# InPUT:
## The Intelligent Parameter Utilization Tool

Felix Dobslaw

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```
PopSize=100
Elite=2
Selection=Tournament
Mutation=Flip
Crossover=SinglePoint
Termininination=1000
...
```

## Restrictions

- structural parameters (algorithm design)
  - definition
  - implementation
- values
  - validation
  - adding

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| Option 1 | Option 2 |
|---|---|
| Selection=Roulette<br>TournamentSize=NA | Selection=Tournament(2) |

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## Restrictions

- structural parameters (algorithm design)
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**Option 1:**

```
selection = prop.get("Selection")

if(selection == "Tournament")
   tournamentSize = prop.get("TournamentSize")
...
else if(selection == "Roulette")
...
else if(selection == "Rank")
```

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## Restrictions

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**Option 2:**

- Does the choice string for *Selection* start with `"Tournament"`?
  - If yes, parse string, and extract value(s).

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## Restrictions

- structural parameters (algorithm design)
  - definition
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  - validation
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**Option 2:**

- Does the choice string for *Selection* start with `"Tournament"`?
  - If yes, parse string, and extract value(s).

In both cases:
. . . redefine and implement for each parameter.

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## Restrictions

- structural parameters (algorithm design)
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```
Selection=Tournametn
PopSize=-1
```

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## Restrictions

- structural parameters (algorithm design)
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  - adding

```
Selection=Tournametn
PopSize=-1
```

No validation at configuration time.
Could be added programatically, for each parameter.

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## Restrictions

- structural parameters (algorithm design)
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```
Selection=Boltzman
```

Adding a value (choice) requires a recompile.
Has to be added programatically, for each parameter.

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# Configuration Criteria

# Configuration Criteria

1. Can parameters be defined using descriptors?
2. Is the format sufficiently general to be used outside EC?
3. Are user defined parameters supported?
4. Are hierarchical user defined parameters supported?
5. Does the format conform to modeling standards using XML (eXchangeable Modeling Language)?
6. Does the structure enforce a separation of concerns? For instance, a separation of problem and algorithm parameters.
7. Is the format compatible with any other framework?
8. Can parameter descriptors be checked for validity?
9. Does the framework impose a proprietary parameter model on the user?
10. Does the framework offer a *meta parameter*, a service component that encapsulates the programmatic parameter lookup and update?
11. Is the framework available for multiple languages?

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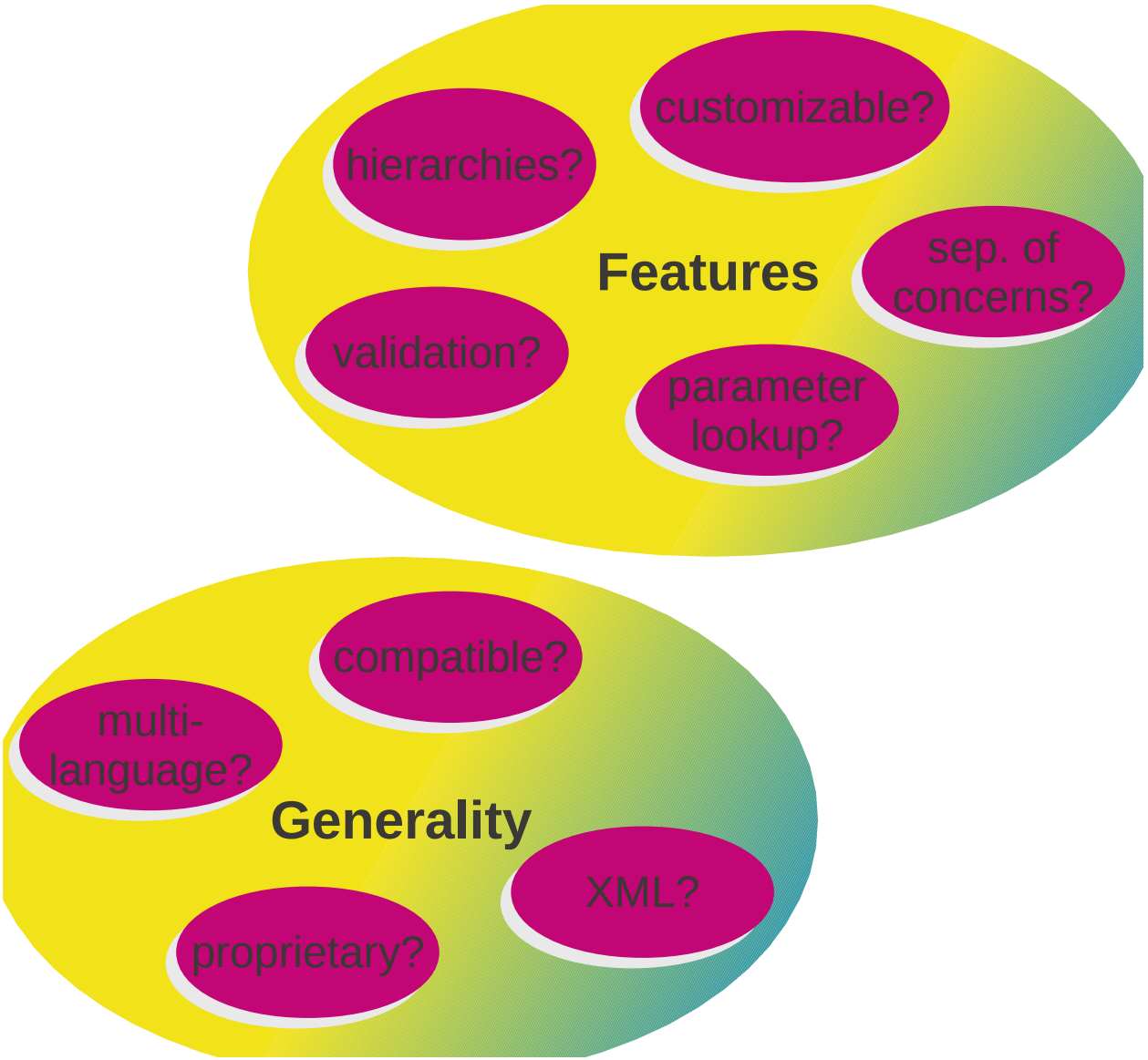
# Configuration Criteria

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# Configuration Criteria: Comparison

| | Criteria / Frameworks | Open Beagle | jMetal | ECJ | OPT4J | ParadisEO (EO) | JCLEC | PISA |
|---|---|---|---|---|---|---|---|---|
| 1 | input descriptors | √ | - | √ | √ | √ | √ | √ |
| 2 | usable outside EC | - | - | - | √/- | - | - | √ |
| 3 | user defined params | √ | - | √ | √/- | √ | √ | √ |
| 4 | hierarchical | √/- | - | - | - | - | - | - |
| 5 | XML | √ | - | - | √ | - | √ | - |
| 6 | sep. of concerns | - | - | - | - | - | - | √ |
| 7 | compatibility | - | - | - | - | - | - | - |
| 8 | validation | √ | - | - | - | - | - | - |
| 9 | implicit param model | - | - | - | √ | - | √ | √ |
| 10 | meta parameter | √ | √ | √ | - | √ | - | - |
| 11 | multi-language | - | √ | - | √ | - | - | √ |

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|---|---|---|---|---|---|---|---|---|
| 1 input descriptors | | √ | - | √ | √ | √ | √ | √ |
| 2 usable outside EC | | - | - | - | √/- | - | - | √ |
| 3 user defined params | | √ | - | √ | √/- | √ | √ | √ |
| 4 hierarchical | | √/- | - | - | - | - | - | - |
| 5 XML | | √ | - | - | √ | - | √ | - |
| 6 sep. of concerns | | - | - | - | - | - | - | √ |
| 7 compatibility | | - | - | - | - | - | - | - |
| 8 validation | | √ | - | - | - | - | - | - |
| 9 implicit param model | | - | - | - | √ | - | √ | √ |
| 10 meta parameter | | √ | √ | √ | - | √ | - | - |
| 11 multi-language | | - | √ | - | √ | - | - | √ |

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# Design Goals

1. *simple, generic, open*

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1. *simple, generic, open*
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   - programming language, framework
   - subject, problem

## Means End

*"Document and share your computer experiments"*

*"Configuration without recompilation"*

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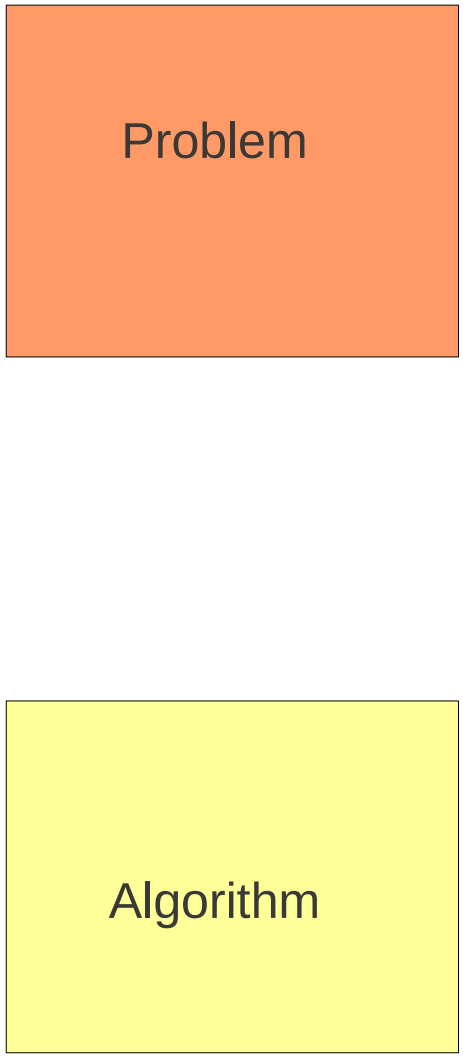


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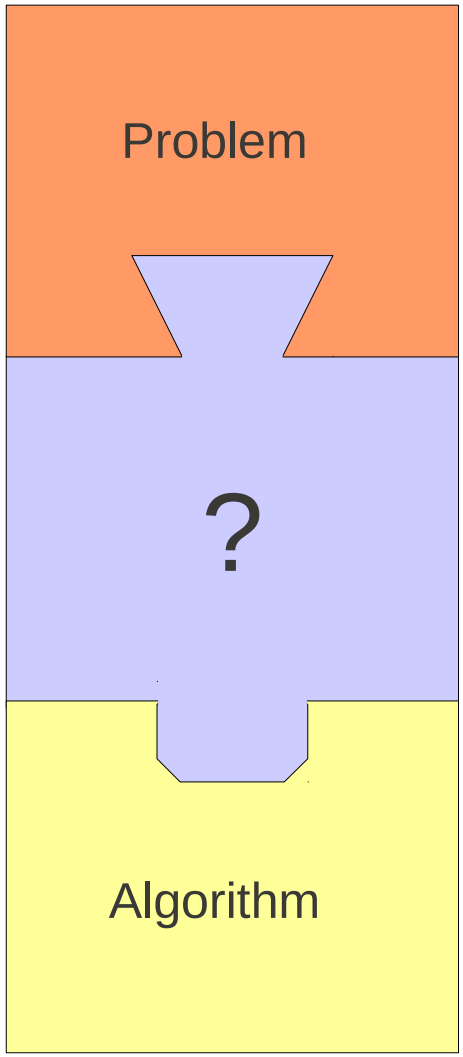
# Vision

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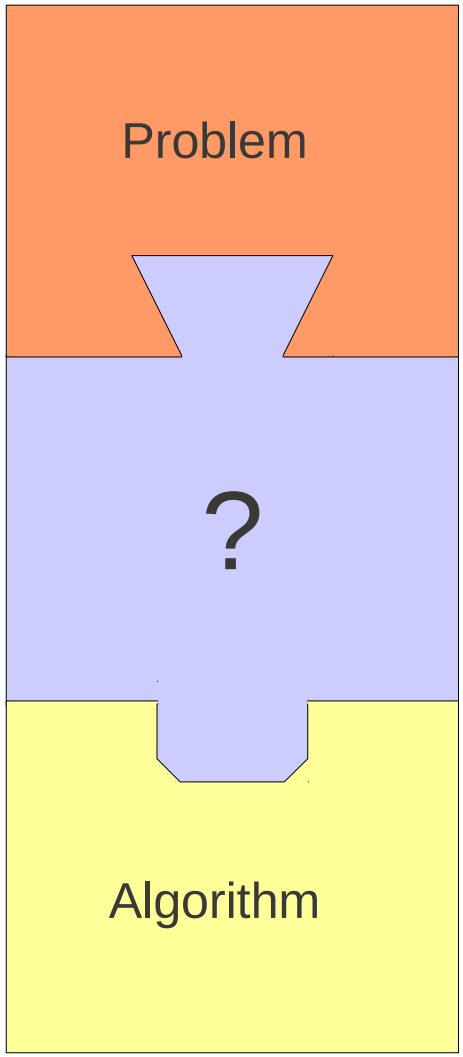


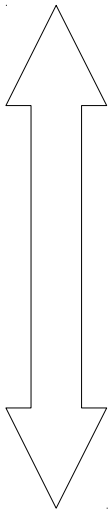

Implementation
Agnostic

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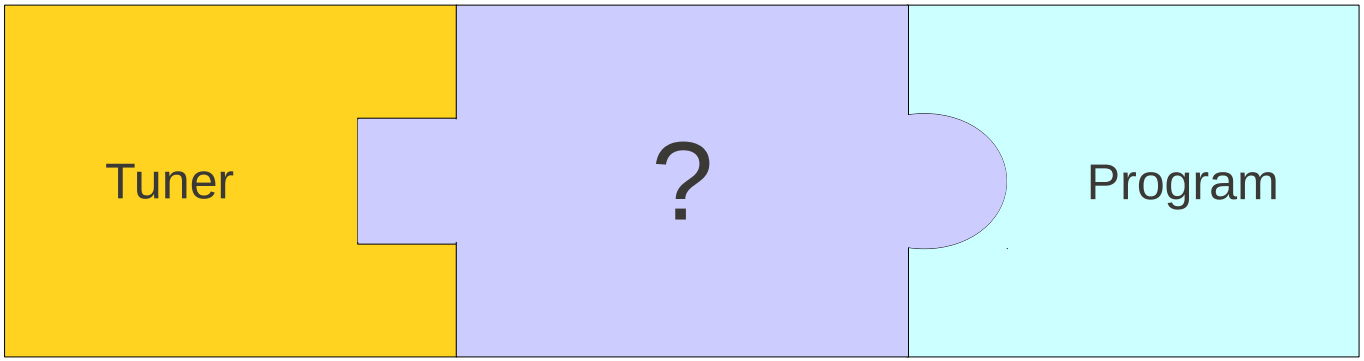


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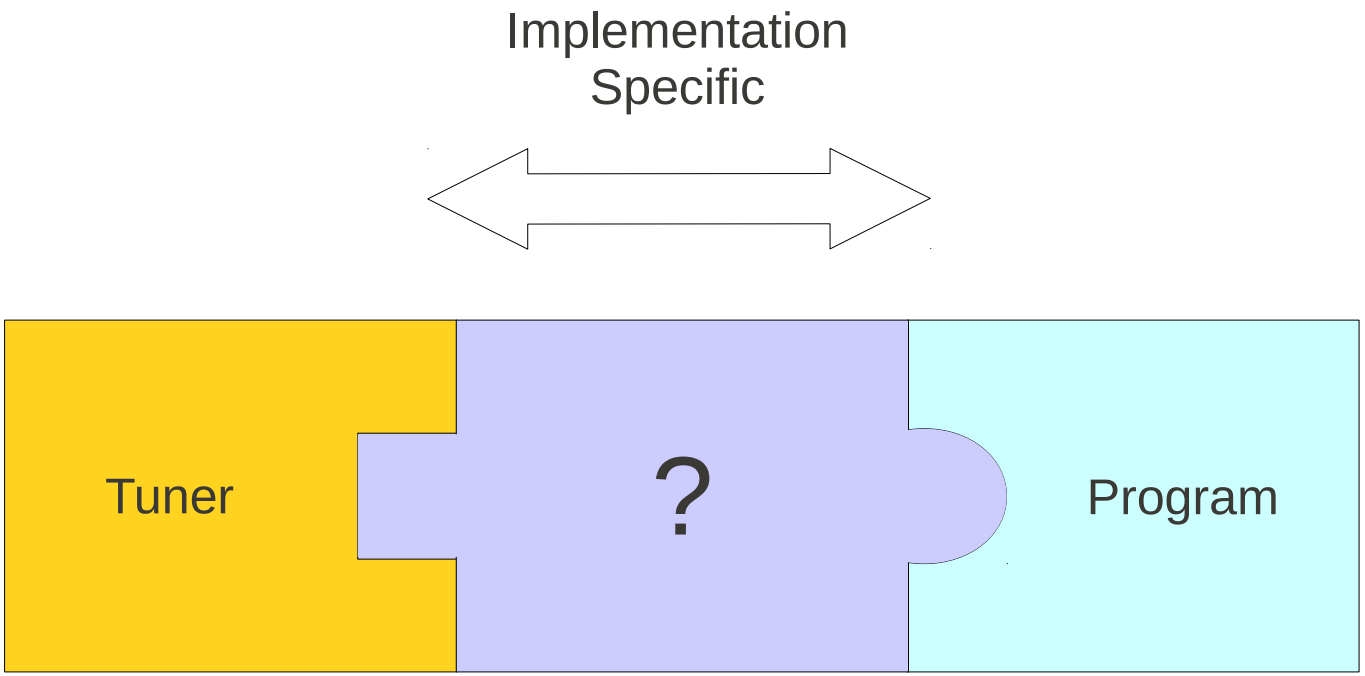


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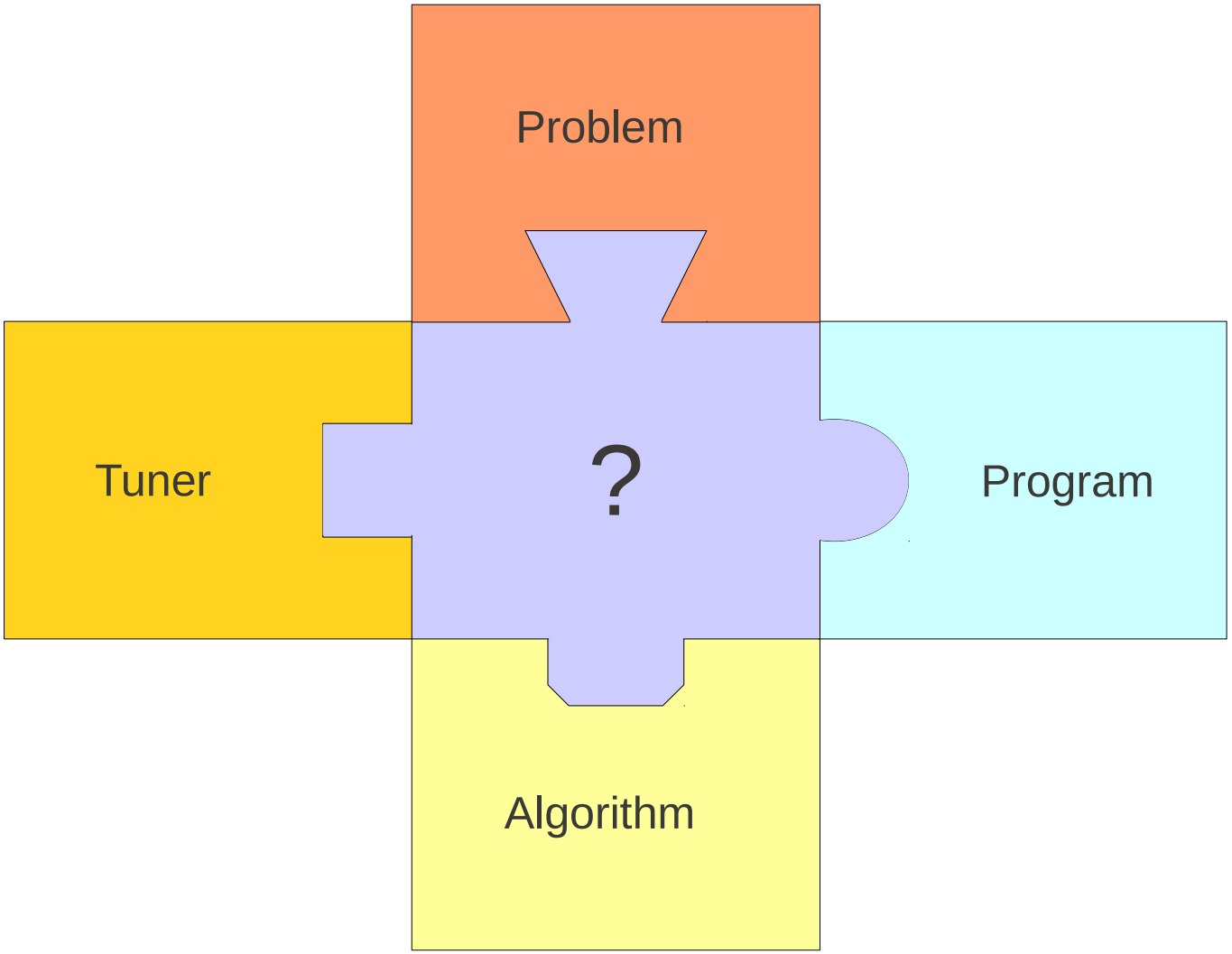


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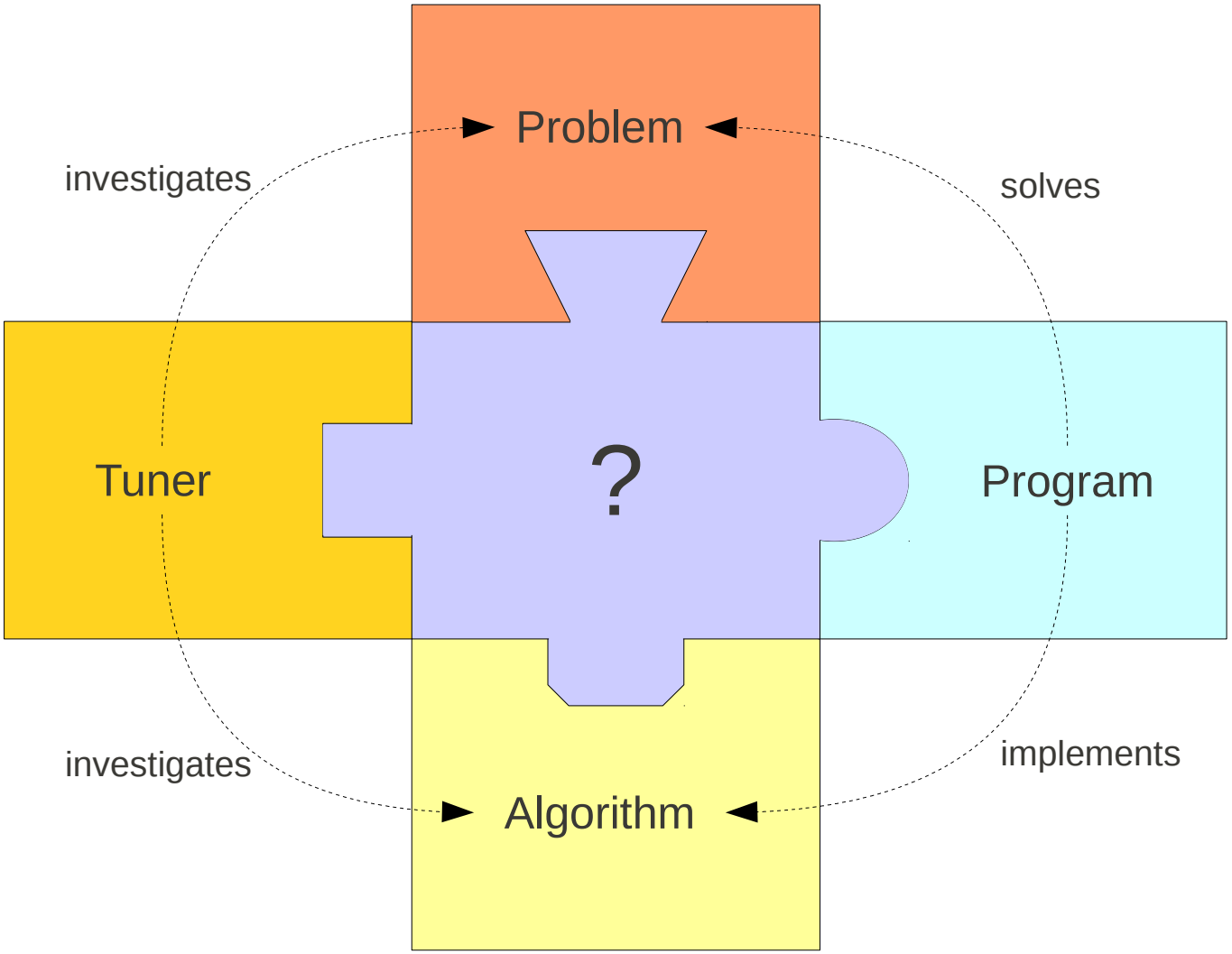


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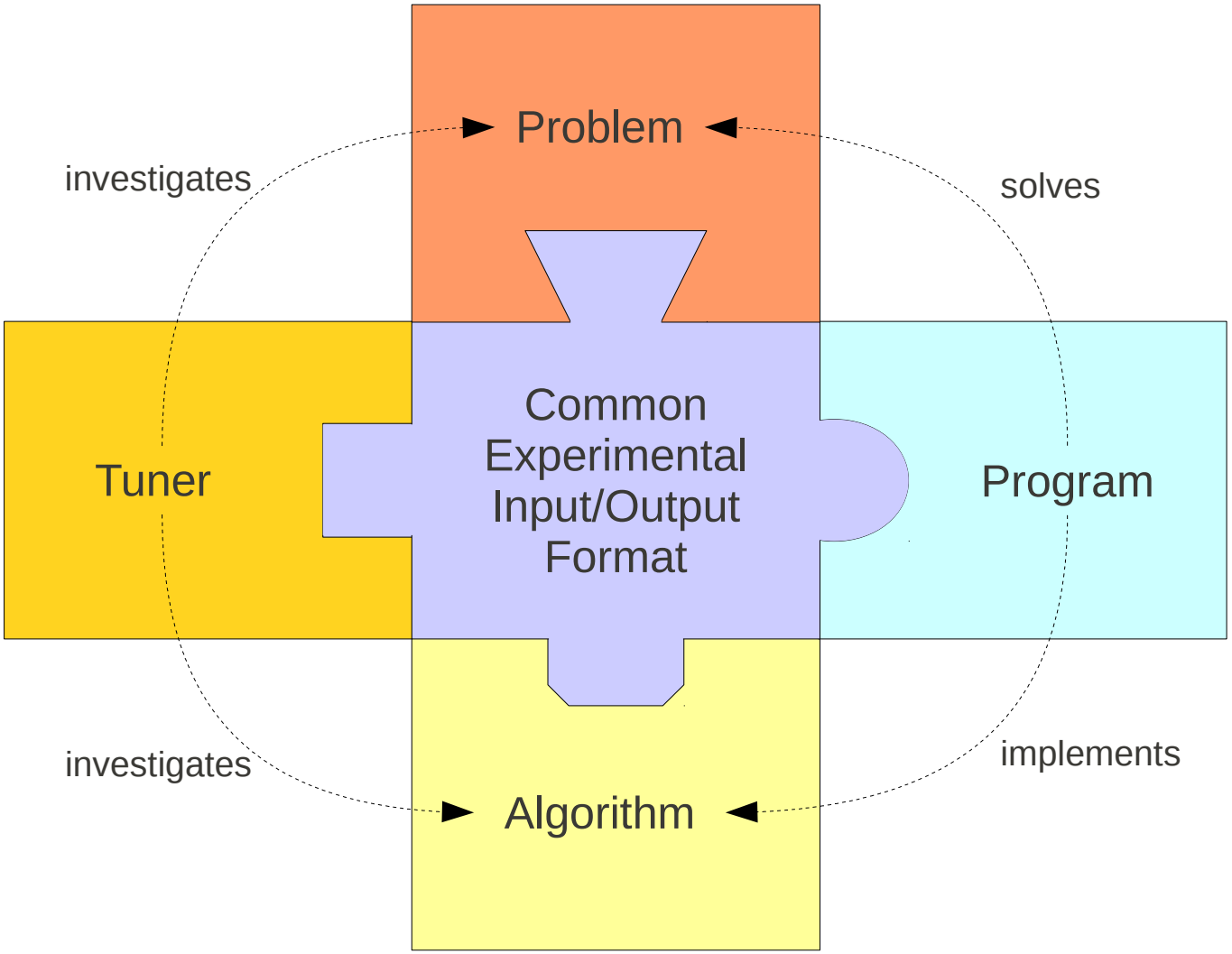


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## Descriptor Types

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1. parameter range (region of interest)

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```
<NParam id="PopSize"
  type="integer"
  inclMin="10"
  inclMax="100"/>
```

```
<SParam id="Selection">
  <SChoice id="Roulette"/>
  <SChoice id="Rank"/>
  ...
</SParam>
```

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## Descriptor Types

1. parameter range (region of interest)

```
<NParam id="PopSize"
  type="integer"
  inclMin="10"
  inclMax="100"/>
```

```
<SParam id="Selection">
  <SChoice id="Roulette"/>
  <SChoice id="Rank"/>
  ...
</SParam>
```

| Type | Range |
|---|---|
| `boolean` | $\{0, 1\}$ |
| `integer` | $\mathbb{Z} \cap [-2^{31}, 2^{31} - 1]$ |
| `short` | $\mathbb{Z} \cap [-2^{15}, 2^{15} - 1]$ |
| `long` | $\mathbb{Z} \cap [-2^{63}, 2^{63} - 1]$ |
| `float` | $\mathbb{R} \cap [0, 1]$ (32-bit `fp`) |
| `double` | $\mathbb{R} \cap [0, 1]$ (64-bit `fp`) |
| `decimal` | $\mathbb{R}$ |

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## Descriptor Types

2. parameter instance (observation, factor)

```
<NParam id="PopSize"
  type="integer"
  inclMin="10"
  inclMax="100"/>
```

```
<SParam id="Selection">
  <SChoice id="Roulette"/>
  <SChoice id="Rank"/>
  ...
</SParam>
```

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## Descriptor Types

2. parameter instance (observation, factor)

```
<NParam id="PopSize"
  type="integer"
  inclMin="10"
  inclMax="100"/>

⇑
<NValue id="PopSize"
value="13"/>
```

```
<SParam id="Selection">
  <SChoice id="Roulette"/>
  <SChoice id="Rank"/>
  ...
</SParam>
⇑
<SValue id="Selection"
value="Roulette"/>
```

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## Descriptor Types

3. parameter to program mapping

```
<SParam id="Selection">
  <SChoice id="Roulette"/>
  <SChoice id="Rank"/>
  ...
</SParam>
```

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## Descriptor Types

3. parameter to program mapping

```
<SParam id="Selection">
  <SChoice id="Roulette"/>
  <SChoice id="Rank"/>
  ...
</SParam>
⇑
<Mapping id="Selection" type="my.Selection"/>
<Mapping id="Selection.Roulette" type="my.Roulette"/>
<Mapping id="Selection.Rank" type="my.Rank"/>
```

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## Descriptor Types

1. parameter range
2. parameter instance
3. parameter to program mapping

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## Descriptor Types

1. parameter range $\rightarrow$ **design space**
2. parameter instance
3. parameter to program mapping

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## Descriptor Types

1. parameter range $\rightarrow$ **design space**
2. parameter instance $\rightarrow$ **design**
3. parameter to program mapping

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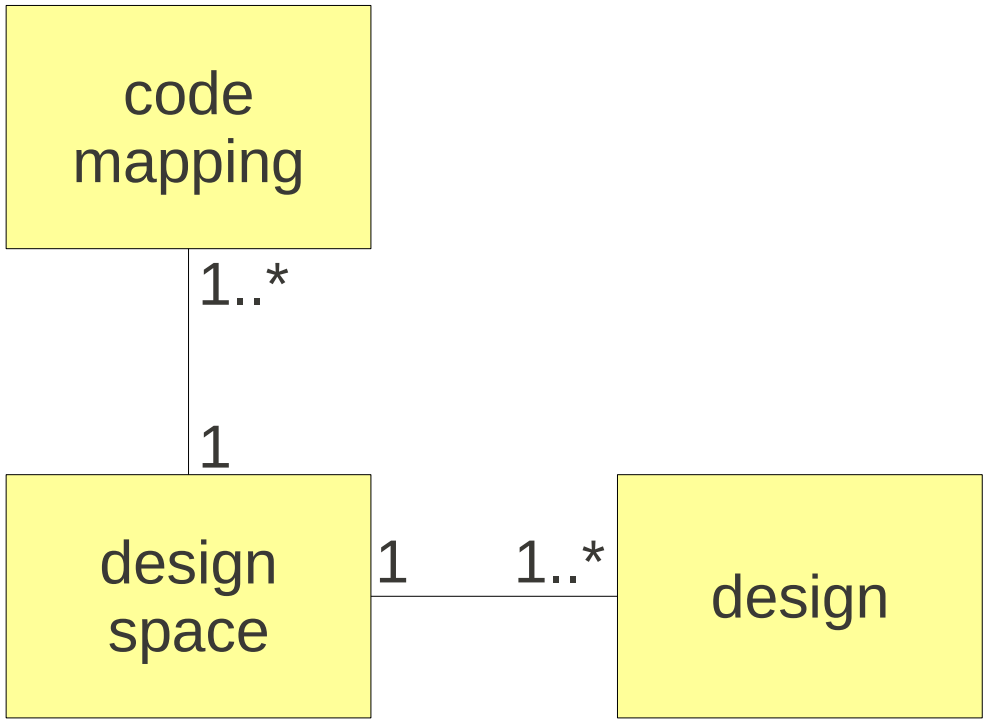
2. parameter instance $\rightarrow$ **design**
3. parameter to program mapping $\rightarrow$ **code mapping**

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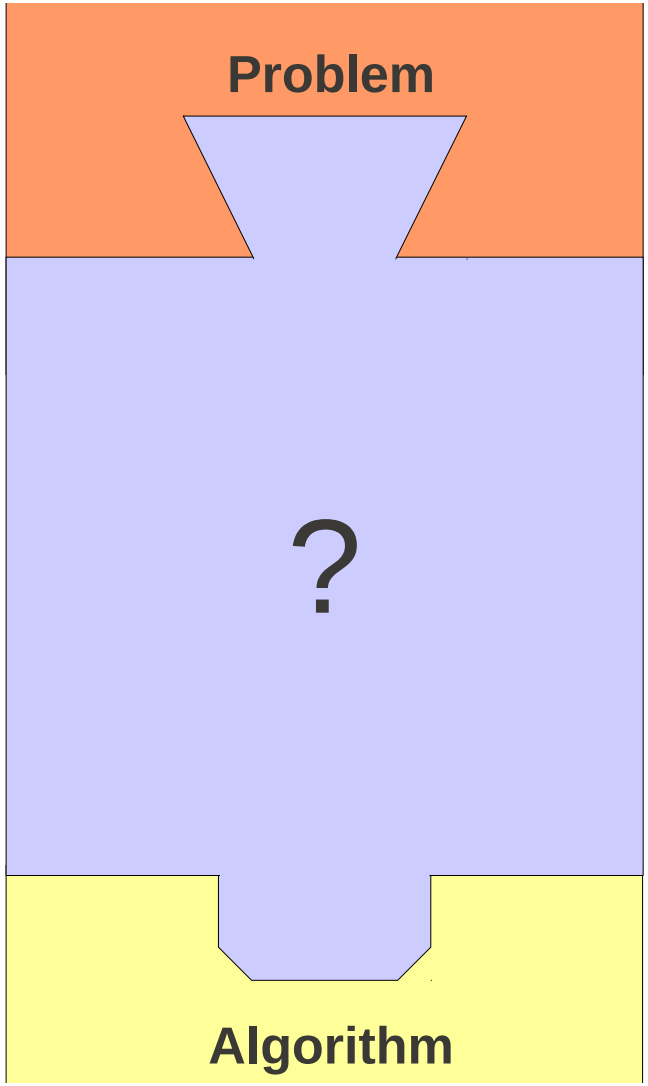
# Approaching the Black Box

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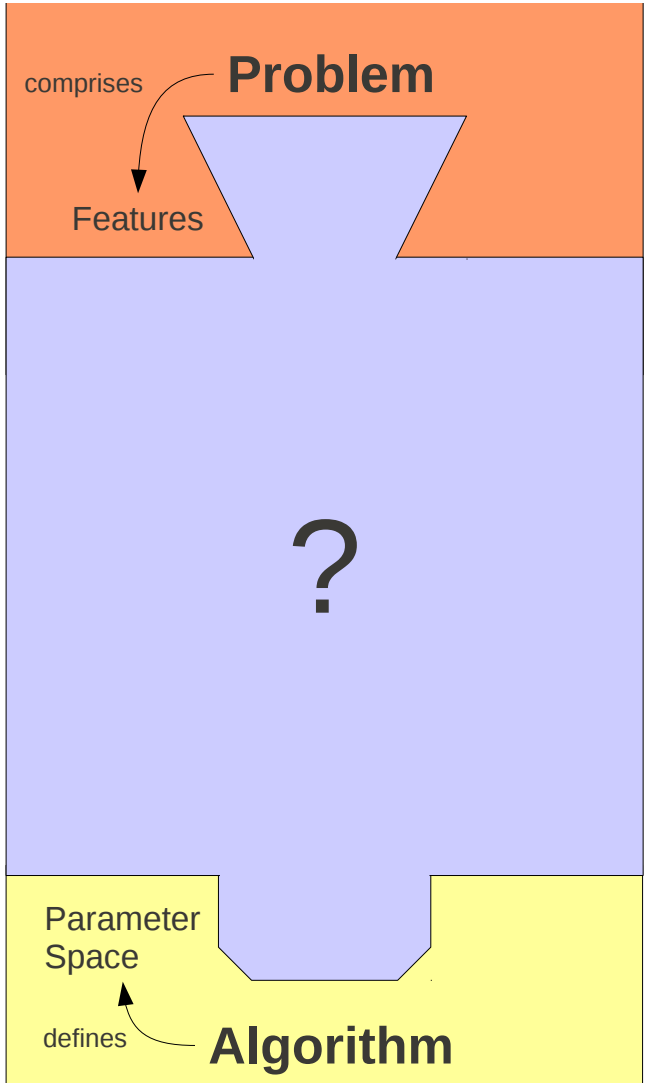


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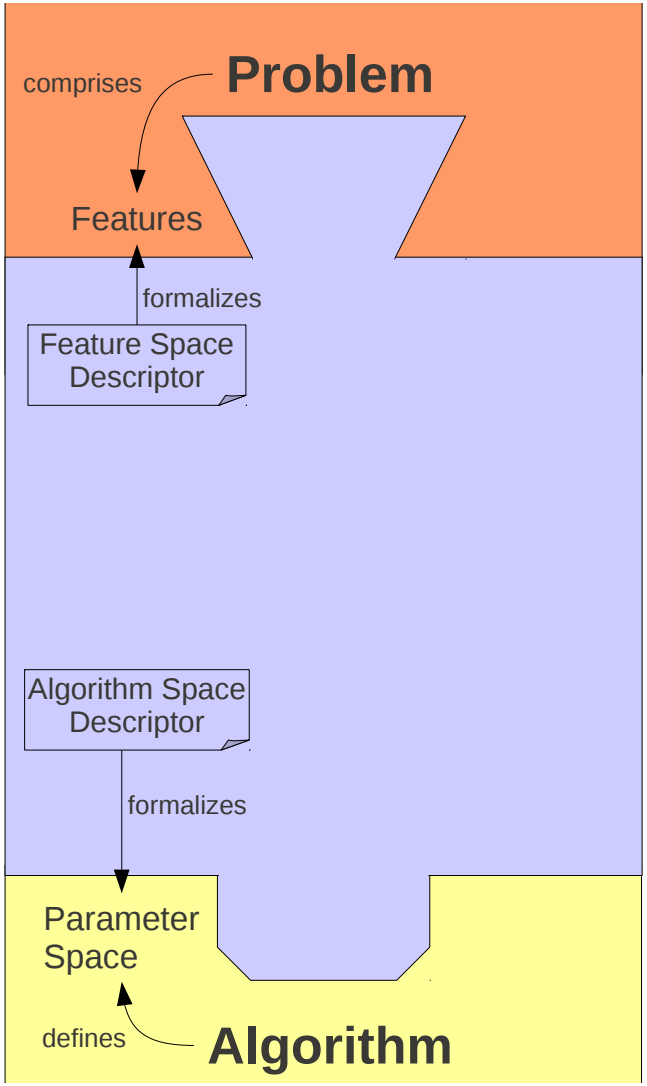


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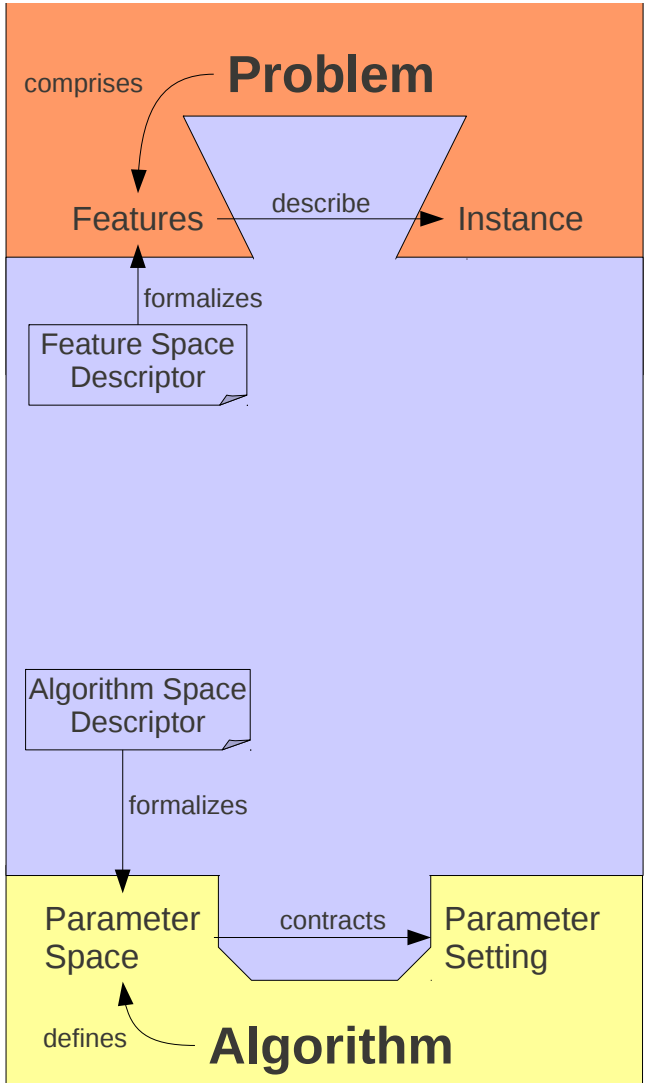


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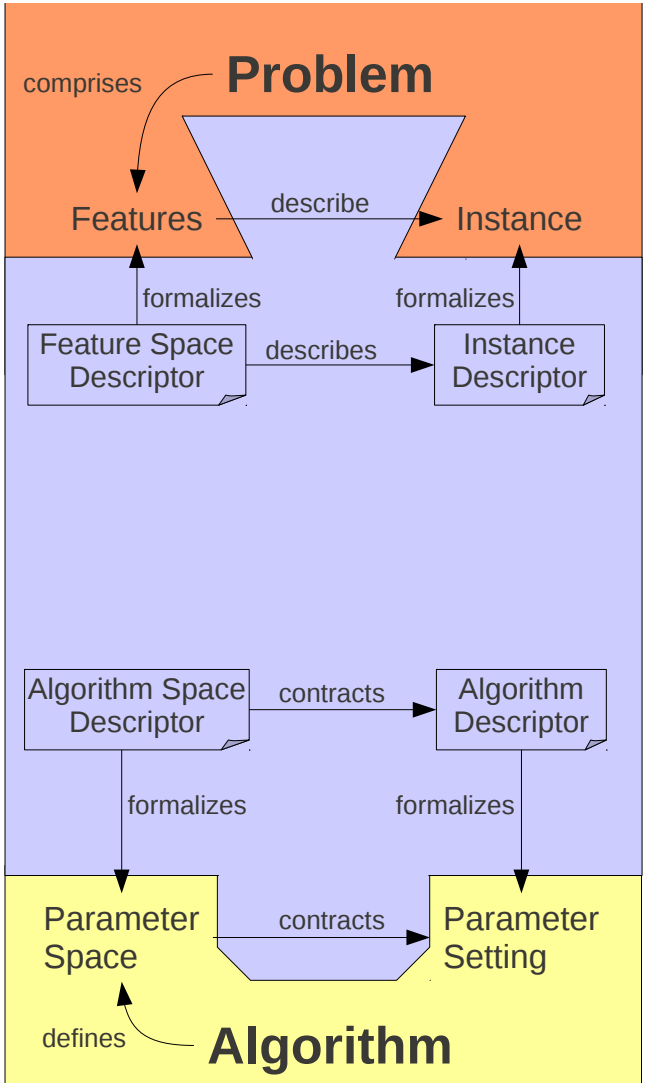


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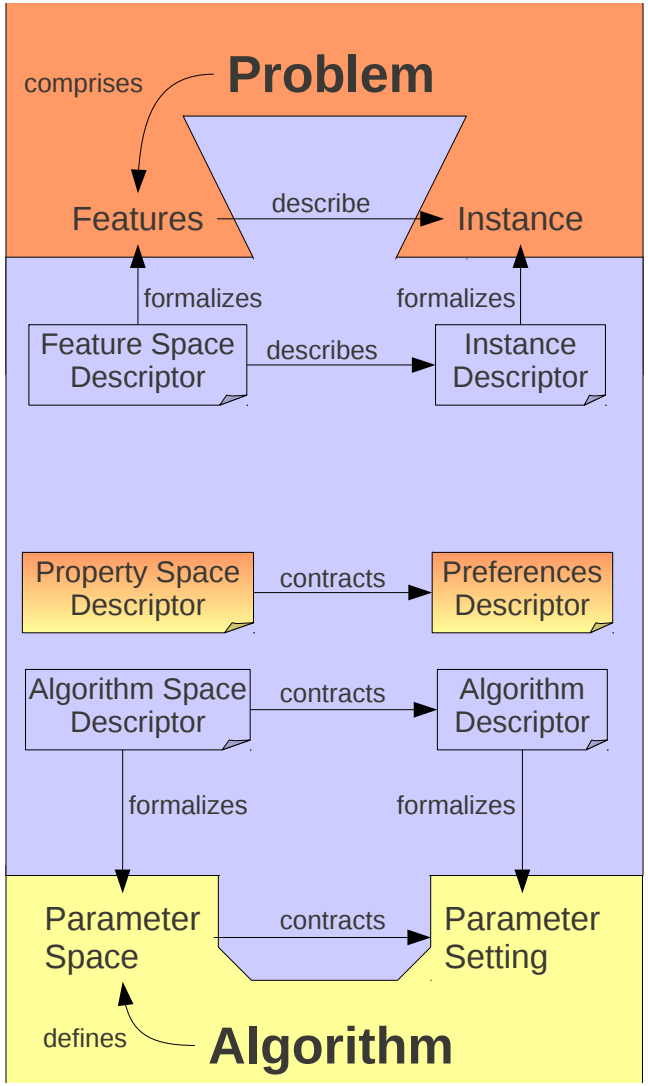


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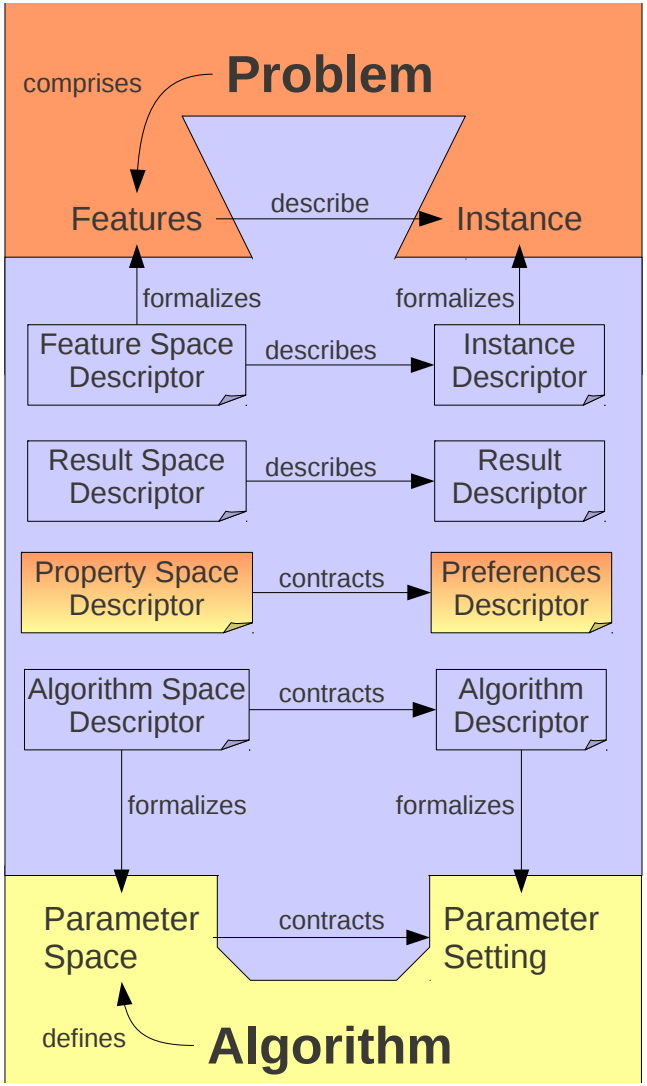


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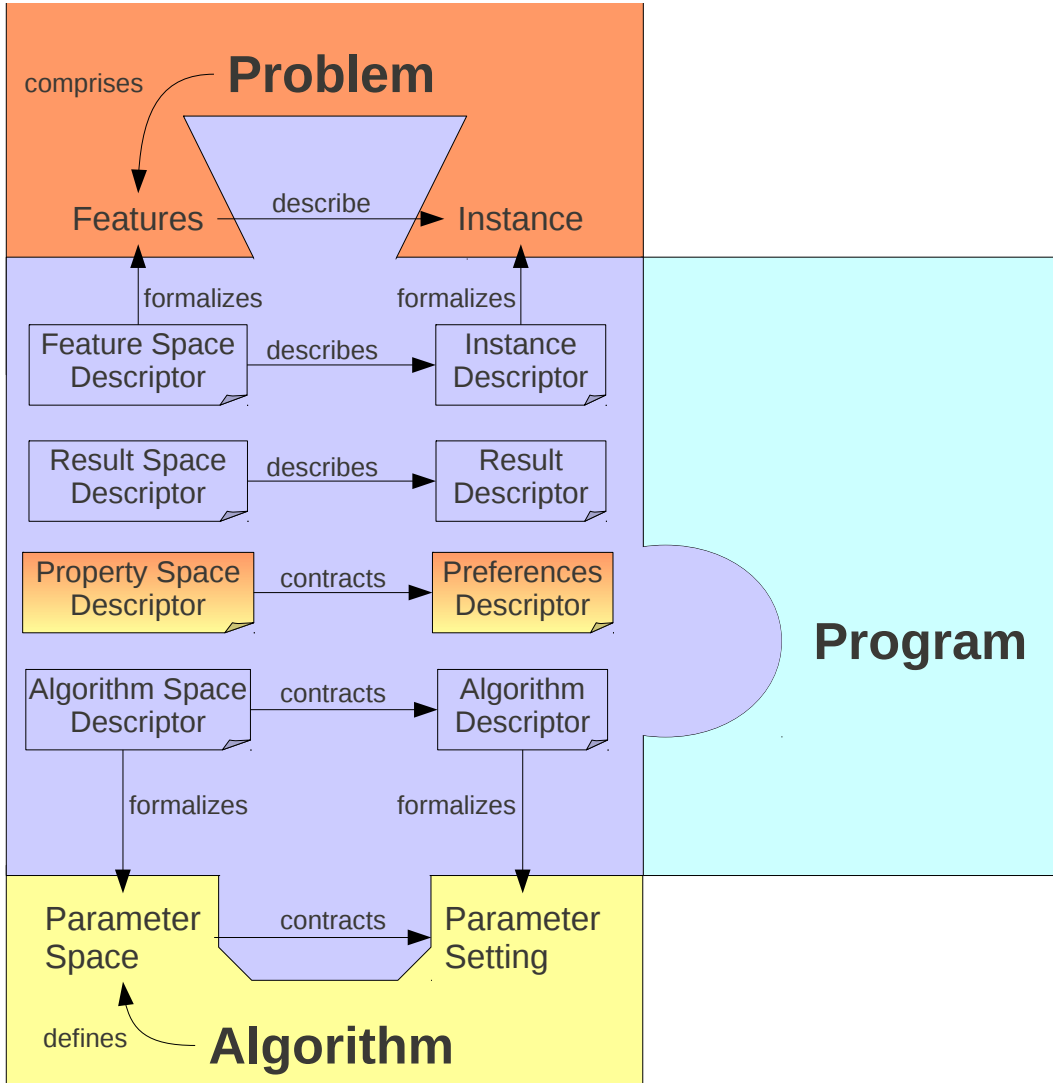


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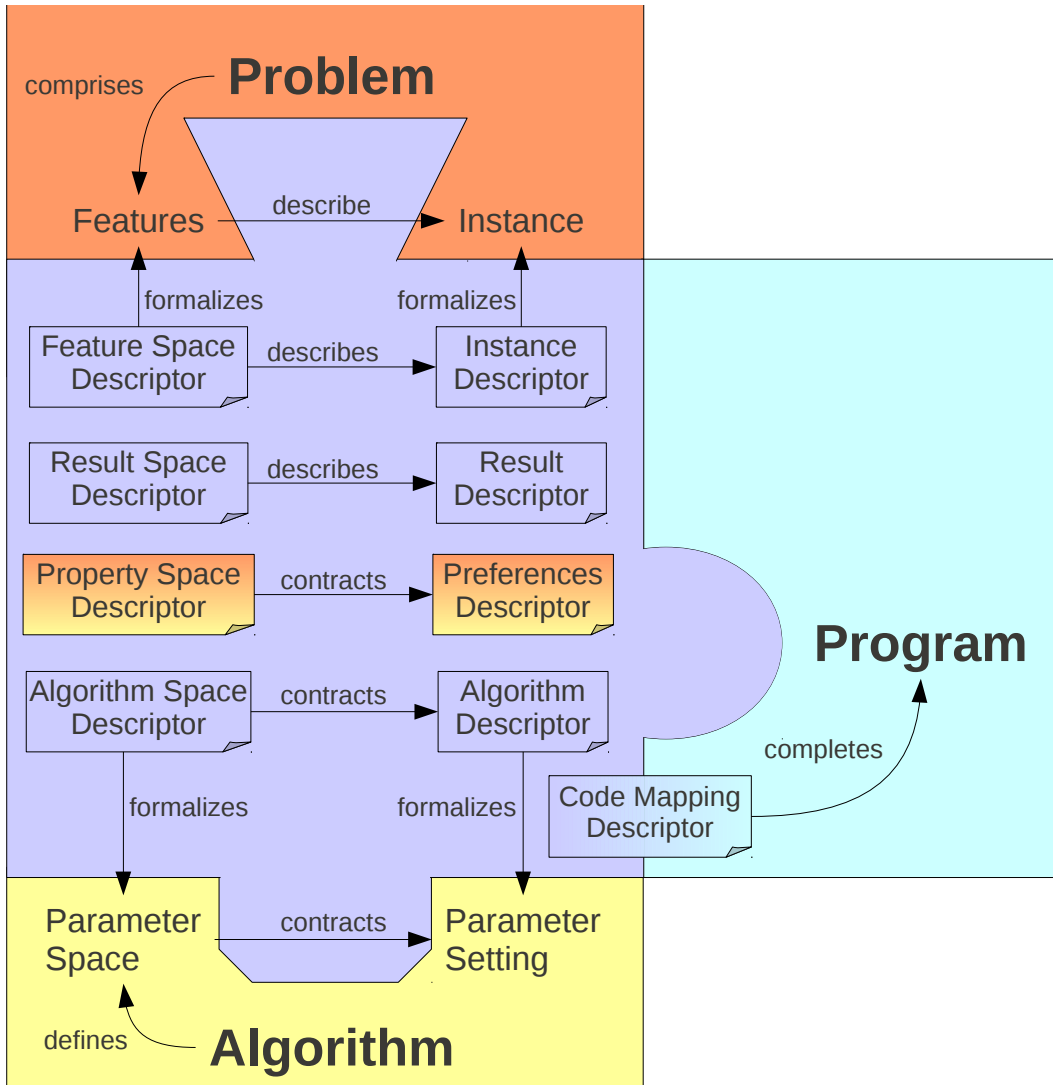


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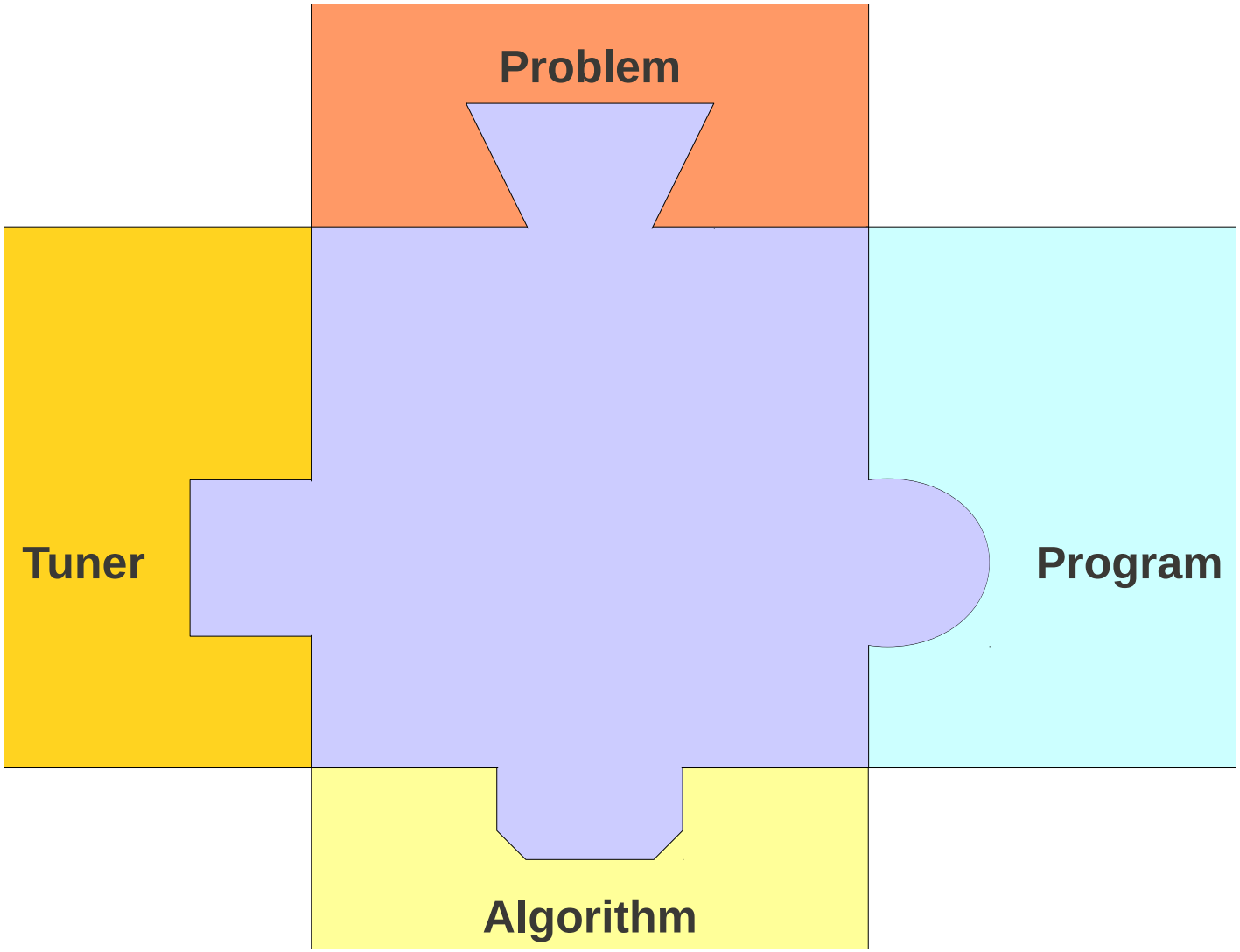
# Automated Parameter Tuning

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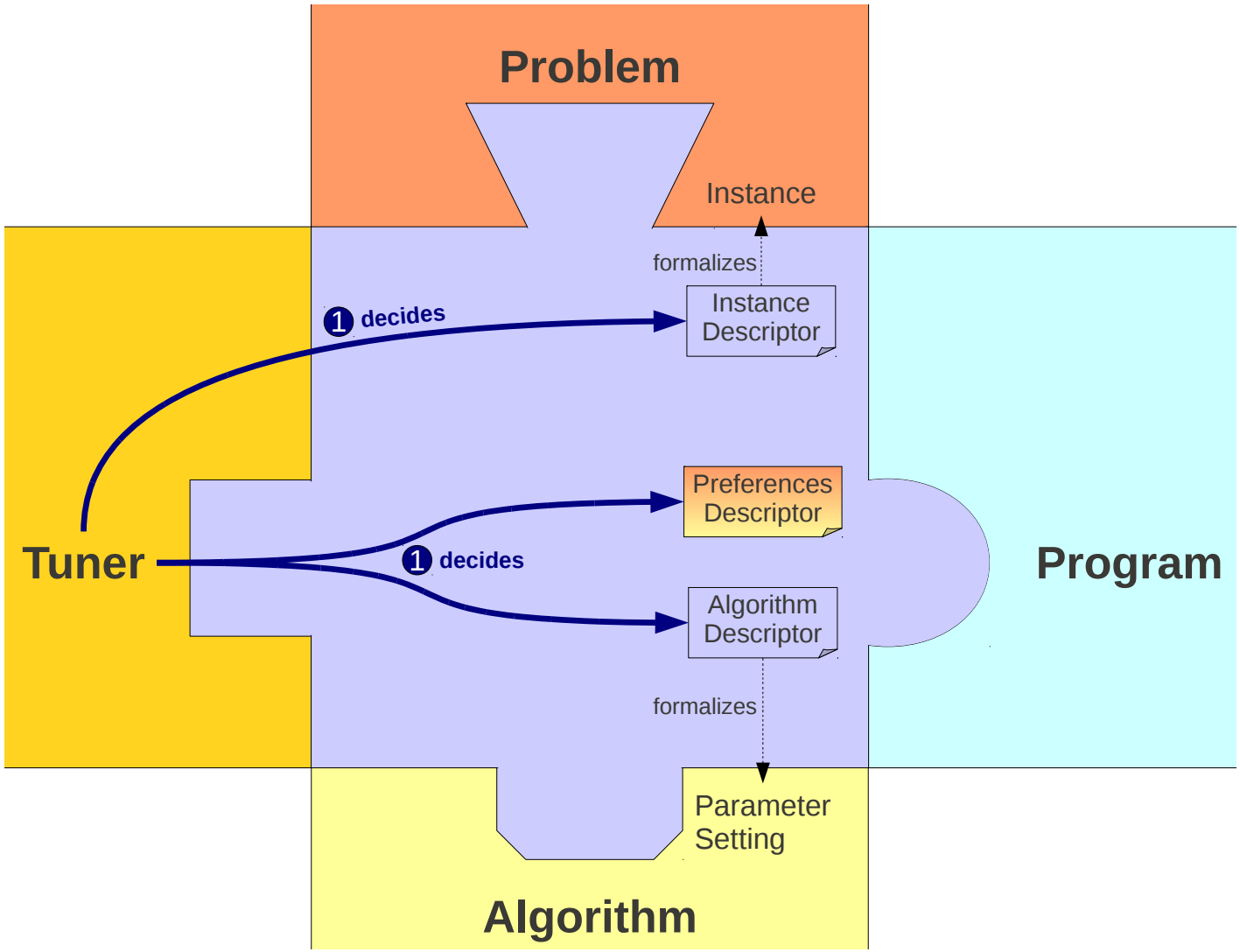


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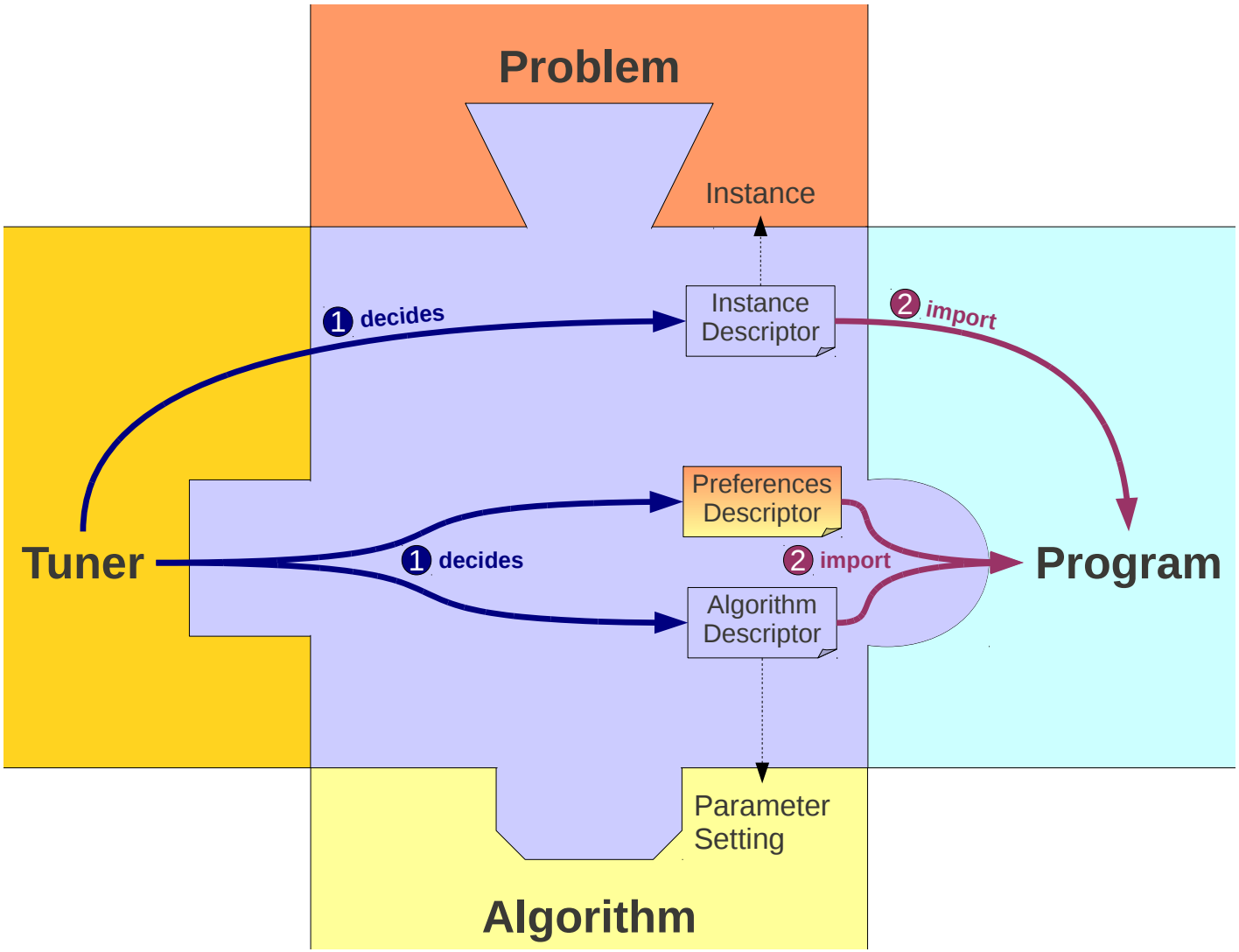


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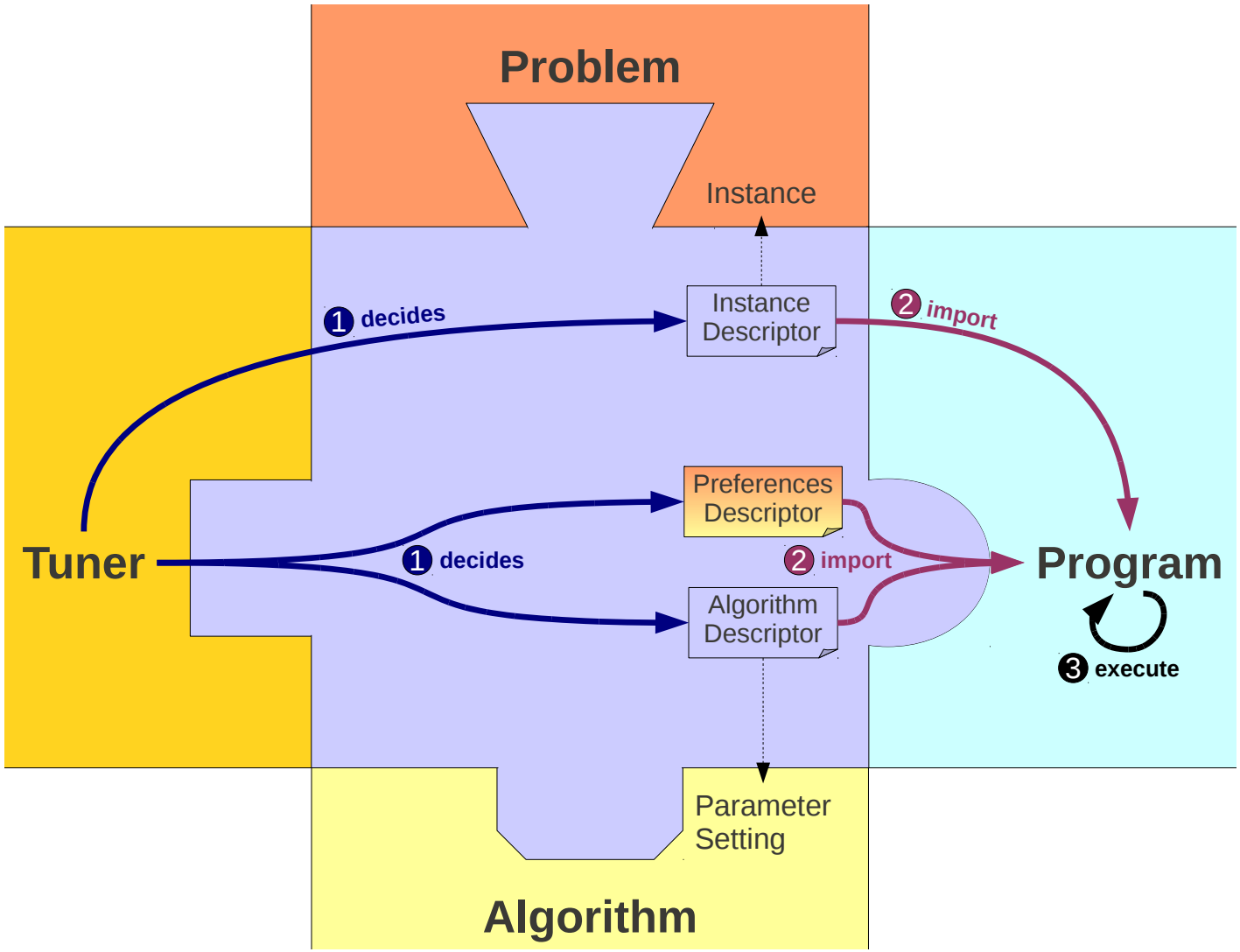


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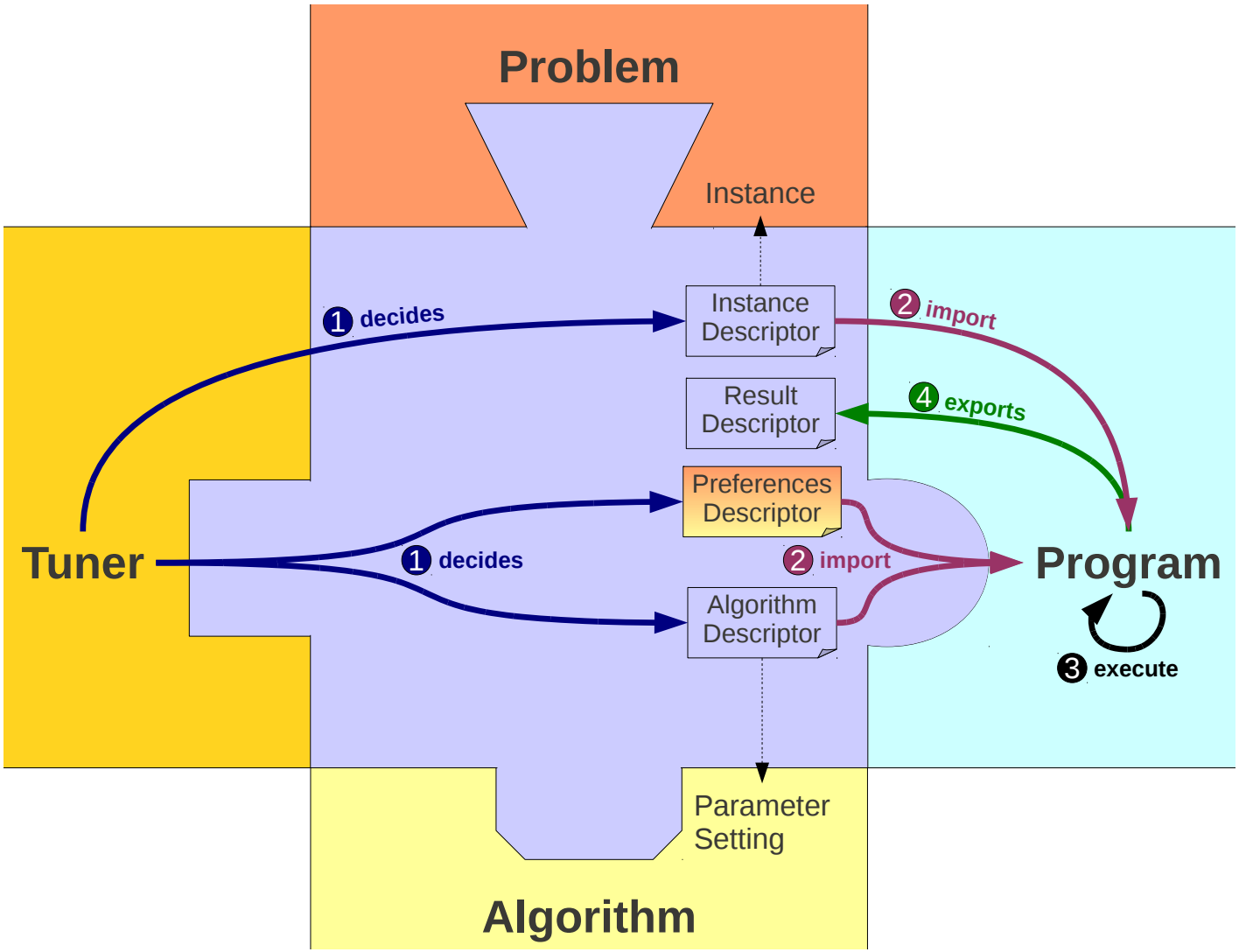


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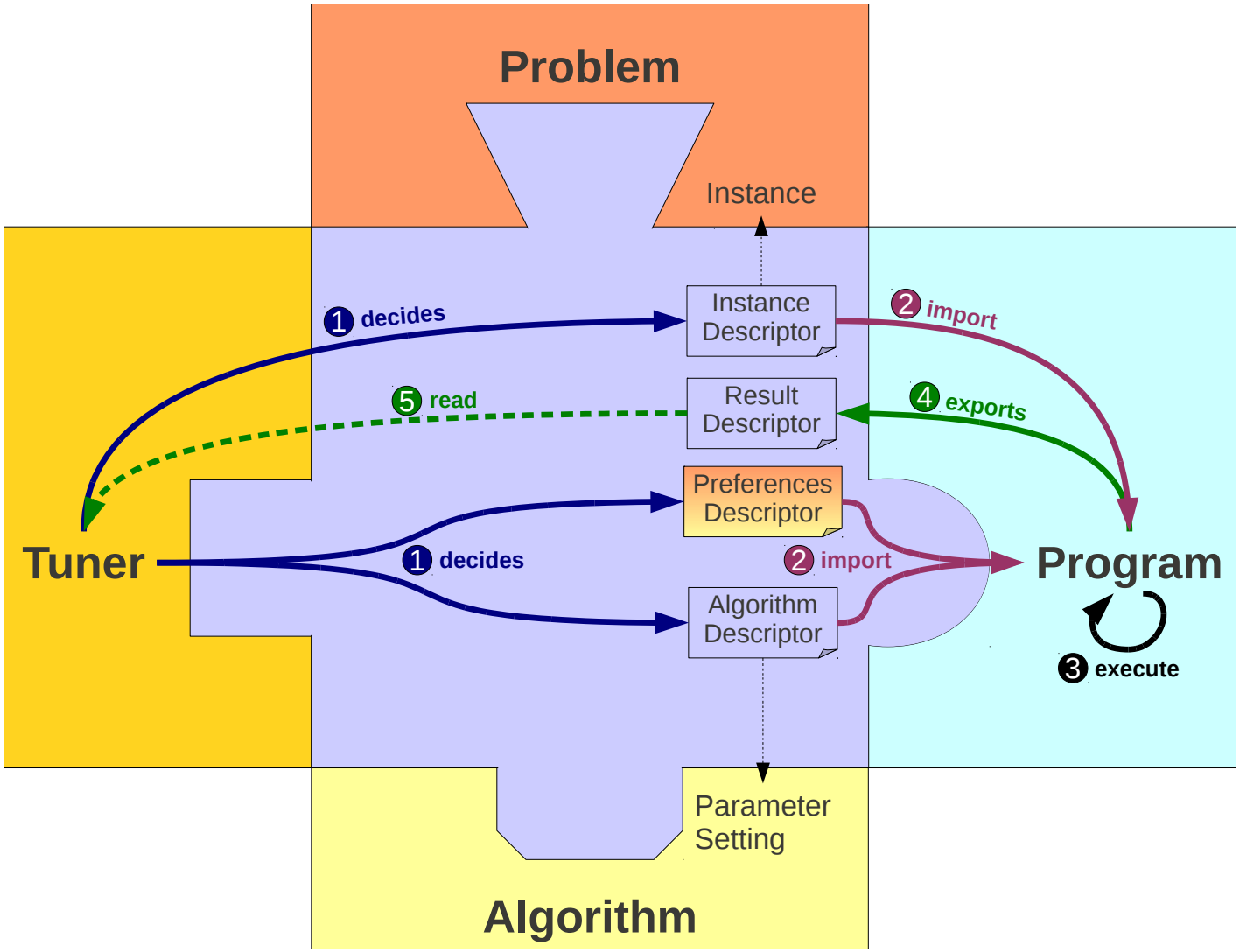


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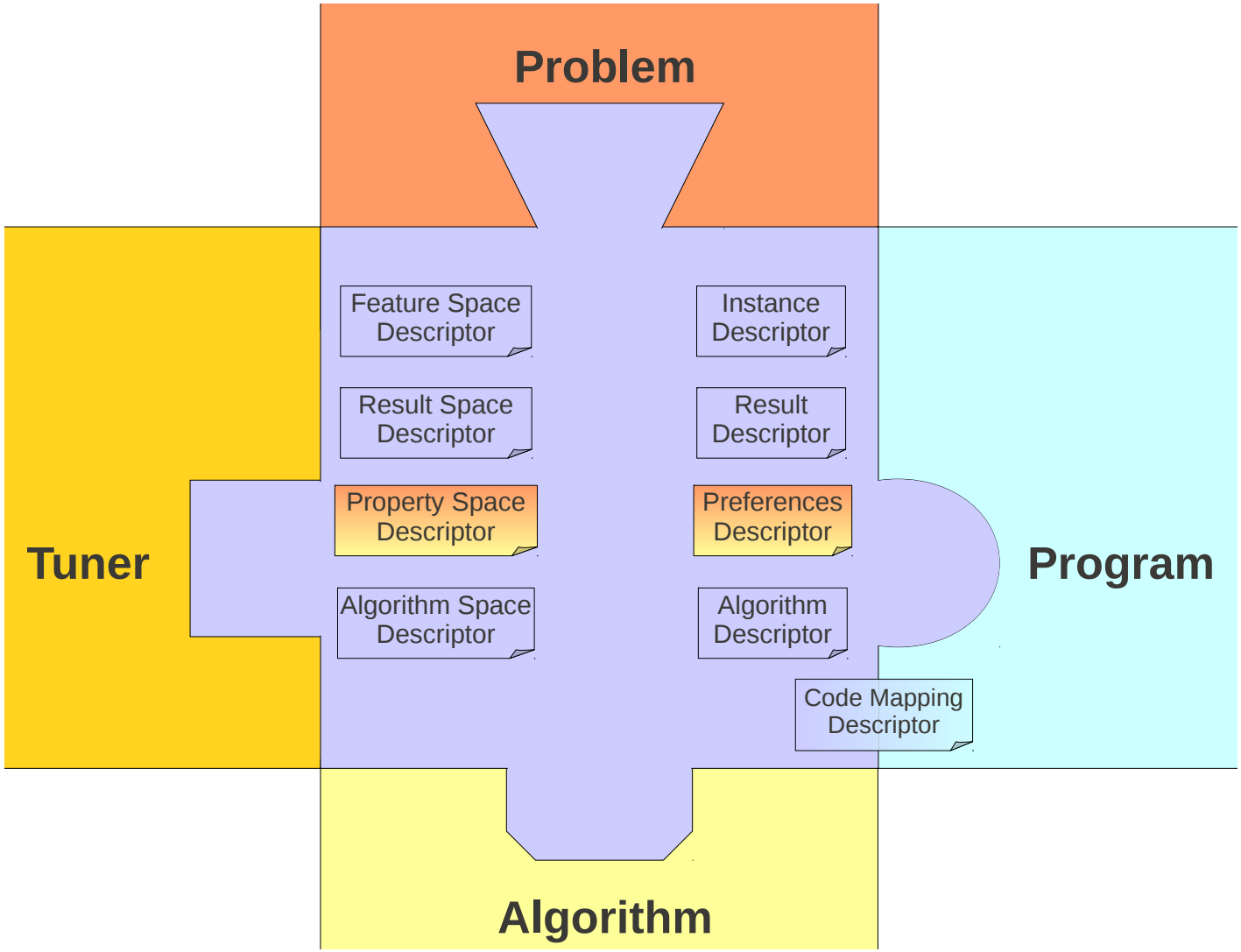


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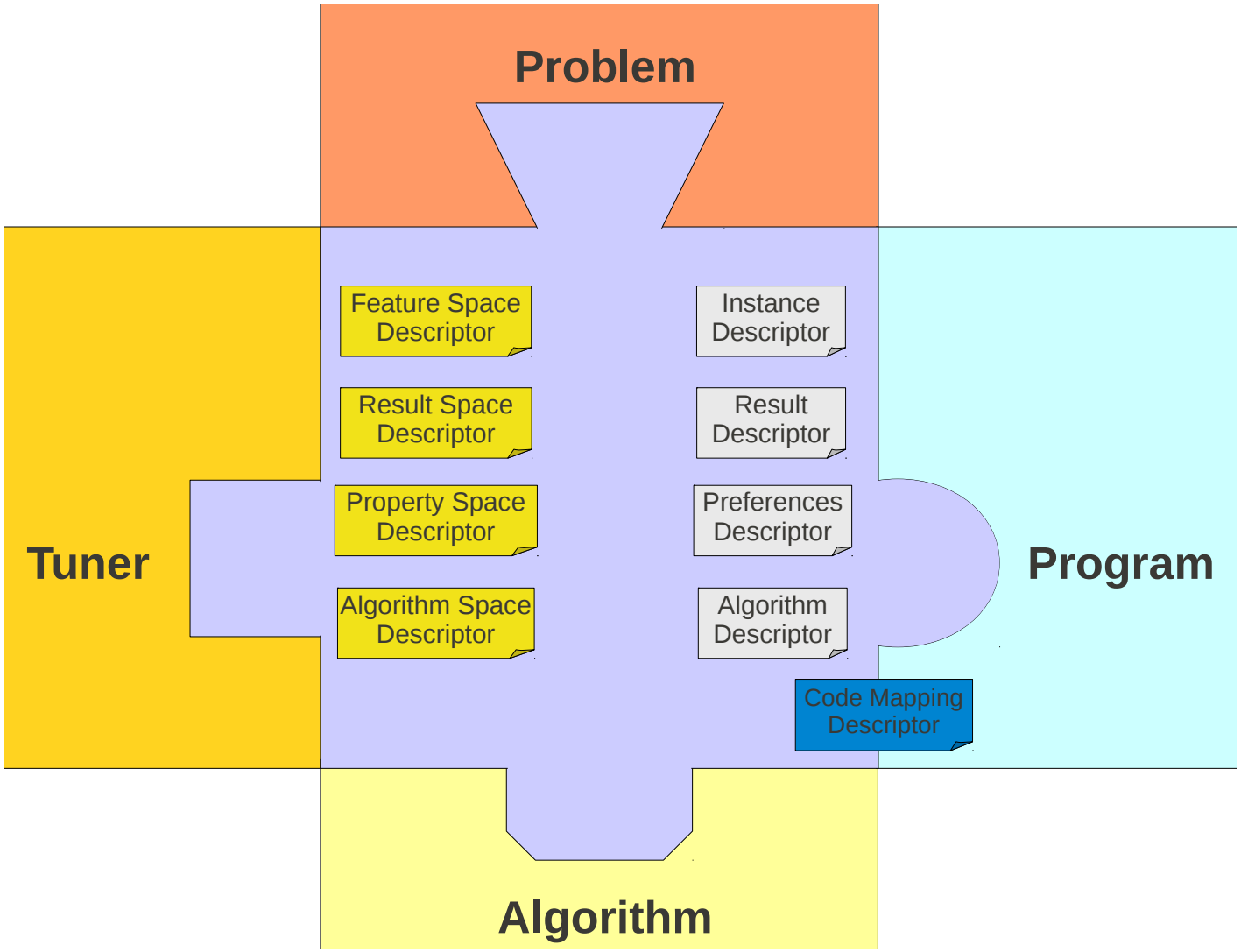


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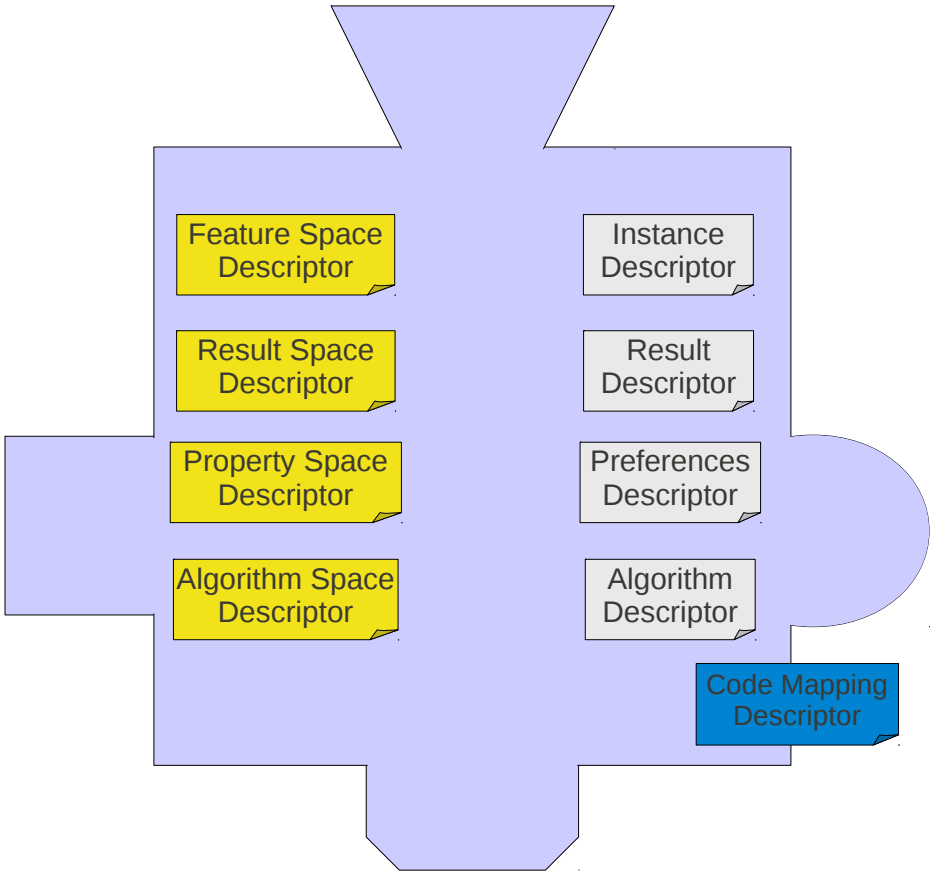


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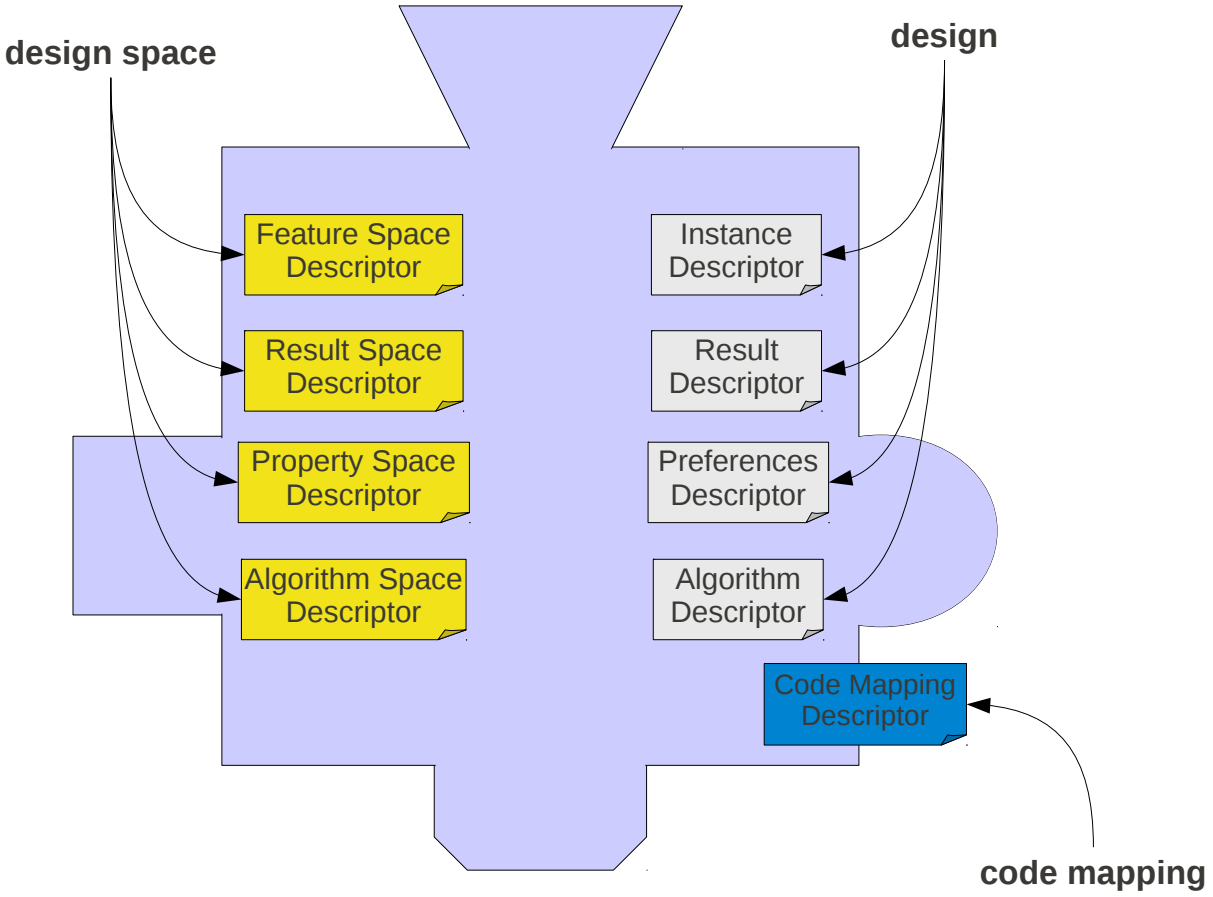


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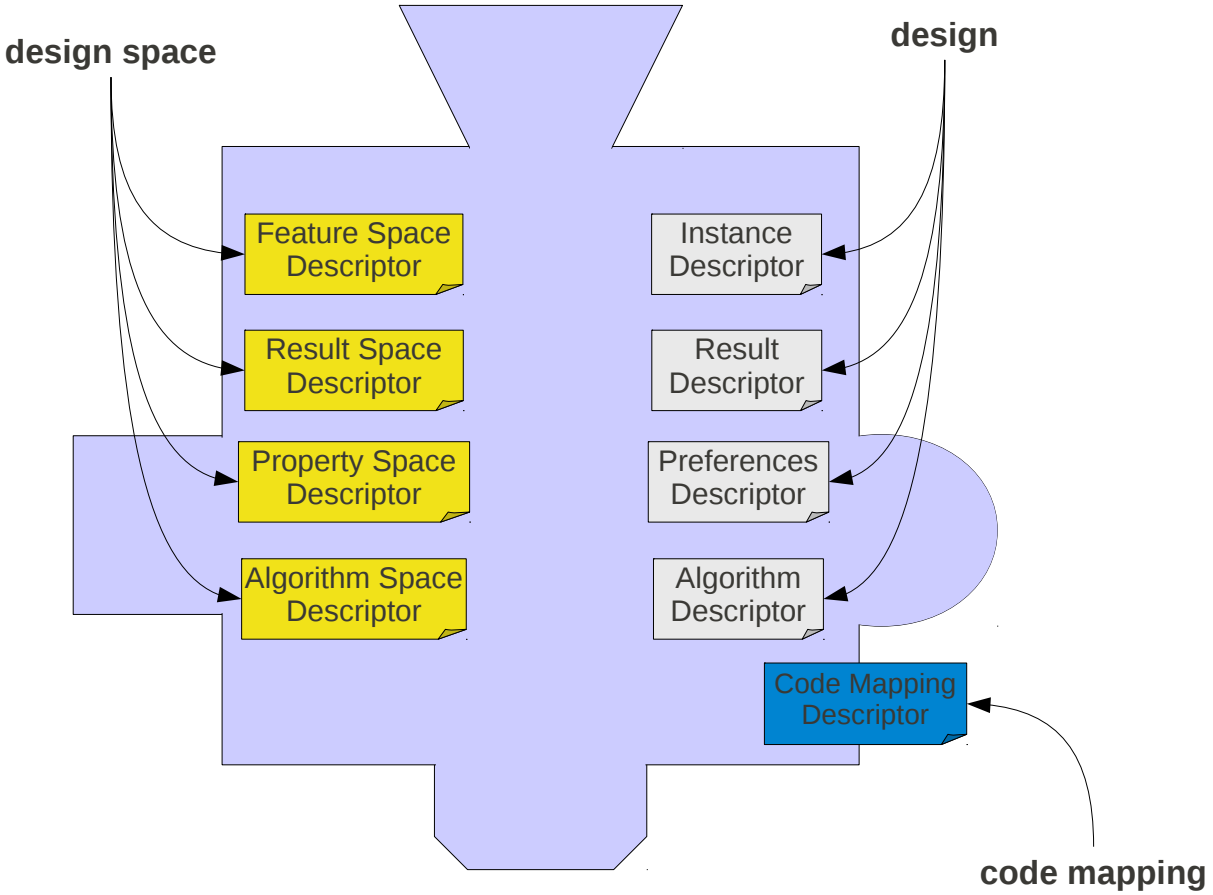


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**Grammar 1. design space:**

$$\langle DesignSpace \rangle \rightarrow \{\langle Param \rangle\}^+$$
$$\langle Param \rangle \rightarrow (\texttt{sParamId}\ \langle SParam \rangle) \mid \texttt{nParamId}$$
$$\langle SParam \rangle \rightarrow \{\langle DesignSpace \rangle\}\ \{\langle SChoice \rangle\}^+$$
$$\langle SChoice \rangle \rightarrow \texttt{sChoiceId} \mid (\texttt{sChoiceId}\ \langle DesignSpace \rangle)$$

**Grammar 2. design:**

$$\langle Design \rangle \rightarrow \{\langle Value \rangle\}^+$$
$$\langle Value \rangle \rightarrow \langle SValue \rangle \mid (\texttt{nParamId nValue})$$
$$\langle SValue \rangle \rightarrow (\texttt{sParamId sChoiceId}\ [\langle Design \rangle])$$

**Grammar 3. code mapping:**

$$\langle Mappings \rangle \rightarrow \{\texttt{paramId componentId}\}$$

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# Example: Hello World

# Example: Hello World

Hello World

# Example: Hello World (Structure)


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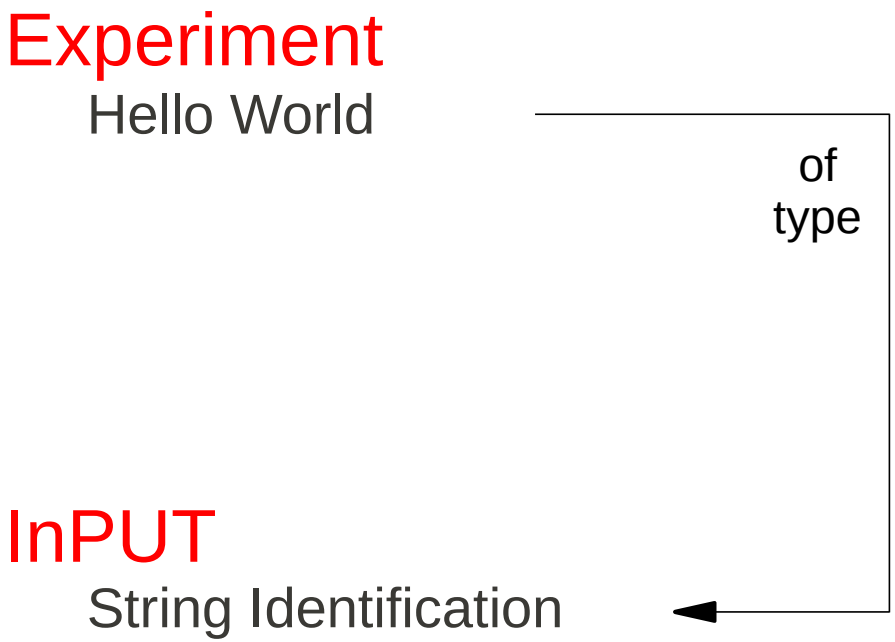
# Example: Hello World (Structure)

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# Example: Hello World (Structure)


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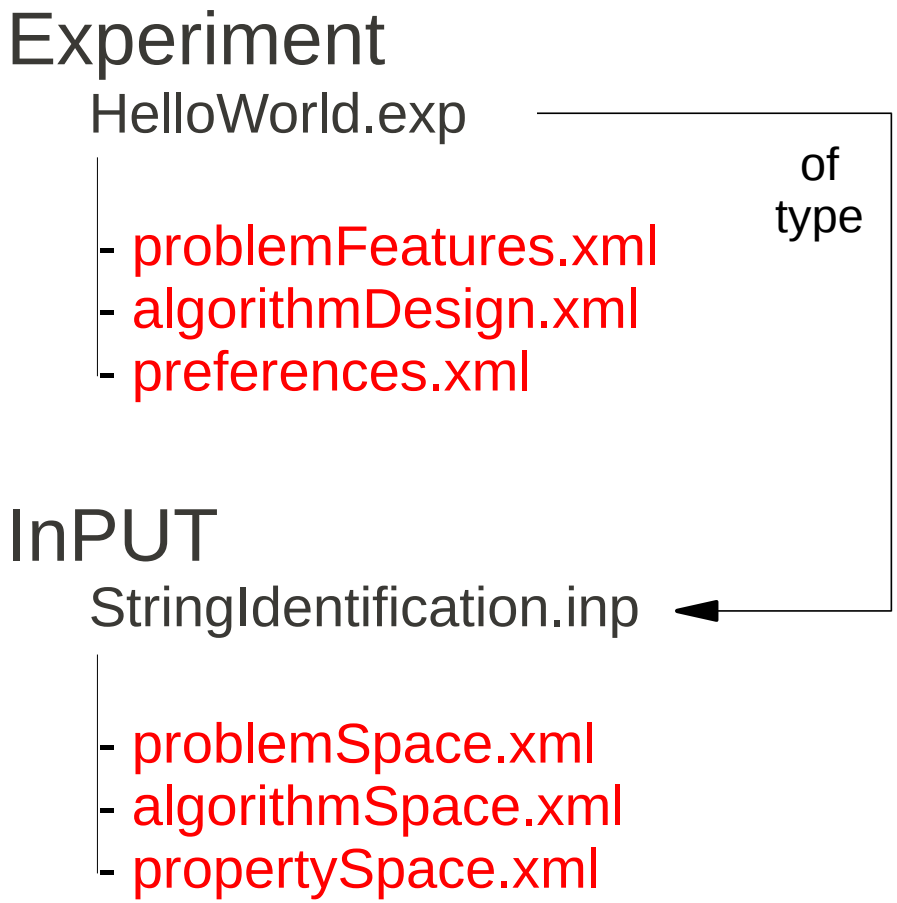
# Example: Hello World (Structure)

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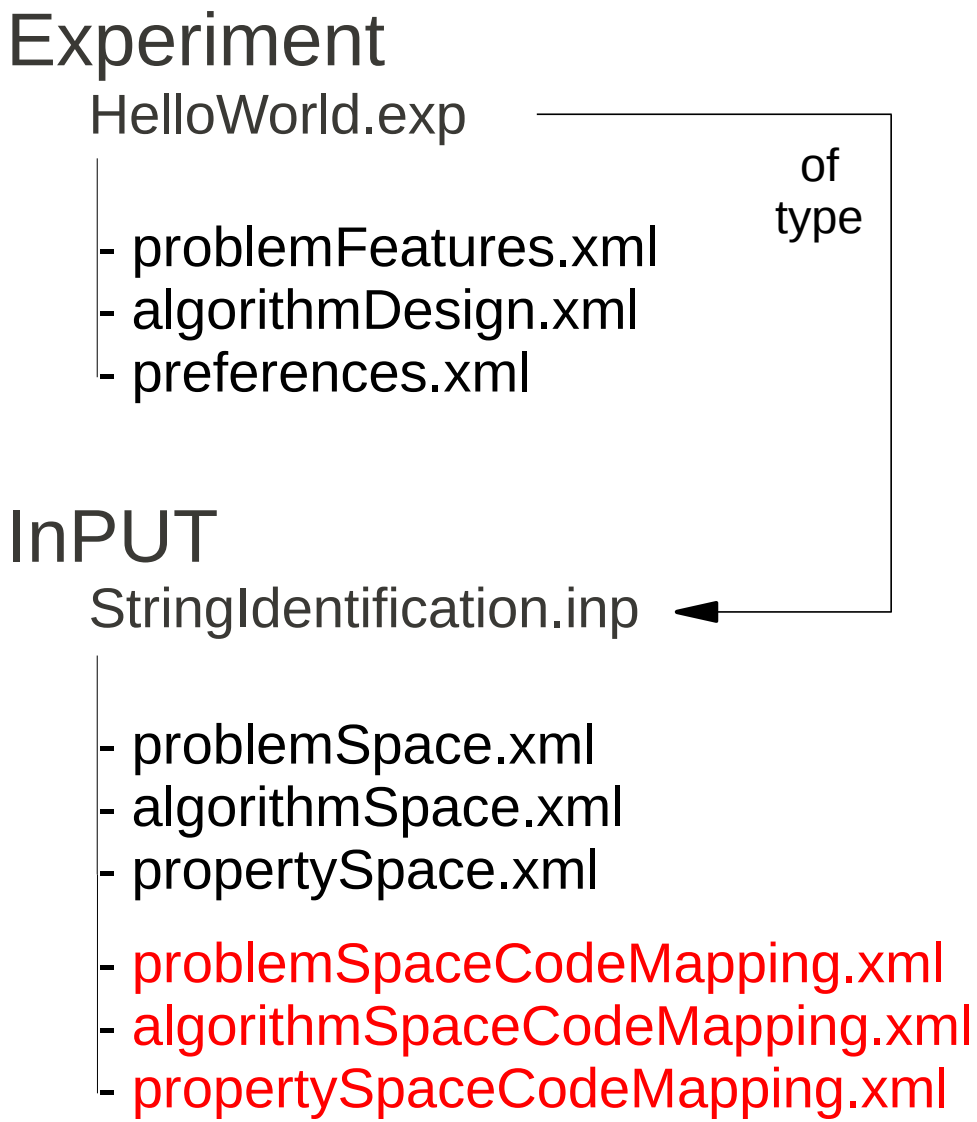
# Example: Hello World (Structure)

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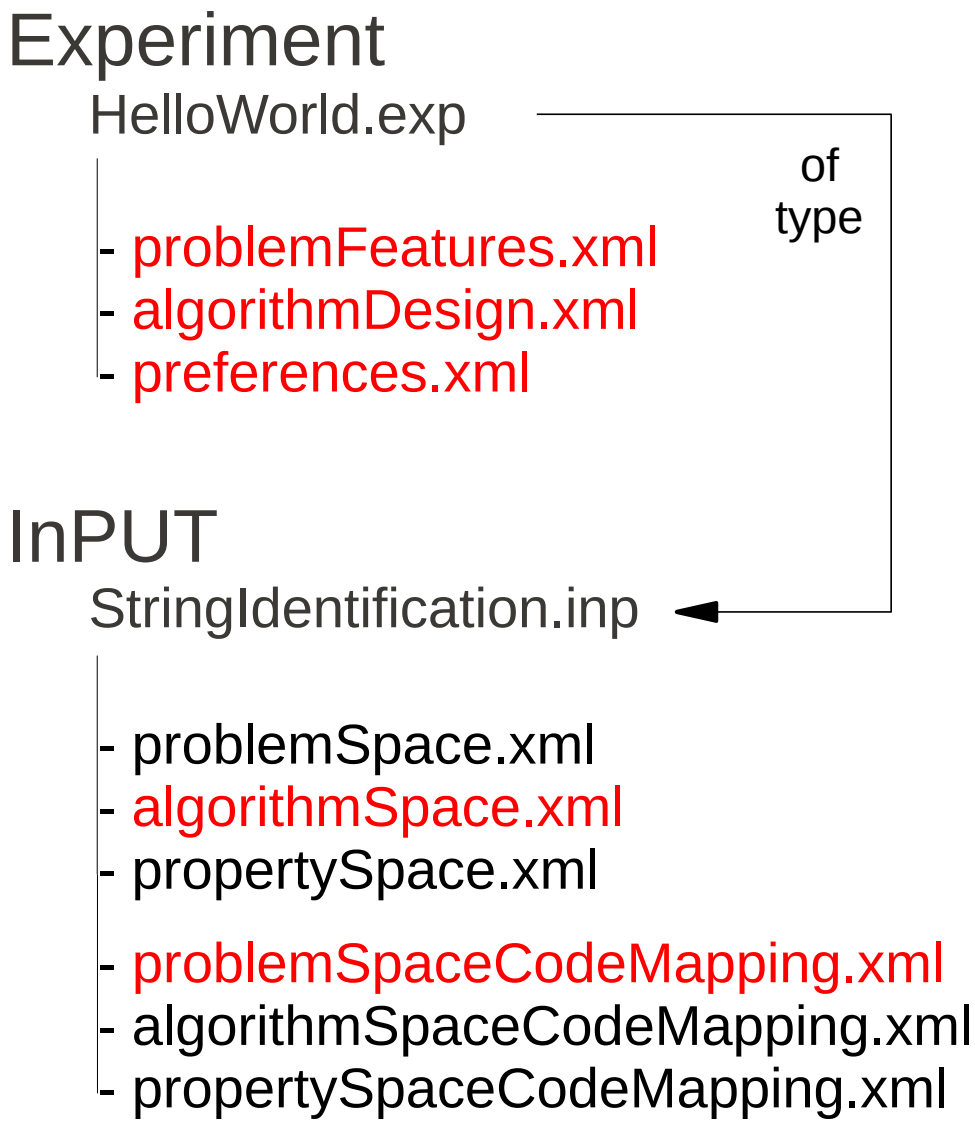
# Example: Hello World (Structure)

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# Example: Hello World (Code, Java)

```
// import experimental meta-context
IInPUT input = InPUT.getInPUT(new InPUTArchiveImporter
        ("StringIdentification","StringIdentification.inp"));
```

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# Example: Hello World (Code, Java)

```
// import experimental meta-context
IInPUT input = InPUT.getInPUT(new InPUTArchiveImporter
        ("StringIdentification","StringIdentification.inp"));

// import experimental assumptions
IExperiment experiment = input.impOrt("HelloWorld",
        new ExperimentArchiveImporter("HelloWorld.exp"));
```

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# Example: Hello World (Code, Java)

```
// import experimental meta-context
IInPUT input = InPUT.getInPUT(new InPUTArchiveImporter
        ("StringIdentification","StringIdentification.inp"));

// import experimental assumptions
IExperiment experiment = input.impOrt("HelloWorld",
        new ExperimentArchiveImporter("HelloWorld.exp"));

// retrieve the algorithm from InPUT
EvolutionEngine<String> engine = experiment.getValue("Algorithm");
```

# Example: Hello World (Code, Java)

```
// import experimental meta-context
IInPUT input = InPUT.getInPUT(new InPUTArchiveImporter
        ("StringIdentification","StringIdentification.inp"));

// import experimental assumptions
IExperiment experiment = input.impOrt("HelloWorld",
        new ExperimentArchiveImporter("HelloWorld.exp"));

// retrieve the algorithm from InPUT
EvolutionEngine<String> engine = experiment.getValue("Algorithm");

// retrieve assumptions
int popSize = experiment.getValue("Algorithm.EA.PopSize");
int elite = experiment.getValue("Algorithm.EA.EliteCount");
TerminationCondition termination = experiment
        .getValue("Algorithm.EA.Termination");
```

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// import experimental meta-context
IInPUT input = InPUT.getInPUT(new InPUTArchiveImporter
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EvolutionEngine<String> engine = experiment.getValue("Algorithm");

// retrieve assumptions
int popSize = experiment.getValue("Algorithm.EA.PopSize");
int elite = experiment.getValue("Algorithm.EA.EliteCount");
TerminationCondition termination = experiment
        .getValue("Algorithm.EA.Termination");

// execute the algorithm
engine.evolve(popSize, elite, termination);
```

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# Example: Hello World (Algorithm Design)

```
<?xml version="1.0" encoding="UTF-8"?>
<Design id="1">
    <SValue id="Algorithm" value="EA">
        <SValue id="Termination" value="TargetFitness">
            <NValue id="Objective" value="0" />
        </SValue>
        <SValue id="Selection" value="Roulette" />
        <NValue id="PopSize" value="100" />
        <NValue id="EliteCount" value="30" />
    </SValue>
</Design>
```

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# Example: Hello World (Algorithm Design Space)

```
<?xml version="1.0" encoding="UTF-8"?>
<DesignSpace id="ea" mapping="algorithmSpaceCodeMapping.xml">
    <SParam id="Algorithm">
        <SChoice id="EA">
    </SParam>
</DesignSpace>
```

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# Example: Hello World (Algorithm Design Space)

```
<?xml version="1.0" encoding="UTF-8"?>
<DesignSpace id="ea" mapping="algorithmSpaceCodeMapping.xml">
    <SParam id="Algorithm">
        <SChoice id="EA">
            <NParam id="PopSize" type="integer" inclMin="2" inclMax="100"/>
            <SParam id="Termination">
            <NParam id="EliteCount" type="integer" inclMin="0"
                inclMax="Math.min(10, Algorithm.EA.PopSize*.3)" />
            <SParam id="Selection">
        </SChoice>
    </SParam>
</DesignSpace>
```

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# Example: Hello World (Algorithm Design Space)

```
<?xml version="1.0" encoding="UTF-8"?>
<DesignSpace id="ea" mapping="algorithmSpaceCodeMapping.xml">
    <SParam id="Algorithm">
        <SChoice id="EA">
            <NParam id="PopSize" type="integer" inclMin="2" inclMax="100"/>
            <SParam id="Termination">
                <SChoice id="ElapsedTime">
                <SChoice id="Generations">
                <SChoice id="Stagnation">
                <SChoice id="TargetFitness">
            </SParam>
            <NParam id="EliteCount" type="integer" inclMin="0"
                inclMax="Math.min(10, Algorithm.EA.PopSize*.3)" />
            <SParam id="Selection">
        </SChoice>
    </SParam>
</DesignSpace>
```

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# Example: Hello World (Algorithm Design Space)

```
<?xml version="1.0" encoding="UTF-8"?>
<DesignSpace id="ea" mapping="algorithmSpaceCodeMapping.xml">
    <SParam id="Algorithm">
        <SChoice id="EA">
            <NParam id="PopSize" type="integer" inclMin="2" inclMax="100"/>
            <SParam id="Termination">
                <SChoice id="ElapsedTime">
                    <NParam type="long" id="MS" />
                </SChoice>
                <SChoice id="Generations">
                <SChoice id="Stagnation">
                <SChoice id="TargetFitness">
            </SParam>
            <NParam id="EliteCount" type="integer" inclMin="0"
                inclMax="Math.min(10, Algorithm.EA.PopSize*.3)" />
            <SParam id="Selection">
        </SChoice>
    </SParam>
</DesignSpace>
```

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# Example: Hello World (Algorithm Design Space)

```
<?xml version="1.0" encoding="UTF-8"?>
<DesignSpace id="ea" mapping="algorithmSpaceCodeMapping.xml">
    <SParam id="Algorithm">
        <SChoice id="EA">
            <NParam id="PopSize" type="integer" inclMin="2" inclMax="100"/>
            <SParam id="Termination">
                <SChoice id="ElapsedTime">
                <SChoice id="Generations">
                <SChoice id="Stagnation">
                <SChoice id="TargetFitness">
            </SParam>
            <NParam id="EliteCount" type="integer" inclMin="0"
                inclMax="Math.min(10, Algorithm.EA.PopSize*.3)" />
            <SParam id="Selection">
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    </SParam>
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# Example: Hello World (Algorithm Design Space)

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<?xml version="1.0" encoding="UTF-8"?>
<DesignSpace id="ea" mapping="algorithmSpaceCodeMapping.xml">
    <SParam id="Algorithm">
        <SChoice id="EA">
            <NParam id="PopSize" type="integer" inclMin="2" inclMax="100"/>
            <SParam id="Termination">
            <NParam id="EliteCount" type="integer" inclMin="0"
                inclMax="Math.min(10, Algorithm.EA.PopSize*.3)" />
            <SParam id="Selection">
        </SChoice>
    </SParam>
</DesignSpace>
```

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# Example: Hello World (Algorithm Design Space)

```
<?xml version="1.0" encoding="UTF-8"?>
<DesignSpace id="ea" mapping="algorithmSpaceCodeMapping.xml">
    <SParam id="Algorithm">
        <SChoice id="EA">
            <NParam id="PopSize" type="integer" inclMin="2" inclMax="100"/>
            <SParam id="Termination">
            <NParam id="EliteCount" type="integer" inclMin="0"
                inclMax="Math.min(10, Algorithm.EA.PopSize*.3)" />
            <SParam id="Selection">
                <NParam type="integer" id="AmountSelected" inclMin="1"
                    inclMax="Math.min(2, Algorithm.EA.PopSize*.3)" />
                <SChoice id="Roulette" />
                <SChoice id="Rank" />
                <SChoice id="Truncation">
                <SChoice id="Tournament">
                <SChoice id="Sigma" />
                <SChoice id="StochasticSampling" />
            </SParam>
        </SChoice>
    </SParam>
</DesignSpace>
```

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# Example: Hello World (Algorithm Design Space)

```
<?xml version="1.0" encoding="UTF-8"?>
<DesignSpace id="ea" mapping="algorithmSpaceCodeMapping.xml">
    <SParam id="Algorithm">
        <SChoice id="EA">
            <NParam id="PopSize" type="integer" inclMin="2" inclMax="100"/>
            <SParam id="Termination">
            <NParam id="EliteCount" type="integer" inclMin="0"
                inclMax="Math.min(10, Algorithm.EA.PopSize*.3)" />
            <SParam id="Selection">
        </SChoice>
    </SParam>
</DesignSpace>
```

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# Example: Hello World (Algorithm Design Space)

```
<?xml version="1.0" encoding="UTF-8"?>
<DesignSpace id="ea" mapping="algorithmSpaceCodeMapping.xml">
    <SParam id="Algorithm">
        <SChoice id="EA">
    </SParam>
</DesignSpace>
```

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# Example: Hello World (Preferences)

```
<?xml version="1.0" encoding="UTF-8"?>
<Design id="1">
  <SValue id="Seed" value="123456789" />
  <SValue id="Factory" value="Random" />
  <SValue id="Evaluator" value="MatchCounter" />
  <SValue id="Operators">
    <SValue id="1" value="StringCrossover">
        <NValue id="Probability" value=".4" />
        <NValue id="Points" value="1" />
    </SValue>
    <SValue id="2" value="StringMutation">
        <NValue id="Probability" value=".05" />
    </SValue>
    <SValue id="3" value="StringCrossover">
        <NValue id="Probability" value=".2" />
        <NValue id="Points" value="1" />
    </SValue>
  </SValue>
</Design>
```

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# Example: Hello World (Problem Design)

```
<?xml version="1.0" encoding="UTF-8"?>
<Design id="HelloWorld">
  <SValue id="Alphabet" value="Latin" />
  <SValue id="TargetString" value="HELLO WORLD" />
</Design>
```

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# Example: Hello World (Problem Code Mapping, Java)

```
<?xml version="1.0" encoding="UTF-8"?>
<CodeMappings id="stringIdentification">
  <Mapping id="Alphabet" type="se.miun.itm.input.example.util.Alphabet" />
  <Mapping id="Alphabet.Latin"
type="se.miun.itm.input.example.util.LatinAlphabet" />
  <Mapping id="TargetString" type="java.lang.String"
constructor="java.lang.String" />
</CodeMappings>
```

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## Reproducibility of experiments

1. Scientific publication (reviewing process)

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## Reproducibility of experiments

1. Scientific publication (reviewing process)
2. Exchange experimental descriptors with peers

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1. Scientific publication (reviewing process)
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3. Documentation, archive

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## Reproducibility of experiments

1. Scientific publication (reviewing process)
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4. Parameter tuning/control, time series data collection (runtime: set, get, snapshots)

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## Reproducibility of experiments

1. Scientific publication (reviewing process)
2. Exchange experimental descriptors with peers
3. Documentation, archive
4. Parameter tuning/control, time series data collection (runtime: set, get, snapshots)

## Simplified experimental design

1. Simple extraction of degrees of freedom
2. Simple extension of existing software, without a recompile
3. Focus on statistical analysis, not implementation
4. Customizable: stick to your preferred programming language, framework

## General

- XML-schema structures for automated schema validation
- Command line tool for random design creation

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# Software as of now. . .

## General

- XML-schema structures for automated schema validation
- Command line tool for random design creation

## InPUT 4j

- Full InPUT support
  - rich API
  - import/export (XML, LaTeX, archives,. . . )

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## General

- XML-schema structures for automated schema validation
- Command line tool for random design creation

## InPUT 4j

- Full InPUT support
  - rich API
  - import/export (XML, LaTeX, archives,. . . )
- Features
  - arbitrary array definitions (integer[10][5][], Operator[4])
  - random parameter/design creation (Problem instance generation)
  - customizable abstract datatypes
  - customizable code mappings: automated recursive object initialization, wrapper classes, string values, customizable constructors, getters, and setters, relative parameter value definition, id-references of parameters in constructor. . .

# Future Work

1. Support for automated algorithm design
   - Use for existing tuners (e.g. SPOT)
   - Genetic programming (GP)

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# Future Work

1. Support for automated algorithm design
   - Use for existing tuners (e.g. SPOT)
   - Genetic programming (GP)
2. Additional programming language support
   - C++ soon, ...

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# Future Work

1. Support for automated algorithm design
   - Use for existing tuners (e.g. SPOT)
   - Genetic programming (GP)
2. Additional programming language support
   - C++ soon, ...
3. Features
   - design spaces and references
   - import/export: database, spread-sheet
   - definition of restrictions based on boolean logic
   - ...

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# Thank you for your attention

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