OSiL: An Open Standard for Expressing and Using Optimization Problem Instances

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XML-Based Standard Formats

Motivation

- for any standard format
- for an XML-based format

"OSxL" standards

- OSiL: problem instances
- OSoL: solver options
- **OSrL: results**

. . . and a host of others
(see www.optimizationservices.org)

Components of OSiL

- XML schema for text file format, *and*
- Corresponding in-memory data structures
- Libraries for reading and writing the above

XML Means “Tagged” Text Files . . .

Example: html for a popular home page

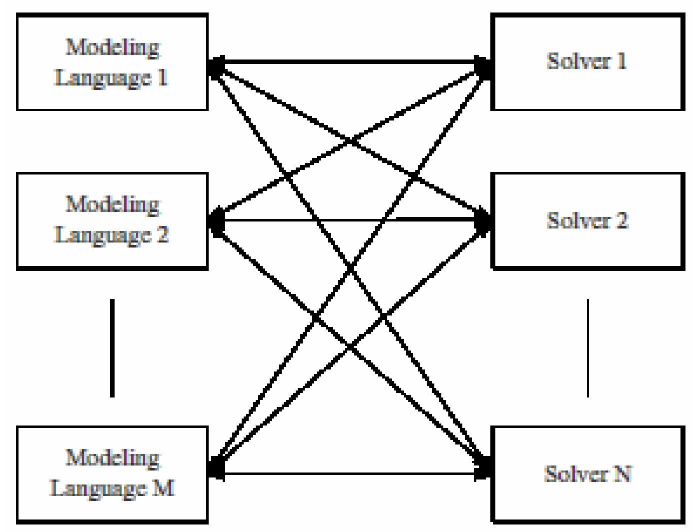
```
<html><head><meta http-equiv="content-type" content="text/html;
charset=UTF-8"><title>Google</title><style><!--
body,td,a,p,.h{font-family:arial,sans-serif;}
.h{font-size: 20px;}
.q{text-decoration:none; color:#0000cc;}
//-->
</style>
</head><body bgcolor=#ffffff text=#000000 link=#0000cc
vlink=#551a8b alink=#ff0000 onLoad=sf()><center><table border=0
cellspacing=0 cellpadding=0><tr><td><img src="/images/logo.gif"
width=276 height=110 alt="Google"></td></tr></table><br>
.......
<font size=-2>&copy;2003 Google - Searching 3,307,998,701 web
pages</font></p></center></body></html>
```

. . . a collection of XML tags is designed for a special purpose

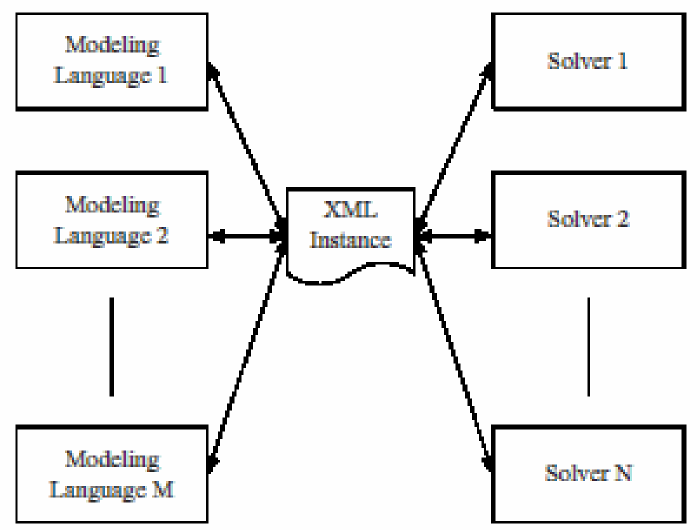
. . . by use of a schema written itself in XML

Advantage of any standard

MN drivers
without a standard



M + N drivers
with a standard



Advantages of an XML Standard

Specifying it

- Unambiguous definition via a *schema*
- Provision for *keys* and *data typing*
- Well-defined expansion to new *name spaces*

Working with it

- Parsing and validation via standard *utilities*
- Amenability to *compression* and *encryption*
- Transformation and display via XSLT *style sheets*
- Compatibility with *web services*

What about "MPS Form"?

Weaknesses

- Standard only for LP and MIP, not for
  nonlinear, network, complementarity, logical, . . .
- Standard not uniform (especially for SP extension)
- Verbose ASCII form, with much repetition of names
- Limited precision for some numerical values

Used for

- Collections of (mostly anonymous) test problems
- Bug reports to solver vendors

Not used for

- **Communication between modeling systems and solvers**

Standards

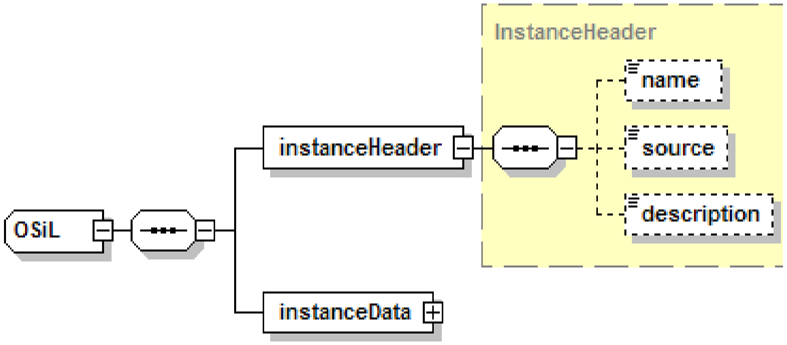
Text from the OSiL Schema

```
<xs:complexType name="Variables">
  <xs:sequence>
    <xs:element name="var" type="Variable" maxOccurs="unbounded"/>
  </xs:sequence>
  <xs:attribute name="number" type="xs:positiveInteger" use="required"/>
</xs:complexType>
```

```
<xs:complexType name="Variable">
  <xs:attribute name="name" type="xs:string" use="optional"/>
  <xs:attribute name="init" type="xs:string" use="optional"/>
  <xs:attribute name="type" use="optional" default="C">
  <xs:simpleType>
    <xs:restriction base="xs:string">
      <xs:enumeration value="C"/>
      <xs:enumeration value="B"/>
      <xs:enumeration value="I"/>
      <xs:enumeration value="S"/>
    </xs:restriction>
  </xs:simpleType>
  </xs:attribute>
  <xs:attribute name="lb" type="xs:double" use="optional" default="0"/>
  <xs:attribute name="ub" type="xs:double" use="optional" default="INF"/>
</xs:complexType>
```

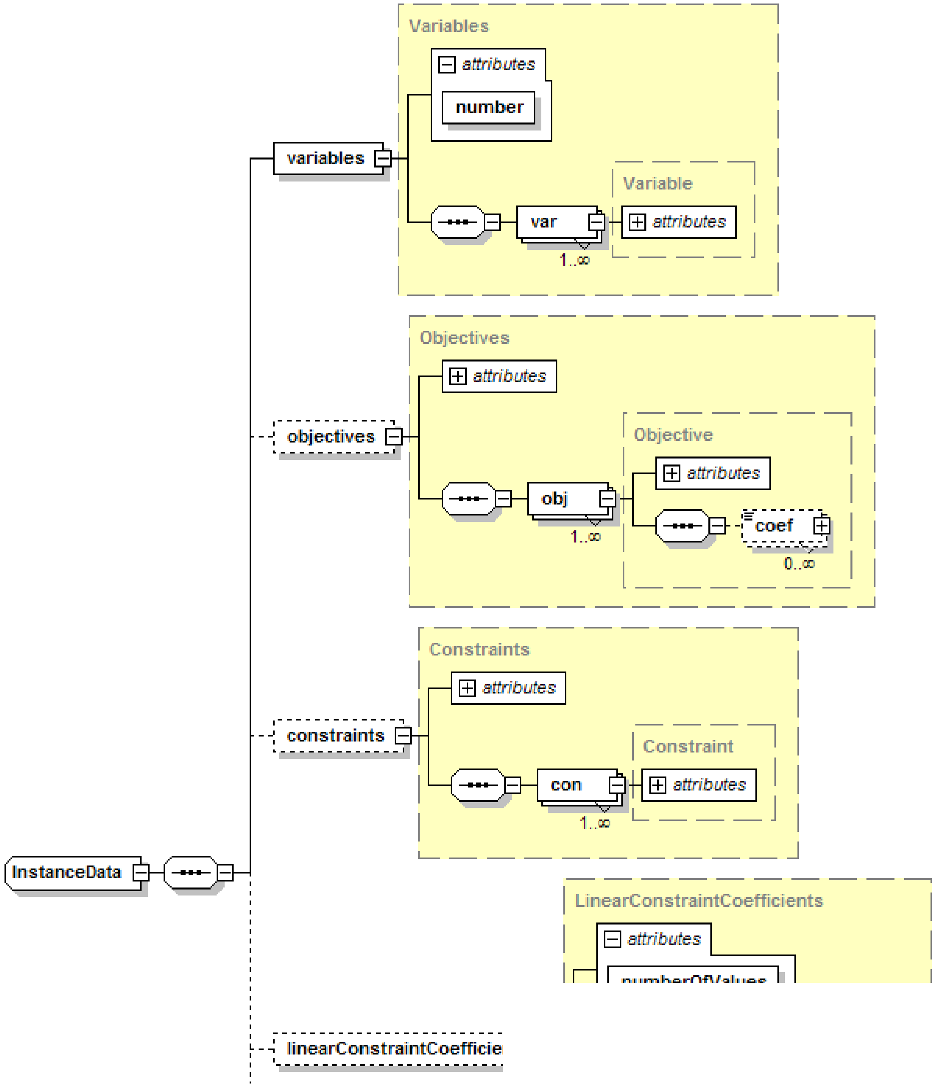
Standards

Diagram of the OSiL Schema



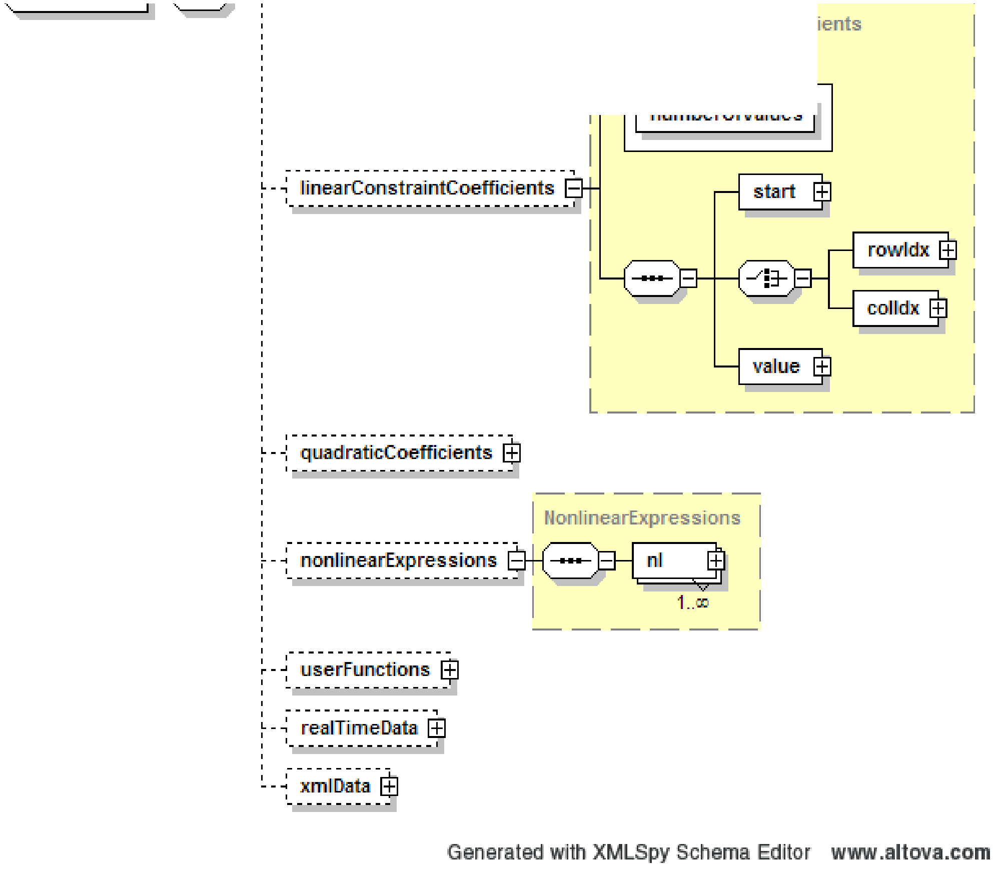
Standards

Details of OSiL’s instanceData Element



Standards

Details of OSiL's instanceData Element



Standards

Example: A Problem Instance (in AMPL)

```
ampl: expand _var;

Coefficients of x[0]:
        Con1   1 + nonlinear
        Con2   7 + nonlinear
        Obj    0 + nonlinear

Coefficients of x[1]:
        Con1   0 + nonlinear
        Con2   5 + nonlinear
        Obj    9 + nonlinear

ampl: expand _obj;

minimize Obj:
        (1 - x[0])^2 + 100*(x[1] - x[0]^2)^2 + 9*x[1];

ampl: expand _con;

subject to Con1:
        10*x[0]^2 + 11*x[1]^2 + 3*x[0]*x[1] + x[0] <= 10;

subject to Con2:
        log(x[0]*x[1]) + 7*x[0] + 5*x[1] >= 10;
```

Standard formats

Example in OSiL

```
<instanceHeader>
   <name>Modified Rosenbrock</name>
   <source>Computing Journal3:175-184, 1960</source>
   <description>Rosenbrock problem with constraints</description>
</instanceHeader>

<variables number="2">
   <var lb="0" name="x0" type="C"/>
   <var lb="0" name="x1" type="C"/>
</variables>

<objectives number="1">
   <obj maxOrMin="min" name="minCost" numberOfObjCoef="1">
      <coef idx="1">9</coef>
   </obj>
</objectives>

<constraints number="2">
   <con ub="10.0"/>
   <con lb="10.0"/>
</constraints>
```

Standard formats

Example in OSiL *(continued)*

```
<linearConstraintCoefficients numberOfValues="3">
   <start>
      <el>0</el>
      <el>1</el>
      <el>3</el>
   </start>
   <rowIdx>
      <el>0</el>
      <el>1</el>
      <el>1</el>
   </rowIdx>
   <value>
      <el>1.0</el>
      <el>7.0</el>
      <el>5.0</el>
   </value>
</linearConstraintCoefficients>

<quadraticCoefficients numberOfQPTerms="3">
   <qpTerm idx="0" idxOne="0" idxTwo="0" coef="10"/>
   <qpTerm idx="0" idxOne="1" idxTwo="1" coef="11"/>
   <qpTerm idx="0" idxOne="0" idxTwo="1" coef="3"/>
</quadraticCoefficients>
```

Standard formats

Example in OSiL *(continued)*

```
<nl idx="-1">
   <plus>
      <power>
         <minus>
            <number type="real" value="1.0"/>
            <variable coef="1.0" idx="1"/>
         </minus>
         <number type="real" value="2.0"/>
      </power>
      <times>
         <power>
            <minus>
               <variable coef="1.0" idx="0"/>
               <power>
                  <variable coef="1.0" idx="1"/>
                  <number type="real" value="2.0"/>
               </power>
            </minus>
            <number type="real" value="2.0"/>
         </power>
         <number type="real" value="100"/>
      </times>
   </plus>
</nl>
```

Standard formats

Example in OSiL *(continued)*

```
<nl idx="1">
   <ln>
      <times>
         <variable idx="0"/>
         <variable idx="1"/>
      </times>
   </ln>
</nl>
```

Compression

Specific to OSiL

- Collapse sequences of row/column numbers
- Collapse repeated element values
- Encode portions using base-64 datatype

General for XML

- Compression schemes designed for XML files

Comparisons

- XML base-64 < MPS
- XML with multiple values collapsed < 2 × MPS
- Compressed XML < Compressed MPS

Other Features in OSiL . . .

In current specification

- Real-time data
- Functions defined by the user

In process of design

- Stochastic programming / optimization under uncertainty
  - *see Gus Gassmann's talk, WB44.4:*
    An XML-Based Schema for Stochastic Programming
- Logical / combinatorial constraints
- Semidefinite / cone programming

Associated languages

- OSoL for communicating options to solvers
- OSrL for communicating results from solvers

. . . broader family of "optimization services" languages (see www.optimizationservices.org)

In-Memory Data Structures

OSInstance object class

- Parallels the OSiL schema
- complexType in schema ←→ class in OSInstance
- attributes / children of an element ←→ members of a class
- choices / sequences in the schema arrays ←→ array members

OS expression tree

- Parallels the *nonlinear* part of the OSiL schema
- Designed to avoid lengthy “switch” statements

Advantages

- One standard instead of two
- Complements COIN-OR’s OSI

Libraries (APIs, Interfaces)

Use by client

- OSInstance `set()` methods generate instance in memory
- `OSiLWriter` writes instance to a file in OSiL format
- Using SOAP over HTTP, instance is sent to a solver

Use by solver

- `OSiLReader` in solver interface
  reads instance from OSiL format back to memory
- OSInstance `get()` methods extract instance data
  as needed by solver
- Solver works on the problem
- Results are sent back similarly, using OSrL

. . . OSiL can be skipped
when instance is passed in memory

For More Information

- R. Fourer, L.B. Lopes and K. Martin, LPFML: A W3C XML Schema for Linear and Integer Programming. *INFORMS Journal on Computing* **17** (2005) 139–158.
- R. Fourer, J. Ma and K. Martin, OSiL: An Instance Language for Optimization. `www.optimization-online.org/DB_HTML/2006/03/1353.html`.