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Fachrichtung 6.2 – Informatik
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2nd Practical Assignment in Artificial Intelligence (SS 2005)

Issued: May 30, 2005 Due: June 13, 2005

- **Please submit your solution by sending an email to your tutor. The e-mail address of your tutor can be found on the webpage.**
- **Indicate the name and matriculation number of each student working in your project.**
- **Make sure to include comments in your code. In order to obtain full credit, your code must be documented and comprehensible.**

Exercise P2.1: **100 P**

In this exercise, you have to implement an unification algorithm which has been specified in the lecture using Lisp. In general, this unification algorithm should take two terms $TERM_1$ and $TERM_2$ and return a substitution that would make $TERM_1$ and $TERM_2$ look the same. If there is no such substitution, this algorithm should return the Lisp symbol `FAIL`. Formally, a $TERM$ has one of three forms:

$$\begin{aligned} TERM &::= (\texttt{VAR}\ x) && (1)\\ &\ \ |\quad (\texttt{CONST}\ c) && (2)\\ &\ \ |\quad (\texttt{APPLY} f\ TERM^+) && (3)\end{aligned}$$

This means, a $TERM$ can be either a variable, a constant or a function applied to at least one argument (where each argument is a $TERM$). Note that `VAR`, `CONST` and `APPLY` are three (3) specific Lisp symbols where x, c and f stand for Lisp symbols naming the particular variable, constant or function.

A substitution ($SUBST$) is a list of pairs associating variables with terms:

$$SUBST \ ::= \ (((\texttt{VAR}\ x)\ TERM)^*) \qquad (4)$$

Note that NIL (the empty list) is a substitution.

1. Implement a lisp function named `KI-PRINT-TERM` which prints a term in the notation from the slides. Namely, (`VAR` x) should be printed as x, (`CONST` c) should be printed as

c and (`APPLY` f $TERM_1$ $\cdots$ $TERM_n$) should be printed as $f(t_1, \ldots, t_n)$ where t_i is the printed version of $TERM_i$. (The return value of this function is not important.) (10 P)

Hint: The Lisp function `format` could be helpful.

Example:

```
> (KI-PRINT-TERM '(APPLY KNOWS (VAR X) (CONST JOHN)))
KNOWS(X,JOHN)
```

2. Implement a lisp function named `KI-PRINT-SUBST` which prints a substitution in the notation `{VAR/TERM,...}`. (The return value of this function is not important.) (10 P)

   Examples:

```
> (KI-PRINT-SUBST NIL)
{}

> (KI-PRINT-SUBST '(((VAR X) (CONST JOHN))))
{X/JOHN}

> (KI-PRINT-SUBST '(((VAR X) (CONST JOHN)) ((VAR Y) (APPLY MOTHER (VAR Z)))))
{X/JOHN,Y/MOTHER(Z)}
```

3. Implement a lisp function named `KI-SUBST` which expects two arguments. The first argument will be a substitution $SUBST_1$ and the second argument will be a term $TERM_1$. The function `KI-SUBST` should return a term $TERM_2$ which is the result of replacing the variables in $TERM_1$ with the values given by $SUBST_1$. (30 P)

   Example:

```
> (KI-SUBST '(((VAR X) (CONST JOHN)) ((VAR Y) (APPLY MOTHER (VAR Z))))
            '(APPLY KNOWS (VAR X) (VAR Y)))
(APPLY KNOWS (CONST JOHN) (APPLY MOTHER (VAR Z)))
```

4. Implement the unification algorithm as a function named `KI-UNIFY` which takes two arguments $TERM_1$ and $TERM_2$ and returns either the Lisp symbol `FAIL` or a substitution $SUBST$ (as described above). (50 P)

   Examples:

```
> (KI-UNIFY '(APPLY KNOWS (CONST JOHN) (VAR X))
            '(APPLY KNOWS (VAR Y) (APPLY MOTHER (VAR Y))))
(((VAR X) (APPLY MOTHER (VAR Y))) ((VAR Y) (CONST JOHN)))

> (KI-UNIFY '(APPLY WITH (VAR X) (CONST WEST-GERMANY))
            '(APPLY WITH (CONST EAST-GERMANY) (VAR X)))
FAIL
```

Hint: Rules for unification are in the slides. There is also a unification algorithm in the book (Figure 9.1, page 278). Be careful! The unification algorithm in the book assumes the inputs are terms or *lists* of terms. Also, the rules in class are written for two sets of equations (pairs of terms) U, E.