The Distributions Package

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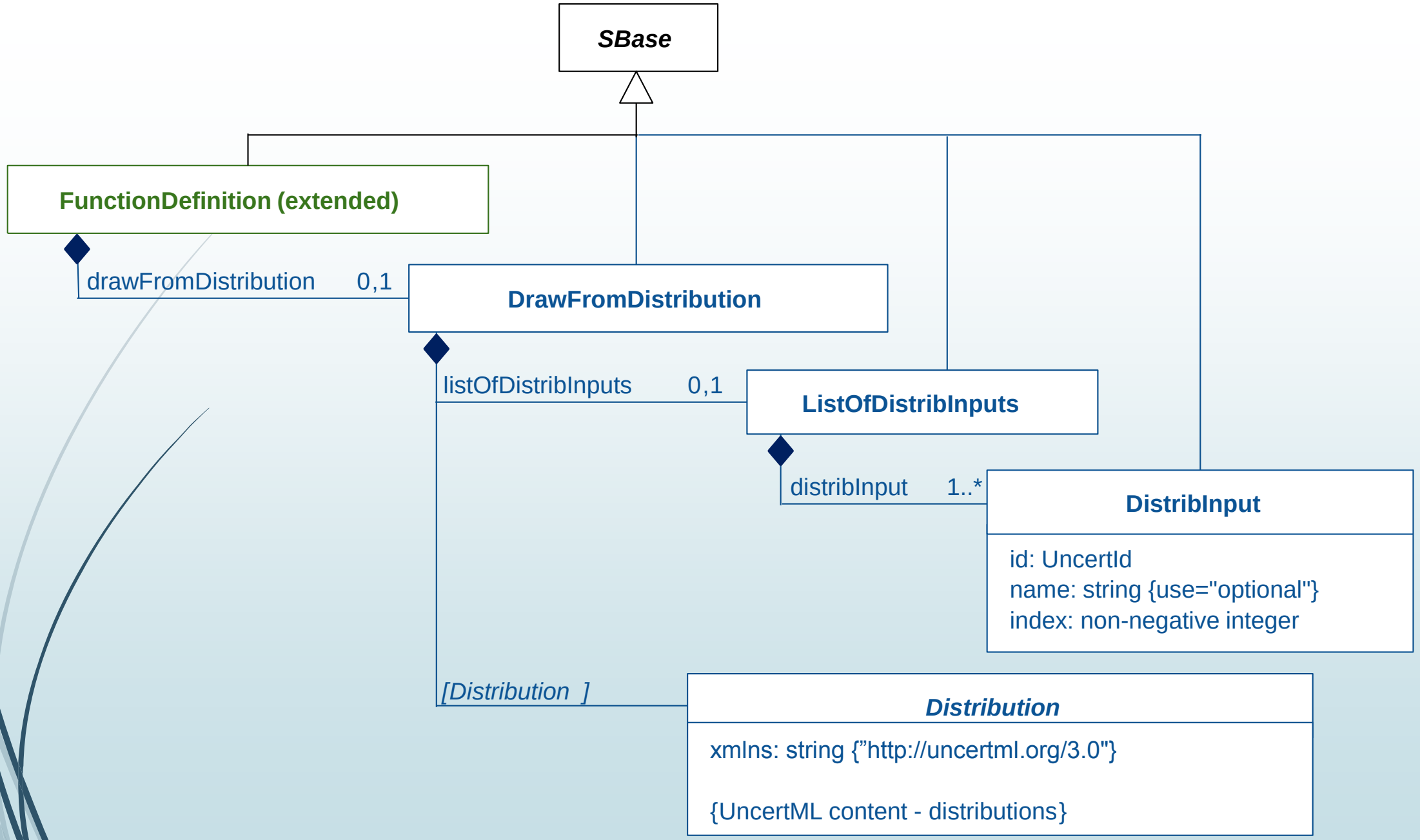
The basic idea: extended function definitions

- Extended FunctionDefinition:
  - UncertML-defined distribution.
  - 'DistribInputs' mimic 'bvars'
- Extend elements with mathematical meaning
  - 'Uncertainty' child defines distribution


SBase
FunctionDefinition (extended)
drawFromDistribution
0,1
DrawFromDistribution
listOfDistribInputs
0,1
ListOfDistribInputs
distribInput
1..*
DistribInput
id: UncertId
name: string {use="optional"}
index: non-negative integer
[Distribution]
Distribution
xmlns: string {”http://uncertml.org/3.0"}
{UncertML content - distributions}

Example

```
<functionDefinition id="normal">
    <math xmlns="http://www.w3.org/1998/Math/MathML">
      <!-- Overridden MathML -->
    </math>
    <drawFromDistribution xmlns="http://www.sbml.org/sbml/level3/version1/distrib/version1">
      <listOfDistribInputs>
        <distribInput id="avg" index="0"/>
        <distribInput id="var" index="1"/>
      </listOfDistribInputs>
      <NormalDistribution xmlns="http://uncertml.org/3.0">
        <mean> avg </mean>
        <variance> var </variance>
      </NormalDistribution>
    </drawFromDistribution>
  </functionDefinition>
```

Removed from HARMONY version:

- Explicit PDFs (mathML)
- Explicit PMFs (rolled into uncertML)

Using extended functions

- In MathML
  - Discrete contexts: single draws from distribution (initial assignments, event assignments, priorities, delays)
  - Continuous contexts: undefined (rules, event triggers)
    - Could be extended in the future by distrib or by another package.
- To annotate elements
  - Error
  - Distributions from which they are drawn

Discrete example

```
<listOfInitialAssignments>
  <initialAssignment symbol="y">
    <math xmlns="http://www.w3.org/1998/Math/MathML">
      <apply>
        <ci> normal </ci>
        <ci> z </ci>
        <cn> 10 </cn>
      </apply>
    </math>
  </initialAssignment>
</listOfInitialAssignments>
```

Continuous example

```
<listOfRules>
   <rateRule variable="y">
     <math xmlns="http://www.w3.org/1998/Math/MathML">
       <apply>
         <ci> normal </ci>
         <ci> z </ci>
         <cn> 10 </cn>
       </apply>
     </math>
   </rateRule>
 </listOfRules>
```

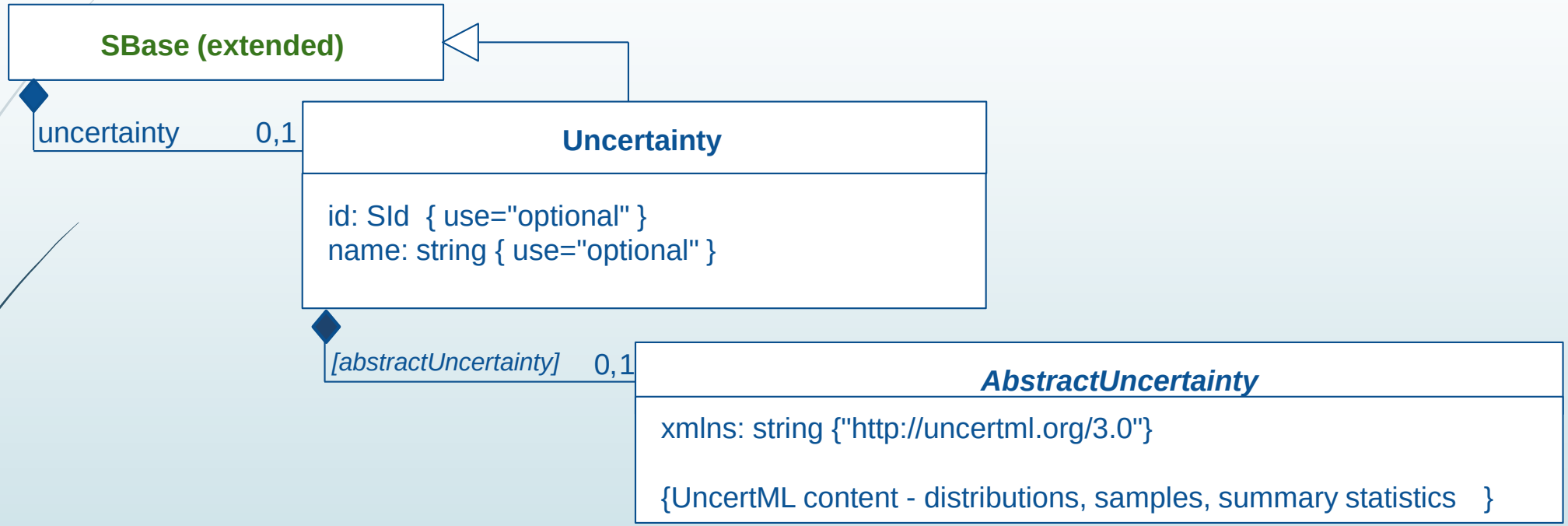
Continuous example: future?

```
<listOfRules>
   <rateRule variable="y">
     <math xmlns="http://www.w3.org/1998/Math/MathML">
       <apply>
         <ci> normal </ci>
         <ci> z </ci>
         <cn> 10 </cn>
         <ci> autocorrelation </ci>
       </apply>
     </math>
   </rateRule>
 </listOfRules>
```

Annotation

- Reference summary statistics or distributions, etc. through UncertML

Annotation


SBase (extended)
uncertainty
0,1
Uncertainty
id: SId { use="optional" }
name: string { use="optional" }
[abstractUncertainty]
0,1
AbstractUncertainty
xmlns: string {"http://uncertml.org/3.0"}
{UncertML content - distributions, samples, summary statistics }

Annotation example: uncertml

```
<species id="x" compartment="C" boundaryCondition="false"
         initialConcentration="3.22"
         hasOnlySubstanceUnits="false" constant="false">
  <distrib:uncertainty>
    <StatisticsCollection xmlns="http://uncertml.org/3.0">
      <NormalDistribution>
        <mean> 3.2 </mean>
        <variance> 0.09 </variance>
      </NormalDistribution>
      <StandardDeviation>
        <values> 0.3 </values>
      </StandardDeviation>
    </StatisticsCollection>
  </distrib:uncertainty>
</species>
```