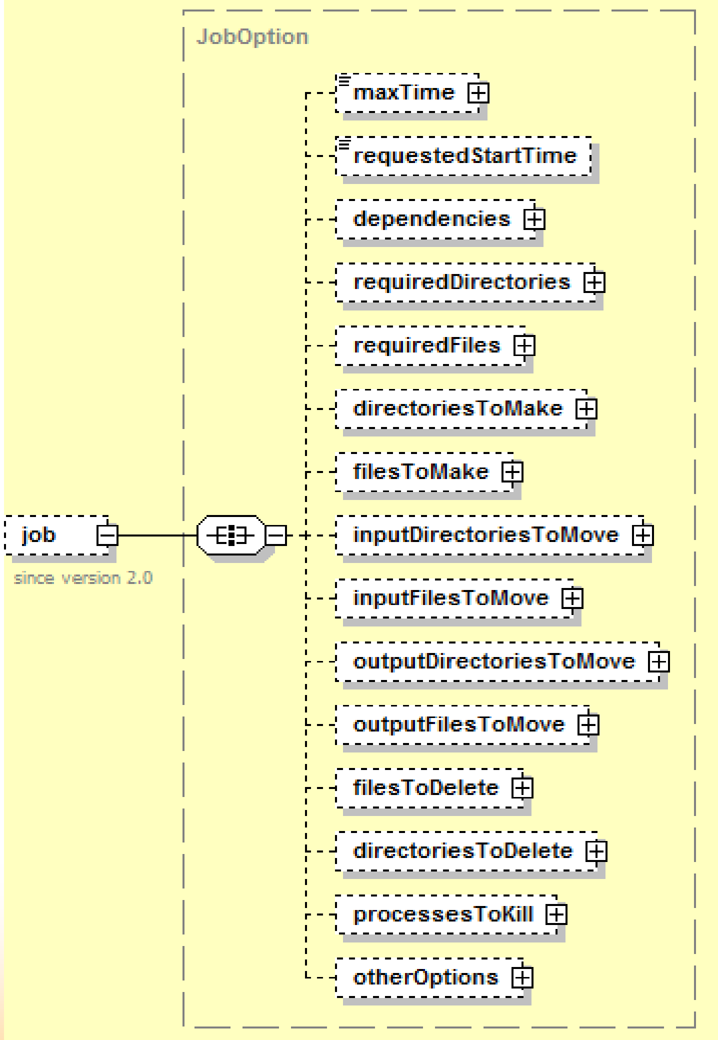
OSoL schema


OSoL
osol
since version 1.0.0
general
since version 1.0.0
system
since version 1.0.0
service
since version 1.0.0
job
since version 1.0.0
optimization
since version 1.0.0
OptimizationOption
attributes
variables
since version 1.0.0
objectives
since version 1.0.0
constraints
since version 1.0.0
solverOptions

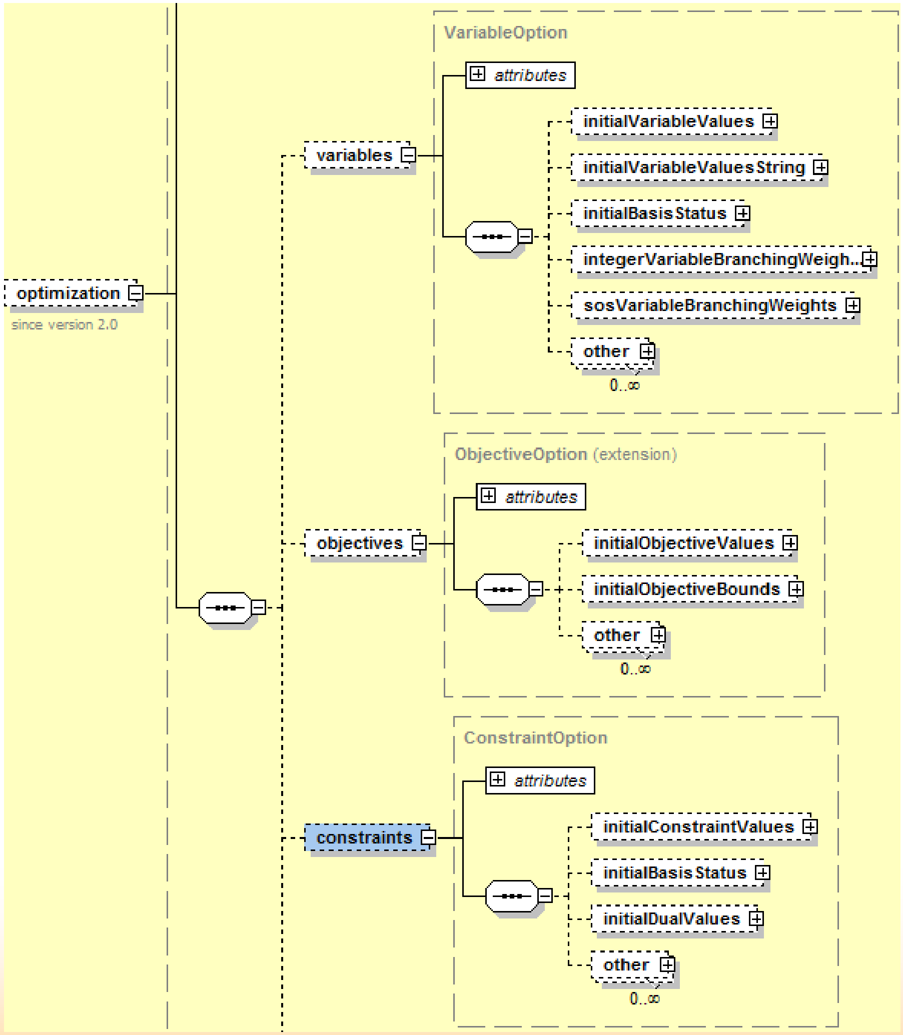
OSoL schema elements







OSoL optimization schema element



Sample .osol file

```
<?xml version="1.0" encoding="UTF-8"?>
<osol xmlns="os.optimizationservices.org"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="os.optimizationservices.org
    http://www.optimizationservices.org/schemas/2.0/OSoL.xsd">
    <optimization numberOfVariables="2">
        <variables>
            <initialVariableValues numberOfVar="2">
                <var idx="0" value="5."/>    <var idx="1" value="5."/>
            </initialVariableValues>
        </variables>
        <solverOptions numberOfSolverOptions="5">
            <solverOption name="tol" solver="ipopt" type="numeric" value="1.e-9"/>
            <solverOption name="print_level" solver="ipopt"
                  type="integer" value="5"/>
            <solverOption name="max_iter" solver="ipopt" type="integer"
                  value="2000"/>
            <solverOption name="LS_IPARAM_LP_PRINTLEVEL" solver="lindo"
                  category="model"  type="integer" value="0"/>
            <solverOption name="LS_IPARAM_LP_PRINTLEVEL" solver="lindo"
                  category="environment" type="integer" value="1"/>
        </solverOptions>
    </optimization>
</osol>
```

OSrL and OSResult

- Result of the optimization
  - Solution status
  - Statistics
  - Value of primal and dual variables
  - Basis information
- Can be displayed in a browser
- In-memory representation: `OSResult`
- API: `get()`, `set()`, `add()` methods

Other recent developments

- Interactive shell
- Semidefinite programming
- Dip solver (decomposition for IP)
- Quadratic objectives for Clp and Cbc

How to get OS

- Download
  - Binaries
    - http://www.coin-or.org/download/binary/OS
      - OS-2.1.1-win32-msvc9.zip
      - OS-2.2.0-linux-x86_64-gcc4.3.2.tgz
  - Stable source
    - http://www.coin-or.org/download/source/OS/
      - OS-2.2.0.tgz
      - OS-2.2.0.zip
  - Development version (using svn)
    - svn co https://projects.coin-or.org/svn/OS/releases/2.2.0 COIN-OS
    - svn co https://projects.coin-or.org/svn/OS/trunk   COIN-OS

QUESTIONS?

http://myweb.dal.ca/gassmann

http://www.optimizationservices.org

http://www.coin-or.org/projects/OS.xml

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