Software-Modellierung und Verifikation
Informatik 2
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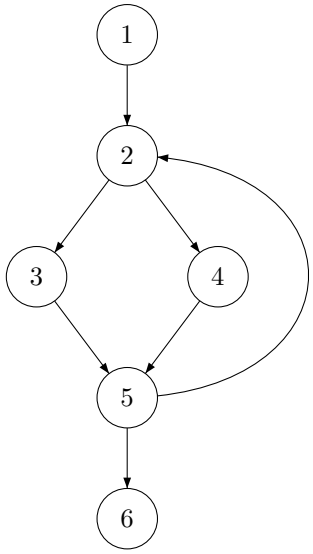
2. Exercise sheet *Static Program Analysis 2011*

Due Mon, 09. May 2011, *before* the exercise course begins.

Exercise 2.1: **(3 points)**

Both, *available expression* and *live variable analysis* had transfer functions of the form $\varphi_l(d) = (d \setminus \mathit{kill}(B^l)) \cup \mathit{gen}(B^l)$. Consider the following flowgraph and transfer functions on domain $2^{\{a,b,c,d\}}$ and determine the minimal fixpoint using the worklist algorithm from the lecture.



$$\varphi_1(M) = (M \setminus \{a\}) \cup \{c\}$$

$$\varphi_2(M) = \begin{cases} M \cup \{b\} & \text{if } b \in M \vee c \in M \\ M & \text{otherwise} \end{cases}$$

$$\varphi_3(M) = \begin{cases} M \cup \{a,c\} & \text{if } (a \in M \vee d \in M) \wedge (b \in M \vee c \in M) \\ M \cup \{a\} & \text{if } a \in M \vee d \in M \\ M \cup \{c\} & \text{if } b \in M \vee c \in M \\ M & \text{otherwise} \end{cases}$$

$$\varphi_4(M) = \begin{cases} M \cup \{b,d\} & \text{if } b \in M \vee c \in M \vee d \in M \\ M \cup \{b\} & \text{otherwise} \end{cases}$$

$$\varphi_5(M) = (M \setminus \{a\}) \cup \{d\}$$

$$\varphi_6(M) = M$$

Hint: LUB = set union, relation = set-inclusion, initial value = $\emptyset$.

Exercise 2.2: **(3 points)**

Perform an available expression analysis on the following program using the meet over all paths (MOP) solution.

$x := x + 1;$
$y := 1;$
if $x * y > y$ **then**
  $x := x + 1;$
  $y := x + y;$
else
  $y := y + 1;$
$x := x + y;$

Exercise 2.3: **(2+2 points)**

Consider domains of the form $D = 2^M$ where M is a finite set. Transfer function $\varphi_l : D \mapsto D$ is called distributive, iff for any $d_1, d_2 \in D$:

$$\varphi_l(d_1 \sqcup d_2) = \varphi_l(d_1) \sqcup \varphi_l(d_2)$$

(a) Show that any transfer function of the form $\varphi_l(d) = (d \setminus \mathit{kill}(B^l)) \cup \mathit{gen}(B^l)$ is distributive in this setting.

(b) Show that the transfer function from Exercise 2.1 is not representable in *kill-gen* style, but still is distributive.

Exercise 2.4: **(2+1+1 points)**

(a) Perform a constant propagation analysis on the following program using the fixpoint iteration which was presented in the lecture (do not use the worklist algorithm!).

$x := 10;$
$y := 1;$
while $x > 1$ **do**
    $y := x * y;$
    $x := x - 1;$

(b) The aim of constant propagation analysis is to shift time needed for calculation from execution to compile time. For the given program with fixed variables x and y it would be possible to perform ALL calculations during compile time. Though constant propagation won't provide this result. Why?

(c) Which of the program statements is the reason that constant propagation analysis is not distributive? Why? Give suitable variable valuations that confirm your explanation.