

# UNIVERSITY OF DUBLIN

## TRINITY COLLEGE

Faculty of Engineering, Mathematics & Science  
School of Computer Science & Statistics

Integrated Computer Science  
B.A. (Mod.) CSLL

Trinity Term 2014

### Compiler Design (CS3071)

Monday 12<sup>th</sup> May 2014

Luce Upper

09:30 – 11:30

Dr DM Abrahamson

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#### Instructions to Candidates

Answer question number 1 and one other question

#### Materials permitted for this examination

None

1. i. Discuss the relationship between the first, follow and select sets in the context of LL(1) parsing, and explain how follow sets are calculated. [10 Marks]

- ii. By computing selection sets for the productions from the following context free grammars, determine which (if any) of them are LL(1):

- a.  $\langle S \rangle \rightarrow \langle A \rangle b$   
 $\langle A \rangle \rightarrow \langle B \rangle$   
 $\langle A \rangle \rightarrow a$   
 $\langle A \rangle \rightarrow \epsilon$   
 $\langle B \rangle \rightarrow b$   
 $\langle B \rangle \rightarrow \epsilon$
- b.  $\langle S \rangle \rightarrow \langle A \rangle \langle B \rangle c$   
 $\langle A \rangle \rightarrow a$   
 $\langle A \rangle \rightarrow \epsilon$   
 $\langle B \rangle \rightarrow b$   
 $\langle B \rangle \rightarrow \epsilon$
- c.  $\langle S \rangle \rightarrow \langle A \rangle \langle B \rangle \langle B \rangle \langle A \rangle$   
 $\langle A \rangle \rightarrow a$   
 $\langle A \rangle \rightarrow \epsilon$   
 $\langle B \rangle \rightarrow b$   
 $\langle B \rangle \rightarrow \epsilon$

[15 Marks]

- iii. Explain why the following two productions are not LL(1) and show how they may be handled by a recursive descent parser:

$\langle \text{statement} \rangle \rightarrow \text{if } \langle \text{condition} \rangle \text{ then } \langle \text{statement} \rangle \text{ else } \langle \text{statement} \rangle$   
 $\langle \text{statement} \rangle \rightarrow \text{if } \langle \text{condition} \rangle \text{ then } \langle \text{statement} \rangle$

[10 Marks]

- iv. Given the L-attributed translation grammar

$\langle \text{statement} \rangle \rightarrow \langle \text{expression} \rangle_p \{ \text{print} \}_p$   
 $\langle \text{expression} \rangle_p \rightarrow + \langle \text{expression} \rangle_q \langle \text{expression} \rangle_r \{ \text{add} \}_{q,r,p}$   
 $\quad \quad \quad \{ \text{add} \}_{p,q,r} \quad r \leftarrow p+q$   
 $\langle \text{expression} \rangle_p \rightarrow * \langle \text{expression} \rangle_q \langle \text{expression} \rangle_r \{ \text{mult} \}_{q,r,p}$   
 $\quad \quad \quad \{ \text{mult} \}_{p,q,r} \quad r \leftarrow p+q$   
 $\langle \text{expression} \rangle_p \rightarrow \text{const}_q$

where  $\langle \text{expression} \rangle_p$  – synthesized  $p$ , all action symbol attributes are inherited and const is a lexical token for an integer constant, design an augmented pushdown machine to compute the value of an arithmetic expression of the form:  $* 2 + 16 32$ .

[25 Marks]

[Total 60 Marks]

2. Describe the information that should be maintained in the symbol table to record the properties of structured variables (eg arrays or records), and show how to design L-attributed translation grammar productions to cater for type and variable declarations of the form:

```

TYPE
  CourseData = RECORD
    code, mark: INTEGER
  END;
  StudentInfo = RECORD
    name: STRING;
    number: INTEGER;
    course: ARRAY [1..8] OF CourseData
  END;
VAR
  Students: ARRAY [1..32] OF StudentInfo;

```

[40 Marks]

3. Discuss the relationship between the output action symbols  $\{label_p\}$  and  $\{jump_{p,q}\}$ , and describe in detail their use in L-attributed translation grammar productions for IF and REPEAT statements of the form:

```

<statement> → IF <condition> THEN <statement>
<statement> → REPEAT <statement> UNTIL <condition>

```

Explain the role of the function “new1” and demonstrate, by example, how the processing of the address field in a generated branch instruction is dependent on the relative position of a  $\{label\}$  and its corresponding  $\{jump\}$  action.

[40 Marks]