

# Examen Compilers 14 juni 2019

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Deel I

Closed Book

## Question 1

1. Give the transfer functions and dataflow equations for *available expressions*.

Statement s	gen[s]	kill[s]
$t \leftarrow b \oplus c$		
$t \leftarrow M[b]$		
$M[a] \leftarrow b$		
$f(a_1, \dots, a_n)$		
$t \leftarrow f(a_1, \dots, a_n)$		

$in[n] =$

$out[n] =$

2. Data flow can be pro

## Question 2

The following code shows two facts about how symbol tables can be implemented. Which facts?

```

struct expty transExp(S_table venv, S_table tenv, A_exp a) {
    switch(a->kind) {
        :
        case A_letExp: {
            struct expty exp;
            A_decList d;
            S_beginScope(venv);
            S_beginScope(tenv);
            for (d = a->u.let.decs; d; d=d->tail)
                transDec(venv,tenv,d->head);
            exp = transExp(venv,tenv,a->u.let.body);
            S_endScope(tenv);
            S_endScope(venv);
            return exp;
        }
        :
    }
}

```

### Question 3

1. Which feature(s) should a programming language offer in order to make static links useful.
2. Explain how static links can be implemented, not necessarily on an architecture which supports static links.

### Question 4

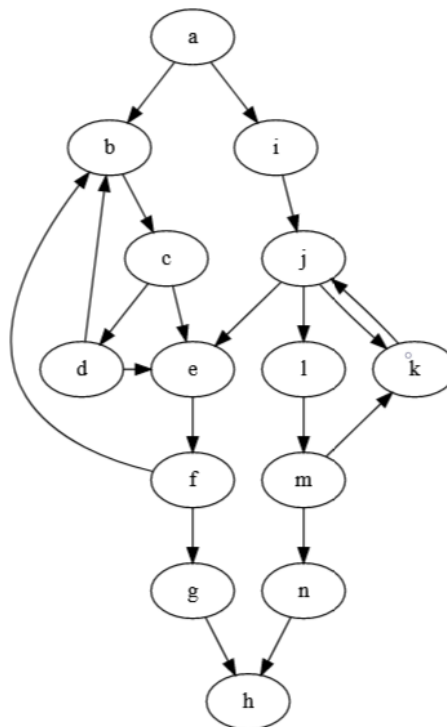
1. Give the definition of a basic block.
2. What is the difference between a graph of basic blocks and a trace of basic blocks?

### Question 5

ToDo: iets over componenten met twee register mode

### Question 6

Consider the following graph:



1. Mark the headers of each natural loop in this graph.
2. Add preheaders in this graph for eventual optimizations.

3. Fill in the table below, which indicates different relationships between nodes:

P indicates that  $x$  (in column) is post-dominated by  $y$  (in row).

D indicates that  $x$  dominates  $y$ .

I indicates that  $x$  is the immediate dominator of  $y$ .

df indicates that  $x$  is in the dominance frontier of  $y$ .

Some cells have been filled, as an example.

	a	b	c	d	e	f	g	h	i	j	k	l	m	n
a								P						
c		I												
e	D													
i					df									
j														

## Question 10

Given the following grammar:

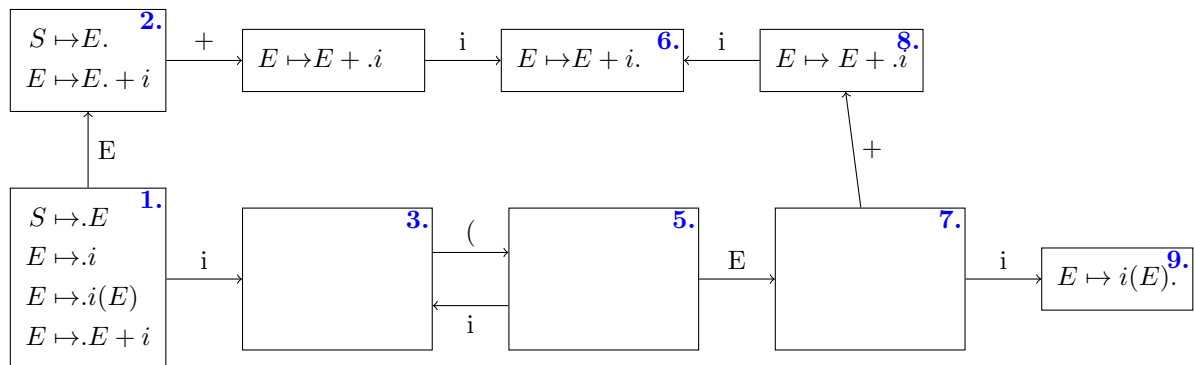
$$S \rightarrow E$$

$$E \rightarrow i$$

$$E \rightarrow i(E)$$

$$E \rightarrow E + 1$$

1. Give the first and follow sets.
2. Give the production rules for the remaining states (3, 5 and 7) in the following SLR state table:



3. Are there shift-reduce conflicts in state 3? Explain.

## Question 11

Consider the following LLVM IR code

```

void function(i32* %0, i64 %1)
  %2:
    %3 = icmp eq %1, 0
    br ... %3, label %4, label %6
  %4:
    %5 = phi [...
    return i32 %11
  %6:
    %7 = phi [...]
    %8 = phi [...]
    %9 = getelementptr i32, i32* %0, i3 %7
    %10 = load i32 %9
    %11 = add %10, %8
    %12 = add %7, 1
    %13 = icmp eq %12, %1
    br %4, %6

```

1. Explain in a few sentences what this code does.
2. Is this IR optimized? Explain.
3. What does the `getelementptr` instruction do?
4. In the labs, the first parameter of the `getelementptr` was zero, why is this not the case in this example?

Deel II

Open Book

### Question 1 (5pt)

The following table gives an interference graph. Cells marked  $x$  mean an non-move reated interferences between vertices. Cells marked  $m$  are move-related. Registers 1-4 are precolored, while registers A-E have to be assigned a color. Color this graph with coalescing and using 5 registers. Show only the phases used in the following format:

```
simplify A
coalesce A and 1 (George) int 1A    # the names are in alphabetical order
freeze A
spill A
select A
```

	1	2	3	4	A	B	C	D	E
A	x		x	mx			x	x	x
B	x		m	x			x	x	m
C	m	x	x		x	x		x	x
D	x	x	x	x	x	x	x		x
E		x			x	m	x	x	

### Question 2 (5pt)