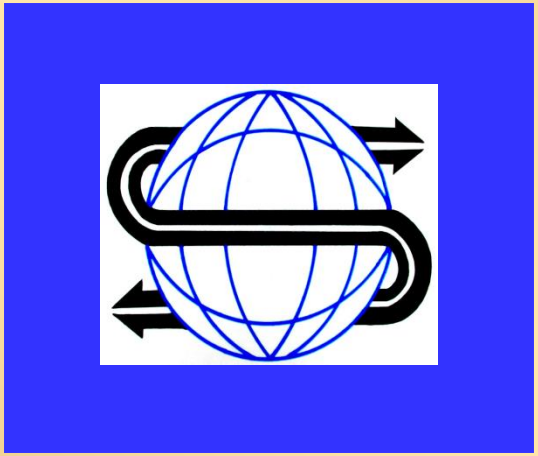

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Recent developments in Optimization Services (OS)

Horand I. Gassmann, Dalhousie University

Jun Ma, Kipp Martin

Outline

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

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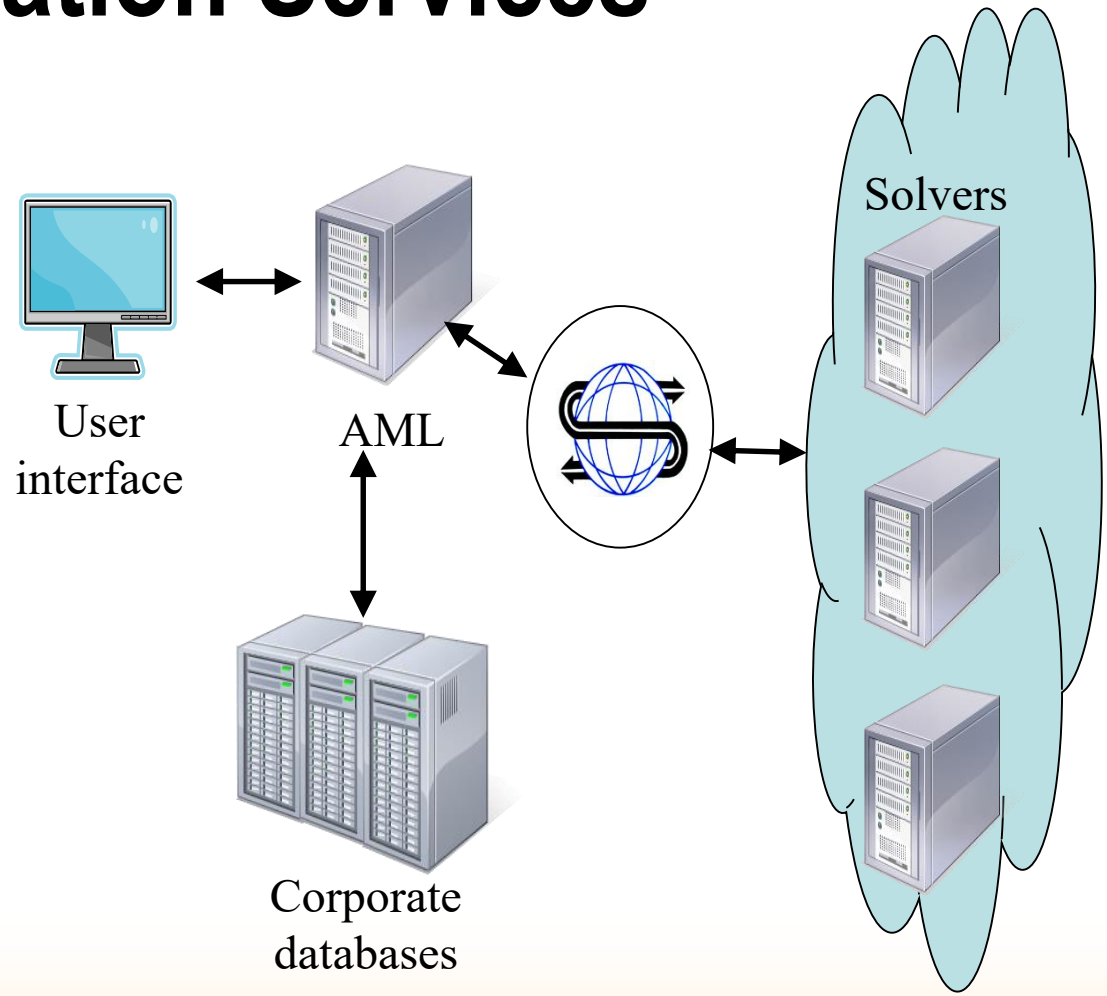
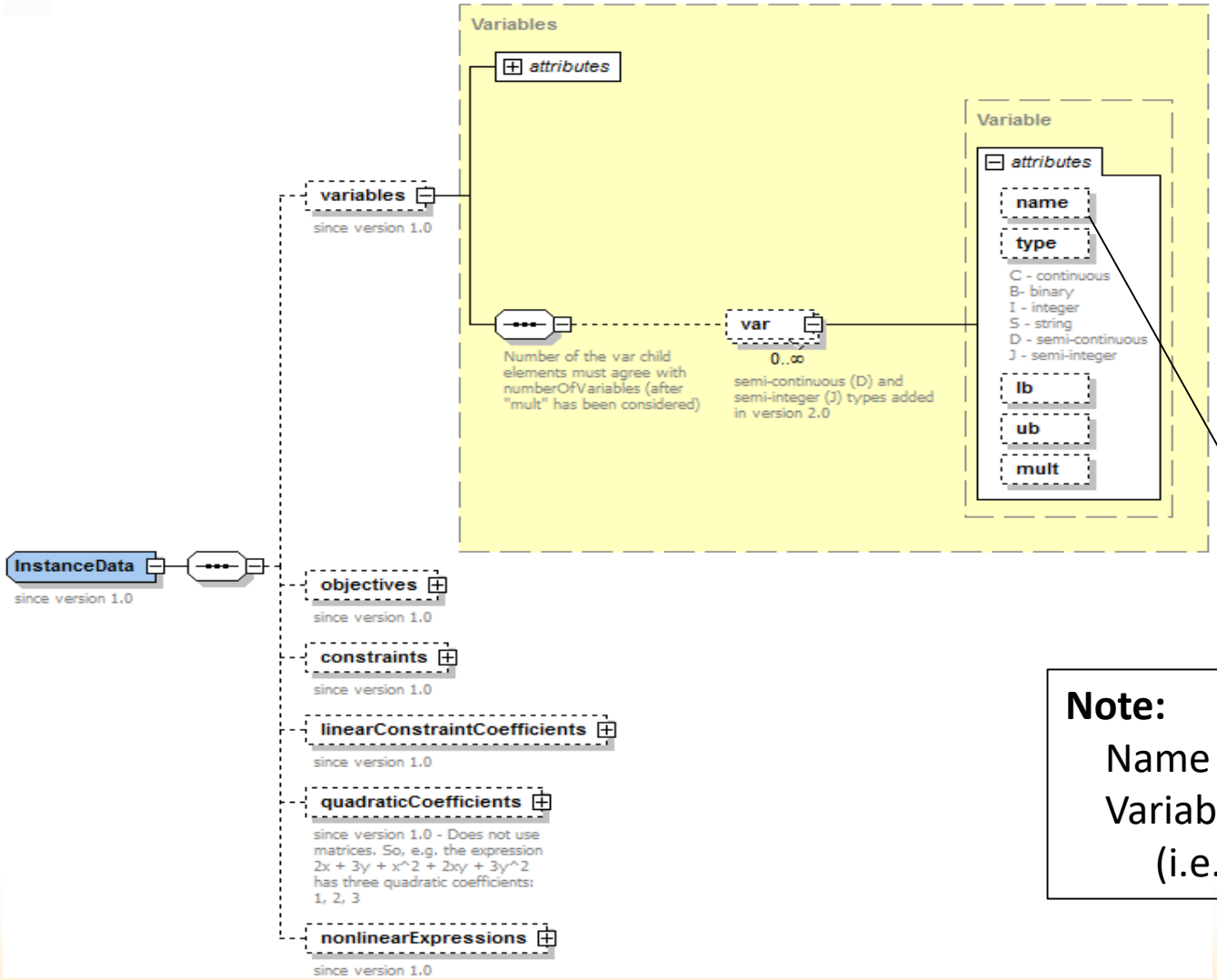
Optimization Services

- 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



OSiL - “Core” elements




```
<variables
  numberOfVariables
    ="10">
  <var mult="10"
    type="C" lb="0"
    ub="1000"/>
</variables>
```

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

Note:

Name attribute is optional

Variables identified by index (i.e., position number)

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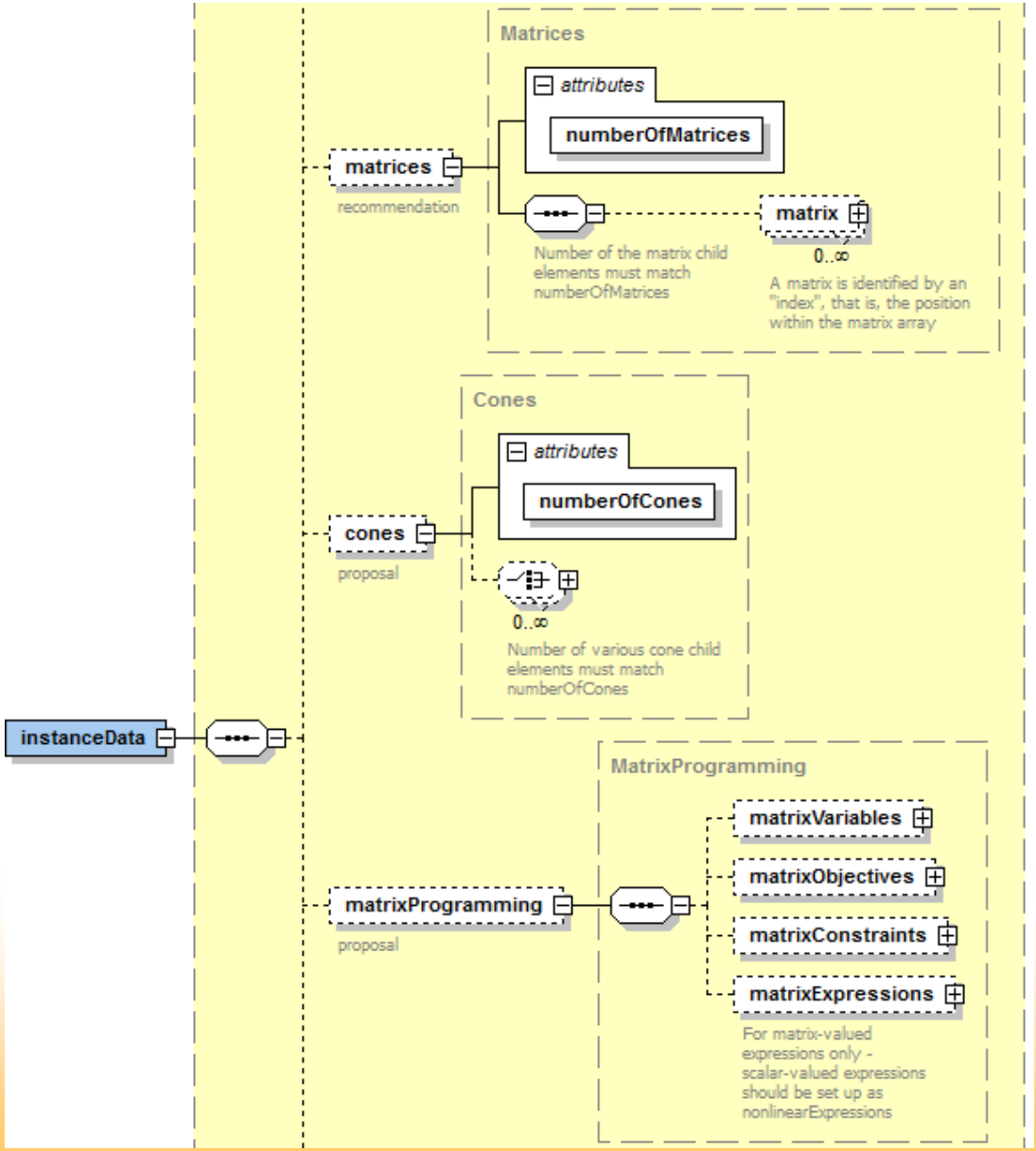
OSiL: Matrix and cone extensions



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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>
```

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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?)

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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”

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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

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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

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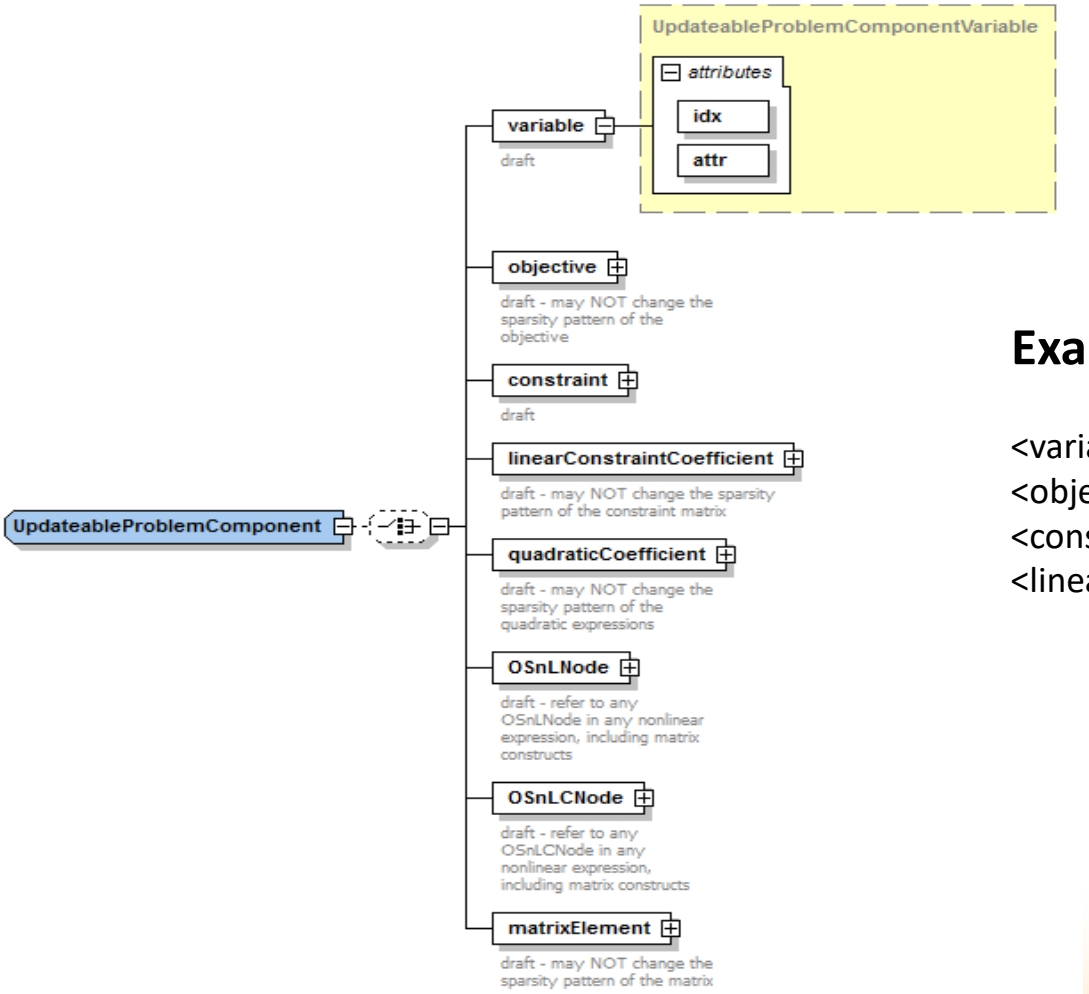
Updateable problem components



Examples:

<variable idx="0" attr="type"/>
<objective idx="-1" attr="coef" coefIdx="1"/>
<constraint idx="1" attr="lb"/>
<linearConstrainCoefficient rowIdx="2" colIdx="3"/>

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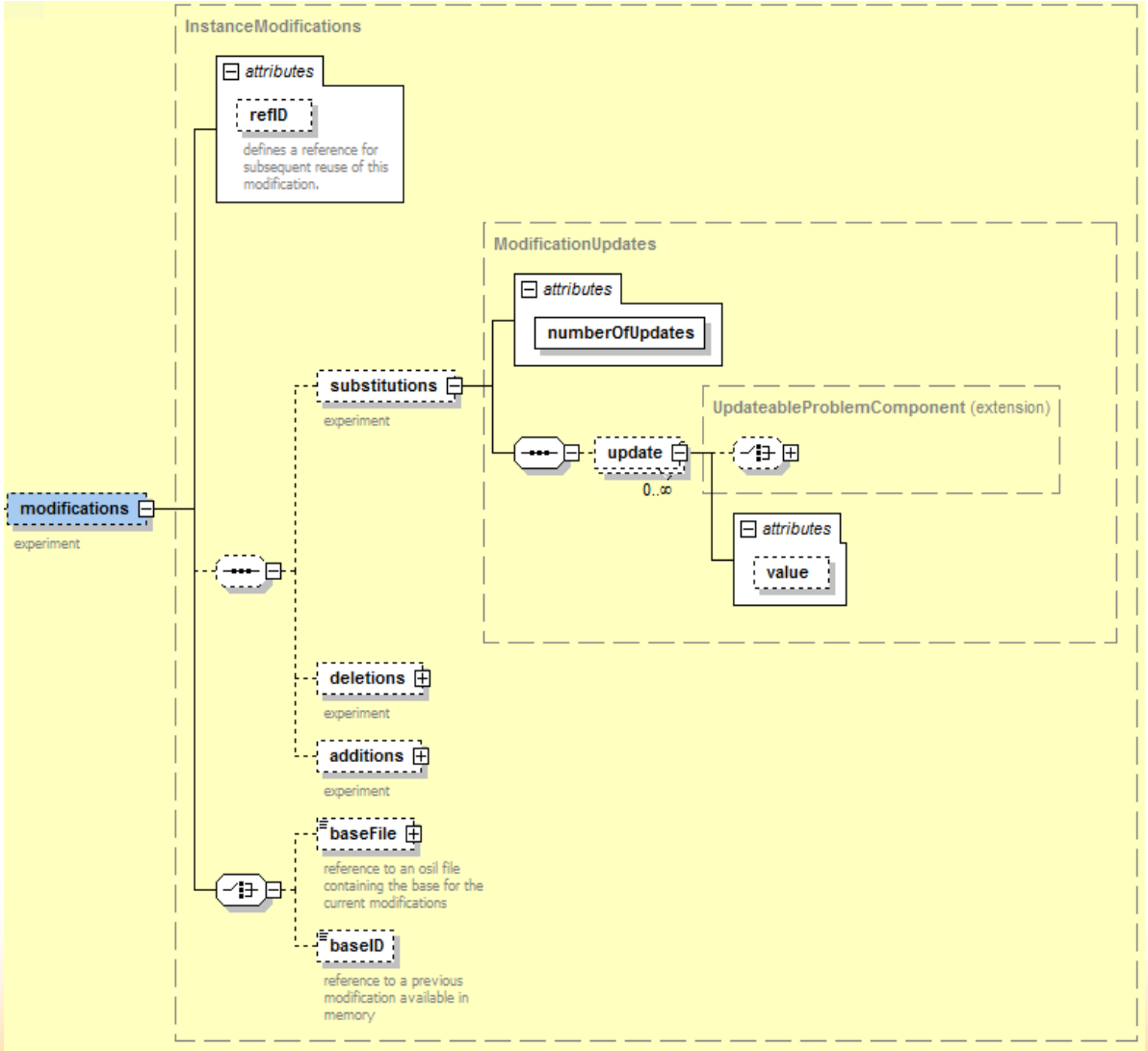
The <modifications> element



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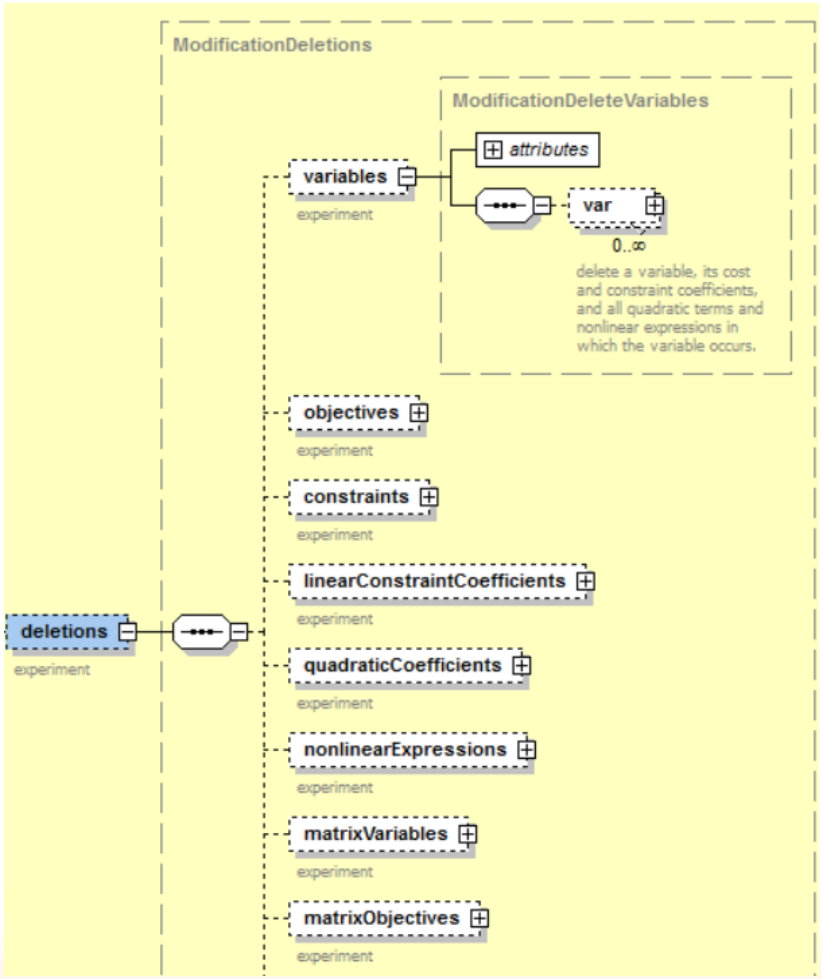
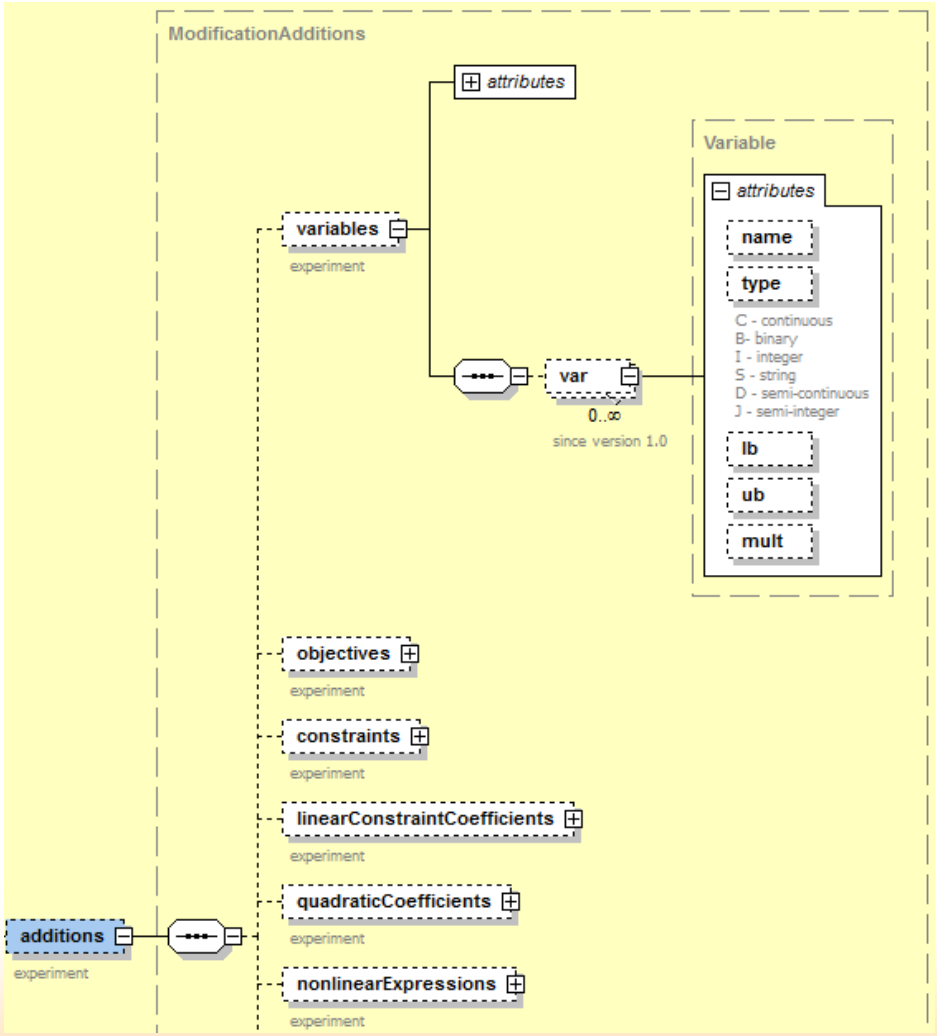
Deletions and additions





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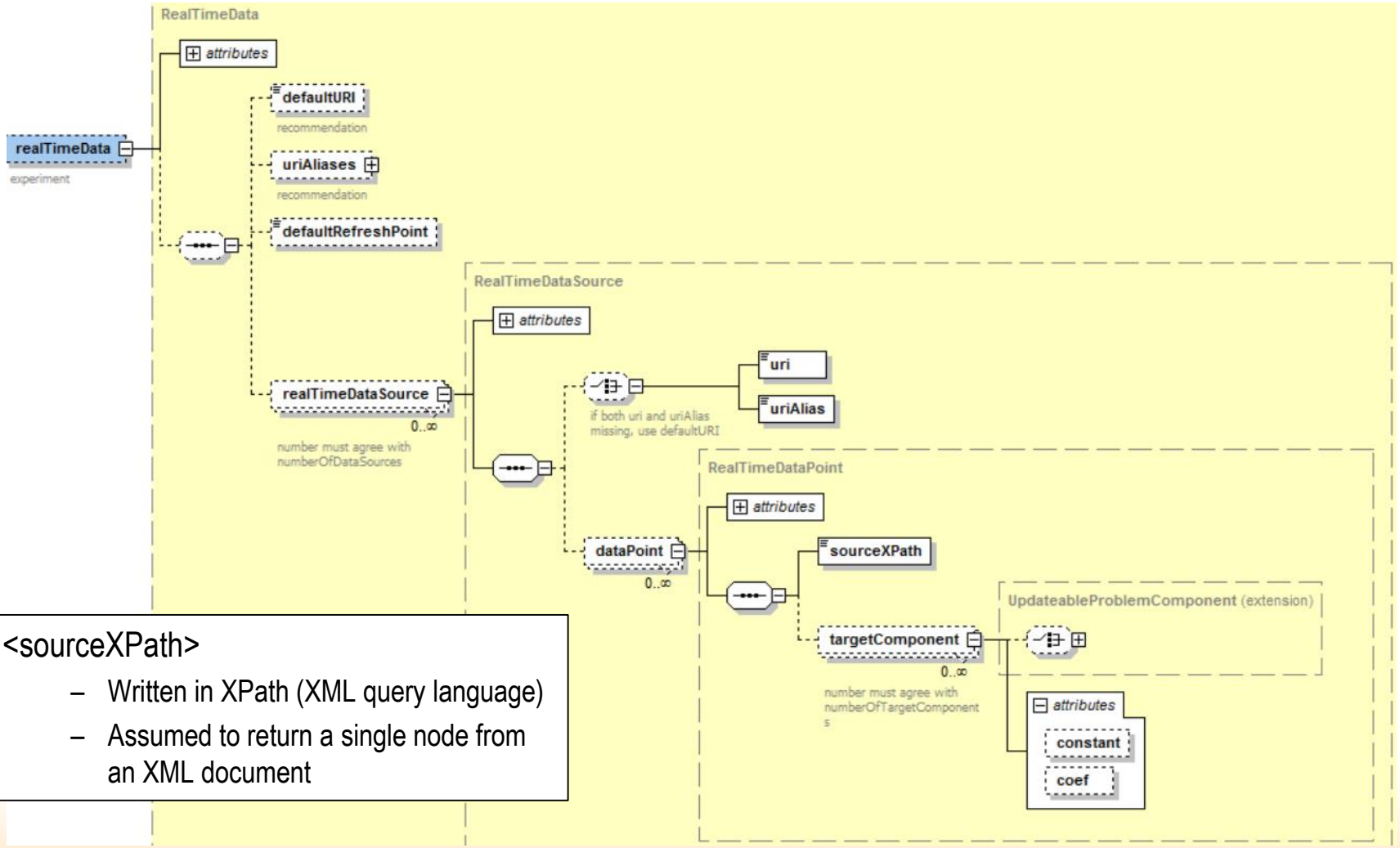
The <realTimeData> element



<sourceXPath>

- Written in XPath (XML query language)
- Assumed to return a single node from an XML document

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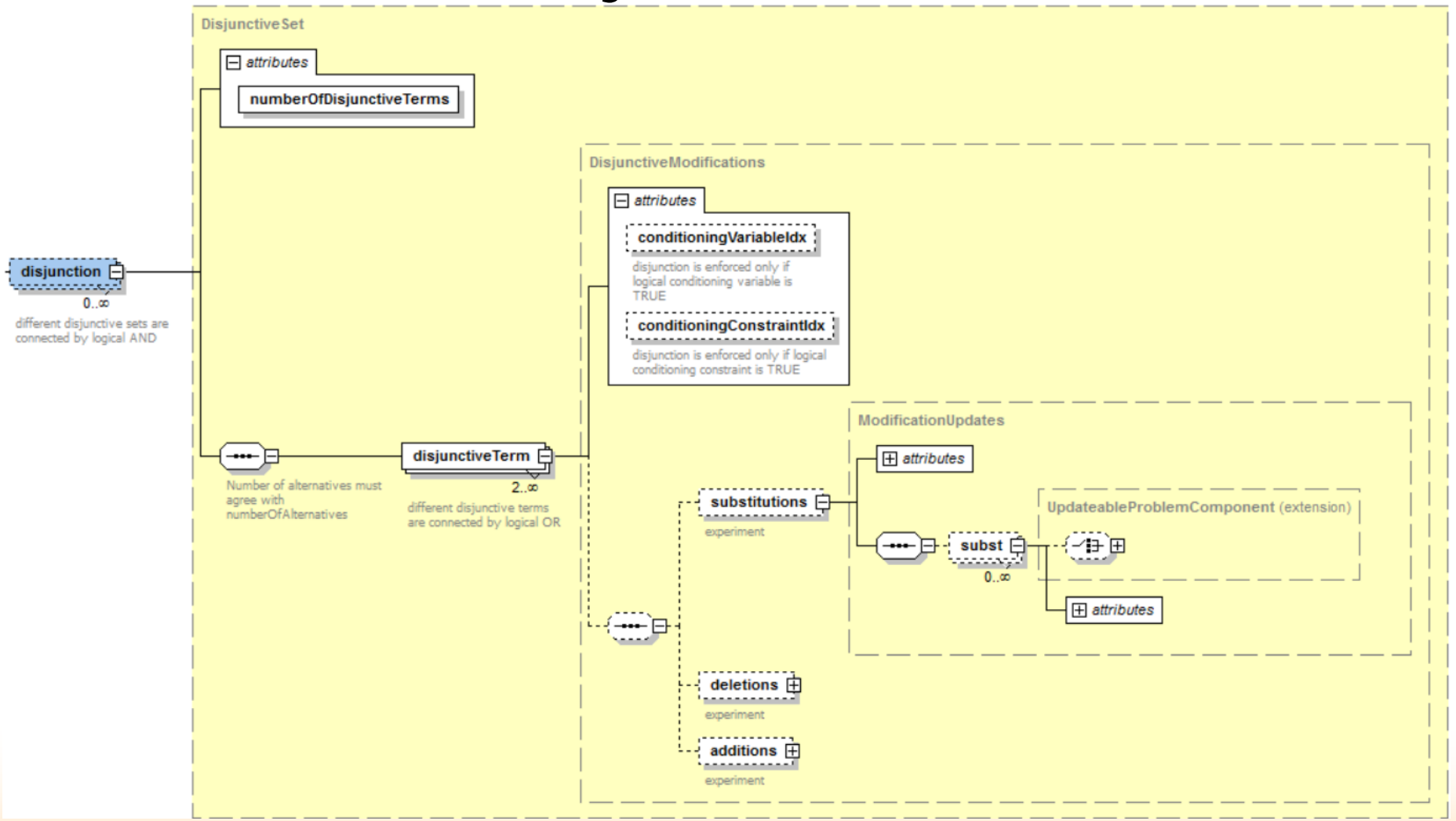
Disjunctions



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

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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

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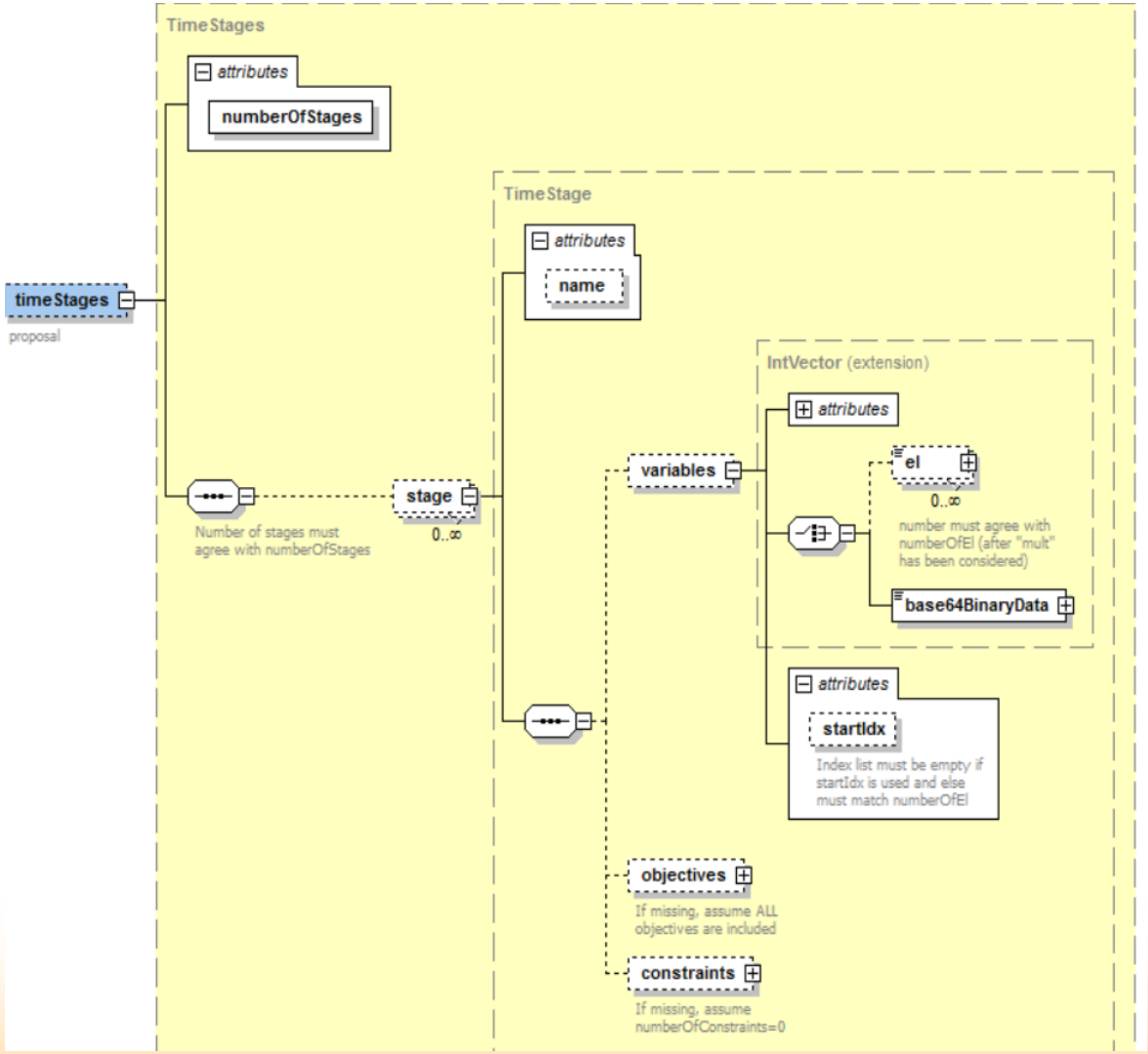
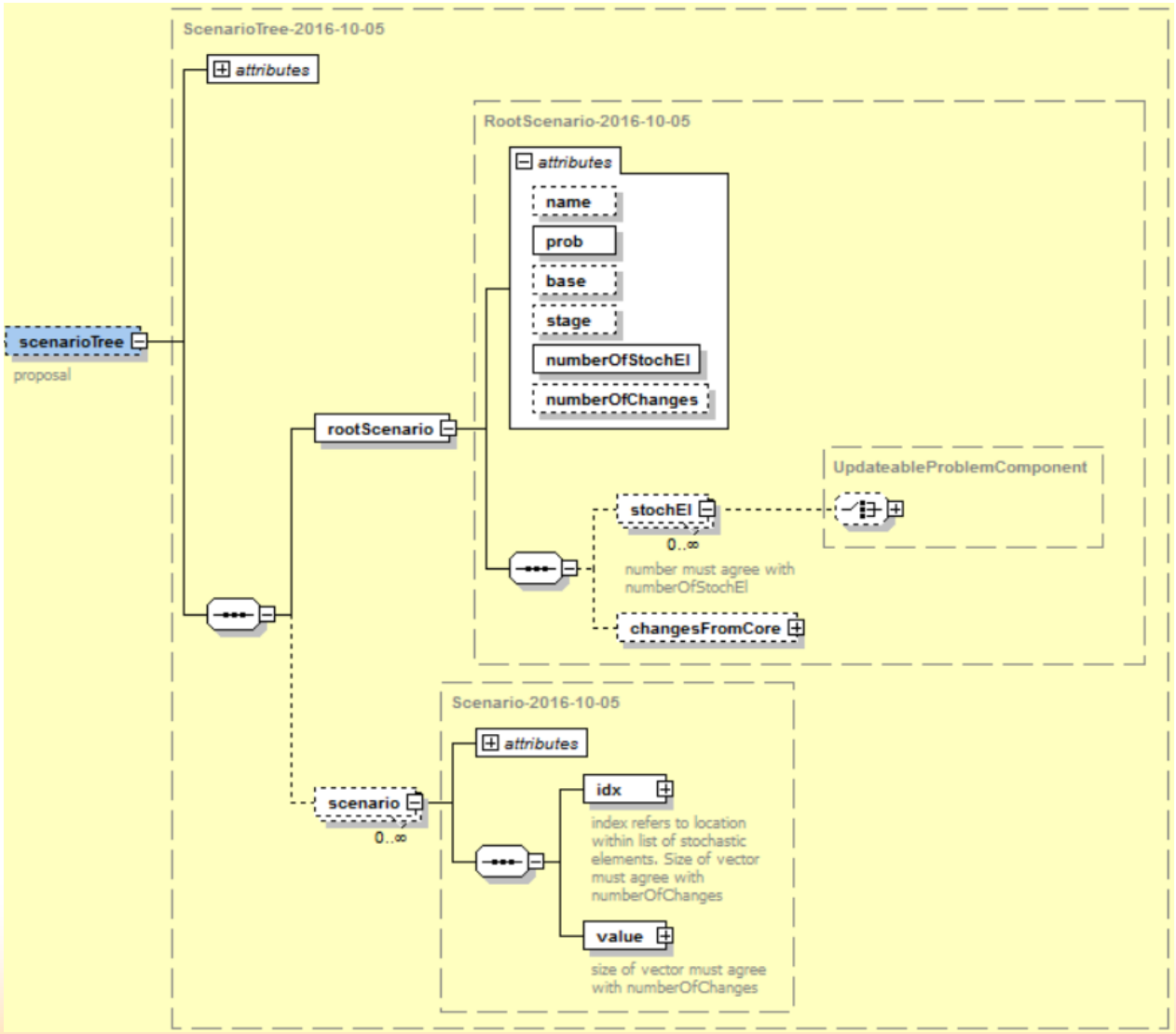
Dynamic structure (time stages)



Scenario trees



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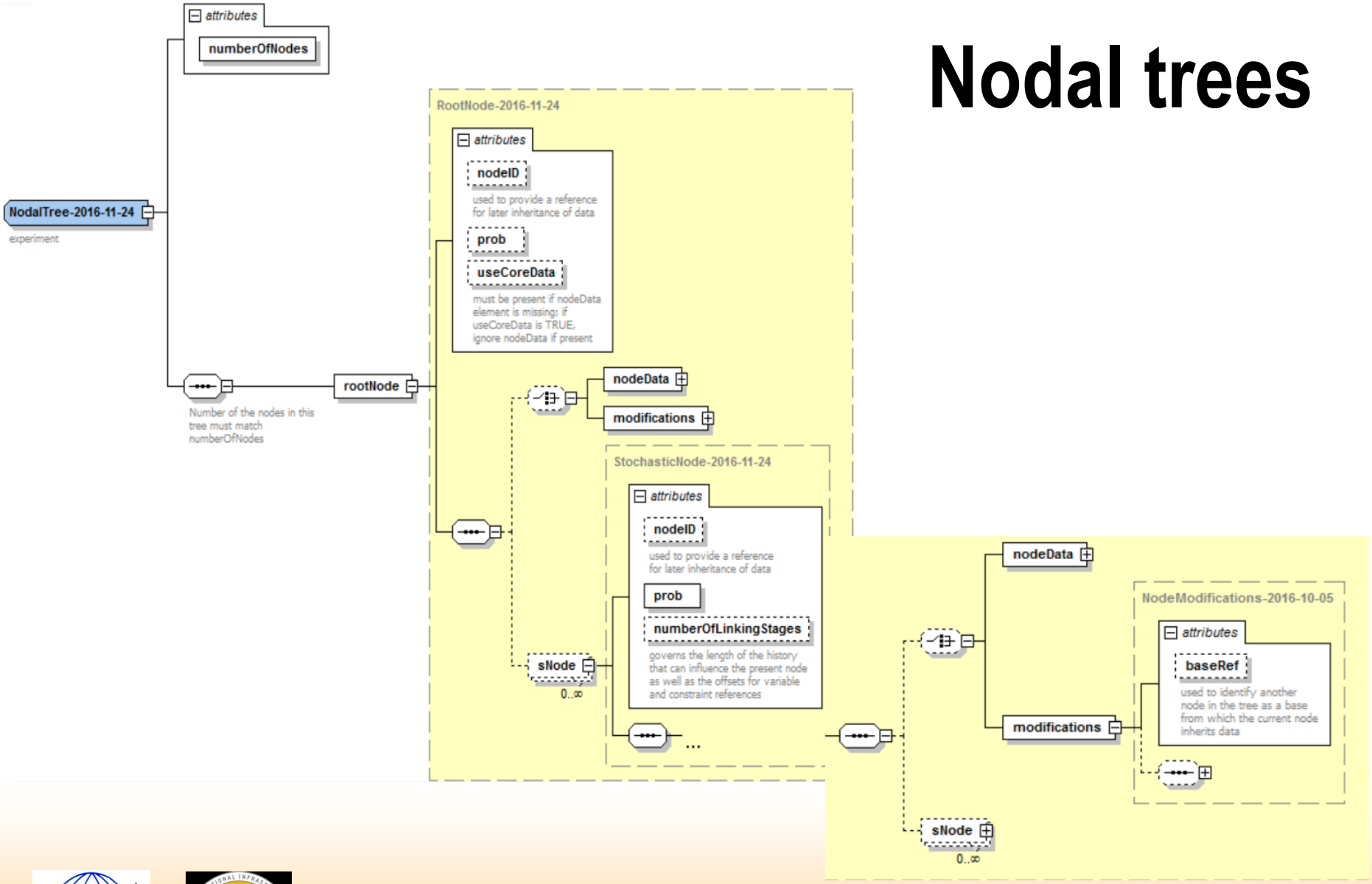
Nodal trees



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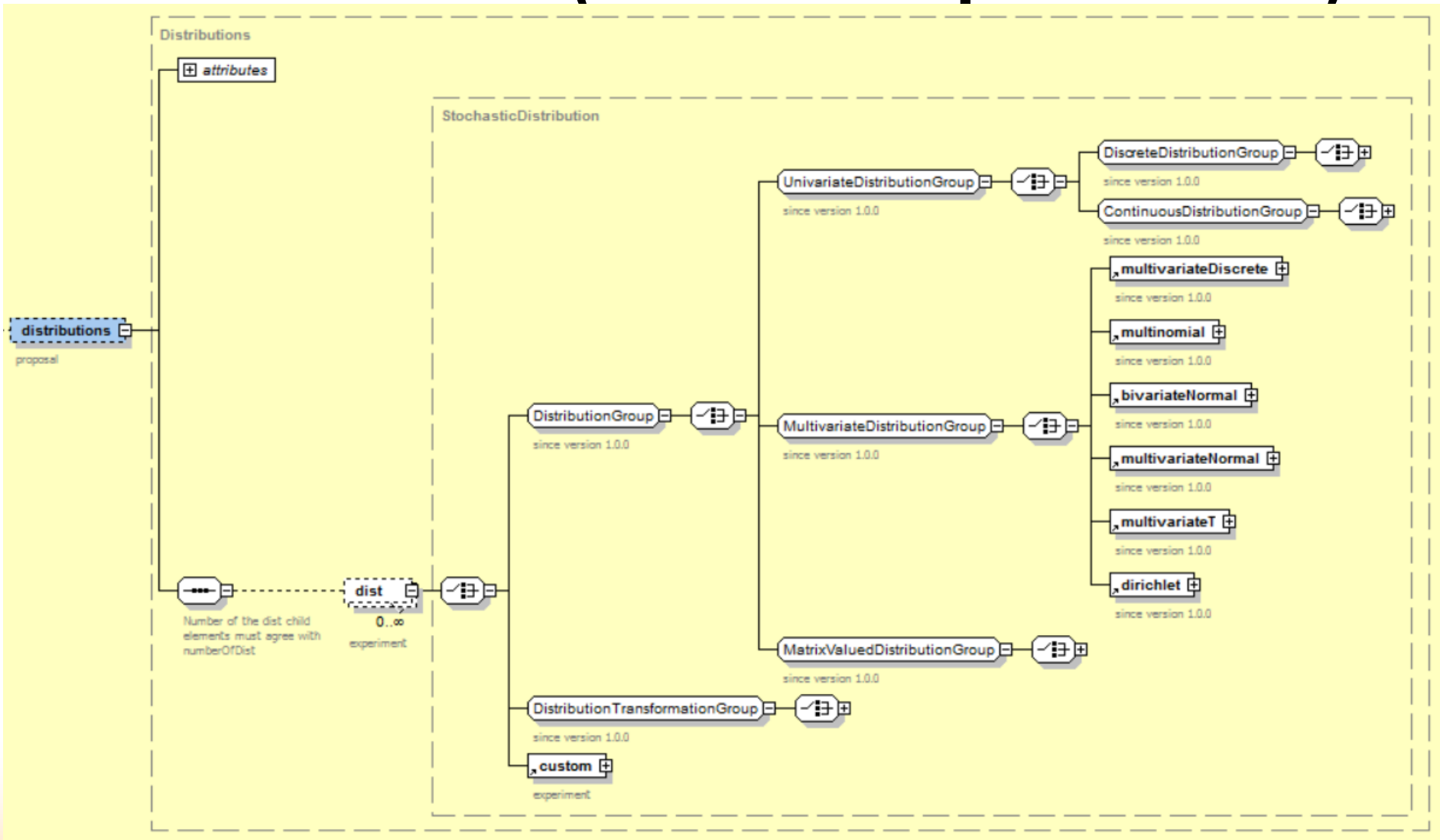
Distributions (used in implicit trees)



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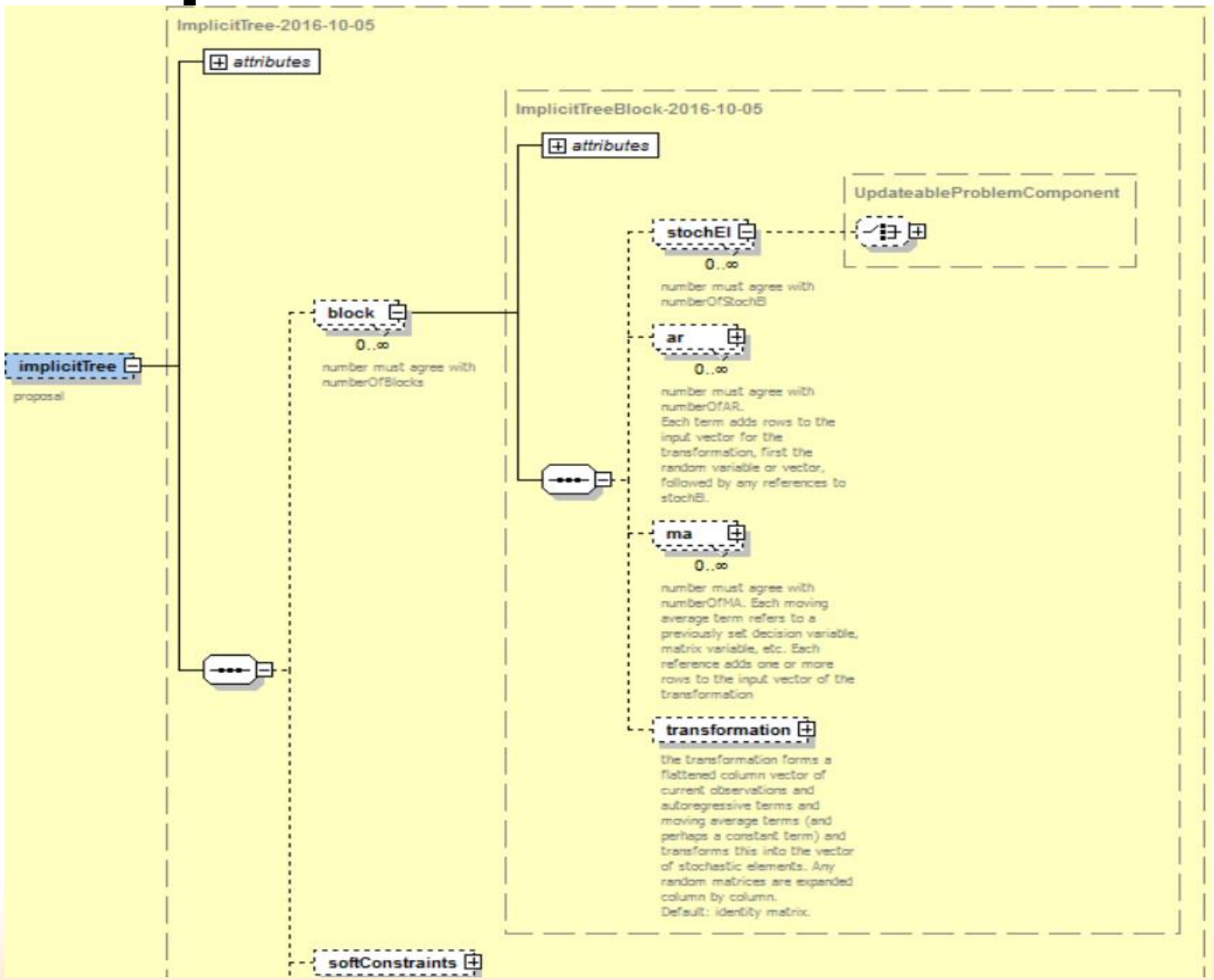
Implicit event trees



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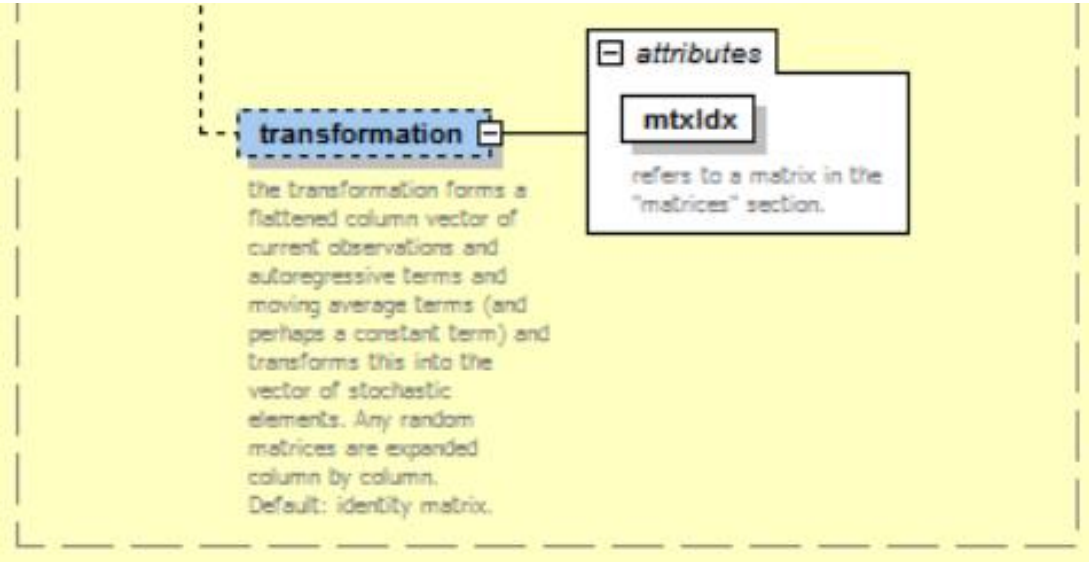
Transformations



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

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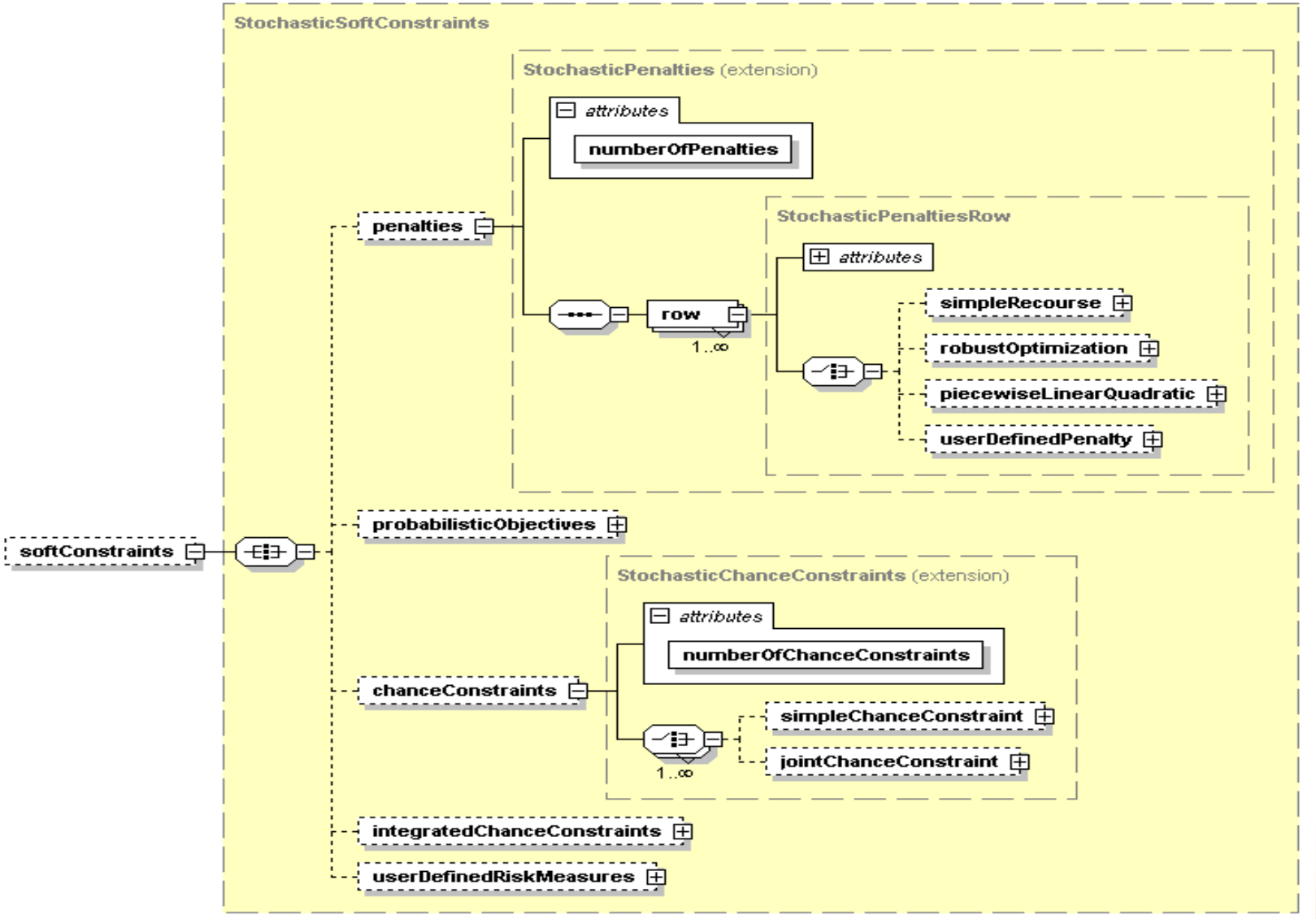
Penalties and probabilistic constraints



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Concluding remarks

- Unifying framework for instance alterations
  - Synergies and avoiding redundancies
  - Stochastic programming:
    - Instance compression (explicit DE – scanarios 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

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How to get OS

- Download
  - Binaries
    - http://www.coin-or.org/download/binary/OS
      - OS-2.1.1-win32-msvc9.zip
      - OS-2.3.0-linux-x86_64-gcc4.3.2.tgz
  - Stable source
    - 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
  - https://projects.coin-or.org/OS
  - Horand.Gassmann@dal.ca

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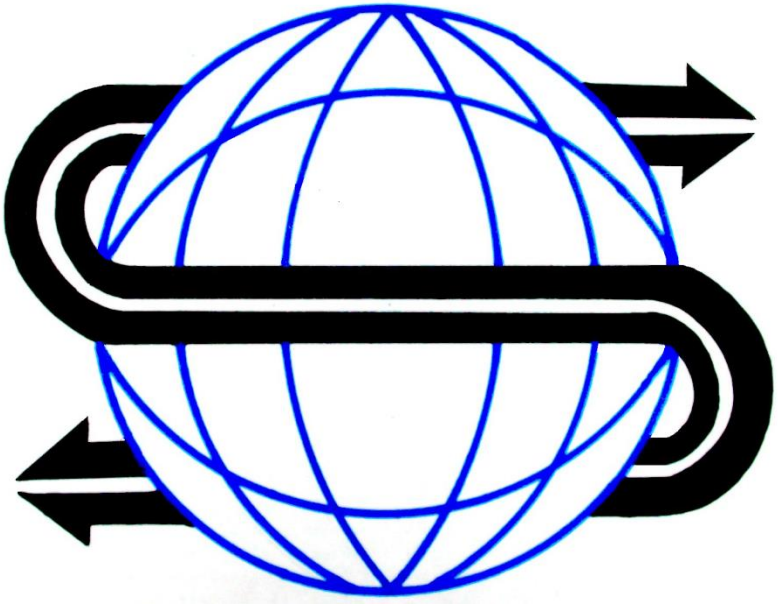
QUESTIONS?



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