Program Optimisation
Solutions of Homework 5

1. The CFG of the given program is in Abbildung 1.

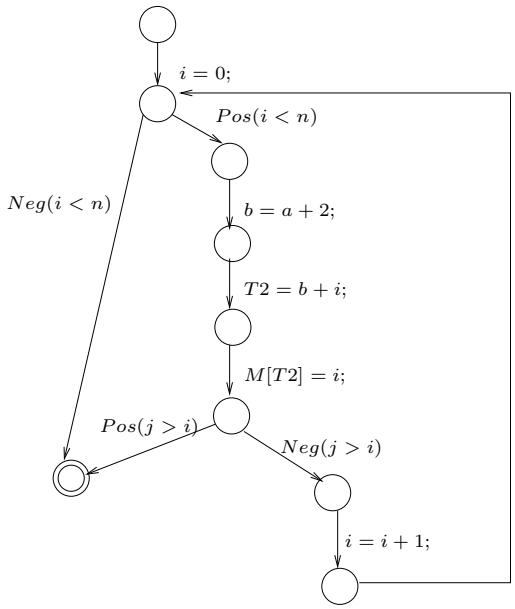

Abbildung 1: CFG of the given program

We perform loop rotation and introduce registers T_e for expressions e. The result is shown in Abbildung 2.

We are interested in the set of expressions $Expr = \{a+2\}$. The set of available and very busy expressions at each program point is as below:

u	$\mathcal{A}[u]$	$\mathcal{B}[u]$
9	$\{\}$	$\{\}$
8	$\{a+2\}$	$\{\}$
7	$\{a+2\}$	$\{\}$
6	$\{a+2\}$	$\{\}$
5	$\{a+2\}$	$\{\}$
4	$\{a+2\}$	$\{\}$
3	$\{a+2\}$	$\{\}$
2	$\{\}$	$\{a+2\}$
1	$\{\}$	$\{\}$
0	$\{\}$	$\{\}$

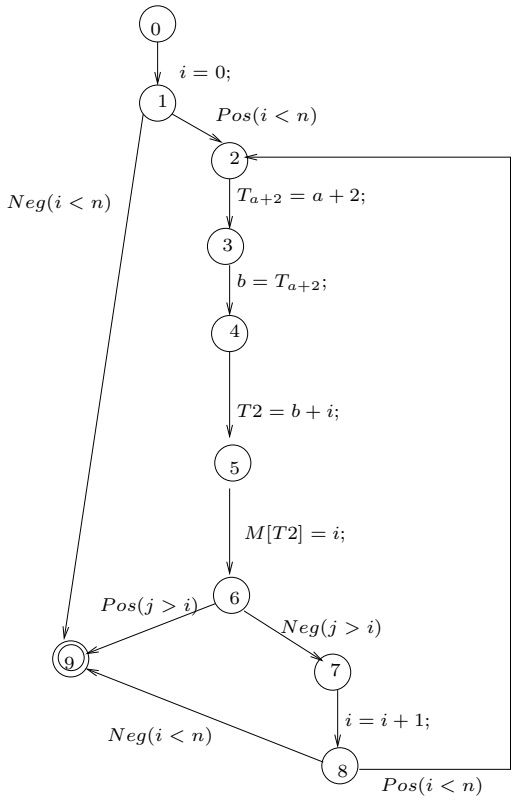

Abbildung 2: After loop rotations

We apply Transformation 6.1 and Transformation 6.2 of the lecture to obtain the CFG in Abbildung 3.

In case the statement `if (j>i) ...` is at the beginning of the body of the loop then instead of Abbildung 2 we have Abbildung 4.

Then we may apply Transformation 7 to obtain the CFG in Abbildung 5.

Then as before we can do the loop invariant computation.

2. a) Let the program be loop dominated. Let I be the set of the unique entry points of the loops in the program. By definition of I, I contains a point from every loop (namely the entry point of the loop). Hence by definition of loop separators, I is a loop separator for the program.
   b) Transformation of the loop of the example program for interval-analysis into a `do-while`-loop leads to the program in Abbildung 6.
   c) Interval analysis without narrowing on this program works as follows. We use the loop separator $I = \{2\}$. So widening is applied only at point 2.

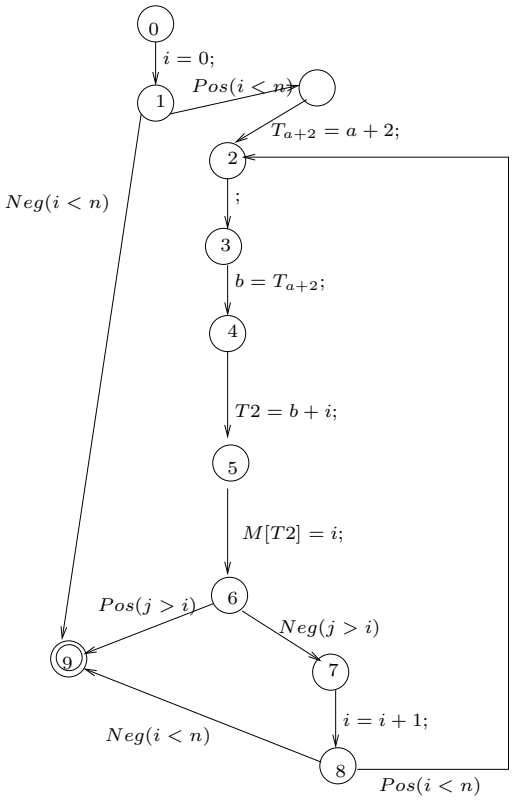

Abbildung 3: After transformations 6.1 and 6.2

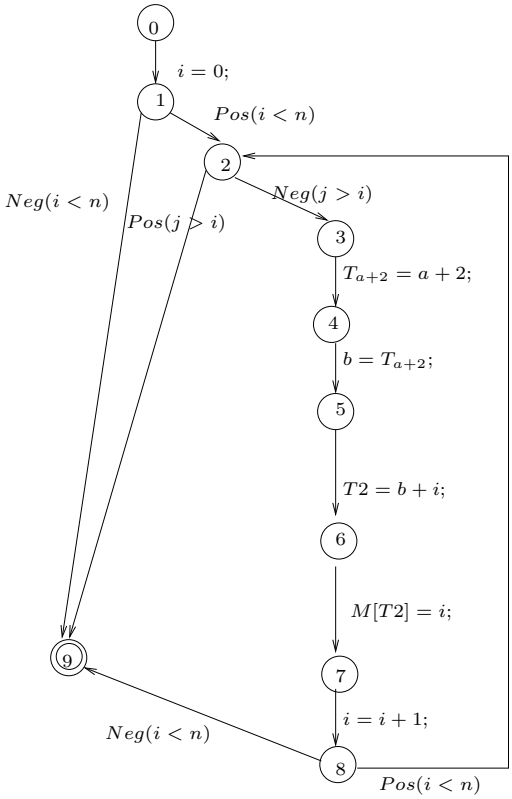

Abbildung 4: CFG with 'if-break' statement at the beginning of loop

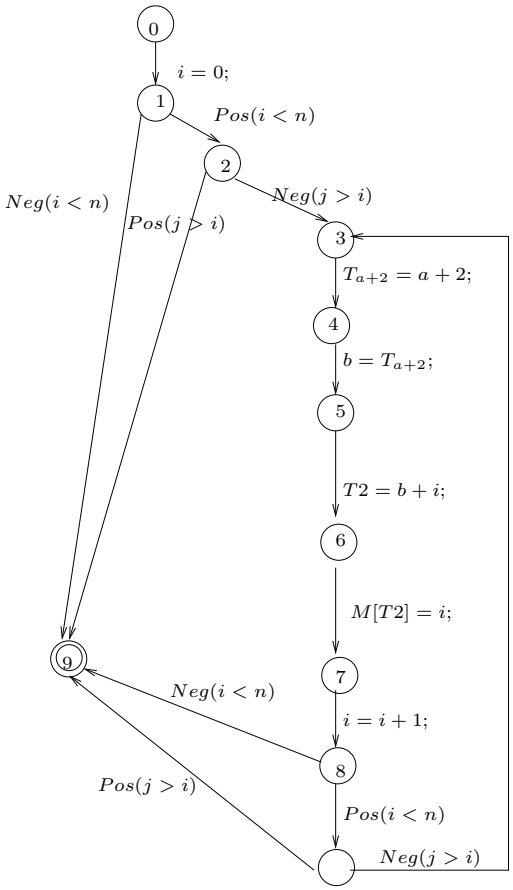

Abbildung 5: After transformation 7

	1		2		3	
	l	u	l	u	l	u
0	$-\infty$	$+\infty$	$-\infty$	$+\infty$		
1	0	0	0	0		
2	0	0	0	$+\infty$		
3	0	0	0	41		
4	0	0	0	41	*dito*	
5	0	0	0	41		
6	1	1	1	42		
7	1	1	1	41		
8	$\perp$		42	$+\infty$		
9	$\perp$		42	42		

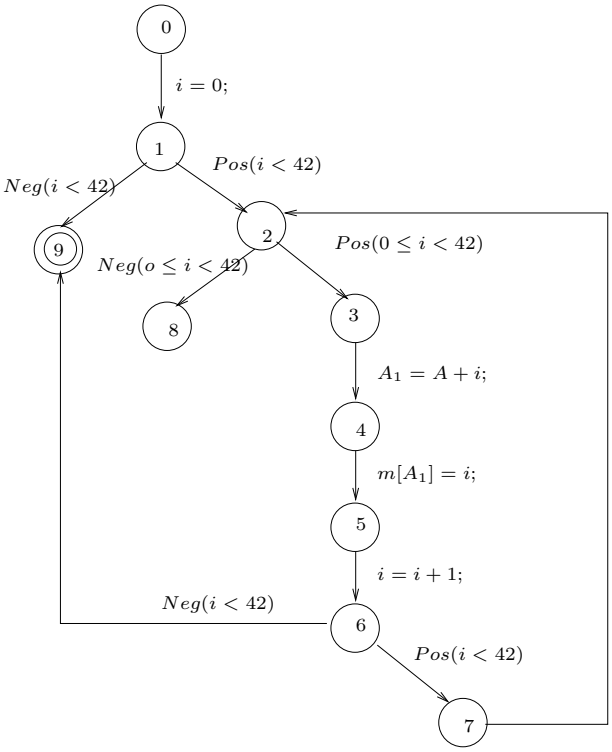

Abbildung 6: After loop rotation