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Hand in until 10:00 on July 12, 2021
Discussion: July 12, 2021

Tutorial for Program Verification
Exercise Sheet 21

In this exercise sheet we work with the automated verification techniques CEGAR (Predicate Abstraction) and Trace Abstraction.

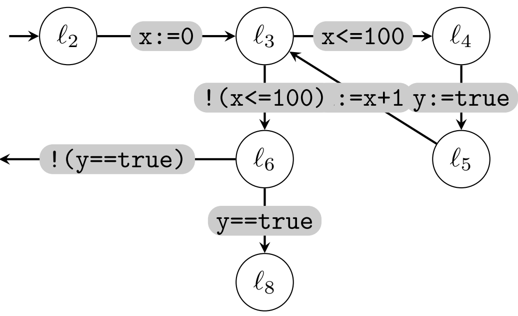
Submit your solution by uploading it as PDF in ILIAS.

Exercise 1: 5 Points

Apply the CEGAR approach to the program below. Whenever you have to provide a sequence of statements you may return any sequence, but we encourage you to take the shortest sequence. Document all intermediate steps.

Hint: If you choose the abstraction of traces wisely, then two iteration steps are sufficient.

```
x := 0;
while (x <= 100) {
  y := true;
  x := x + 1;
}
assert y == true;
```



Exercise 2: Abstraction of a Trace 2 Points

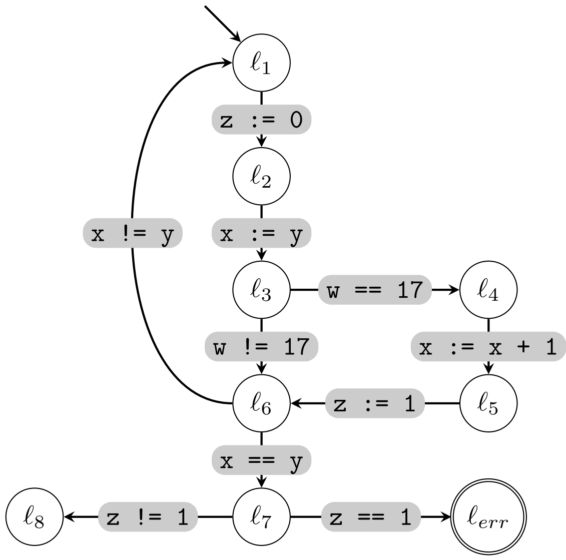
In the lecture we defined an *abstraction* $\pi^\#$ of a trace π, derived by replacing some of the statements *st* with their abstract counterpart *abstract*(*st*). The intuition is that sometimes a few statements in π are sufficient to make it infeasible. A proof of infeasibility of $\pi^\#$ is then also a proof of infeasiblity of π.

In this exercise, we consider a modified concept of abstraction: Instead of replacing assignments with their abstraction (`havoc`), we delete them from the trace entirely.

Show that this is not a good notion of abstraction. In particular, give a trace π and a corresponding abstraction $\pi^\#$, such that $\pi^\#$ is infeasible, but π is feasible. Give a proof of infeasibility for $\pi^\#$, and an execution for π.

Exercise 3: Trace Abstraction 3 Points

Consider the following control-flow graph for a program P, and let $\mathcal{A}_P$ be the corresponding automaton. In this task, you should apply trace abstraction to prove that the program P is safe.



Give two error traces π_1 and π_2 and construct corresponding Floyd-Hoare automata $\mathcal{A}_1$ and $\mathcal{A}_2$ such that the inclusion $L(\mathcal{A}_P) \subseteq L(\mathcal{A}_1) \cup L(\mathcal{A}_2)$ holds.