

# CSE 401 - LL Parsing and FIRST/FOLLOW/nullable Worksheet - Week 4

1. Compute the FIRST, FOLLOW, and nullable sets for each non-terminal in the following grammar:

$A ::= x C B y$   
 $B ::= z \mid \epsilon$   
 $C ::= y \mid B x$

Non-Terminal	FIRST	FOLLOW	nullable
A			
B			
C			

2. For each of the following grammars, identify whether or not the grammar satisfies the LL(1) condition. If the grammar is not LL(1), explain the problem. *Hint:* Although you are not required to follow the formal algorithm, you may find it helpful to examine the grammar in terms of the FIRST, FOLLOW, and nullable sets.

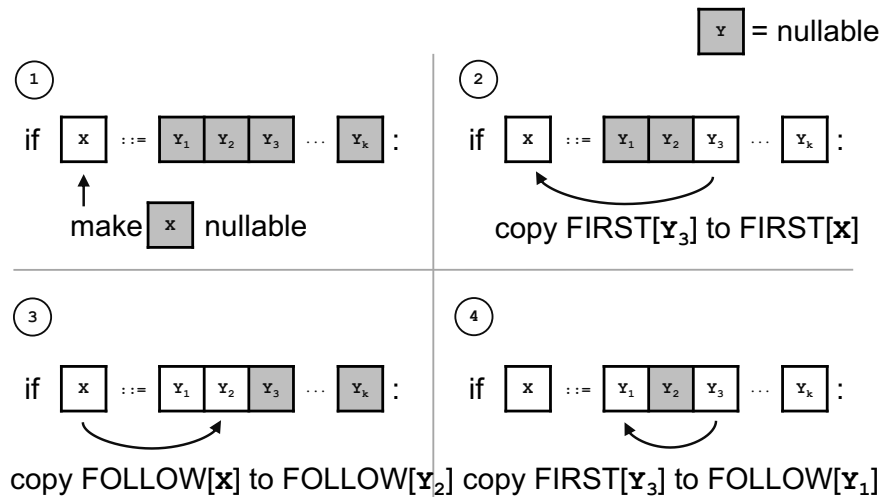
a)  $X ::= a Y \mid Z$   
 $Y ::= a \mid c$   
 $Z ::= b Y$

b)  $P ::= d R$   
 $R ::= o \mid S$   
 $S ::= g \mid o g$

c)  $J ::= a K L$   
 $K ::= c \mid \epsilon$   
 $L ::= c$

d)  $J ::= a K L$   
 $K ::= c \mid \epsilon$   
 $L ::= b$

## Computing FIRST, FOLLOW, & nullable (3)



## Computing FIRST, FOLLOW, and nullable

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repeat
  for each production  $X ::= Y_1 Y_2 \dots Y_k$ 
    if  $Y_1 \dots Y_k$  are all nullable (or if  $k = 0$ )
      set  $\text{nullable}[X] = \text{true}$ 
    for each  $i$  from 1 to  $k$  and each  $j$  from  $i+1$  to  $k$ 
      if  $Y_1 \dots Y_{i-1}$  are all nullable (or if  $i = 1$ )
        add  $\text{FIRST}[Y_i]$  to  $\text{FIRST}[X]$ 
      if  $Y_{i+1} \dots Y_k$  are all nullable (or if  $i = k$ )
        add  $\text{FOLLOW}[X]$  to  $\text{FOLLOW}[Y_i]$ 
      if  $Y_{i+1} \dots Y_{j-1}$  are all nullable (or if  $i+1=j$ )
        add  $\text{FIRST}[Y_j]$  to  $\text{FOLLOW}[Y_i]$ 
  Until  $\text{FIRST}$ ,  $\text{FOLLOW}$ , and  $\text{nullable}$  do not change
  
```

### Canonical FIRST & FIRST FOLLOW conflicts & their solutions:

#### FIRST Conflict:

Both productions of  $A$  have  $\alpha$  in their FIRST sets

0.  $A ::= \alpha\beta \mid \alpha\gamma$

#### Solution:

Factor out the prefix ( $\alpha$ )

0.  $A ::= \alpha \text{Tail}$

1.  $\text{Tail} ::= \beta \mid \gamma$

#### FIRST FOLLOW Conflict:

$B$  is nullable,  $\alpha$  in FIRST & FOLLOW

0.  $A ::= B \alpha$

1.  $B ::= \alpha \mid \epsilon$

#### Solution:

Substitute  $B$  into  $A$

0.  $A ::= \alpha\alpha \mid \alpha$

Factor out the prefix ( $\alpha$ )

0.  $A ::= \alpha \text{Tail}$

1.  $\text{Tail} ::= \alpha \mid \epsilon$