

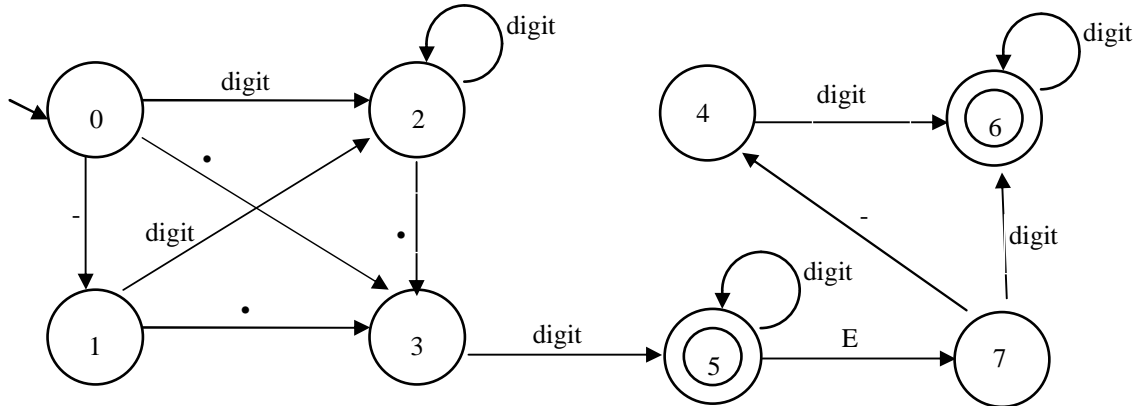
CA448 Compiler Construction 1 End of Year Examination Answers 2009

1. $(- | \epsilon) \text{digit}^* \cdot \text{digit digit}^* ((E (- | \epsilon) \text{digit digit}^*) | \epsilon)$

[10 marks]

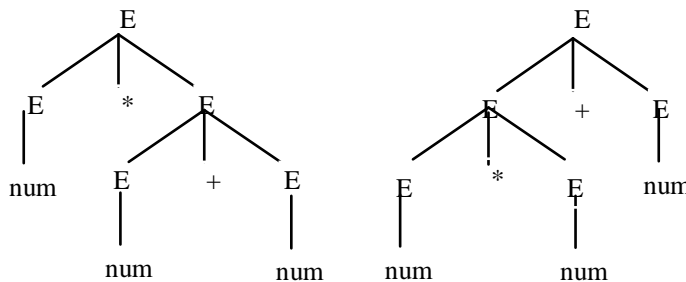
2

[10 marks]



3. The following parse trees are produced for the expression $\text{num} * \text{num} + \text{num}$:

[10 marks]



Therefore the grammar is ambiguous.

4. $\text{LOOKAHEAD}(S \rightarrow XYZ) = (\text{FIRST}(X) - \{\epsilon\}) \cup (\text{FIRST}(Y) - \{\epsilon\}) \cup \text{FIRST}(Z)$

[10 marks]

$$= \{a, d\} \cup \{c\} \cup \{d\} = \{a, c, d\}$$

$$\begin{aligned} \text{LOOKAHEAD}(X \rightarrow a) &= \text{FIRST}(a) \\ &= \{a\} \end{aligned}$$

$$\begin{aligned} \text{LOOKAHEAD}(X \rightarrow Zb) &= \text{FIRST}(Z) \\ &= \{d\} \end{aligned}$$

$$\begin{aligned} \text{LOOKAHEAD}(X \rightarrow \epsilon) &= \text{FOLLOW}(X) \\ &= \{c, d\} \end{aligned}$$

$$\begin{aligned} \text{LOOKAHEAD}(Y \rightarrow c) &= \text{FIRST}(c) \\ &= \{c\} \end{aligned}$$

$$\begin{aligned} \text{LOOKAHEAD}(Y \rightarrow \epsilon) &= \text{FOLLOW}(Y) \\ &= \{d\} \end{aligned}$$

$$\text{LOOKAHEAD}(Z \rightarrow d) = \text{FIRST}(d) = \{d\}$$

The grammar is not LL(1) since d predicts both $X \rightarrow Zb$ and $X \rightarrow \epsilon$

5. The converted grammar is as follows:

[10 marks]

$Stat \rightarrow id Stat'$
 $Stat' \rightarrow := Exp$
 $Stat' \rightarrow (ArgList)$
 $ArgList \rightarrow Exp ArgList'$
 $ArgList' \rightarrow , Exp ArgList'$
 $ArgList' \rightarrow \epsilon$
 $Exp \rightarrow id Exp'$
 $Exp' \rightarrow (ArgList)$
 $Exp' \rightarrow \epsilon$

6. The following LR(0) items are produced for this grammar:

[10 marks]

1: $S \rightarrow \bullet Xb$
 $S \rightarrow \bullet Y$
 $X \rightarrow \bullet aY$
 $Y \rightarrow \bullet a$
 $Y \rightarrow \bullet aX$
2: $S \rightarrow X\bullet b$
3: $S \rightarrow Xb\bullet$
4: $S \rightarrow Y\bullet$
5: $X \rightarrow a\bullet Y$
 $Y \rightarrow a\bullet$
 $Y \rightarrow a\bullet X$
 $Y \rightarrow \bullet a$
 $Y \rightarrow \bullet aX$
 $X \rightarrow \bullet aY$
6: $X \rightarrow aY\bullet$
7: $Y \rightarrow aX\bullet$

There is a shift-reduce conflict in state 5, so the grammar is not LR(0).

7. The following LR(0) items are produced for this grammar:

[10 marks]

1: $S \rightarrow \bullet Aa$
 $S \rightarrow \bullet bAc$
 $S \rightarrow \bullet dc$
 $S \rightarrow \bullet bda$
 $A \rightarrow \bullet d$
2: $S \rightarrow A\bullet a$
3: $S \rightarrow Aa\bullet$
4: $S \rightarrow d\bullet c$
 $A \rightarrow d\bullet$
5: $S \rightarrow dc\bullet$
6: $S \rightarrow b\bullet Ac$
 $S \rightarrow b\bullet da$
 $A \rightarrow \bullet d$

- 7: $S \rightarrow bA\bullet c$
- 8: $S \rightarrow bAc\bullet$
- 9: $S \rightarrow bd\bullet a$
- $A \rightarrow d\bullet$
- 10: $S \rightarrow bda\bullet$

FOLLOW(A) = {a,c}. There are therefore shift-reduce conflicts in states 4 and 9, so the grammar is not SLR(1).

8. The following LR(1) items are produced for this grammar:

[10 marks]

- 1: $S \rightarrow \bullet Aa, \$$
- $S \rightarrow \bullet bAc, \$$
- $S \rightarrow \bullet dc, \$$
- $S \rightarrow \bullet bda, \$$
- $A \rightarrow \bullet d, a$
- 2: $S \rightarrow A\bullet a, \$$
- 3: $S \rightarrow Aa\bullet, \$$
- 4: $S \rightarrow d\bullet c, \$$
- $A \rightarrow d\bullet, a$
- 5: $S \rightarrow dc\bullet, \$$
- 6: $S \rightarrow b\bullet Ac, \$$
- $S \rightarrow b\bullet da, \$$
- $A \rightarrow \bullet d, c$
- 7: $S \rightarrow bA\bullet c, \$$
- 8: $S \rightarrow bAc\bullet, \$$
- 9: $S \rightarrow bd\bullet a, \$$
- $A \rightarrow d\bullet, c$
- 10: $S \rightarrow bda\bullet, \$$

There are no conflicts, so the grammar is LR(1).

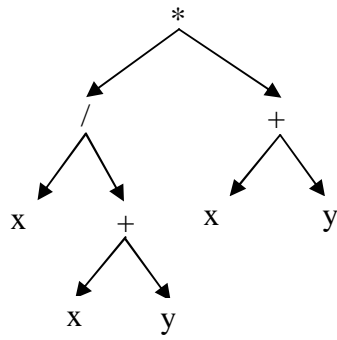
9. The attribute grammar is as follows:

[10 marks]

$\text{Num} \rightarrow \text{SignedInt}_1 \text{ 'E' } \text{SignedInt}_2$	$\text{Num.value} := \text{SignedInt}_1.\text{value} \times 10^{\text{SignedInt}_2.\text{value}}$
$\text{SignedInt} \rightarrow \text{Sign Int}$	if Sign.neg then $\text{SignedInt.value} := -\text{Int.value}$ else $\text{SignedInt.value} := \text{Int.value}$
$\text{Sign} \rightarrow +$	$\text{Sign.neg} := \text{false}$
$\text{Sign} \rightarrow -$	$\text{Sign.neg} := \text{true}$
$\text{Int}_1 \rightarrow \text{Int}_2 \text{ Digit}$	$\text{Int}_1.\text{value} := 10 \times \text{Int}_2.\text{value} + \text{Digit.value}$
$\text{Int} \rightarrow \text{Digit}$	$\text{Int.value} := \text{Digit.value}$

10. The abstract syntax tree is as follows:

[10 marks]



The corresponding directed acyclic graph is as follows:

