23MT2014

THEORY OF COMPUTATION

Topic:

Simplification of Context Free Grammer-Part2

Session – 12-b

AIM OF THE SESSION

Aim: The aim of studying this topic is to learn simplification techniques that help to reduce the complexity of grammars while preserving their language-generating power.

INSTRUCTIONAL OBJECTIVES

This Session is designed to:

1. Apply the CNF to transform context-free grammars into more structured forms.
2. Simplify context-free grammars while preserving the language they generate, thereby reducing ambiguity and improving parsing efficiency.
3. Analyze the impact of grammar simplification on language recognition and parsing algorithms.

LEARNING OUTCOMES

At the end of this session, you should be able to:

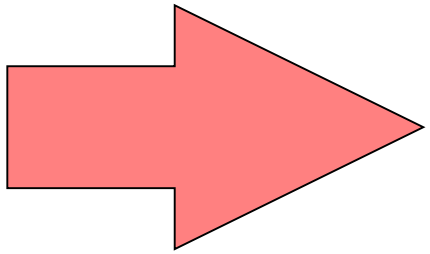
1. Simplify context-free grammars while preserving the languages they generate, ensuring that the simplified grammars retain the same expressive power.
2. Transform context-free grammars by unit productions, and by converting them to CNF.
3. Apply their understanding of grammar simplification to optimize parsing algorithms for context-free languages.

Remove repeated productions

$$S \rightarrow aA \mid aB \mid \cancel{aA}$$

$$A \rightarrow a$$

$$B \rightarrow bb$$



Final grammar

$$S \rightarrow aA \mid aB$$

$$A \rightarrow a$$

$$B \rightarrow bb$$

Useless Productions

$$S \rightarrow aSb$$

$$S \rightarrow \lambda$$

$$S \rightarrow A$$

$$A \rightarrow aA$$ Useless Production

Some derivations never terminate…

$$S \Rightarrow A \Rightarrow aA \Rightarrow aaA \Rightarrow \ldots \Rightarrow aa\ldots aA \Rightarrow \ldots$$

Another grammar:

$$S \rightarrow A$$

$$A \rightarrow aA$$

$$A \rightarrow \lambda$$

$$B \rightarrow bA$$ Useless Production

Not reachable from S

In general:

contains only terminals

if $S \Rightarrow \ldots \Rightarrow xAy \Rightarrow \ldots \Rightarrow w$

$w \in L(G)$

then variable A is useful

otherwise, variable A is useless

A production $A \rightarrow x$ is useless
if any of its variables is useless

$S \rightarrow aSb$

$S \rightarrow \lambda$

Variables		Productions
	$S \rightarrow A$	useless
useless	$A \rightarrow aA$	useless
useless	$B \rightarrow C$	useless
useless	$C \rightarrow D$	useless

Removing Useless Productions

Example Grammar:

$$S \rightarrow aS \mid A \mid C$$

$$A \rightarrow a$$

$$B \rightarrow aa$$

$$C \rightarrow aCb$$

First: find all variables that can produce strings with only terminals

$$S \rightarrow aS \mid A \mid C$$

$$A \rightarrow a$$

$$B \rightarrow aa$$

$$C \rightarrow aCb$$

Round 1: $\{A, B\}$

$$S \rightarrow A$$

Round 2: $\{A, B, S\}$

Keep only the variables
that produce terminal symbols: $\{A, B, S\}$

(the rest variables are useless)

$S \rightarrow aS \mid A \mid C$

$A \rightarrow a$

$B \rightarrow aa$

$C \rightarrow aCb$

$S \rightarrow aS \mid A$

$A \rightarrow a$

$B \rightarrow aa$

Remove useless productions

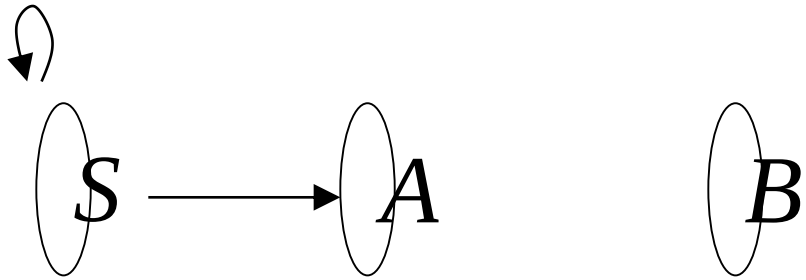
Second: Find all variables reachable from S

Use a Dependency Graph

$$S \rightarrow aS \mid A$$

$$A \rightarrow a$$

$$B \rightarrow aa$$



not reachable

Keep only the variables reachable from S

(the rest variables are useless)

$S \rightarrow aS \mid A$

$A \rightarrow a$

~~$B \rightarrow aa$~~

Final Grammar

$S \rightarrow aS \mid A$

$A \rightarrow a$

Remove useless productions

Removing All

- **Step 1:** Remove Nullable Variables
- **Step 2:** Remove Unit-Productions
- **Step 3:** Remove Useless Variables

Problems

- Problem: 1
- Consider the following Grammar
- $S \rightarrow aS_1b$
- $S1 \rightarrow aS1b / \lambda$
- **Remove λ - Production**
- Problem: 2
- Show that the two grammars are equivalent

G1: S→ abAB / ba

A→ aa

B → aA / bb

G2: S→ abAaA / abAbb / ba

A→ aa

Problems

- Problem: 3
- Eliminate all useless productions from the grammar
- S→aS / AB
- A→aA
- B→ AA
- **What languages does this grammar generate?**
- Problem: 4
- Eliminate useless productions from:
- S→a / aA / B / C
- A→ aB / λ
- B→ Aa
- C→ cCD
- D→ ddd

Problems

- Problem: 5
- Eliminate all λ - Productions from
- S→AaB / aaB
- A→ λ
- B→ bbA / λ
- Problem: 6
- Remove all unit productions, all useless productions and λ-productions from:
- S→ aA / aBB
- A→ aaA / λ
- B→ bB / bbC
- C→ B

Problems

- Problem: 7
- Eliminate all λ - Productions from
- S→aX / bX
- X→ a / b / λ
- Problem: 8
- Eliminate all λ - Productions from
- S→aX / bS / a / b
- X→ aX /a / λ
- Problem: 9
- Remove all unit productions from the following grammar:
- S→ aX / Yb
- X→ S
- Y→ bY / b

Problems

- Problem: 10
- Remove all unit productions from the following grammar:
- S→ AA
- A→ B / BB
- B→ abB / b / bb

MCQ

Question 1:

Which of the following is a technique used to eliminate left recursion in a context-free grammar?

A) Introducing new terminals

B) Removing non-terminals

C) Replacing left-recursive rules with right-recursive rules

D) Expanding existing production rules

Answer:

C) Replacing left-recursive rules with right-recursive rules

Question 2:

What is the purpose of factoring in the simplification of a context-free grammar?

A) To increase the number of production rules

B) To eliminate non-terminals

C) To remove ambiguity in the grammar

D) To reduce redundancy in the grammar

Answer:

D) To reduce redundancy in the grammar

MCQ

Question 3:

What is the role of normalizing a context-free grammar?

A) To ensure all non-terminals have at least one production rule

B) To make the grammar more ambiguous

C) To simplify the parsing process

D) To bring the grammar into a standard form for easier analysis

Answer:

D) To bring the grammar into a standard form for easier analysis

Question 4:

Which of the following is NOT a step in the simplification of a context-free grammar?

A) Removing unreachable symbols

B) Eliminating left recursion

C) Adding more non-terminals

D) Factoring common prefixes in production rules

Answer:

C) Adding more non-terminals

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Terminal questions

Question 1: Explain the concept of left recursion in a context-free grammar. How does it impact the parsing process, and why is it necessary to eliminate left recursion?

Question 2: Describe the process of removing left recursion from a context-free grammar. Discuss the steps involved and provide an example.

Question 3: Explain the concept of unreachable non-terminals in a context-free grammar. How can they be identified and eliminated?

Question 4: Discuss the process of removing unreachable non-terminals from a context-free grammar. Provide an example to illustrate the steps involved.

Question 5: What are useless symbols in a context-free grammar? Explain how they can be identified and eliminated.

Question 6: Discuss the importance of simplifying a context-free grammar. How does it impact the language analysis and parsing process?

Question 7: Explain the process of factoring a production rule in the simplification of a context-free grammar. How does it help in reducing redundancy?

Question 8: Describe the concept of nullable non-terminals in a context-free grammar. How does identifying nullable non-terminals assist in simplification?

Question 9: Explain the role of simplification in language design and compiler construction. How does it contribute to the overall development process?

Question 10:Discuss the potential trade-offs involved in simplifying a context-free grammar. What factors should be considered when deciding how much simplification is appropriate?

THANK YOU

Team – TOC