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Compilers Exam – 13.February.2008

STUDENT NAME:
STUDENT NUMBER:
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This Exam will constitute the 70% of the overall course assessment.

1 Exercise: Grammar Rewriting

Consider the following ambiguous grammar for Arithmetic expressions (where num stands for the terminal "number"):

$$E \rightarrow E + E \mid E - E \mid E * E \mid E \div E \mid \mathsf{num}$$

1. Explain why the grammar is ambiguous with an example sentence.
2. Rewrite the grammar eliminating ambiguity by considering the Arithmetic operators as left-associative and the following precedence: $+, - < *, \div$.
3. Show that the example you provided in point 1 is no more ambiguous.
4. Define the notion of *Left Recursive Grammar*, say if the grammar of this exercise is Left recursive, and explain why Top Down parsers cannot handle Left Recursive Grammars.

2 Exercise: LR(1) Parser

Given the following Grammar for Statements with productions r1.–r6.

r1.	$SList$	$\rightarrow$	$SList$; S
r2.	$SList$	$\rightarrow$	S
r3.	S	$\rightarrow$	id $=$ E
r4.	E	$\rightarrow$	E $+$ id
r5.	E	$\rightarrow$	(E)
r6.	E	$\rightarrow$	id

where:
$V_N = \{SList, S, E\}$, $V_T = \{\mathsf{id}, =, ;, +, (,)\}$ and $SList$ is the scope.

Show the following:

1. The canonical LR(1) collection
2. The transition diagram describing the automaton which recognizes handles at the top of the stack
3. The parsing table for the LR(1) parser
4. The stack and the moves of the LR(1) parser on input: $\mathsf{id}_1 = (\mathsf{id}_2)$
5. The canonical LALR(1) collection

Suggestion: The first Item, I_0 is:

S'	$\rightarrow$	$\cdot SList$	\$
$SList$	$\rightarrow$	$\cdot SList$; S	\$/;
$SList$	$\rightarrow$	$\cdot S$	\$/;
S	$\rightarrow$	$\cdot$id $=$ E	\$/;

3 Exercise: Semantic Analysis

Given the following grammar together with the semantic rules:

Production	Semantic Rules
$Prog \rightarrow S$	$S.next := newlabel; Prog.code := S.code \parallel gen(S.next\ ' :')$
$S \rightarrow S_1\ ;\ S_2$	$S_1.next := newlabel; S_2.next := S.next;$
	$S.code := S_1.code \parallel gen(S_1.next\ ' :') \parallel S_2.code$
$S \rightarrow \mathsf{while}\ Test\ \mathsf{do}\ S_1$	$Test.begin := newlabel;\ Test.true := newlabel;$
	$Test.false := S.next;\ S_1.next := Test.begin;$
	$S.code := gen(Test.begin\ ' :') \parallel Test.code \parallel gen(Test.true\ ' :') \parallel$
	$S_1.code \parallel gen('\mathsf{goto}'\ Test.begin)$
$S \rightarrow \mathsf{id} := E$	$S.code := E.code \parallel gen(\mathsf{id}.place\ ' :='\ \ E.place)$
$Test \rightarrow \mathsf{id}_1\ \mathsf{relop}\ \mathsf{id}_2$	$Test.code := gen('\mathsf{if}'\ \mathsf{id}_1.place\ \mathsf{relop}.op\ \mathsf{id}_2.place\ '\mathsf{goto}'\ Test.true) \parallel$
	$gen('\mathsf{goto}'\ Test.false)$
$E \rightarrow E_1 + \mathsf{id}$	$E.place := newtemp;$
	$E.code := E_1.code \parallel gen(E.place\ ' :='\ \ E_1.place\ ' +'\ \mathsf{id}.place)$
$E \rightarrow \mathsf{id}$	$E.place := \mathsf{id}.place; E.code := ''$

where:

- The function *newlabel* generates new symbolic labels.
- The function *newtemp* generates new variables names.
- The function *gen* generates strings such that everything in quotes is generated literally while the rest is evaluated.
- The attribute *code* produces the three-address code.
- The attribute id.*place* represents the name of the variable associated to the token id.
- The attribute relop.*op* represents the comparison operators (i.e., $<, <=, =, <>, >, >=$).
- The symbol $\parallel$ means string concatenation.

Given the input:

```
while w > z do
    z := z + a
```

Show the following:

1. The annotated parse tree (without the *code* attribute) for the input together with the values of the attributes;
2. The three-address code produced by the semantic actions for the given input.
3. The semantic rules for the production: $S \rightarrow \mathsf{if}\ Test\ \mathsf{then}\ S_1$.