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Parameter Description Language: describing parameters (and their constraints) within the Virtual Observatory

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- Our needs comes from the requirements of Theory Group: they would like to deploy online codes with complex sets of in(out)put data making them **interoperable with databases** (Sim-DB, spectra, images,...).

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- Finely describe the set of parameters (**inputs** & **outputs**) of a given service (in the largest informatics sense) in a way that
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Input:

- $\boldsymbol{p}_1$ is a m/s vector speed and $\|\boldsymbol{p}_1\| < c$
- p_2 is a Kelvin temperature and $p_2 > 0$
- p_3 is a kg mass and $p_3 \geq 0$

Output:

- p_4 is a Joule Energy and $p_4 \geq 0$

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Input:

- $\mathbb{R} \ni p_1 > 0$; $p_2 \in \mathbb{N}$; $p_3 \in \mathbb{R}$
- if $p_1 \in]0, \pi/2]$ then
  $p_2 \in \{2; 4; 6\}$, $p_3 \in [-1, +1]$ and $(|\sin(p_1)^{p_2} - p_3|)^{1/2} < 3/2$.
- if $p_1 \in]\pi/2, \pi]$ then
  $0 < p_2 < 10$, $p_3 > \log(p_2)$ and $(p_1 \cdot p_2)$ must belong to $\mathbb{N}$.

Output:

- $\boldsymbol{p}_4, \boldsymbol{p}_5 \in \mathbb{R}^3$
- Always $\frac{\|\boldsymbol{p}_5\|}{\|\boldsymbol{p}_4\|} \leq 0.01$.

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Our ideas lead to a working solution fitting our requirements.

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- The grammar and syntax for building parameters description are fixed in a XML schema:

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  - Service providers (unless they want) don't need to handle directly the XSD file

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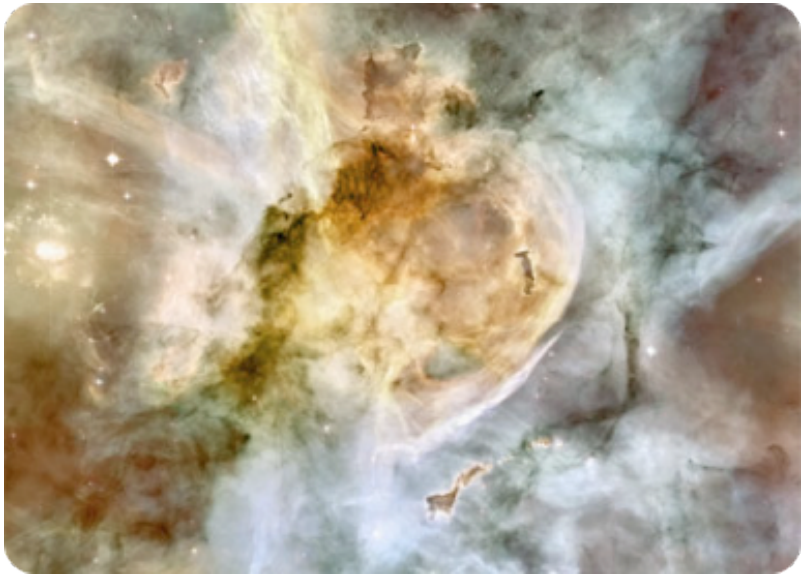
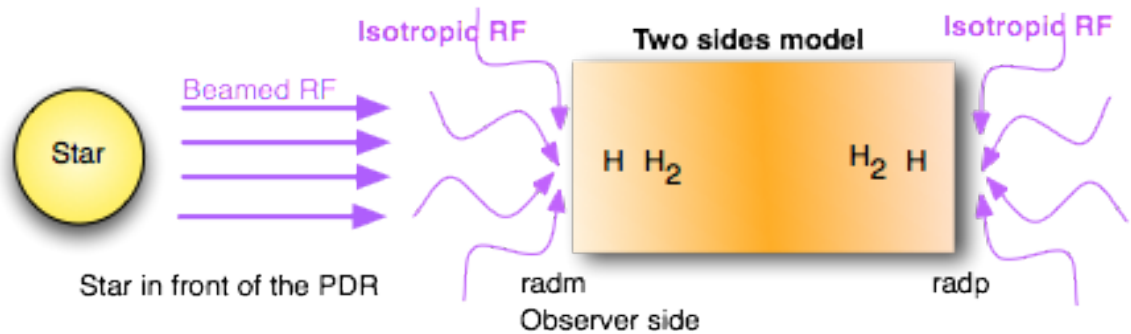
  - With our protocol, one could easy express
    - All the possible mathematical expressions involving parameters
    - All the possible conditional sentences (provided they have a logical sense)
  - All the following examples are automatically generated from Java code using the JaxB Api.

A working example : the PDR code

- Code modeling the micro-physics of interstellar clouds (used to interpret HERSCHEL observations)

- Already Implemented in Astrogrid (CEA) in 2007.





- Incident radiation field
- observer and back side
- ISRF intensity
- Type of stellar spectrum
- distance of the star
- ...

- State equation
- isochore (density)
- isobare (pressure)
- specific user density profile
- ...

- Grains properties
- R min and max
- Extinction properties
- ...

Non trivial relationships between parameters

```xml
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<UWS_Service xmlns="http://www.ivoa.net/xml/Parameter/v0.1"
      xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
      xsi:schemaLocation="http://www.ivoa.net/xml/Parameter/v0.1 UWS2-
V1.1.xsd">
      <ServiceId>PDR_ONLINE</ServiceId>
      <serviceName>PDR-1D</serviceName>
      <Description>Description layer of the PDR code</Description>
      <ParameterList>
            <parameter>
                  <Name>F_ISRF</Name>
                  <ParameterType>integer</ParameterType>
                  <Unit>None</Unit>
                  <Precision>0</Precision>
            </parameter>
            <parameter>
                  <Name>radm</Name>
                  <ParameterType>real</ParameterType>
            </parameter>
            <parameter>
                  <Name>radp</Name>
                  <ParameterType>real</ParameterType>
            </parameter>
            <parameter>
                  <Name>d_sour</Name>
                  <ParameterType>real</ParameterType>
            </parameter>
            <parameter>
                  <Name>srcpp</Name>
                  <ParameterType>string</ParameterType>
            </parameter>
            <parameter>
                  <Name>srcpp_spectrum</Name>
                  <ParameterType>Spectrum</ParameterType>
            </parameter>
             ...
```

Parameter list

```xml
<ParameterGroup>
    <Name>RadiationFieldAndGeometry</Name>
    <parameterRef parameterName="F_ISRF" />
    <parameterRef parameterName="radm" />
    <parameterRef parameterName="radp" />
    <parameterRef parameterName="d_sour" />
    <parameterRef parameterName="srcpp" />
    <parameterRef parameterName="srcpp_spectrum" />
</ParameterGroup>
```

Parameter groups

```xml
<conditionalStatement xsi:type="IfThenConditionalStatement">
    <if>
        <Criterion xsi:type="Criterion">
            <expression xsi:type="AtomicParameterExpression">
                <parameterRef parameterName="d_sour" />
            </expression>
            <conditionType xsi:type="ValueDifferentOf">
                <Value>0</Value>
            </conditionType>
            <logicalConnector xsi:type="and">
                <criterion xsi:type="Criterion">
                    <expression xsi:type="AtomicParameterExpression">
                        <parameterRef parameterName="srcpp" />
                    </expression>
                    <conditionType xsi:type="BelongToSet">
                        <Value>spectro1</Value>
                        <Value>spectro2</Value>
                        <Value>spectroN</Value>
                    </conditionType>
                </criterion>
            </logicalConnector>
        </Criterion>
    </if>
    <then>
        <Criterion xsi:type="Criterion">
            <expression xsi:type="AtomicParameterExpression">
                <parameterRef parameterName="srcpp_spectrum" />
            </expression>
            <conditionType xsi:type="IsNull" />
        </Criterion>
    </then>
</conditionalStatement>
```

Constraints

About the interoperability

Let

- S_1 and S_2 be two services.
- $p^j(S_i)$ be the jth parameter of S_i.
- $\mathcal{I}(S_i)$ (resp. $\mathcal{O}(S_i)$) be the set of input (resp. output) parameters of S_i.
- $\mathcal{C}^{p^j}_{\mathcal{I}(S_i)}$ (resp. $\mathcal{C}^{p^j}_{\mathcal{O}(S_i)}$) the set of all constraints on $\mathcal{I}(S_i)$ (resp. $\mathcal{O}(S_i)$) involving p^j.

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S_2 could follow S_1 into a workflow iff $\forall p^k(S_2) \in \mathcal{I}(S_2)\, \exists\, p^l(S_1) \in \mathcal{O}(S_1)$ such that:

- $p^k(S_2) = p^l(S_1)$
- $p^l(S_1)$ satisfies $\mathcal{C}^{p^l}_{\mathcal{O}(S_1)} \implies p^k(S_2)$ satisfies $\mathcal{C}^{p^k}_{\mathcal{I}(S_2)}$

- The equality is in the sense that parameters have same
  - UCDs
  - UTypes
  - SkossConcepts
  - Units

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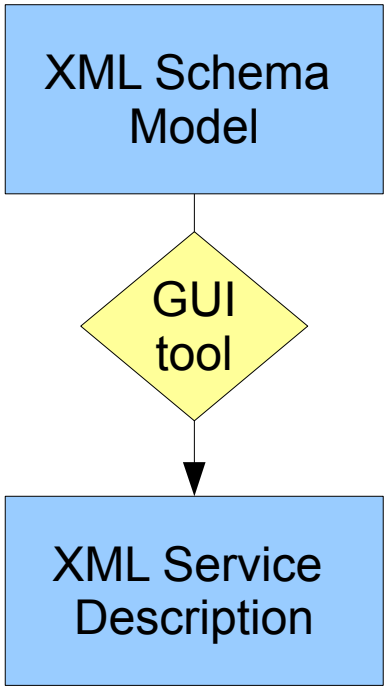
- If the difference is on units, the services are still **compatibles**: we can build a third service performing the unit change, making interoperability possible.

Sketch of the integral solution



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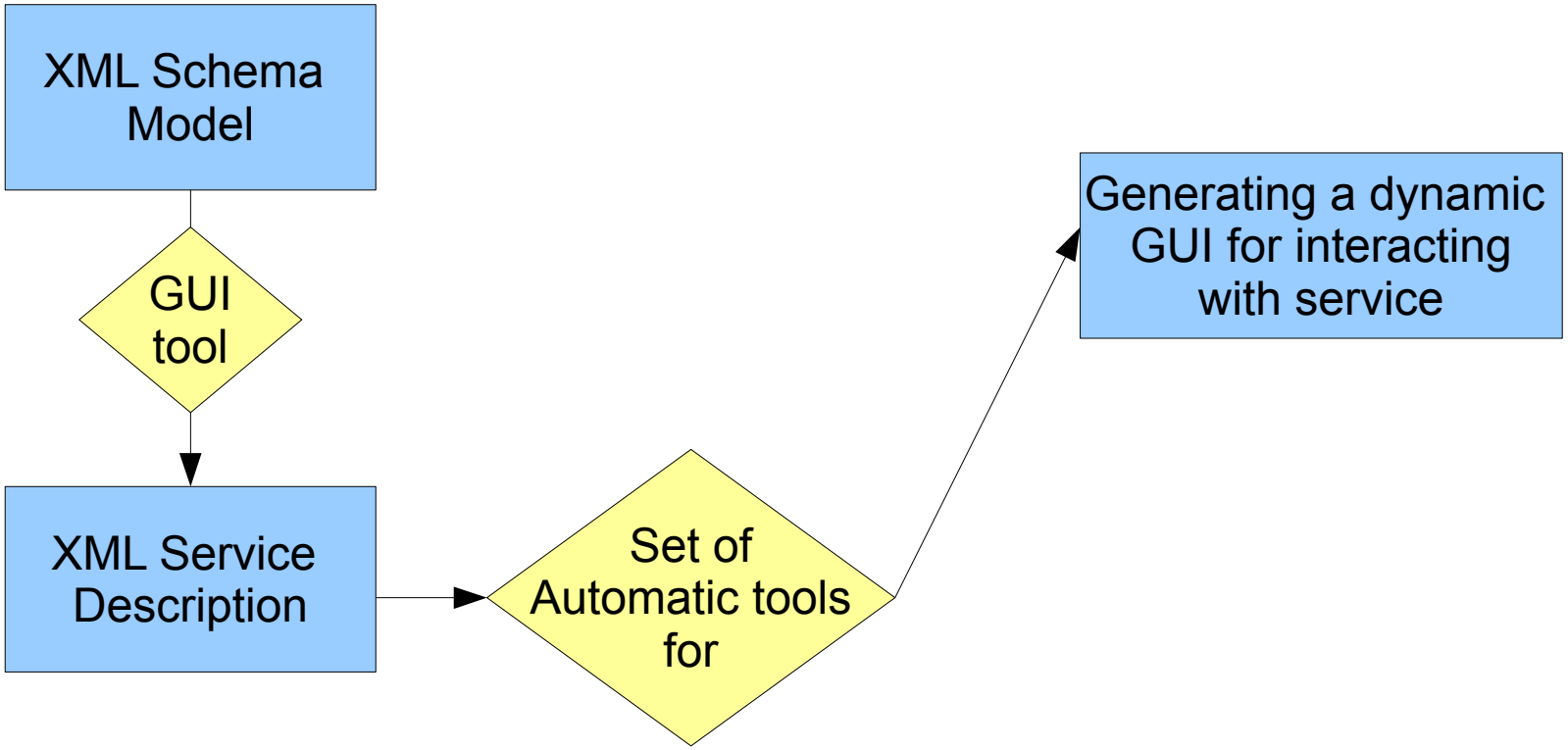

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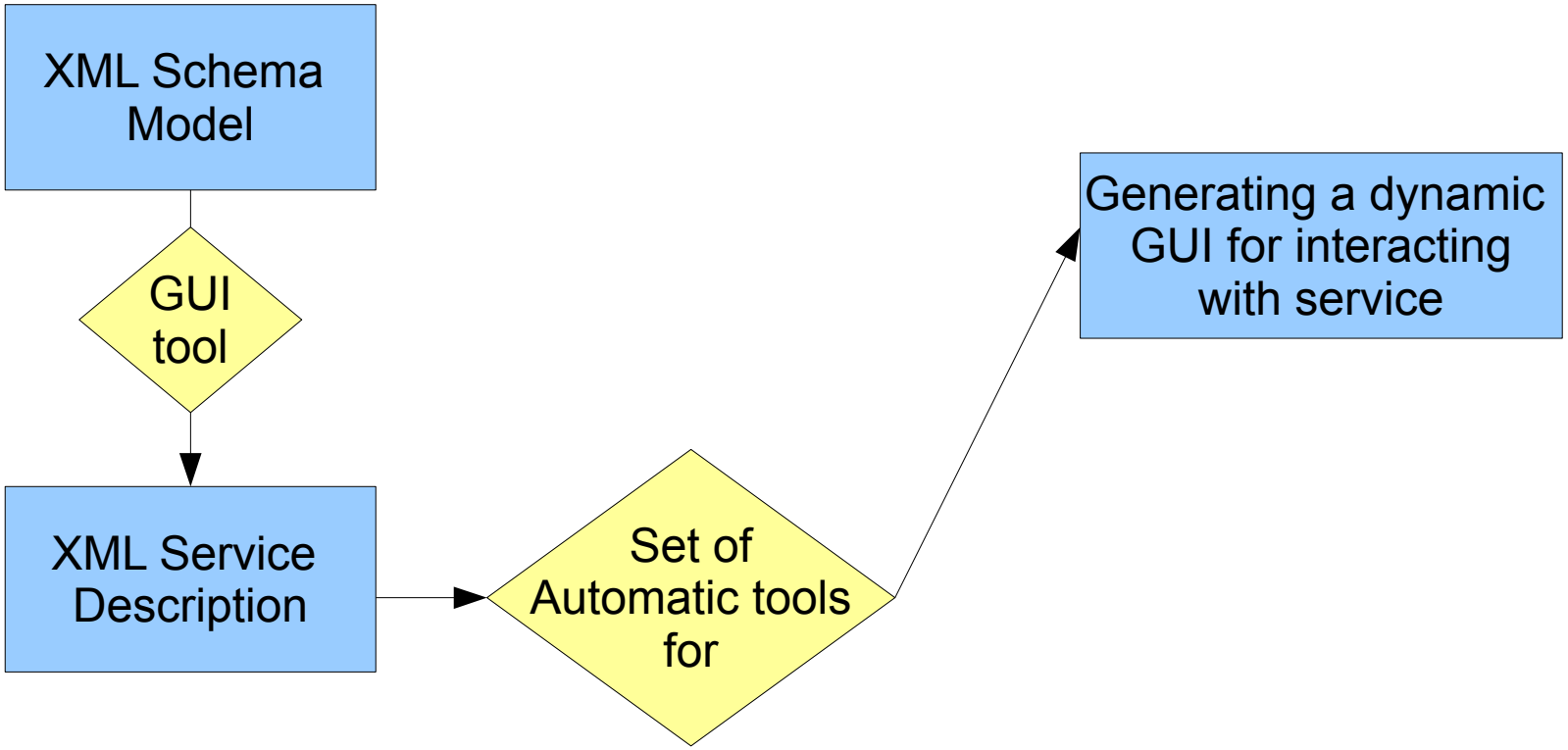

Service description:

- $p_1 \in \mathbb{R}$, $p_2 \in \mathbb{N}$ and p_3 is boolean.
- if $p_1 > 0 \implies p_2 \in \{2; 4; 6\}$ and p_3 must be false.
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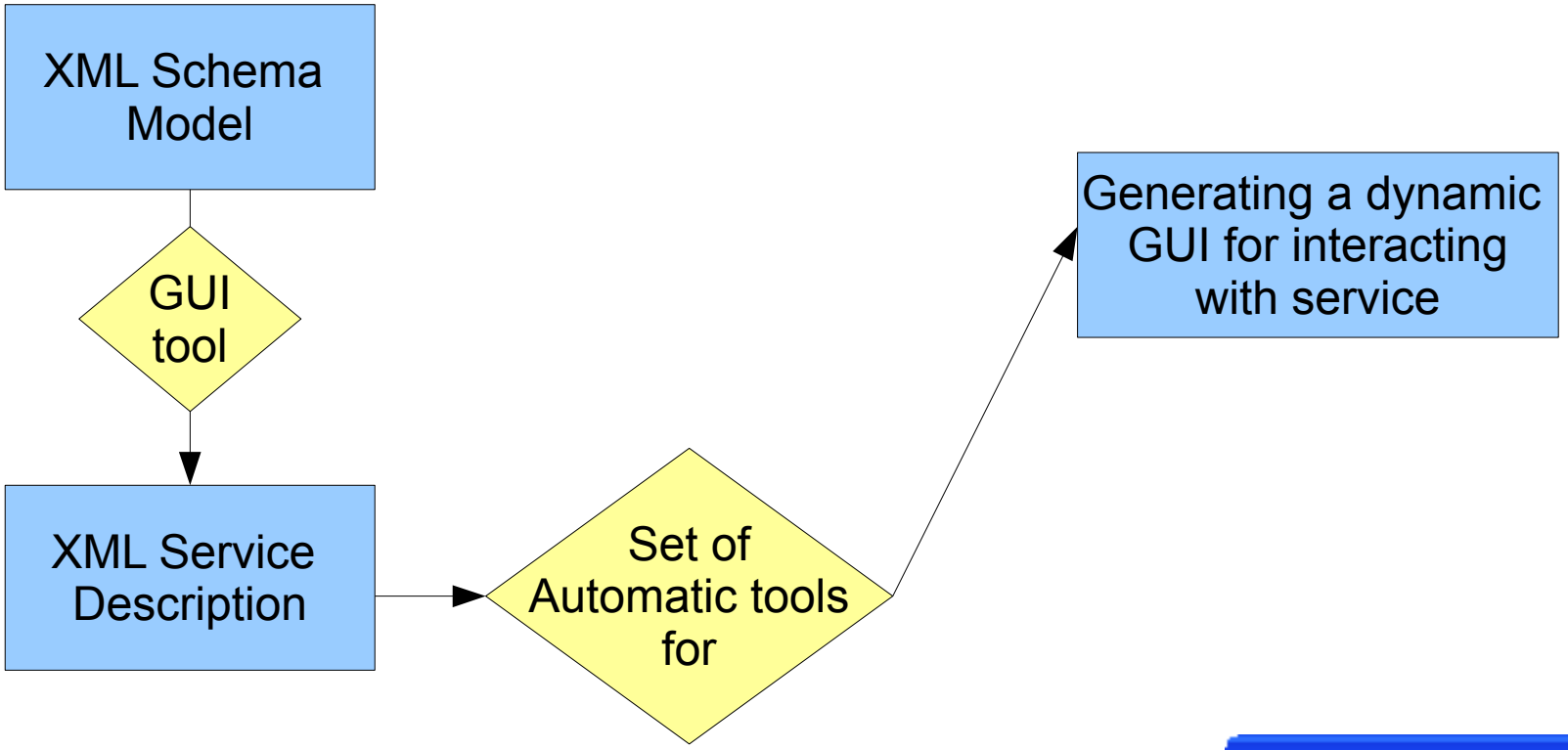

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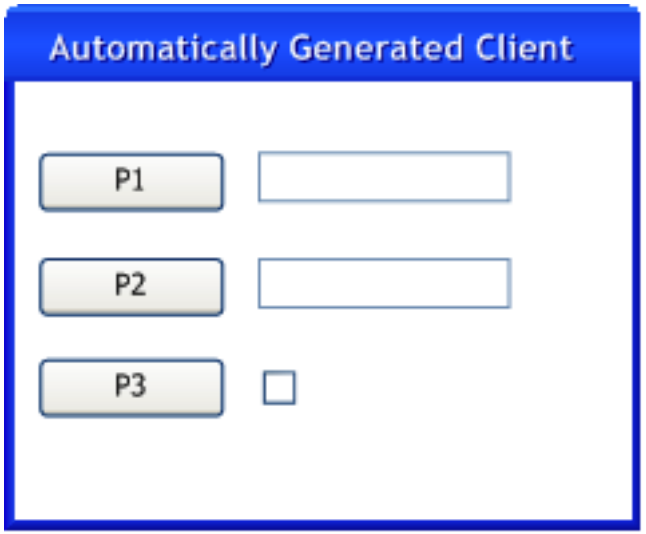

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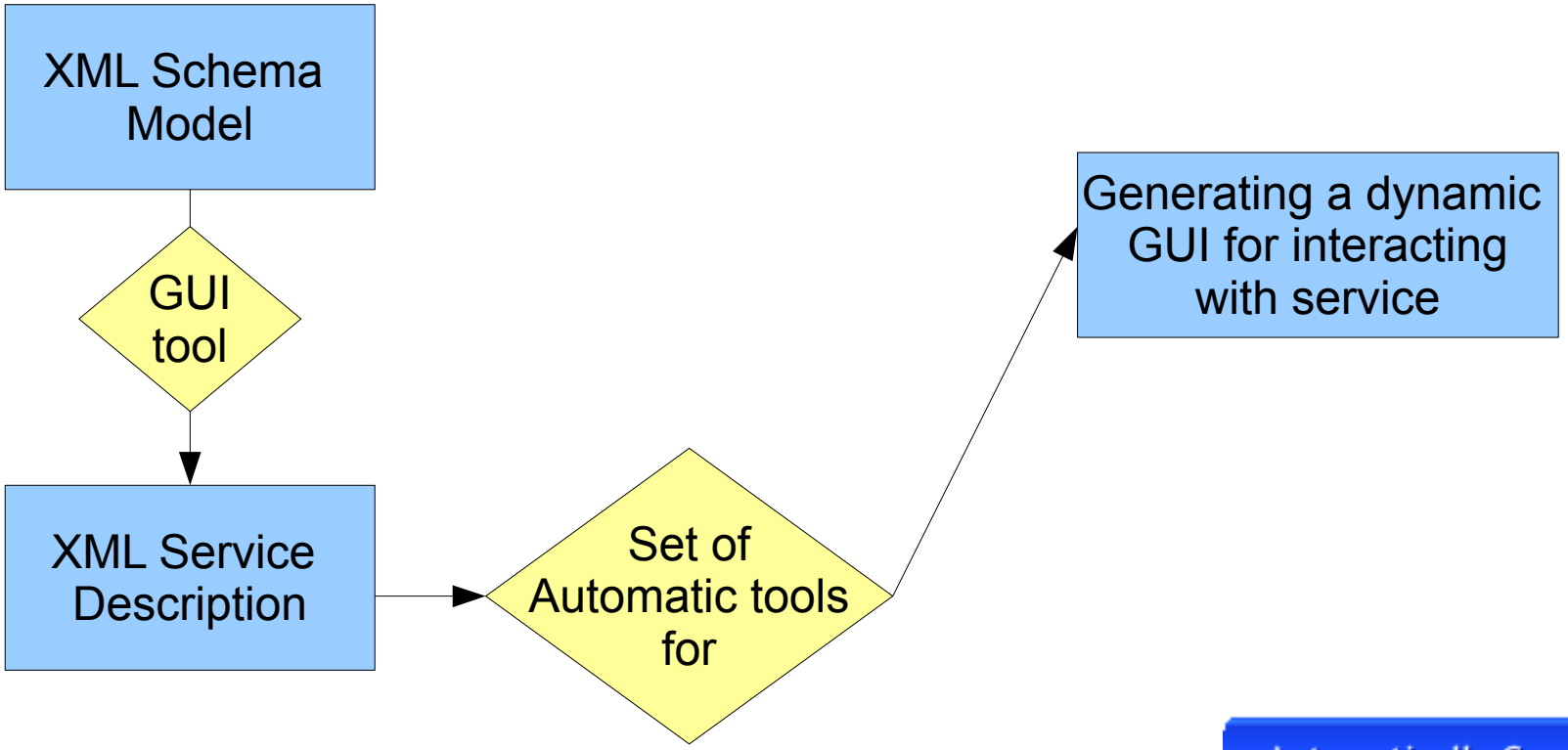

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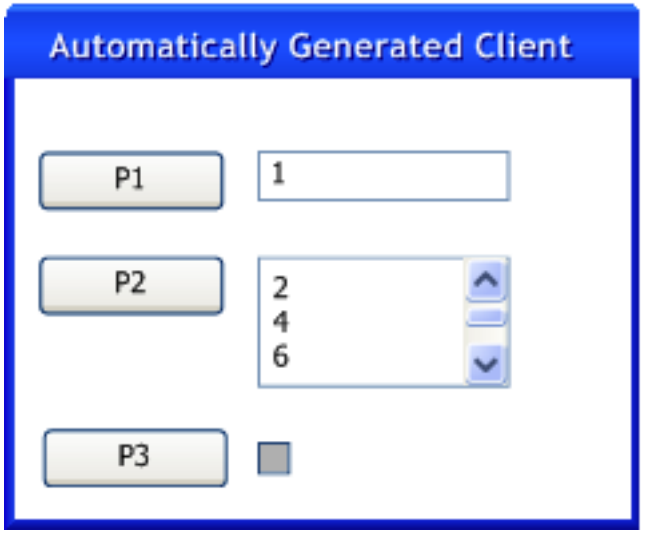

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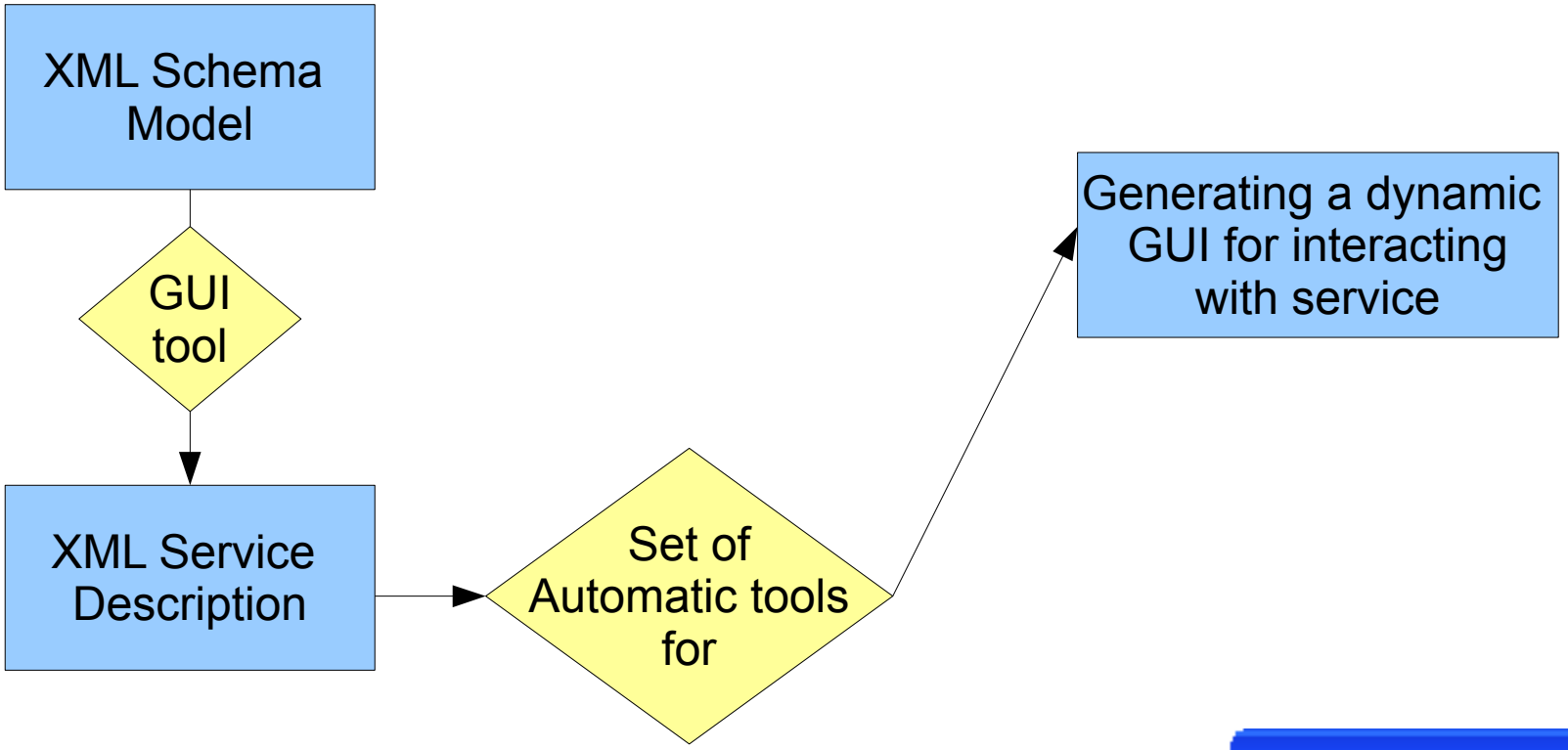

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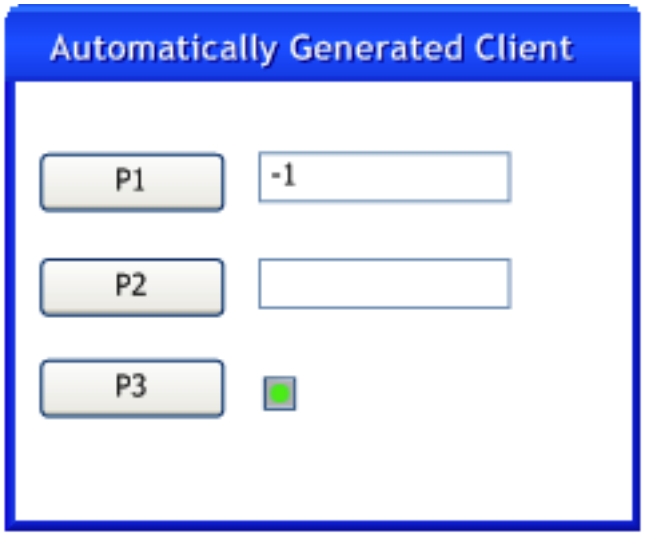

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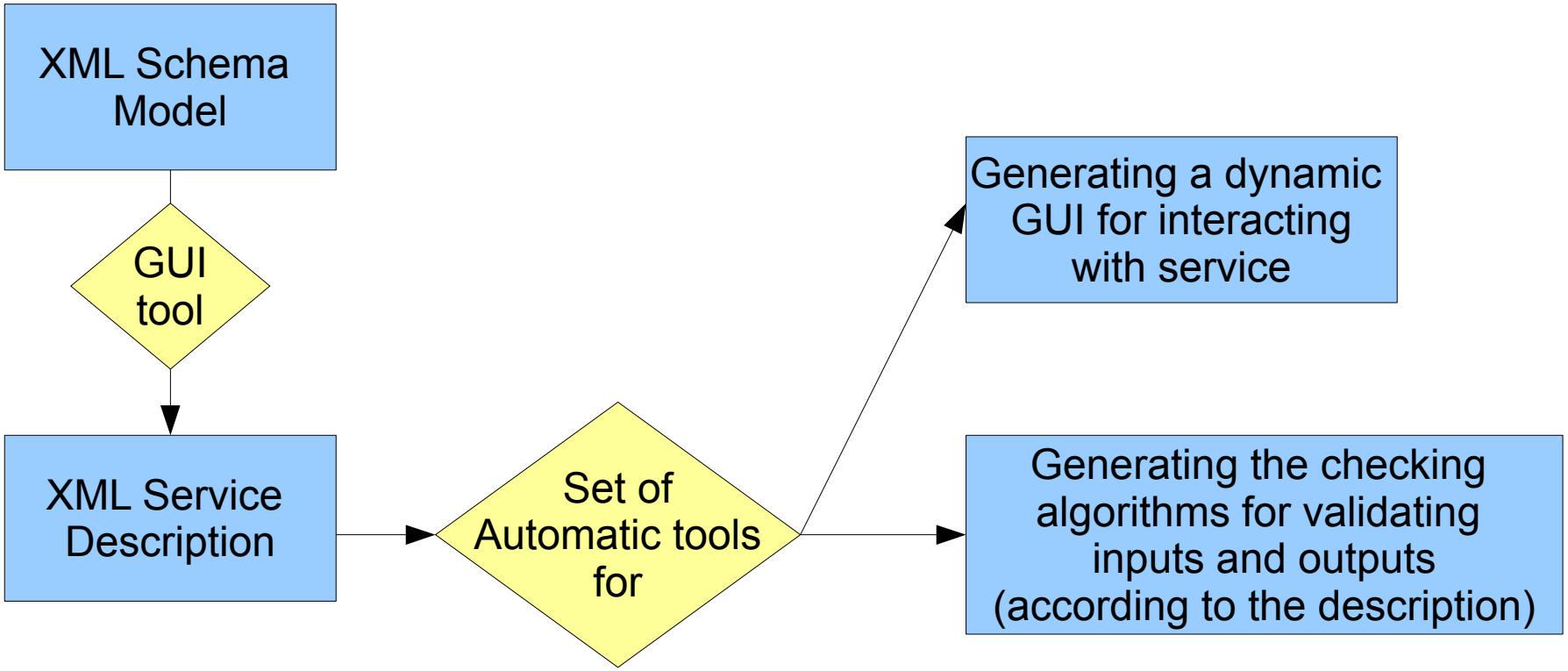

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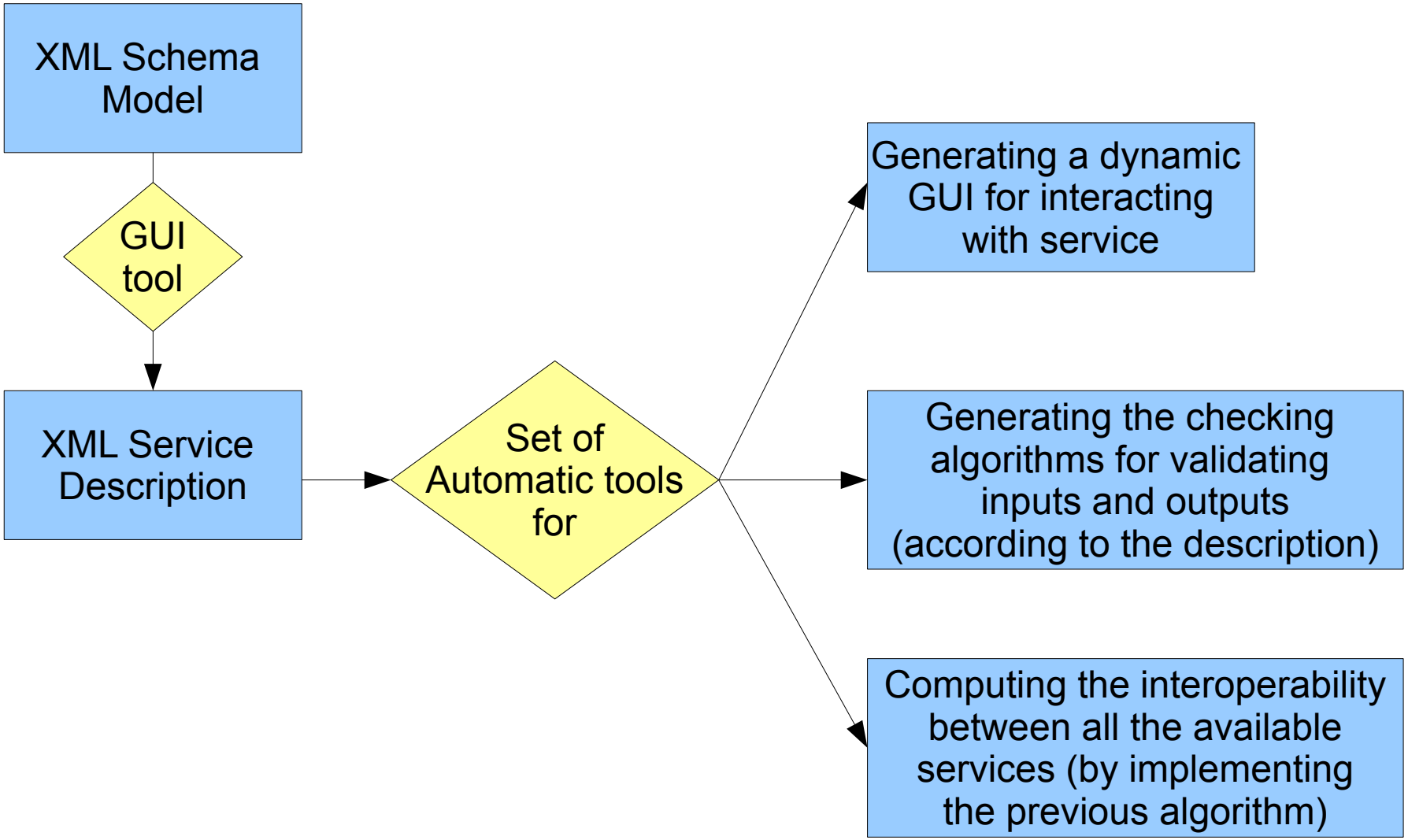

Concluding remarks

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- Users can easily describe parameters and overall their constraints in a **unified way**
- Descriptions are human readable and could be understood by computers.

Interoperability graphs connecting services can be computed *a priori* automatically

It is a consistent step towards a real and integrated interoperability in the VO.

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