Project: Solving proximity constraints

Jan-Michael Holzinger[*] Sophie Hofmanninger[†]

JKU Linz — SS2019

Version Number	Changes Summary	Author
0.1		Jan-Michael
0.2	added System Model	Jan-Michael
0.3	modified Parser, added Workflow	Jan-Michael
0.4	add ConstraintSimplification	Sophie
0.5	Proximity Relation (as Matrix) added	Jan-Michael
0.6	update system model, update matrix	Sophie
0.7	added UML	Jan-Michael
0.8	added User Interfaces	Jan-Michael
0.9	minor changes in matrix description update constraint simplification	Sophie
0.10	updated UML files	Jan-Michael
0.11	added Input Checker	Jan-Michael
0.12	added Command Line Interface	Jan-Michael

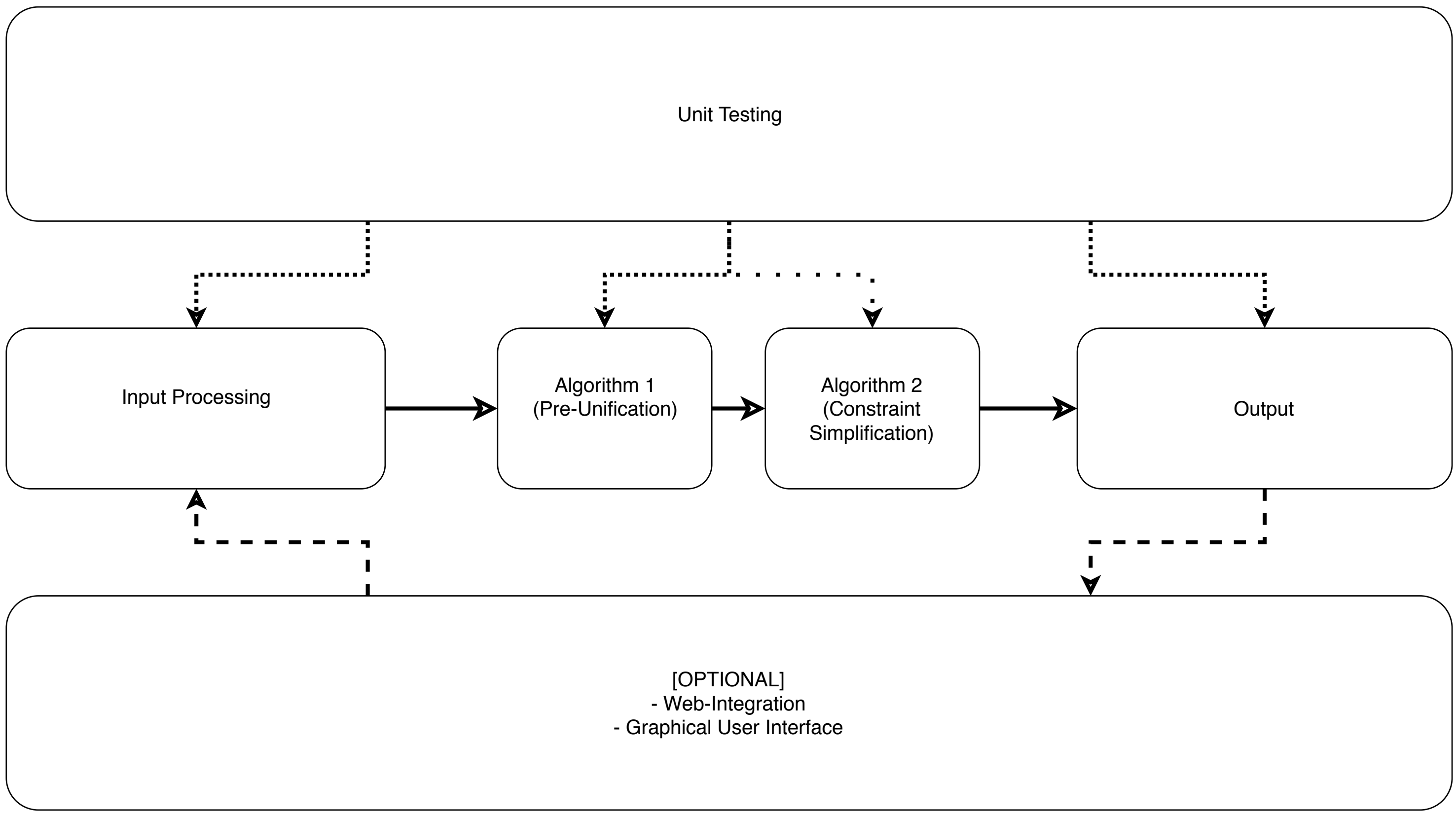
1 System Overview

We split the problem in 4 (5) smaller tasks:

1. Input Processing,
2. Pre-Unification,
3. Constraint Simplification,
4. Input/Output.

O. Web-Integration.

[*]jan.holzinger@gmx.at
[†]sophie@hofmanninger.co.at


Unit Testing
Input Processing
Algorithm 1
(Pre-Unification)
Algorithm 2
(Constraint
Simplification)
Output
[OPTIONAL]
- Web-Integration
- Graphical User Interface

1.1 Input Processing

1.1.1 InputParser

The first idea here is to copy, alter and extend the existing code, in the class InputParser.

1.1.2 Input Checker

We want to be able to check the input for example for missing parenthesis and so on. Therefore we will allow the user to specify an InputChecker. The idea is, to create an Interface, with just a method check(String):boolean. This then can be implemented by the implementation of the checkers.

1.1.3 Proximity Relations

For the Proximity Relations $\mathcal{R}$ and the λ-*cut* we have the following idea:

1. We try to get the number of function symbols with the same arity.
2. We let the user input the values to construct a symmetric matrix that consists of values in $[0, 1]$. This matrix must have a 1 in the main diagonal. All values below are 0. Therefore they will not be stored in the implementation.
3. We let the user (later) input $\lambda \in [0, 1]$ and calculate the set $\mathcal{R}_\lambda$.

The current implementation of InputParser creates a list of all Functions. This list is then sorted by arity, i.e. let f, g be functions with arity $a, b \in \mathbb{N}$ respectively. Then $a < b \Rightarrow f \prec g$.
Let now $n \in \mathbb{N}$ be the size of the list, the list then represents the caption of a $n \times n$ matrix. Assume the problem contains functions with arity 0,1,...,m. Let k_l be the number of Functions with arity l. Then

$$\sum_{l=0}^{m} k_l = n.$$

The matrix then looks like

$$\begin{array}{cc}
 & \begin{array}{ccccccccccccc} f_{0_1} & f_{0_2} & \cdots & f_{0_{k_0}} & f_{1_1} & f_{1_2} & \cdots & f_{1_{k_1}} & \cdots & f_{m_1} & f_{m_2} & \cdots & f_{m_{k_m}} \end{array} \\
\begin{array}{c} f_{0_1} \\ f_{0_2} \\ \vdots \\ f_{0_{k_0}} \\ f_{1_1} \\ f_{1_2} \\ \vdots \\ f_{1_{k_1}} \\ \vdots \\ f_{m_1} \\ f_{m_2} \\ \vdots \\ f_{m_{k_m}} \end{array} &
\begin{pmatrix}
1 & (*) & (*) & (*) & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
* & 1 & (*) & (*) & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
* & * & \ddots & (*) & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
* & * & * & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & (*) & (*) & (*) & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & * & 1 & (*) & (*) & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & * & * & \ddots & (*) & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & * & * & * & 1 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \ddots & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & (*) & (*) & (*) \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & * & 1 & (*) & (*) \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & * & * & \ddots & (*) \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & * & * & * & 1
\end{pmatrix}
\end{array},$$

where:

- the 1's in the diagonal are fixed, as a function must have proximity 1 to itself,
- the 0's are fixed, as functions with different aritys can't be close,
- the values where the entry is * must be of the same value as their (*) counterpart, as the matrix is symmetric.

Hence, we only need to get the values for the positions marked with (*). We call such a position "open case", and we make a list of open cases. Before asking the user to enter relation values, we will generate the list of open cases inside of the matrix. After generation of the list, we will wait for user input. With the valid user input we will build the proximity relation matrix.

If we want to retrieve a value, i.e. if we want to know $\mathcal{R}(s_1, s_2)$ for given s_1, s_2, we can call $getRelation(s_1, s_2)$. To get all relation pairs of s_1, that have a relation value greater or equal to λ, the method $getRelations(s_1, \lambda)$ can be used. Moreover it is possible to get all reation elements of the matirix by calling $getListOfFunctions()$. This will return all $f_{i_{k_j}}$, where $0 \leq i \leq m$ and $0 \leq j \leq m$.

1.2 Algorithms

We implement the Algorithms in an own class, that has two public static functions, preUnification and constraintSimplification. The other methods are only used for the construction of the two simplification algorithms and therefore they are private and static. The methods should take two inputs, mandatory an unification problem, and optional a StringBuffer, to log certain events.

1.2.1 Pre-Unification Algorithm

The preUnification method consists of a loop, that runs until either $\mathrm{P} = \emptyset$ or it is detected, that there is no solution to the problem.
Inside the loop body, the 7 pre-unification rules are iteratively applied to the first element (which gets popped by doing so). The method returns true, iff the pre-unification was successful.

The method changes the problems constraints and pre-unifier accordingly.

1.2.2 Constraint Simplification Algorithm

The constraintSimplification method will be called, if the preUnification method returns true. As the preUnification method, the constraintSimplification method consists of a loop. This loop runs until the set of constraints is empty. As input the method needs the problem, more precisely the set of constraints, and the relation matrix $\mathcal{R}$. If the set of constraints could be simplified, the method returns true and otherwise false.
Inside the loop, the seven rules to simplify the constraint set, will be applied. Three of the seven rules are hidden, because the NN2 rule is integrated in the NN1 rule, the Fail1 is implemented in FFS and the Fail2 is integrated in the NN1 rule. Moreover it is possible to run the constraint simplification algorithm with and without logging.

1.3 Input/Output

We provide a command line user interface for the program. This user interface is implemented in the "SPC_CL" class(SolvingProximityConstraints_via_CommandLine). The program can be accessed with no or some of this optional arguments: Note: the first argument if any are given is always the equation in the format "lhs =? rhs" where the blanks in between are mandatory.

the equation in the format "lhs =? rhs" (left hand side and right hand side of the equation.

-f <PATH> a path given to a file where (parts) of the proximity relations are stored the format must follow the convention, that is mentioned below.

-s silent mode on/off, default is off, -s with no argument switches on, optional argument "n" switches off.

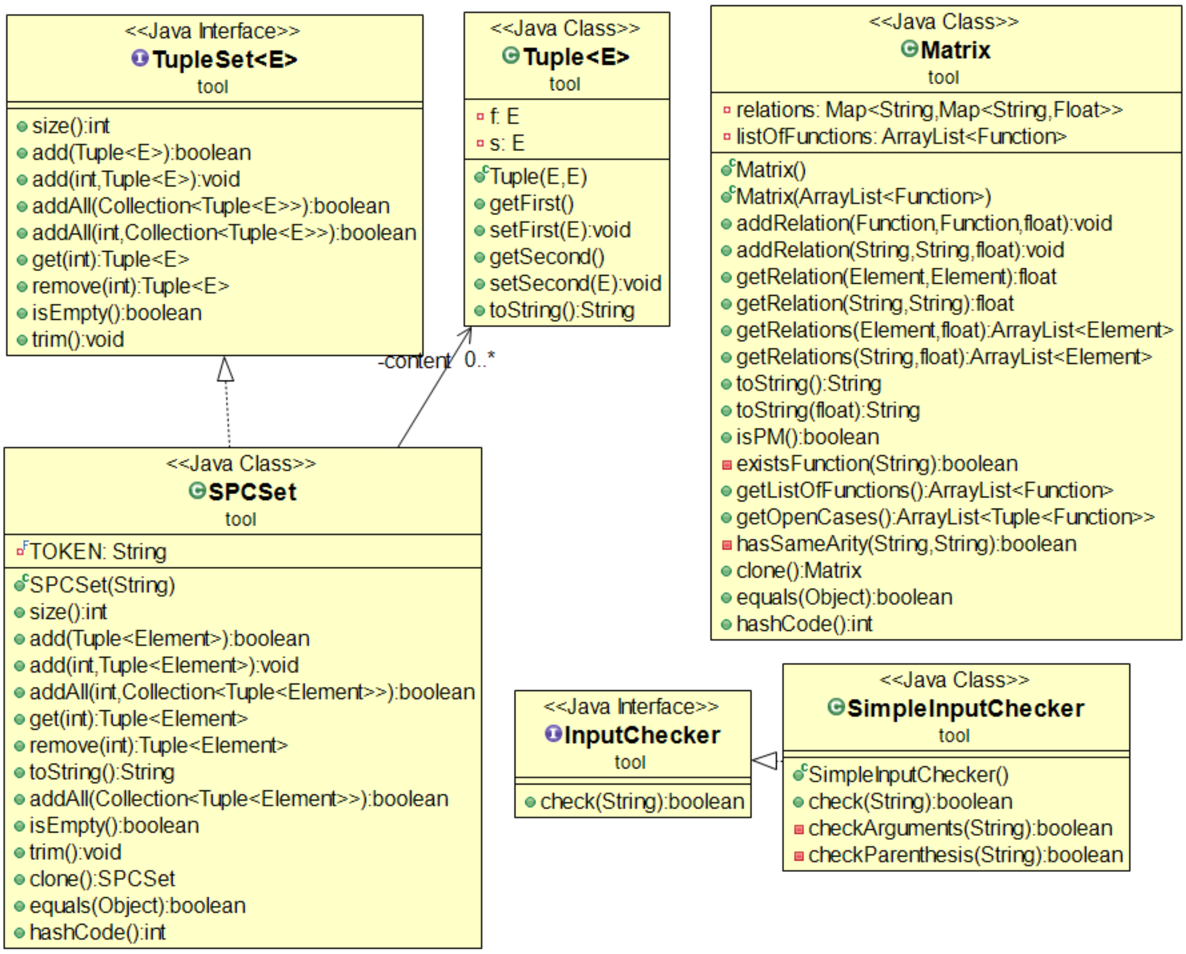
-l followed by the lambda value.

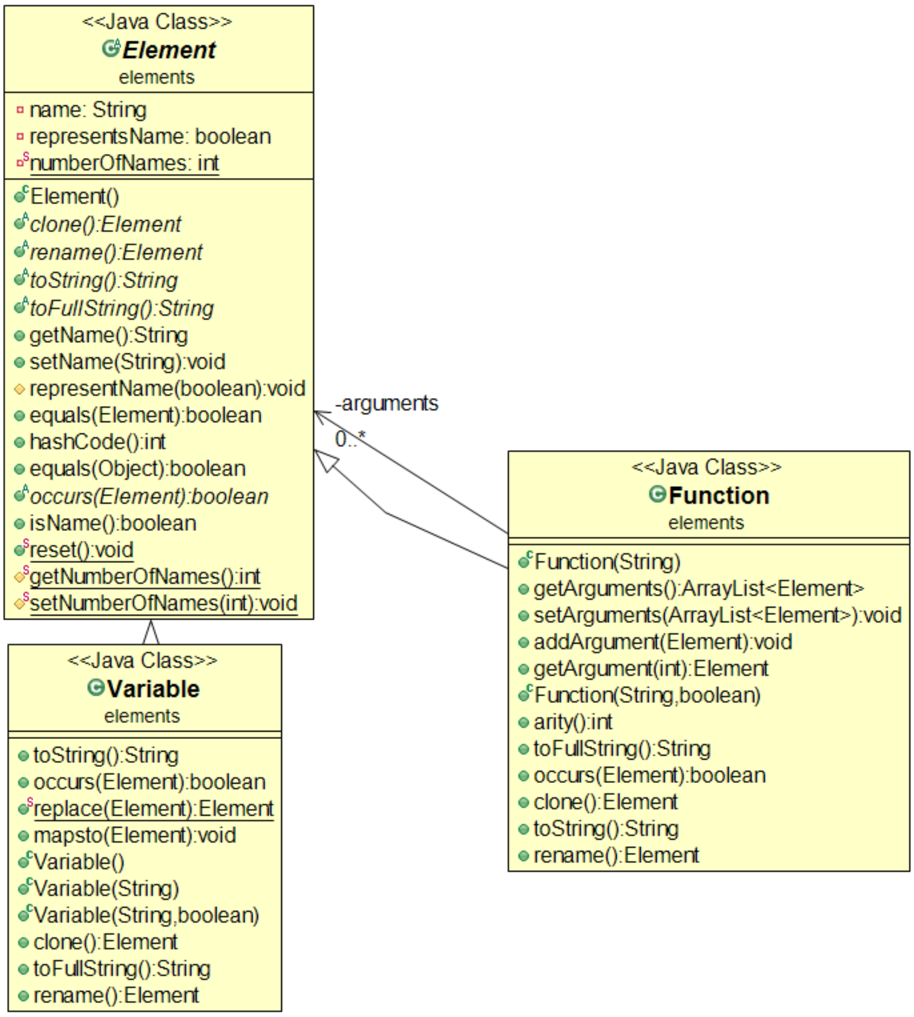
The proximity relations must be stored in a text file, one line for each relation, where the two functions (or constants) are separated with "," (comma) and the lambda value, also separated with ",".

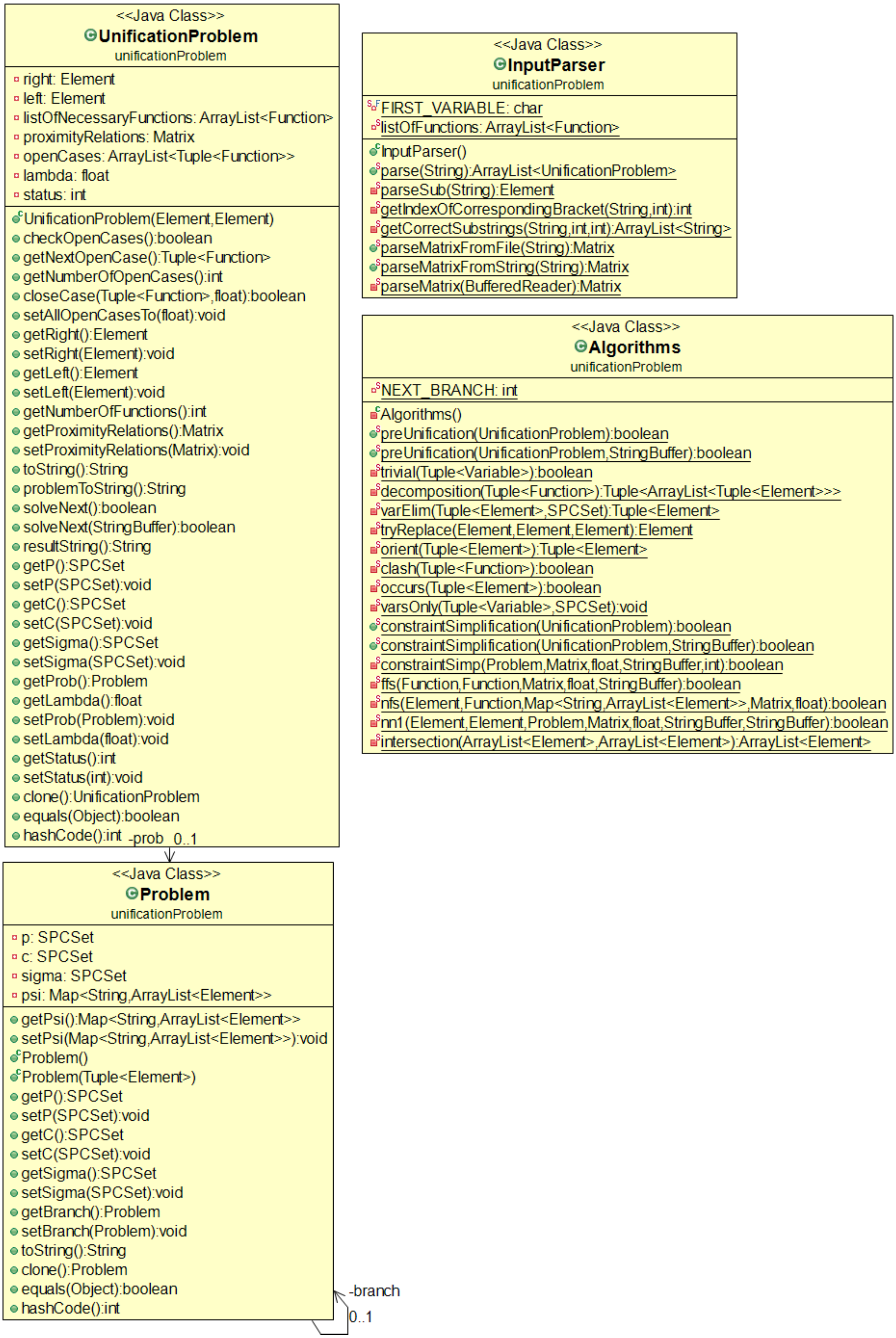
2 System Model

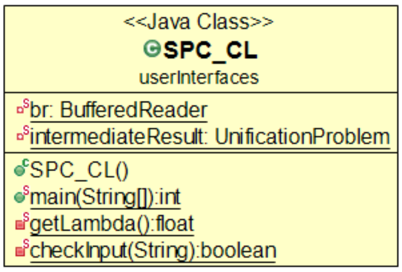
The program consists of 4 packages,

- tool
- elements
- unificationProblem
- userInterfaces



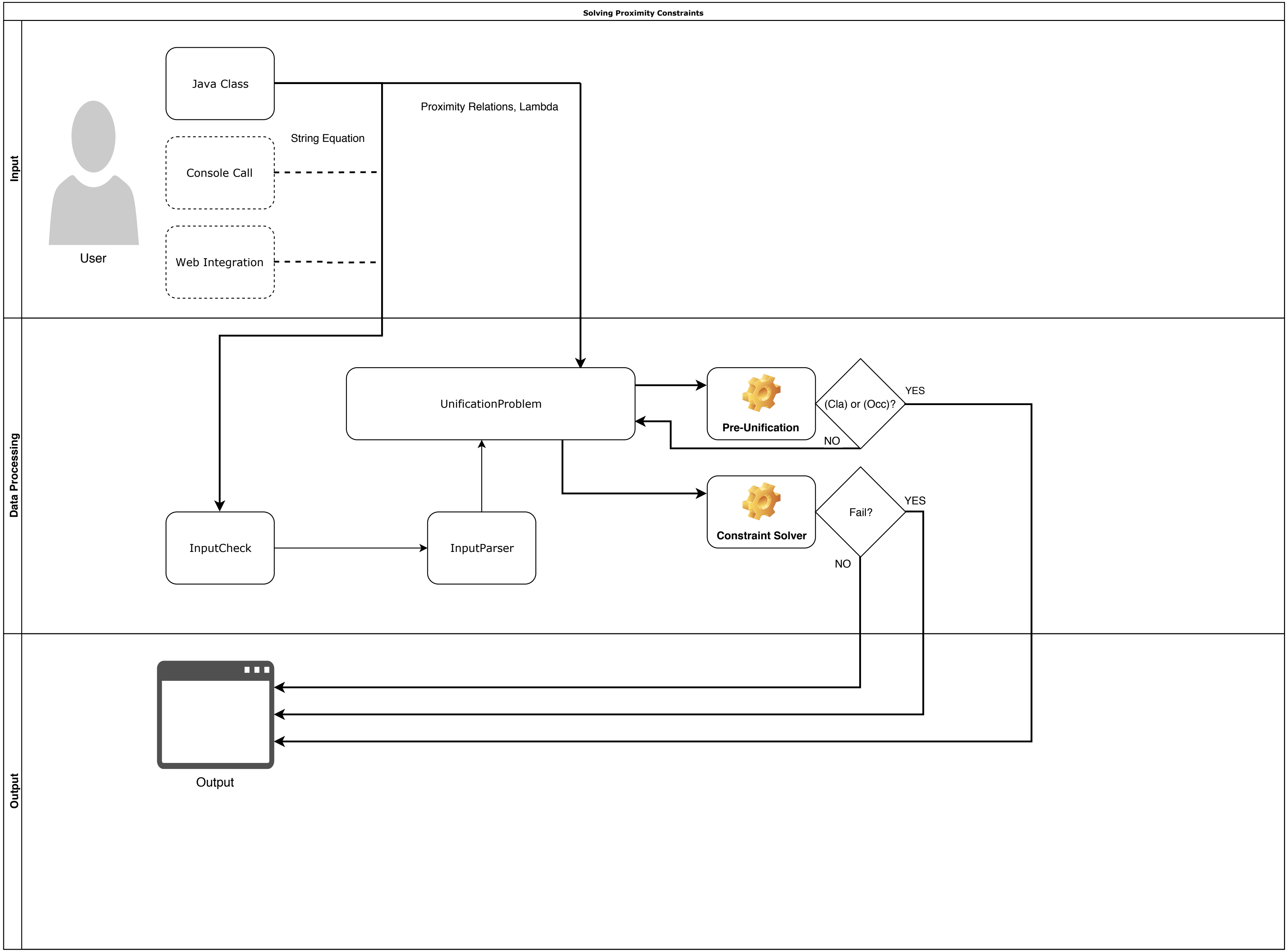

<<Java Class>>
Element
elements
name: String
representsName: boolean
numberOfNames: int
Element()
clone():Element
rename():Element
toString():String
toFullString():String
getName():String
setName(String):void
representName(boolean):void
equals(Element):boolean
hashCode():int
equals(Object):boolean
occurs(Element):boolean
isName():boolean
reset():void
getNumberOfNames():int
setNumberOfNames(int):void
-arguments
0..*
<<Java Class>>
Function
elements
Function(String)
getArguments():ArrayList<Element>
setArguments(ArrayList<Element>):void
addArgument(Element):void
getArgument(int):Element
Function(String,boolean)
arity():int
toFullString():String
occurs(Element):boolean
clone():Element
toString():String
rename():Element
<<Java Class>>
Variable
elements
toString():String
occurs(Element):boolean
replace(Element):Element
mapsto(Element):void
Variable()
Variable(String)
Variable(String,boolean)
clone():Element
toFullString():String
rename():Element


<<Java Class>>
UnificationProblem
unificationProblem
right: Element
left: Element
listOfNecessaryFunctions: ArrayList<Function>
proximityRelations: Matrix
openCases: ArrayList<Tuple<Function>>
lambda: float
status: int
UnificationProblem(Element,Element)
checkOpenCases():boolean
getNextOpenCase():Tuple<Function>
getNumberOfOpenCases():int
closeCase(Tuple<Function>,float):boolean
setAllOpenCasesTo(float):void
getRight():Element
setRight(Element):void
getLeft():Element
setLeft(Element):void
getNumberOfFunctions():int
getProximityRelations():Matrix
setProximityRelations(Matrix):void
toString():String
problemToString():String
solveNext():boolean
solveNext(StringBuffer):boolean
resultString():String
getP():SPCSet
setP(SPCSet):void
getC():SPCSet
setC(SPCSet):void
getSigma():SPCSet
setSigma(SPCSet):void
getProb():Problem
getLambda():float
setProb(Problem):void
setLambda(float):void
getStatus():int
setStatus(int):void
clone():UnificationProblem
equals(Object):boolean
hashCode():int
-prob 0..1
<<Java Class>>
Problem
unificationProblem
p: SPCSet
c: SPCSet
sigma: SPCSet
psi: Map<String,ArrayList<Element>>
getPsi():Map<String,ArrayList<Element>>
setPsi(Map<String,ArrayList<Element>>):void
Problem()
Problem(Tuple<Element>)
getP():SPCSet
setP(SPCSet):void
getC():SPCSet
setC(SPCSet):void
getSigma():SPCSet
setSigma(SPCSet):void
getBranch():Problem
setBranch(Problem):void
toString():String
clone():Problem
equals(Object):boolean
hashCode():int
-branch
0..1
<<Java Class>>
InputParser
unificationProblem
FIRST_VARIABLE: char
listOfFunctions: ArrayList<Function>
InputParser()
parse(String):ArrayList<UnificationProblem>
parseSub(String):Element
getIndexOfCorrespondingBracket(String,int):int
getCorrectSubstrings(String,int,int):ArrayList<String>
parseMatrixFromFile(String):Matrix
parseMatrixFromString(String):Matrix
parseMatrix(BufferedReader):Matrix
<<Java Class>>
Algorithms
unificationProblem
NEXT_BRANCH: int
Algorithms()
preUnification(UnificationProblem):boolean
preUnification(UnificationProblem,StringBuffer):boolean
trivial(Tuple<Variable>):boolean
decomposition(Tuple<Function>):Tuple<ArrayList<Tuple<Element>>>
varElim(Tuple<Element>,SPCSet):Tuple<Element>
tryReplace(Element,Element,Element):Element
orient(Tuple<Element>):Tuple<Element>
clash(Tuple<Function>):boolean
occurs(Tuple<Element>):boolean
varsOnly(Tuple<Variable>,SPCSet):void
constraintSimplification(UnificationProblem):boolean
constraintSimplification(UnificationProblem,StringBuffer):boolean
constraintSimp(Problem,Matrix,float,StringBuffer,int):boolean
ffs(Function,Function,Matrix,float,StringBuffer):boolean
nfs(Element,Function,Map<String,ArrayList<Element>>,Matrix,float):boolean
nn1(Element,Element,Problem,Matrix,float,StringBuffer,StringBuffer):boolean
intersection(ArrayList<Element>,ArrayList<Element>):ArrayList<Element>



3 Work Flow

The typical workflow looks like this:


Solving Proximity Constraints
Input
Data Processing
Output
User
Java Class
Console Call
Web Integration
String Equation
Proximity Relations, Lambda
UnificationProblem
Pre-Unification
(Cla) or (Occ)?
YES
NO
Constraint Solver
Fail?
YES
NO
InputCheck
InputParser
Output