

Principles of Programming Languages

Answers for small examination 2

Problem 1 Show the type consistency of the following program fragment, which is written in the subset of C language presented in the lecture, according to (1) and (2).

(Answer)

```
int *p;
int x[3];
p = x;
```

- (1) Rewrite the variable declarations `int *p;` and `int x[3];` in the postfix notation presented in the lecture.

(Answer)

```
p : int *
x : int [3]
```

- (2) Show the type consistency of the assignment expression `p=x` by applying the inference rules to the declarations of `p` and `x` in the postfix notation obtained in (1).

(Answer)

$$\frac{\begin{array}{l} x : \text{int } [3] \\ p : \text{int } * \quad x : \text{int } \& \end{array}}{p = x : \text{int } \&}$$

Problem 2 A lambda expression $(\lambda x. \lambda y. x) ((\lambda z. z) w)$ can be transformed to $(\lambda y. w)$ by applying the β reductions. Write the each step of the β reductions. (Although there are more than one sequences of β reductions, write one of them.)

(Answer 1)

$$(\lambda x. \lambda y. x) ((\lambda z. z) w) \xrightarrow{\beta} (\lambda x. \lambda y. x) w \xrightarrow{\beta} \lambda y. w$$

(Answer 2)

$$(\lambda x. \lambda y. x) ((\lambda z. z) w) \xrightarrow{\beta} \lambda y. ((\lambda z. z) w) \xrightarrow{\beta} \lambda y. w$$

Problem 3 Write the output to the display when executing the following program in

C++.

```
#include <stdio.h>
class Shape {
public:
    virtual void draw (void) {
        printf ("Shape\n");
    }
};
class Box : public Shape {
    void draw (void) {
        printf ("Box\n");
    }
};
```

```
int main (void) {
    Shape *s;
    s = new Box ();
    s->draw();
    return 0;
}
```

(Answer)

Box

Problem 4

Show the meaning of the following programs (1) and (2) by using the rules presented in the lecture. Note that the programs are in the small subset of C presented in the lecture. Let the states before executing the programs both to be $\sigma = \{(X, 3), (Y, 1), (Z, 0)\}$.

(1) $Z=(X+4);$

$$\frac{\frac{\langle X, \sigma \rangle \rightarrow 3 \quad \langle 4, \sigma \rangle \rightarrow 4}{\langle (X+4), \sigma \rangle \rightarrow 7}}{\langle Z = (X+4);, \sigma \rangle \rightarrow \sigma[7/Z]}$$

So in the state σ , after executing the program $Z=(X+4);$ the state becomes as follows.

$$\sigma[7/Z] = \{(X, 3), (Y, 1), (Z, 7)\}$$

(2) $\text{while}(Y)\{Y=(Y-1);\}$

$$\frac{\frac{\frac{\langle Y, \sigma \rangle \rightarrow 1 \quad \langle 1, \sigma \rangle \rightarrow 1}{\langle (Y-1), \sigma \rangle \rightarrow 0}}{\langle Y, \sigma \rangle \rightarrow 1 \quad \langle Y = (Y-1);, \sigma \rangle \rightarrow \sigma[0/Y]} \quad \frac{\langle Y, \sigma[0/Y] \rangle \rightarrow 0}{\langle \text{while}(Y)\{Y = (Y-1);\}, \sigma[0/Y] \rangle \rightarrow \sigma[0/Y]}}{\langle \text{while}(Y)\{Y = (Y-1);\}, \sigma \rangle \rightarrow \sigma[0/Y]}$$

So in the state σ , after executing the program $\text{while}(Y)\{Y=(Y-1);\}$ the state becomes as follows.

$$\sigma[0/Y] = \{(X, 3), (Y, 0), (Z, 0)\}$$