Context-Free Grammar (CFG)

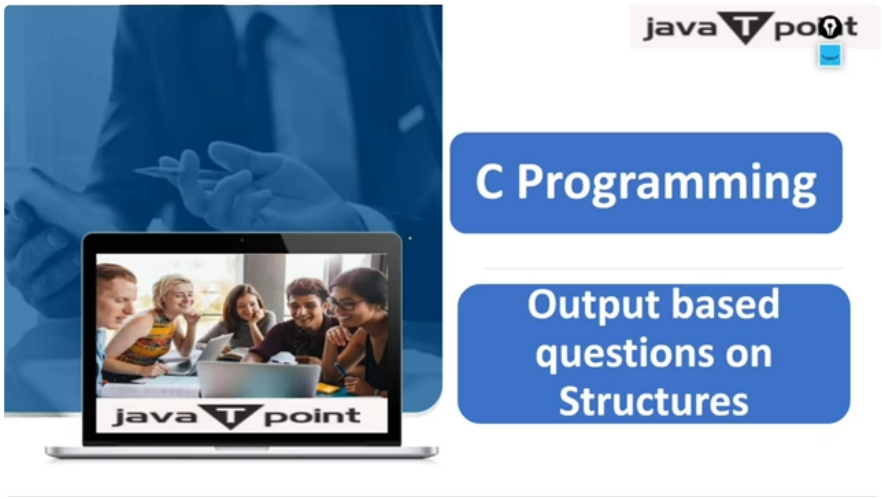
CFG stands for context-free grammar. It is is a formal grammar which is used to generate all possible patterns of strings in a given formal language. Context-free grammar G can be defined by four tuples as:

> G = (V, T, P, S)

Where,

G is the grammar, which consists of a set of the production rule. It is used to generate the string of a language.

T is the final set of a terminal symbol. It is denoted by lower case letters.



V is the final set of a non-terminal symbol. It is denoted by capital letters.

P is a set of production rules, which is used for replacing non-terminals symbols(on the left side of the production) in a string with other terminal or non-terminal symbols(on the right side of the production).

S is the start symbol which is used to derive the string. We can derive the string by repeatedly replacing a non-terminal by the right-hand side of the production until all non-terminal have been replaced by terminal symbols.

Example 1:

Construct the CFG for the language having any number of a's over the set ∑= {a}.

Solution:

As we know the regular expression for the above language is

> r.e. = a*

Production rule for the Regular expression is as follows:

> S → aS rule 1
> S → ε rule 2

Now if we want to derive a string "aaaaaa", we can start with start symbols.

```
 S
aS
aaS          rule 1
aaaS         rule 1
aaaaS        rule 1
aaaaaS       rule 1
aaaaaaS      rule 1
aaaaaaε      rule 2
aaaaaa
```

The r.e. = a* can generate a set of string {ε, a, aa, aaa,.....}. We can have a null string because S is a start symbol and rule 2 gives S → ε.

Example 2:

Construct a CFG for the regular expression (0+1)*

Solution:

The CFG can be given by,

Production rule (P):
S → 0S | 1S
S → ε

The rules are in the combination of 0's and 1's with the start symbol. Since (0+1)* indicates {ε, 0, 1, 01, 10, 00, 11, ...}. In this set, ε is a string, so in the rule, we can set the rule S → ε.

Example 3:

Construct a CFG for a language L = {wcwR | where w € (a, b)*}.

Solution:

The string that can be generated for a given language is {aacaa, bcb, abcba, bacab, abbcbba, ...}

The grammar could be:

> S → aSa rule 1
> S → bSb rule 2
> S → c rule 3

Now if we want to derive a string "abbcbba", we can start with start symbols.

> S → aSa
> S → abSba from rule 2
> S → abbSbba from rule 2
> S → abbcbba from rule 3

Thus any of this kind of string can be derived from the given production rules.

Example 4:

Construct a CFG for the language L = $a^n b^{2n}$ where n>=1.

Solution:

The string that can be generated for a given language is {abb, aabbbb, aaabbbbbb....}.

The grammar could be:

> S → aSbb | abb

Now if we want to derive a string "aabbbb", we can start with start symbols.

> S → aSbb
> S → aabbbb

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