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Today's Class Topics

-Properties of LL(1) Grammar
-How to Test LL(1) Grammar
-LL(1) PYQ discussion
-Bottom up parsing

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Properties of LL(1) Grammar:

1) A Left Recursive Grammar is not LL(1)

$G = \{S \rightarrow Sa \mid b\}$ not LL(1)

$S \rightarrow Sa$

$S \rightarrow b$

	a	b	$
S		S→b S→Sa	

Not LL(1)

2) A left factor Grammar is not LL(1)

$G = \{S \rightarrow aS \mid a \mid b\}$

	a	b	$
S	S→aS S→a		

not LL(1)

3) An Ambiguous Grammar is not LL(1)

4) Every LL(1) Grammar is UnAmbiguous But every UnAmbiguous Grammar is not LL(1)

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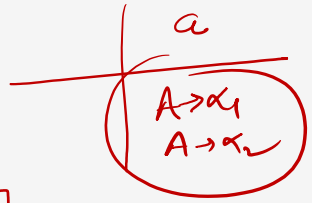
5) If Any Productions are of the form $A \to \alpha_1 | \alpha_2$ Then

$First(\alpha_1) \cap First(\alpha_2) \neq \phi \Rightarrow$ not LL(1)



6) If Any Productions are of the form $A \to \alpha_1 | \alpha_2 | \alpha_3 | \cdots | \alpha_n$ Then any two Productions having Common elements in First set then it is not LL(1)

7) If any Productions are of form $A \to \alpha | \in$, Then

$A \to \alpha$ $A \to \in$

If $First(\alpha) \cap Follow(A) \neq \phi \Rightarrow$ not LL(1)

Ex:

$G = \{ S \to aSa | \in \}$ not LL(1)

$First(aSa) \cap Follow(S) = \{a\} \neq \phi$

	a	$
S	S→aSa S→∈	S→∈

not LL(1)

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(Non left Recursive ∧ left factored ∧ Un Ambiguous) $\not\Rightarrow$ LL(1)

Not LL(1):

1- if any entry of table is multiple defined then G is not LL(1)

2- if G is Ambiguous

3- if G is Left Recursive

4- if G is Left factor

5- And some other cases also

$x \to y \equiv \sim y \to \sim x$

LL(1) → (Non left Recursive) ∧ (left factored) ∧ (Un Ambiguous)

(Left Recursive ∨ left factoring ∨ Ambiguous) → LL'(1)

Ex: ① $S \to AB \mid ab$, $A \to a$, $B \to b$ — not LL(1) — Ambiguous, left factoring

② $S \to Sa \mid b$ — not LL(1) — Because 1) Left Recursive 2) Left factor

③ $S \to a \mid as$ — not LL(1) — because of Contain Common prefix

④ $S \to asa \mid \epsilon$ — 1) it is Un Ambiguous 2) it is non left Recursive 3) it is Left factored

First(asa) ∩ Follow(S) = a ≠ ϕ — not LL(1)

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Testing LL(1) Grammar:

Case 1: $A \to \alpha_1 | \alpha_2 | \alpha_3$

$\in \notin first(\alpha_1)$

$\in \notin First(\alpha_2)$

$\in \notin First(\alpha_3)$

$first(\alpha_1) \cap first(\alpha_2) = \phi$

$first(\alpha_2) \cap first(\alpha_3) = \phi$

$first(\alpha_3) \cap first(\alpha_1) = \phi$

$\Rightarrow$ LL(1)

Case 2: $A \to \alpha_1 | \alpha_2 | \alpha_3$

$\in \notin first(\alpha_1)$

$\in \notin first(\alpha_2)$

$\in \in first(\alpha_3)$

$first(\alpha_1) \cap first(\alpha_2) = \phi$

$first(\alpha_1) \cap [(first(\alpha_3) - \in) \cup follow(A)] = \phi$

$first(\alpha_2) \cap [(first(\alpha_3) - \in) \cup follow(A)] = \phi$

$\Longrightarrow$ LL(1)

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Case 3: $A \rightarrow \alpha_1 \mid \alpha_2 \mid \alpha_3$

$\in \notin first(\alpha_1)$

$\in \in first(\alpha_2)$

$\in \in first(\alpha_3)$

} never LL(1)

$first(\alpha_1) \cap [(first(\alpha_2) - \in) \cup follow(A)] = \phi$

$first(\alpha_1) \cap [(first(\alpha_3) - \in) \cup follow(A)] = \phi$

$[(first(\alpha_2) - \in) \cup follow(A)] \cap [(first(\alpha_3) - \in) \cup follow(A)] \neq \phi$

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LL(1) = ?

$A \to \alpha_1 | \alpha_2$ $\quad$ $A \to \alpha_1 | \alpha_2$

Ex: $G = \{ S \to aS \mid Ab,\ A \to bA \mid b \}$

first(bA) ∩ first(b) = b ≠ ϕ } not LL(1)

Ex: $G = \{ S \to SaAb \mid bA,\ A \to bA \mid \in \}$

not LL(1)

Ex: $G = \{ S \to AaBb \mid \in,\ A \to Bb \mid b,\ B \to aB \mid \in \}$

first(AaBb) ∩ follow(S) = {a, b} ∩ {$} = ϕ ✓

first(Bb) ∩ first(b) = {a, b} ∩ {b} = b ≠ ϕ not LL(1)

first(aB) ∩ follow(B)

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Ex:- $G = \{ S \to aS \mid AbS \mid \in \ , \ A \to aA \mid b \}$

$first(aS) \cap first(AbS)$

$= \{a\} \cap \{a, b\}$

$= a$

$\neq \phi$

] not LL(1)

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$G = \{ S \to eETSS' \mid a,\ S' \to eS \mid \epsilon,\ E \to a \}$

$first(eS) \cap follow(S')$

$e \cap \{e, \$\} \Rightarrow e \neq \$$ } not LL(1)

$follow(S') = follow(S) = \{\$, first(S')\}$

$= \{\$, e, follow(S)\} = \{e, \$\}$

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LL(K) :-

① $S \to aA$, $A \to b$ — LL(0)

② $S \to abaA \mid bbA$, $A \to c \mid d$ — LL(1)

③ $S \to abA \mid acA$, $A \to c \mid d$ — LL(2)

④ $S \to abaA \mid abbA$, $A \to c \mid d$ — LL(3)

Ex: $S \to abc \mid def \Rightarrow$ ~~LL(0)~~ $\Rightarrow$ LL(1)

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$S \to Aa$

$A \to bc$

LL(0)

~~LL(2) ⇒ LL(1)~~

$S \to abc \mid ade$ ⇒ LL(2)

LL(0) ⇒ LL(1) ⇒ LL(2) ⇒ LL(3) ⇒ LL(4) ⇒ ... LL(K)

LL(K) ⇒ LL(K+1) = LL'(K+1) ⇒ LL'(K)

~~LL(K+1) ⇒ LL(K)~~

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$LL(0) \Rightarrow LL(1) \Rightarrow LL(2) \Rightarrow LL(3) \Rightarrow \cdots\cdots LL(K)$

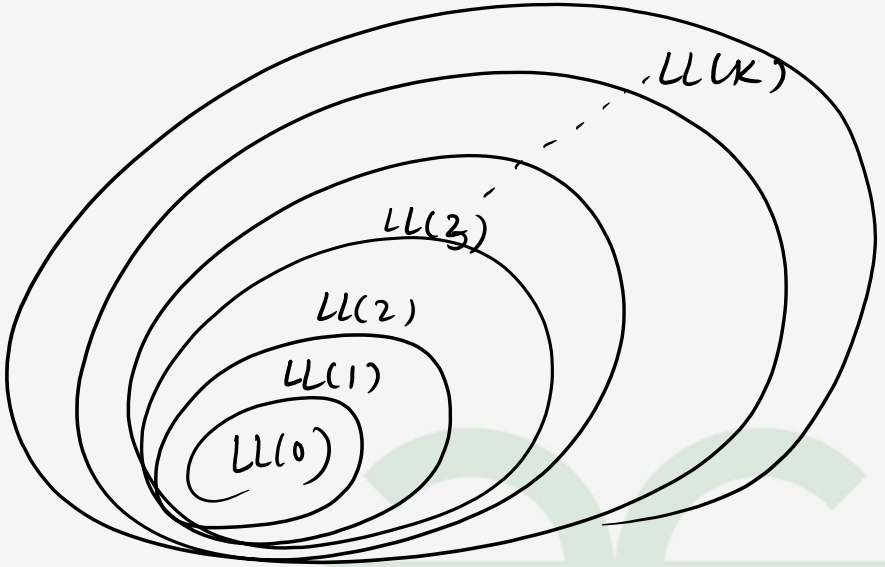
$LL(K) \Rightarrow LL(K+1)$

$LL(K+1) \not\Rightarrow LL(K)$

$LL(K+1) \Rightarrow LL(K)$

Ex: $\left\{ \begin{array}{l} S \rightarrow CC \ \$ \\ C \rightarrow cC \mid d \end{array} \right\} \Rightarrow LL(1) = ?$

$first(cC) \cap first(d)$
$= c \cap d = \phi$



Every $LL(1) \subset LL(2) \subset LL(3) \cdots\cdots \subset LL(K)$

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Question:- Which of the following grammar is LL(3) but not LL(2) and not LL(1)

a) { S → aS | b } LL(1)

b) { S → aaS | ab | b } LL(2)

c) { S → aaaS | aab | ab | b } LL(3) but not LL(2) & not LL(1)

d) None

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Question: The following Grammar $G = \{S \to aA|b, A \to aB|a, B \to bB|a\}$

a) LL(1) but not LL(2)

b) LL(2) but not LL(1) Ans

c) Both LL(1) & LL(2)

d) Neither LL(1) nor LL(2)

LL(2)

$S \to aA|b$

first(aA) ∩ first(b)

a first(A) ∩ first(b)

$a\{a\} \cap \{b\}$

$\Rightarrow aa \cap b = \phi$

LL(2)

$A \to aB|a$

first(aB) ∩ first(a)

$a\{first(B)\} \cap first(a)$

$a\{a, b\} \cap \{a\}$

$\{aa, ab\} \cap \{a\}$

$= \phi \Rightarrow LL(2)$

$B \to bB|a$

first(bB) ∩ first(a)

b first(B) ∩ first(a)

$b\{a, b\} \cap \{a\} \Rightarrow \{ba, bb\} \cap \{a\} = \phi \Rightarrow LL(2)$

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Question: $G = \{ S \to aA/ab,\ A \to aA/b \}$

a) LL(2) but not LL(1)

b) LL(1) but not LL(2)

c) LL(1) & LL(2)

d) None of these.

first(aA) ∩ first(ab)

a first(A) ∩ {ab}

a{a, b} ∩ {ab}

{aa, ab} ∩ {ab}

= ab

≠ ϕ not LL(2)

neither LL(1) nor LL(2) Ans

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Question: LL(1)

$S \rightarrow aBDh$, LL(1) = ?

$B \rightarrow cC$

$C \rightarrow bC \mid \epsilon$ ✓ → $First(bC) \cap follow(C) = \phi$

$D \rightarrow EF$

$E \rightarrow g \mid \epsilon$ ✓ → $First(g) \cap follow(E) = \phi$

$F \rightarrow f \mid \epsilon$ ✓ → $first(f) \cap follow(F) = \phi$

Question:

$S \rightarrow AaAb \mid BbBa$

$A \rightarrow \epsilon$

$B \rightarrow \epsilon$ ✗

$First(AaAb) \cap First(BbBa)$

$a \cap b = \phi$

⇒ LL(1)

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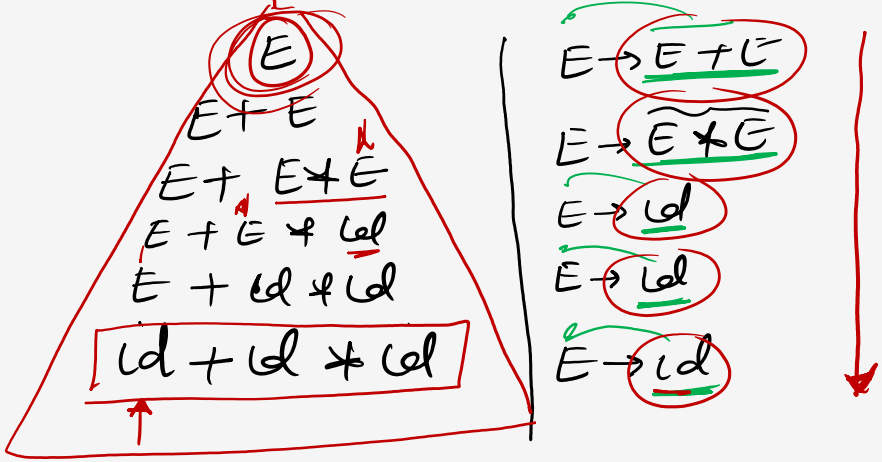
LR(K)

Bottom-up parsing: From leaves to root, uses right most derivation in reverse order. (uses reduction process)

Ex:... $G = \{E \to E+E \mid E*E \mid id\}$



$E \to E+E$

$E \to E*E$

$E \to id$

$E \to id$

$E \to id$

Bottom up Parsing

Right most derivation in Reverse order

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Handle Pruning: Reducing the string to start symbol using the handles

Handle: A Handle is a substring of a string that matched with any of the right side of the productions then That handle will be reduced with left side of the production.

Bottom-up parsing is a process of finding the handles And using them in the reductions to get the start symbol, This entire process of reducing the string to the start symbol is called as handle pruning

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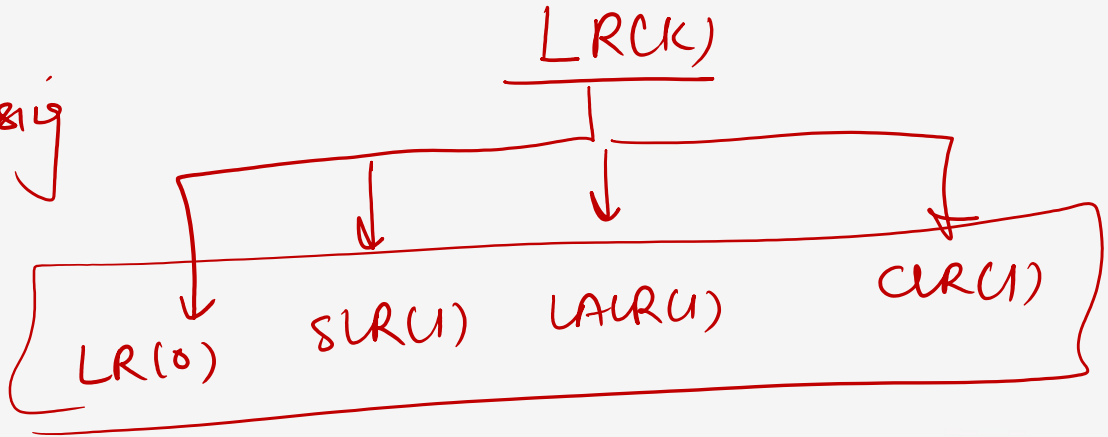
Shift-Reduce Parsing:

or

Bottom up Parsing



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Question:- Consider the following grammar and Parse the input string aab using Shift Reduce Parser

$G_1 = \{ S \to AB, A \to aA \mid a, B \to bB \mid b \}$

Always No. of Shift Action will be Length of String = 3

Reduce Action = 4

Accept = 1

Total Actions = 8

STACK	Input Buffer	Actions
$	aab$	Shift
$a	ab$	Shift
$aa	b$	Reduce A→a (1)
$aA	b$	Reduce A→aA (2)
$A	b$	Shift
$Ab	$	Reduce B→b (3)
$AB	$	Reduce S→AB (4)
$S	$	Accept

Viable prefixes

Handles

Starting Symbol or Rootnode

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Thank You !