PES

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Exercise to the Lecture
Analysis and Optimisation of Embedded Systems
SoSe 2015

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Exercise 6 (graded)

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- This is the first of two graded exercise sheets. Please work on it in groups of three students.
- One groups member needs to submit the solution via the ISIS website **by the delivery date**.
- You need 10 of 20 points to pass this exercise sheet.

For Problem 1 and Problem 2, the following (nonsense) program is given.

$$(if\ [(5 * x) - y < 5]^1\ then\ [z := (y + 4) * x]^2\ else\ [z := (5 * x) * (y + 4)]^3)\ ;$$
$$while\ [x + y > 1]^4\ do\ [y := (y/2) - x]^5\ od\ ;$$
$$[z := (5 * x) + (y + 4)]^6$$

Problem 1: Available Expressions Analysis (9 points)

a) Construct the control flow graph of the given program.

b) What is $AExp_\star$ for the given program?
Hint: $AExp_\star$ does not contain "trivial" expressions like sole variables or sole constants.

c) Construct a table illustrating the *kill* and *gen* functions for the given program.

d) Construct the equation system for the available expression analysis.

e) Simplify the equations as much as possible and find the largest solution.

f) Calculate the largest solution using the algorithm from the slides.

Problem 2: Live Variables Analysis (6 points)

a) Define the pseudo code of the worklist algorithm for the Live Variables Analysis.

b) Calculate the smallest solution for the live variables analysis using this algorithm. Hint: Illustrate the worklist and the information at the entrance of each block after the initialisation phase. For each iteration, illustrate what the worklist is at the **beginning of the loop body** and illustrate what the information at the entrance of each block is at the **end of the loop body**.

c) Perform four steps of the program according to the small-step operational semantics given in the lecture starting with the state $[x = 4, y = 32, z = 3]$.

d) Briefly justify why the initial analysis result of the live variables analysis remains valid for the visited sub-statements.

Problem 3: Verification of Live Variables Analysis (5 points)

a) Prove the remaining cases of Lemma 1 from the lecture, i.e., show (iii) and (iv).

b) Prove the case for *skip* and the second case for *sequential composition* in the proof of the main theorem from the lecture (slide 22).