

## Практична робота 5. Семантичні терми

### № 3

- $3^x$
- Вхідні дані:  $X=3$
- Програма:

```
begin
  R := 1;
  while X > 0 do
    begin
      R := R * 3;
      X := X - 1
    end
  end
end
```

### 4. Побудувати семантичний терм програми

```
sem_P(begin
  R := 1;
  while X > 0 do
    begin
      R := R * 3;
      X := X - 1
    end
  end) =
```

```
sem_P(begin S end) = sem_S(S)
```

```
= sem_S(R := 1;
  while X > 0 do
    begin
      R := R * 3;
```

X := X - 1  
end) =

$$\text{sem\_S}(S1 ; S2) = \text{sem\_S}(S1) \bullet \text{sem\_S}(S2)$$

$$= \text{sem\_S}(R := 1) \bullet \text{sem\_S}(\text{while } X > 0 \text{ do} \\ \quad \text{begin} \\ \quad \quad R := R * 3; \\ \quad \quad X := X - 1 \\ \quad \text{end}) =$$

$$\text{sem\_S}(x := a) = AS^x(\text{sem\_A}(a))$$

$$= AS^R(\text{sem\_A}(1)) \bullet \text{sem\_S}(\text{while } X > 0 \text{ do} \\ \quad \text{begin} \\ \quad \quad R := R * 3; \\ \quad \quad X := X - 1 \\ \quad \text{end}) =$$

$$\text{sem\_S}(\text{while } b \text{ do } S) = WH(\text{sem\_B}(b), \text{sem\_S}(S))$$

$$= AS^R(\text{sem\_A}(1)) \bullet WH(\text{sem\_B}(X > 0), \text{sem\_S}(\text{begin} \\ \quad R := R * 3; \\ \quad X := X - 1 \\ \quad \text{end})) =$$

$$\text{sem\_B}(a1 > a2) = S^2(\text{gr}, \text{sem\_A}(a1), \text{sem\_A}(a2))$$

$$= AS^R(\text{sem\_A}(1)) \bullet WH(S^2(\text{gr}, \text{sem\_A}(X), \text{sem\_A}(0)), \\ \text{sem\_S}(\text{begin} \\ \quad R := R * 3; \\ \quad X := X - 1$$

end)) =

$$\text{sem\_A}(x) = x \Rightarrow, \text{sem\_A}(n) = \bar{n}$$

$$= AS^R(\bar{1}) \bullet \text{WH}(S^2(\text{gr}, X \Rightarrow, \bar{0}), \text{sem\_S}(\begin{array}{l} R := R * 3; \\ X := X - 1 \\ \text{end})) = \end{array}$$

$$\text{sem\_S}(\text{begin } S \text{ end}) = (\text{sem\_S}(S))$$

$$= AS^R(\bar{1}) \bullet \text{WH}(S^2(\text{gr}, X \Rightarrow, \bar{0}), \text{sem\_S}(R := R * 3; \\ X := X - 1)) =$$

$$\text{sem\_S}(S1 ; S2) = \text{sem\_S}(S1) \bullet \text{sem\_S}(S2)$$

$$= AS^R(\bar{1}) \bullet \text{WH}(S^2(\text{gr}, X \Rightarrow, \bar{0}), \text{sem\_S}(R := R * 3) \bullet \text{sem\_S}(X := \\ X - 1)) =$$

$$\text{sem\_S}(x := a) = AS^x(\text{sem\_A}(a))$$

$$= AS^R(\bar{1}) \bullet \text{WH}(S^2(\text{gr}, X \Rightarrow, \bar{0}), AS^R(\text{sem\_A}(R * 3)) \bullet AS^x \\ (\text{sem\_A}(X - 1))) =$$

$$\text{sem\_A}(a1 * a2) = S^2(\text{mult}, \text{sem\_A}(a1), \text{sem\_A}(a2)), \\ \text{sem\_A}(a1 - a2) = S^2(\text{sub}, \text{sem\_A}(a1), \text{sem\_A}(a2))$$

$$= AS^R(\bar{1}) \bullet \text{WH}(S^2(\text{gr}, X \Rightarrow, \bar{0}), AS^R(S^2(\text{mult}, \text{sem\_A}(R), \\ \text{sem\_A}(3)))) \bullet AS^x(S^2(\text{sub}, \text{sem\_A}(X), \text{sem\_A}(1)))) =$$

$$\text{sem\_}A(x) = x \Rightarrow, \text{sem\_}A(n) = \bar{n}$$

$$= AS^R(\bar{1}) \bullet WH(S^2(\text{gr}, X \Rightarrow, \bar{0}), AS^R(S^2(\text{mult}, R \Rightarrow, \bar{3})) \bullet AS^x(S^2(\text{sub}, X \Rightarrow, \bar{1}))))$$

**Відповідь:**

$$AS^R(\bar{1}) \bullet WH(S^2(\text{gr}, X \Rightarrow, \bar{0}), AS^R(S^2(\text{mult}, R \Rightarrow, \bar{3})) \bullet AS^x(S^2(\text{sub}, X \Rightarrow, \bar{1}))))$$

## 5. Перевірити синтаксичну правильність програми

st = [X -> 3]

$$AS^R(\bar{1}) \bullet WH(S^2(\text{gr}, X \Rightarrow, \bar{0}), AS^R(S^2(\text{mult}, R \Rightarrow, \bar{3})) \bullet AS^x(S^2(\text{sub}, X \Rightarrow, \bar{1}))))(st) = \text{Послідовне виконання} = WH(S^2(\text{gr}, X \Rightarrow, \bar{0}), AS^R(S^2(\text{mult}, R \Rightarrow, \bar{3})) \bullet AS^x(S^2(\text{sub}, X \Rightarrow, \bar{1}))))(AS^R(\bar{1})(st))$$

$$AS^R(\bar{1})(st) = \text{Присвоювання} = st \nabla [R \rightarrow \bar{1}(st)] = st \nabla [R \rightarrow 1] = [X \rightarrow 3, R \rightarrow 1] = \underline{\text{st'}}$$

$$\underline{\text{st'} = [X \rightarrow 3, R \rightarrow 1]}$$

$$\text{Обчислимо } WH(S^2(\text{gr}, X \Rightarrow, \bar{0}), AS^R(S^2(\text{mult}, R \Rightarrow, \bar{3})) \bullet AS^x(S^2(\text{sub}, X \Rightarrow, \bar{1}))))(st')$$

**Умова:**  $S^2(\text{gr}, X \Rightarrow, \bar{0})(st') = \text{Суперпозиція} = \text{gr}(X \Rightarrow (st'), \bar{0}(st')) = \text{gr}(3, 0) = \text{true}$  - звідси робимо висновок, що цикл виконується принаймні один раз.

- $st1 = AS^R(S^2(mult, R \Rightarrow, \bar{3})) \bullet AS^x(S^2(sub, X \Rightarrow, \bar{1}))(st') =$   
**Послідовне виконання** =  $AS^x(S^2(sub, X \Rightarrow, \bar{1}))(AS^R(S^2(mult, R \Rightarrow, \bar{3}))(st'))$

$AS^R(S^2(mult, R \Rightarrow, \bar{3}))(st') =$  **Присвоювання** =  $st' \nabla [R \rightarrow S^2(mult, R \Rightarrow, \bar{3})(st')]$  = **Суперпозиція** =  $st' \nabla [R \rightarrow mult(R \Rightarrow (st'), \bar{3}(st'))]$  =  $st' \nabla [R \rightarrow mult(1, 3)]$  =  $st' \nabla [R \rightarrow 3]$  =  $[X \rightarrow 3, R \rightarrow 3] = \underline{st''}$

$st'' = [X \rightarrow 3, R \rightarrow 3]$

$AS^x(S^2(sub, X \Rightarrow, \bar{1}))(st'') =$  **Присвоювання** =  $st'' \nabla [X \rightarrow S^2(sub, X \Rightarrow, \bar{1})(st'')]$  = **Суперпозиція** =  $st'' \nabla [X \rightarrow sub(X \Rightarrow (st''), \bar{1}(st''))]$  =  $st'' \nabla [X \rightarrow sub(3, 1)]$  =  $st'' \nabla [X \rightarrow 2]$  =  $[X \rightarrow 2, R \rightarrow 3] = \underline{st1}$

$st1 = [X \rightarrow 2, R \rightarrow 3]$

Перевіряємо умову:

$S^2(gr, X \Rightarrow, \bar{0})(st1) =$  **Суперпозиція** =  $gr(X \Rightarrow (st1), \bar{0}(st1))$   
 $= gr(2, 0) = true$

- $st2 = AS^R(S^2(mult, R \Rightarrow, \bar{3})) \bullet AS^x(S^2(sub, X \Rightarrow, \bar{1}))(st1) =$   
**Послідовне виконання** =  $AS^x(S^2(sub, X \Rightarrow, \bar{1}))(AS^R(S^2(mult, R \Rightarrow, \bar{3}))(st1))$

$AS^R(S^2(\text{mult}, R \Rightarrow, \bar{3}))(st1) = \text{Присвоювання} = st1 \nabla [R \rightarrow$   
 $S^2(\text{mult}, R \Rightarrow, \bar{3})(st1)] = \text{Суперпозиція} = st1 \nabla [R \rightarrow \text{mult}(R \Rightarrow$   
 $(st1), \bar{3}(st1))] = st1 \nabla [R \rightarrow \text{mult}(3, 3)] = st1 \nabla [R \rightarrow 9] = [X \rightarrow 2,$   
 $R \rightarrow 9] = \text{st1'}$

$st1' = [X \rightarrow 2, R \rightarrow 9]$

$AS^x(S^2(\text{sub}, X \Rightarrow, \bar{1}))(st1') = \text{Присвоювання} = st1' \nabla [X \rightarrow$   
 $S^2(\text{sub}, X \Rightarrow, \bar{1})(st1')] = \text{Суперпозиція} = st1' \nabla [X \rightarrow \text{sub}(X \Rightarrow$   
 $(st1'), \bar{1}(st1'))] = st1' \nabla [X \rightarrow \text{sub}(2, 1)] = st1' \nabla [X \rightarrow 1] = [X \rightarrow 1,$   
 $R \rightarrow 9] = \text{st2}$

$st2 = [X \rightarrow 1, R \rightarrow 9]$

Перевіряємо умову:

$S^2(\text{gr}, X \Rightarrow, \bar{0})(st2) = \text{Суперпозиція} = \text{gr}(X \Rightarrow(st2), \bar{0}(st2))$   
 $= \text{gr}(1, 0) = \text{true}$

- $st3 = AS^R(S^2(\text{mult}, R \Rightarrow, \bar{3})) \cdot AS^x(S^2(\text{sub}, X \Rightarrow, \bar{1}))(st2) =$   
**Послідовне виконання** =  $AS^x(S^2(\text{sub}, X \Rightarrow, \bar{1}))(AS^R(S^2$   
 $(\text{mult}, R \Rightarrow, \bar{3}))(st2))$

$AS^R(S^2(\text{mult}, R \Rightarrow, \bar{3}))(st2) = \text{Присвоювання} = st2 \nabla [R \rightarrow$   
 $S^2(\text{mult}, R \Rightarrow, \bar{3})(st2)] = \text{Суперпозиція} = st2 \nabla [R \rightarrow \text{mult}(R \Rightarrow$   
 $(st2), \bar{3}(st2))] = st2 \nabla [R \rightarrow \text{mult}(9, 3)] = st2 \nabla [R \rightarrow 27] = [X \rightarrow 1,$   
 $R \rightarrow 27] = \text{st2'}$

$st2' = [X \rightarrow 1, R \rightarrow 27]$

$AS^x(S^2(\text{sub}, X \Rightarrow, \bar{1}))(\text{st2}') = \text{Присвоювання} = \text{st2}' \nabla [X \rightarrow$   
 $S^2(\text{sub}, X \Rightarrow, \bar{1})(\text{st2}')] = \text{Суперпозиція} = \text{st2}' \nabla [X \rightarrow \text{sub}(X \Rightarrow$   
 $(\text{st2}'), \bar{1}(\text{st2}')]) = \text{st2}' \nabla [X \rightarrow \text{sub}(1, 1)] = \text{st2}' \nabla [X \rightarrow 0] = [X \rightarrow 0,$   
 $R \rightarrow 27] = \text{st3}$

**st3 = [X -> 0, R -> 27]**

Перевіряємо умову:

$S^2(\text{gr}, X \Rightarrow, \bar{0})(\text{st3}) = \text{Суперпозиція} = \text{gr}(X \Rightarrow(\text{st3}), \bar{0}(\text{st3}))$   
 $= \text{gr}(0, 0) = \text{false}$

**Результат:** st3 = [X -> 0, R -> 27].

У змінній R записано результат виконання програми  $3^x$  для значення  $x=3$ , отже протестована функція вірна на вхідних даних.