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COMPUTER SCIENCE

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# Development of Safety-Critical Embedded Systems
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## Exercise Sheet 5

Please hand in the solutions to the theoretical exercises until the beginning of the next lecture, Fri. 2012-12-14, 10:00. Please write your name, the number of your tutorial group, and/or the date/time slot on the first sheet of your solution.

## Exercise 5.1: Am I Doing this Right? (Points: 3)

Establish a description relation $\Delta_v$ between the concrete values of program variables and their signs as derived by our rule-of-signs analysis. Furthermore, formally define a corresponding concretization function $\gamma_v$. Define analogously functions $\Delta_b$ and $\gamma_b$ for the variable bindings used in the rules-of-sign analysis and then extend these functions to functions $\Delta_s$ and $\gamma_s$ that relate analysis results to (program) states.

## Exercise 5.2: Even Or Odd? Faites vos jeux! (Points: 8)

Modify the constant propagation known from the lecture in such a way that it computes for each variable not its content, but whether the value stored in this variable is even or odd. I.e. whether the value stored in the variable modulo 2 yields 0 or 1.

**Domain** Start by defining a suitable domain for your analysis. Explicitly name the top and bottom elements of your lattice. Give explicit definitions for the $\sqcup$-operation (least upper bound) and the relation $\sqsubseteq$.

**Abstract Expression Evaluation** Continue by defining how expressions are evaluated using your domain. Define an abstract expression evaluation and provide at least definitions for the following operations. Your operation definitions shall preserve as much precision as possible.

1. Abstract addition and multiplication.
2. Abstract less or equal to ($\leq$) and equal to ($=$) operators.

**Edge Effects** Give the edge effects/transfer functions for all possible edge labels of our simple toy language. Explicitly, state whether all edge effects are distributive functions.

## Exercise 5.3: Monotonic vs Distributive (Points: 3+1)

In the lecture, you learned that distributive functions are always monotonic. Formally prove this! Does the other direction also hold? Formally prove or disprove that all monotonic functions are also distributive!