

## 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)  $J ::= a K L$

$K ::= c \mid \epsilon$

$L ::= b$

3. Edit the following Grammars to make them LL(1). Then walk through the top down parse for the string given in the parenthesis. (Follow along)

**Grammar 1 (“azx”)**

0.  $S ::= a B \mid a w$

1.  $B ::= C x \mid y$

2.  $C ::= \epsilon \mid z$

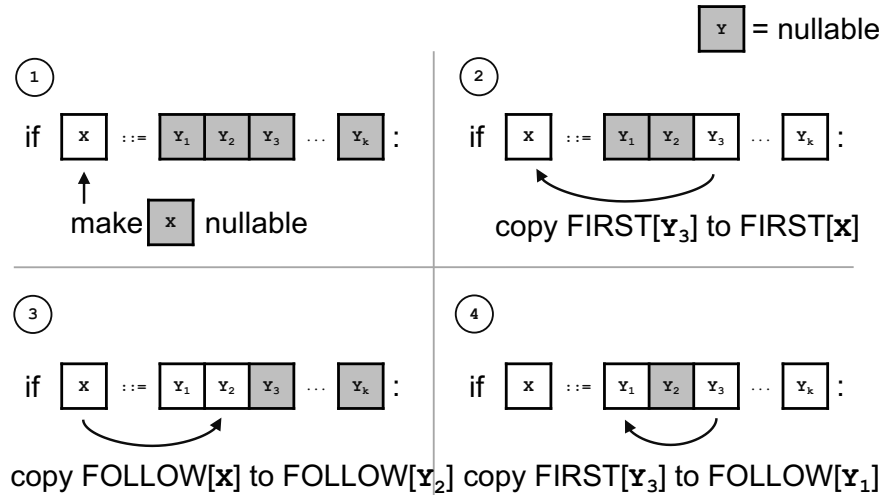
**Grammar 2 (“ax”)**

0.  $S ::= a B$

1.  $B ::= C x \mid y$

2.  $C ::= \epsilon \mid x$

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



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## Computing FIRST, FOLLOW, and nullable

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 FIRST, FOLLOW, and 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.  $\text{Tail} ::= \alpha \mid \epsilon$