

## Solution – Homework 7: Lectures 13 & 14

CS 440: Programming Languages and Translators, Spring 2020

### Lectures 13 & 14: LL(1) Parsing

1. (LL(1) derivation & parse)

1a. HW 07 Leftmost Derivation of  $x(x^*x, x)$

$S$   
 $\rightarrow E \$$   
 $\rightarrow T Tt \$$   
 $\rightarrow F Ft Tt \$$   
 $\rightarrow x PArgs Ft Tt \$$   
 $\rightarrow x ( Args ) Ft Tt \$$   
 $\rightarrow x ( E At ) Ft Tt \$$   
 $\rightarrow x ( T Tt At ) Ft Tt \$$   
 $\rightarrow x ( F Ft Tt At ) Ft Tt \$$   
 $\rightarrow x ( x PArgs Ft Tt At ) Ft Tt \$$   
 $\rightarrow x ( x \epsilon Ft Tt At ) Ft Tt \$$   
 $\rightarrow x ( x * F Ft Tt At ) Ft Tt \$$   
 $\rightarrow x ( x * x PArgs Ft Tt At ) Ft Tt \$$   
 $\rightarrow x ( x * x \epsilon Ft Tt At ) Ft Tt \$$   
 $\rightarrow x ( x * x \epsilon Tt At ) Ft Tt \$$   
 $\rightarrow x ( x * x \epsilon At ) Ft Tt \$$   
 $\rightarrow x ( x * x , E At ) Ft Tt \$$   
 $\rightarrow x ( x * x , T Tt At ) Ft Tt \$$   
 $\rightarrow x ( x * x , F Ft Tt At ) Ft Tt \$$   
 $\rightarrow x ( x * x , x PArgs Ft Tt At ) Ft Tt \$$   
 $\rightarrow x ( x * x , x \epsilon Ft Tt At ) Ft Tt \$$   
 $\rightarrow x ( x * x , x \epsilon Tt At ) Ft Tt \$$   
 $\rightarrow x ( x * x , x \epsilon At ) Ft Tt \$$   
 $\rightarrow x ( x * x , x \epsilon ) Ft Tt \$$   
 $\rightarrow x ( x * x , x ) Ft Tt \$$   
 $\rightarrow x ( x * x , x ) \epsilon Tt \$$   
 $\rightarrow x ( x * x , x ) \epsilon \$$

1b. LL(1) Parse trace of  $x(x^*x, x)$

Stack (top to left)	Rule / match terminal	Input
$S$	1	$x(x^*x, x) \$$
$E \$$	2	$x(x^*x, x) \$$
$T Tt \$$	5	$x(x^*x, x) \$$
$F Ft Tt \$$	8	$x(x^*x, x) \$$
$x PArgs Ft Tt \$$	match	$x(x^*x, x) \$$
$PArgs Ft Tt \$$	12	$(x^*x, x) \$$
$( Args ) Ft Tt \$$	match	$(x^*x, x) \$$
$Args ) Ft Tt \$$	12	$x^*x, x) \$$
$E At ) Ft Tt \$$	1	$x^*x, x) \$$
$T Tt At ) Ft Tt \$$	2	$x^*x, x) \$$
$F Ft Tt At ) Ft Tt \$$	5	$x^*x, x) \$$
$x PArgs Ft Tt At ) Ft Tt \$$	match	$x^*x, x) \$$
$PArgs Ft Tt At ) Ft Tt \$$	11	$x^*x, x) \$$
$\epsilon Ft Tt At ) Ft Tt \$$	6	$*x, x) \$$
$* F Ft Tt At ) Ft Tt \$$	match	$*x, x) \$$
$F Ft Tt At ) Ft Tt \$$	8	$*x, x) \$$
$x PArgs Ft Tt At ) Ft Tt \$$	match	$x, x) \$$
$PArgs Ft Tt At ) Ft Tt \$$	11	$, x) \$$
$\epsilon Ft Tt At ) Ft Tt \$$	7	$, x) \$$
$\epsilon Tt At ) Ft Tt \$$	4	$, x) \$$
$\epsilon At ) Ft Tt \$$	14	$, x) \$$
$, E At ) Ft Tt \$$	match	$, x) \$$
$E At ) Ft Tt \$$	2	$x) \$$
$T Tt At ) Ft Tt \$$	5	$x) \$$
$F Ft Tt At ) Ft Tt \$$	8	$x) \$$
$x PArgs Ft Tt At ) Ft Tt \$$	match	$x) \$$
$PArgs Ft Tt At ) Ft Tt \$$	11	$x) \$$
$\epsilon Ft Tt At ) Ft Tt \$$	7	$) \$$
$\epsilon Tt At ) Ft Tt \$$	4	$) \$$
$\epsilon At ) Ft Tt \$$	13	$) \$$
$\epsilon ) Ft Tt \$$	match	$) \$$
$Ft Tt \$$	7	$\$$
$\epsilon Tt \$$	4	$\$$
$\epsilon \$$	success!	$\$$

2. [36 points] Study the grammar below.

- [8 points] Write out the *First* set for the grammar.
- [8 points] Write out the *Follow* set for the grammar.
- [8 points] Write out the *Predict* table for the grammar. (You don't have to include your reasoning but if you do it might be worth partial credit.) You should find that the grammar is LL(1).
- [12 points] Write out a trace of the LL(1) parsing algorithm for the input `s u v r s p`

Rules

Rule #	Rule
0	$S' \rightarrow S \$$
1	$S \rightarrow P S$
2	$S \rightarrow \epsilon$
3	$P \rightarrow p$
4	$P \rightarrow Q R s P$
5	$R \rightarrow r R$
6	$R \rightarrow \epsilon$
7	$Q \rightarrow u Q v$
8	$Q \rightarrow \epsilon$

2d. LL(1) Parse trace of `s u v r s p`

Stack (top to left)	Rule / match terminal	Input
$S'$	0	s u v r s p \$
$S \$$	1	s u v r s p \$
$P S \$$	4	s u v r s p \$
$Q R s P S \$$	8	s u v r s p \$
$\epsilon R s P S \$$	6	s u v r s p \$
$\epsilon s P S \$$	match	s u v r s p \$
$Q R s P S \$$	7	u v r s p \$
$u Q v R s P S \$$	match	u v r s p \$
$Q v R s P S \$$	8	v r s p \$
$\epsilon v R s P S \$$	match	v r s p \$
$R s P S \$$	5	r s p \$
$r R s P S \$$	match	r s p \$
$R s P S \$$	6	s p \$
$\epsilon s P S \$$	match	p \$
$P S \$$	3	p \$
$p S \$$	match	p \$
$S \$$	2	\$
$\epsilon \$$	success!	\$

2a, 2b: First &amp; Follow Tables

Nonterm	First	Follow
$S'$	p r s u \$	$\emptyset$
$S$	p r s u $\epsilon$	\$
$P$	p r s u	p r s u \$
$R$	r $\epsilon$	s
$Q$	u $\epsilon$	r s v

2c: Predict Table

Nonterm	p	r	s	u	v	\$
$S'$	0	0	0	0	.	0
$S$	1	1	1	1	.	2
$P$	3	4	4	4	.	.
$R$	.	5	6	.	.	.
$Q$	.	8	8	7	8	.