Recent developments in Optimization Services (OS)

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Outline

• Optimization Services
• Optimization Services instance Language (OSiL)
• Recent extensions
  – Modifications
  – Real-time data
  – Disjunctions
  – Stochastic programming
• Concluding remarks
Optimization Services

• Framework for optimization in a distributed computing environment or in a compute cloud
• XML schemas for communicating
  – instances (OSiL)
  – options (OSoL)
  – results (OSrL)
• Implementation (COIN-OR)
• Connects to COIN-OR and other third-party linear, integer and nonlinear solvers
  – Clp, Cbc, Ipopt, SYMPHONY, …
  – Glpk, Cplex, Gurobi, Matlab, …
  – CSDP

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OSiL - “Core” elements

Sets up 10 continuous variables with lb=0 and ub=1000

Note:
Name attribute is optional
Variables identified by index (i.e., position number)
OSiL: Matrix and cone extensions
Defining a positive semidefinite matrix

<cones numberOfCones="1">
  <semidefiniteCone numberOfRows="2" numberOfColumns="2"/>
</cones>

<matrixProgramming>
  <matrixVariables numberOfMatrixVar="1">
    <matrixVar numberOfRows="2" numberOfColumns="2"
      lbConeIdx="0"/>
  </matrixVariables>
</matrixProgramming>
Instance alterations

- Solver sees a different problem than formulated in the modeling environment and instantiated in the OSiL file
- Modifications
  - (e.g., Post-optimality analysis, cut/column generation)
- Real-time data
- Stochastic data
- Disjunctions
- Often change is incremental
- Smaller problem representation; faster file transmission
- Reuse schema elements and exploit synergies
- Separation of location and data process (What is changed? vs. How?)
Modifications

• **Substitute** → delete → add
  – Order matters to avoid ambiguity
  – Variables, objectives, constraints
  – Linear and quadratic coefficients
  – Nonlinear expressions
  – Matrix elements

• **Substitute**: List of instance elements; values

• **Delete**: List of instance components

• **Add**: Just like “core”
Real-time data and stochastic programming

• Some instance elements are generated by
  – real time data lookup
  – stochastic processes

• List of alterable instance elements
  – Extensible catalog
    (variable lower/upper bound, LP coefficient, rhs, …)

• Description of generator
  – Real time: URI, XPath
  – Stochastic programming: random variables or vectors
    correlation and other complications
Disjunctions

• Variables / objectives / constraints / terms selectively activated (or deactivated)

• Example:
  – If condition C holds,
    • then $0 \leq x_0 \leq 5$; $g_1(x) \geq 0$
    • else $5 \leq x_0 \leq 10$; $g_2(x) \geq 0$

• Similar to a list of modifications
Updateable problem components

Examples:

<variable idx="0" attr="type"/>
<objective idx="-1" attr="coef" coefIdx="1"/>
<constraint idx="1" attr="lb"/>
<linearConstrainCoefficient rowIdx="2" colIdx="3"/>
The `<modifications>` element
Deletions and additions
The `<realTimeData>` element

- `<sourceXPath>`
  - Written in XPath (XML query language)
  - Assumed to return a single node from an XML document
Disjunctions
Stochastic data

- **Scenario-based modelling**
  - Condensed representation of the deterministic equivalent
  - Finite fixed discretization
- **Node-based modelling**
  - Random problem dimensions
- **Distribution-based modelling**
  - Discrete or possibly continuous distributions
  - Recourse problems
    - All constraints hold with probability 1
  - Chance-constraints
  - Integrated chance-constraints
  - Stochastic programming under ambiguity
    - Partial description of distributions
    - Robust optimization
      - Only support of random variables known
Timing issues

• Stochastic data
  – Time structure (stages / periods)
  – Nonanticipativity

• Real-time data
  – Before instance is transmitted
  – Before remote solver is started
  – Whenever accessed by algorithm
Dynamic structure (time stages)
Scenario trees
Nodal trees
Distributions (used in implicit trees)
Implicit event trees

ImplicitTree-2016-10-05

attributes

ImplicitTreeBlock-2016-10-05

attributes

UpdateableProblemComponent

block

number must agree with numberOfBlocks

ar

number must agree with numberOfAR. Each term adds rows to the input vector for the transformation, first the random variable or vector, followed by any references to stockAR.

ma

number must agree with numberOfMA. Each moving average term refers to a previously fit decision variable, matrix variable, etc. Each reference adds one or more rows to the input vector of the transformation

transformation

The transformation forms a flattened column vector of current observations and autoregressive terms and moving average terms (and perhaps a constant term) and transforms this into the vector of stochastic elements. Any random matrices are expanded row by column. Default: identity matrix.

softConstraints

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Transformations

- Random variables separated from model entities
- Linked to stochastic problem elements by transformations (linear or nonlinear)
- Useful for factor models and other stochastic processes
Penalties and probabilistic constraints
Concluding remarks

• Unifying framework for instance alterations
  – Synergies and avoiding redundancies
  – Stochastic programming:
    • Instance compression (explicit DE – scenarios and nodes)
    • Distribution information (implicit event trees)
  – Robust optimization NOT included in proposal
    • Special reformulation of original instance
    • Before reformulation: stochastic program with ambiguities
    • After reformulation: deterministic problem
    • Use OSiL input into automatic reformulation software to generate new OSiL
How to get OS

• Download
  – Binaries
    • [http://www.coin-or.org/download/binary/OS](http://www.coin-or.org/download/binary/OS)
      – OS-2.3.0-linux-x86_64-gcc4.3.2.tgz
  – Stable source
    • [http://www.coin-or.org/download/source/OS/](http://www.coin-or.org/download/source/OS/)
      – OS-2.10.0.tgz
      – OS-2.10.0.zip
  – Development version (using svn)
    • svn co https://projects.coin-or.org/svn/OS/releases/2.10.0
    • svn co https://projects.coin-or.org/svn/OS/trunk

• More information
  – [http://www.optimizationservices.org](http://www.optimizationservices.org)
  – [https://projects.coin-or.org/OS](https://projects.coin-or.org/OS)
  – Horand.Gassmann@dal.ca
QUESTIONS?

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