LL(1) Parser

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Current lab: Repository Link

Implementation details

Class **Parser** is responsible for implementing the LL(1) parser. It contains the first and follow methods that are used to obtain the *first* and *follow* tables. These two methods are implemented in the same way they were specified in the lectures.

The class Parser keeps only the final version of the *first* and *follow* tables. That means, the steps that lead to the final version of *first* and *follow* are not stored because they are not relevant for the problem.

In order to write a cleaner implementation for the *first* and *follow* methods, some methods were added to the Grammar class. These methods are:

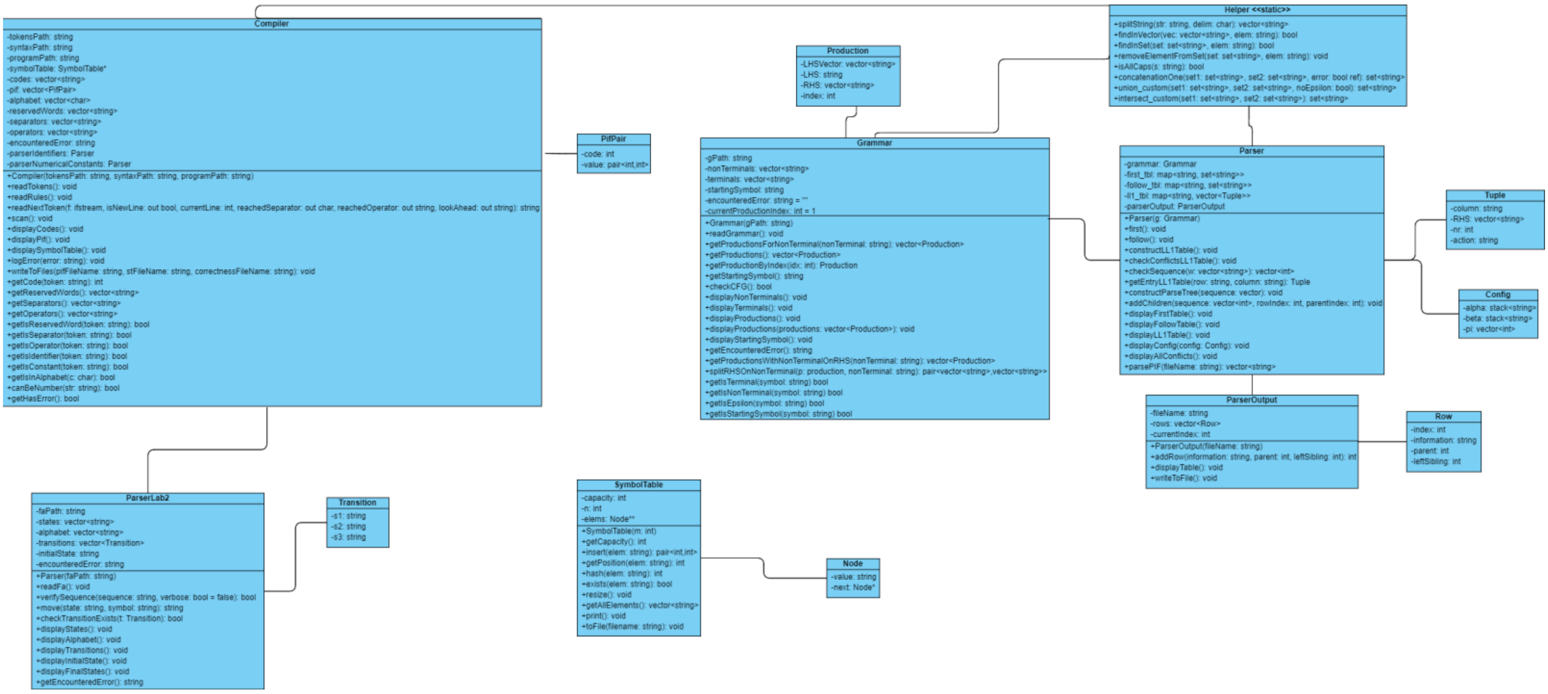
- *getIsTerminal*, *getIsNonTerminal*, *getIsEpsilon*, *getIsStartingSymbol*: these are used for checking whether a given symbol belongs to one of the above-mentioned classes
- *getProductionsWithNonTerminalOnRHS*: this method retrieves a vector of productions containing a given symbol in the right-hand side. This method is used in the *follow* algorithm.
- *splitRHSOnNonTerminal*: this method takes a production and a non-terminal (which must belong to the right-handside of the production). It splits the production into two parts, denoted by alpha and gamma. Alpha is the sequence of symbols before the non-terminal and gamma is the sequence after.

The set operations (union, concatenation of length one) were implented in the **Helper** class.

The method for constructing the LL(1) parse table is *constructLL1Table*. Method *checkSequence* receives a sequence of terminal symbols and checks whether the sequence belongs to the language generated by grammar G or not. It returns a vector of integers representing the indexes of the productions that must be performed to solve the sequence.

Class **ParserOutput** is responsible for storing the parse tree (or syntax tree) generated by method *constructParseTree*. This method requires the sequence of indexes from *checkSequence*.

The class diagram (with the integration with the analyser) becomes:

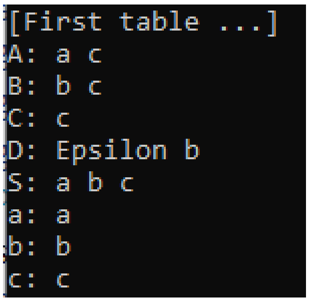


Compiler
-tokensPath: string
-syntaxPath: string
-programPath: string
-symbolTable: SymbolTable*
-codes: vector<string>
-pif: vector<PifPair>
-alphabet: vector<char>
-reservedWords: vector<string>
-separators: vector<string>
-operators: vector<string>
-encounteredError: string
-parserIdentifiers: Parser
-parserNumericalConstants: Parser
+Compiler(tokensPath: string, syntaxPath: string, programPath: string)
+readTokens(): void
+readRules(): void
+readNextToken(f: ifstream, isNewLine: out bool, currentLine: int, reachedSeparator: out char, reachedOperator: out string, lookAhead: out string): string
+scan(): void
+displayCodes(): void
+displayPif(): void
+displaySymbolTable(): void
+logError(error: string): void
+writeToFiles(pifFileName: string, stFileName: string, correctnessFileName: string): void
+getCode(token: string): int
+getReservedWords(): vector<string>
+getSeparators(): vector<string>
+getOperators(): vector<string>
+getIsReservedWord(token: string): bool
+getIsSeparator(token: string): bool
+getIsOperator(token: string): bool
+getIsIdentifier(token: string): bool
+getIsConstant(token: string): bool
+getIsInAlphabet(c: char): bool
+canBeNumber(str: string): bool
+getHasError(): bool
PifPair
-code: int
-value: pair<int,int>
Production
-LHSVector: vector<string>
-LHS: string
-RHS: vector<string>
-index: int
Grammar
-gPath: string
-nonTerminals: vector<string>
-terminals: vector<string>
-startingSymbol: string
-encounteredError: string = ""
-currentProductionIndex: int = 1
+Grammar(gPath: string)
+readGrammar(): void
+getProductionsForNonTerminal(nonTerminal: string): vector<Production>
+getProductions(): vector<Production>
+getProductionByIndex(idx: int): Production
+getStartingSymbol(): string
+checkCFG(): bool
+displayNonTerminals(): void
+displayTerminals(): void
+displayProductions(): void
+displayProductions(productions: vector<Production>): void
+displayStartingSymbol(): void
+getEncounteredError(): string
+getProductionsWithNonTerminalOnRHS(nonTerminal: string): vector<Production>
+splitRHSOnNonTerminal(p: production, nonTerminal: string): pair<vector<string>,vector<string>>
+getIsTerminal(symbol: string) bool
+getIsNonTerminal(symbol: string) bool
+getIsEpsilon(symbol: string) bool
+getIsStartingSymbol(symbol: string) bool
Helper <<static>>
+splitString(str: string, delim: char): vector<string>
+findInVector(vec: vector<string>, elem: string): bool
+findInSet(set: set<string>, elem: string): bool
+removeElementFromSet(set: set<string>, elem: string): void
+isAllCaps(s: string): bool
+concatenationOne(set1: set<string>, set2: set<string>, error: bool ref): set<string>
+union_custom(set1: set<string>, set2: set<string>, noEpsilon: bool): set<string>
+intersect_custom(set1: set<string>, set2: set<string>): set<string>
Parser
-grammar: Grammar
-first_tbl: map<string, set<string>>
-follow_tbl: map<string, set<string>>
-ll1_tbl: map<string, vector<Tuple>>
-parserOutput: ParserOutput
+Parser(g: Grammar)
+first(): void
+follow(): void
+constructLL1Table(): void
+checkConflictsLL1Table(): void
+checkSequence(w: vector<string>): vector<int>
+getEntryLL1Table(row: string, column: string): Tuple
+constructParseTree(sequence: vector): void
+addChildren(sequence: vector<int>, rowIndex: int, parentIndex: int): void
+displayFirstTable(): void
+displayFollowTable(): void
+displayLL1Table(): void
+displayConfig(config: Config): void
+displayAllConflicts(): void
+parsePIF(fileName: string): vector<string>
Tuple
-column: string
-RHS: vector<string>
-nr: int
-action: string
Config
-alpha: stack<string>
-beta: stack<string>
-pi: vector<int>
ParserOutput
-fileName: string
-rows: vector<Row>
-currentIndex: int
+ParserOutput(fileName: string)
+addRow(information: string, parent: int, leftSibling: int): int
+displayTable(): void
+writeToFile(): void
Row
-index: int
-information: string
-parent: int
-leftSibling: int
ParserLab2
-faPath: string
-states: vector<string>
-alphabet: vector<string>
-transitions: vector<Transition>
-initialState: string
-encounteredError: string
+Parser(faPath: string)
+readFa(): void
+verifySequence(sequence: string, verbose: bool = false): bool
+move(state: string, symbol: string): string
+checkTransitionExists(t: Transition): bool
+displayStates(): void
+displayAlphabet(): void
+displayTransitions(): void
+displayInitialState(): void
+displayFinalStates(): void
+getEncounteredError(): string
Transition
-s1: string
-s2: string
-s3: string
SymbolTable
-capacity: int
-n: int
-elems: Node**
+SymbolTable(m: int)
+getCapacity(): int
+insert(elem: string): pair<int,int>
+getPosition(elem: string): int
+hash(elem: string): int
+exists(elem: string): bool
+resize(): void
+getAllElements(): vector<string>
+print(): void
+toFile(filename: string): void
Node
-value: string
-next: Node*

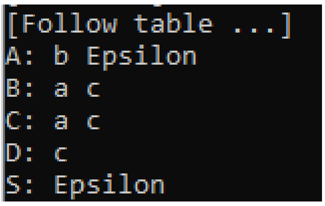
Experiments:

Example 1 (g1.in)

S A B C D
a b c
5
S -> a A b | B A
A -> a A | c A | c
B -> D C
D -> Epsilon | b
C -> c
S



```
[First table ...]
A: a c
B: b c
C: c
D: Epsilon b
S: a b c
a: a
b: b
c: c
```



```
[Follow table ...]
A: b Epsilon
B: a c
C: a c
D: c
S: Epsilon
```

First table:

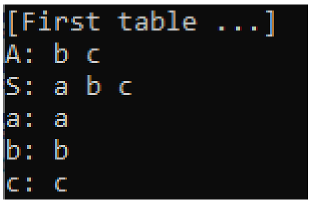
	F_0	F_1	F_2	$F_3=F_2$
S	a	a	a, b, c	
A	a, c	a, c	a, c	
B	∅	b, c	b, c	
C	c	c	c	
D	ε, b	ε, b	ε, b	

Follow table:

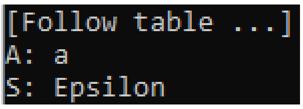
	L_0	L_1	L_2	$L_3=L_2$
S	ε	ε	ε	
A	∅	b, ε	b, ε	
B	∅	a, c	a, c	
C	∅	∅	a, c	
D	∅	c	c	

Example 2 (g2.in)

S A
a b c
2
S -> A a | a
A -> b A | c
S



```
[First table ...]
A: b c
S: a b c
a: a
b: b
c: c
```



```
[Follow table ...]
A: a
S: Epsilon
```

First table:

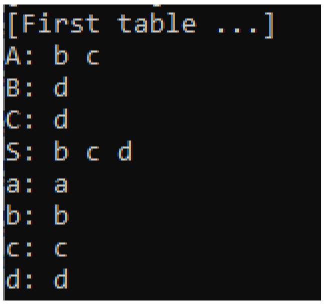
	F_0	F_1	$F_2=F_1$
S	a	a, b, c	
A	b, c	b, c	

Follow table:

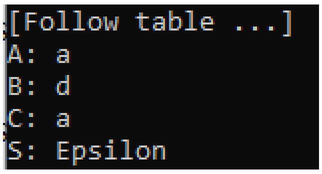
	L_0	L_1	$L_2=L_1$
S	ε	ε	
A	∅	a	

Example 3 (g3.in)

S A B C
a b c d
4
S -> A a | B B
A -> b A | c
B -> C a
C -> d
S



```
[First table ...]
A: b c
B: d
C: d
S: b c d
a: a
b: b
c: c
d: d
```



```
[Follow table ...]
A: a
B: d
C: a
S: Epsilon
```

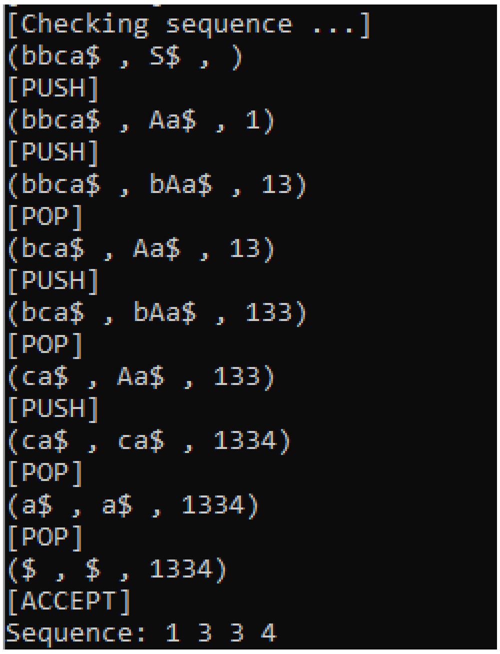
First table:

	F_0	F_1	F_2	F_3=F_2
S	∅	b, c	b, c, d	
A	b, c	b, c	b, c	
B	∅	d	d	
C	d	d	d	

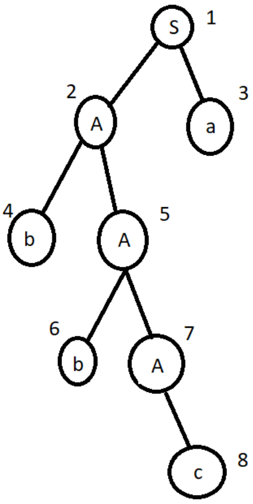
Follow table:

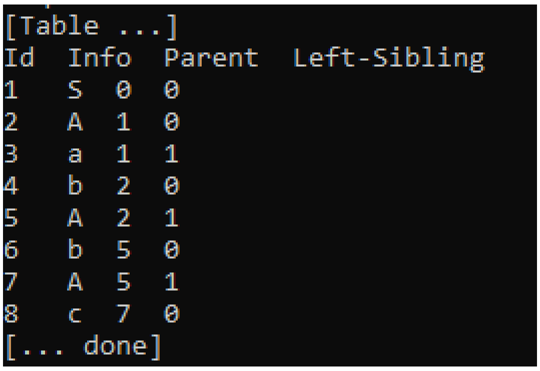
	L_0	L_1	L_2=L_1
S	ε	ε	
A	∅	a	
B	∅	d	
C	∅	a	

Sequence: bbca

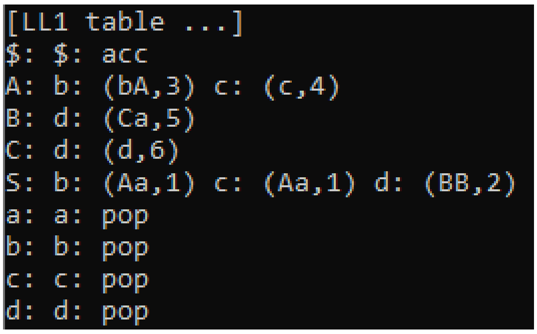


```
[Checking sequence ...]
(bbca$ , S$ , )
[PUSH]
(bbca$ , Aa$ , 1)
[PUSH]
(bbca$ , bAa$ , 13)
[POP]
(bca$ , Aa$ , 13)
[PUSH]
(bca$ , bAa$ , 133)
[POP]
(ca$ , Aa$ , 133)
[PUSH]
(ca$ , ca$ , 1334)
[POP]
(a$ , a$ , 1334)
[POP]
($ , $ , 1334)
[ACCEPT]
Sequence: 1 3 3 4
```





```
[Table ...]
Id  Info  Parent  Left-Sibling
1   S  0  0
2   A  1  0
3   a  1  1
4   b  2  0
5   A  2  1
6   b  5  0
7   A  5  1
8   c  7  0
[... done]
```

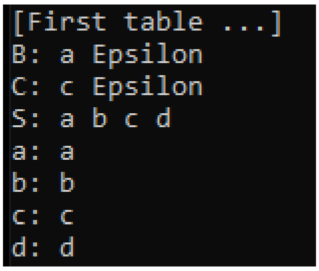


```
[LL1 table ...]
$: $: acc
A: b: (bA,3) c: (c,4)
B: d: (Ca,5)
C: d: (d,6)
S: b: (Aa,1) c: (Aa,1) d: (BB,2)
a: a: pop
b: b: pop
c: c: pop
d: d: pop
```

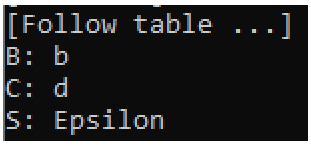
Example 4 (g4.in)

S B C
a b c d
3

S -> B b | C d
B -> a B | Epsilon
C -> c C | Epsilon
S



```
[First table ...]
B: a Epsilon
C: c Epsilon
S: a b c d
a: a
b: b
c: c
d: d
```



```
[Follow table ...]
B: b
C: d
S: Epsilon
```

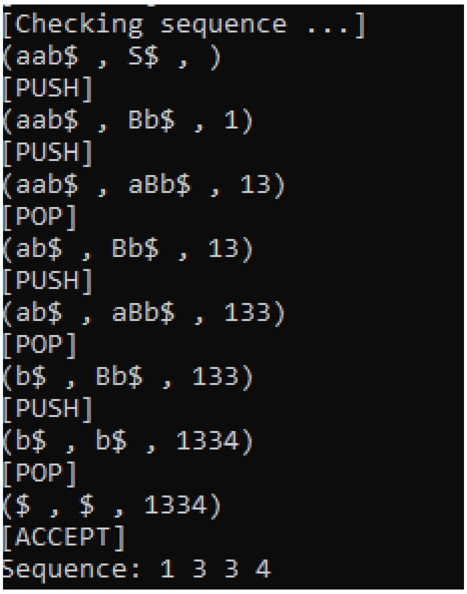
First table:

	F_0	F_1	$F_2=F_1$
S	∅	a, b, c, d	
B	a, ε	a, ε	
C	c, ε	c, ε	

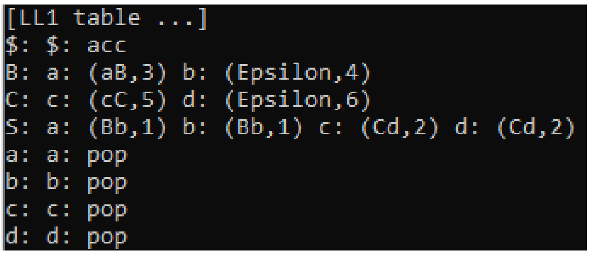
Follow table:

	L_0	L_1	$L_2=L_1$
S	ε	ε	
B	∅	b	
C	∅	d	

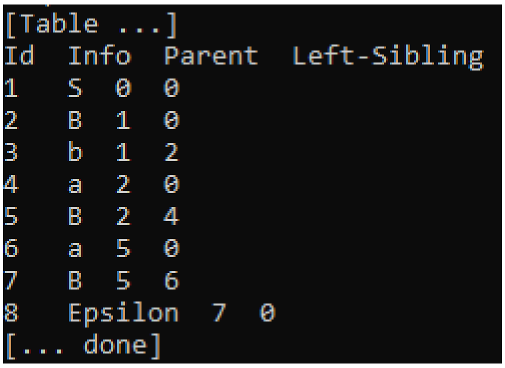
Sequence: aab



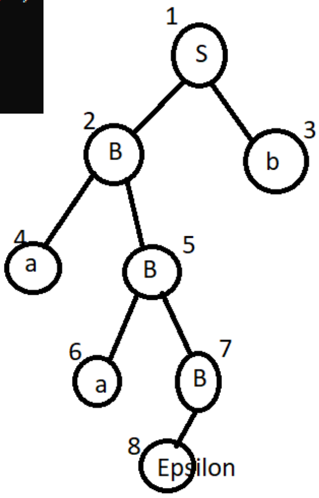
```
[Checking sequence ...]
(aab$ , S$ , )
[PUSH]
(aab$ , Bb$ , 1)
[PUSH]
(aab$ , aBb$ , 13)
[POP]
(ab$ , Bb$ , 13)
[PUSH]
(ab$ , aBb$ , 133)
[POP]
(b$ , Bb$ , 133)
[PUSH]
(b$ , b$ , 1334)
[POP]
($ , $ , 1334)
[ACCEPT]
Sequence: 1 3 3 4
```



```
[LL1 table ...]
$: $: acc
B: a: (aB,3) b: (Epsilon,4)
C: c: (cC,5) d: (Epsilon,6)
S: a: (Bb,1) b: (Bb,1) c: (Cd,2) d: (Cd,2)
a: a: pop
b: b: pop
c: c: pop
d: d: pop
```

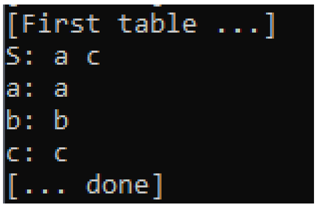


```
[Table ...]
Id  Info  Parent  Left-Sibling
1   S   0   0
2   B   1   0
3   b   1   2
4   a   2   0
5   B   2   4
6   a   5   0
7   B   5   6
8   Epsilon   7   0
[... done]
```

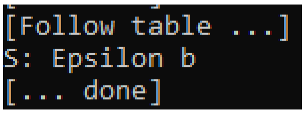


Example 8 (g8.in)

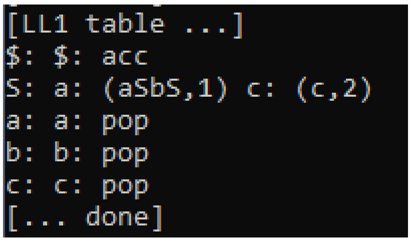
S
a b c
1
S -> a S b S | c
S



```
[First table ...]
S: a c
a: a
b: b
c: c
[... done]
```

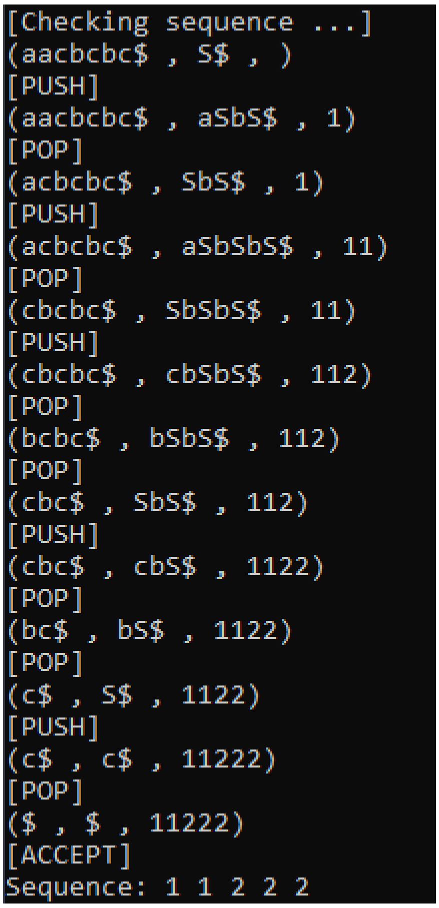


```
[Follow table ...]
S: Epsilon b
[... done]
```

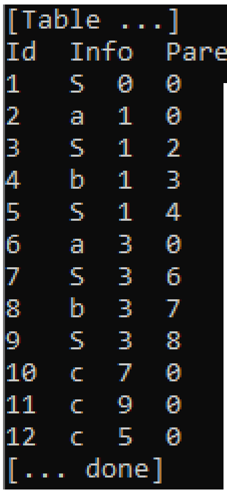


```
[LL1 table ...]
$: $: acc
S: a: (aSbS,1) c: (c,2)
a: a: pop
b: b: pop
c: c: pop
[... done]
```

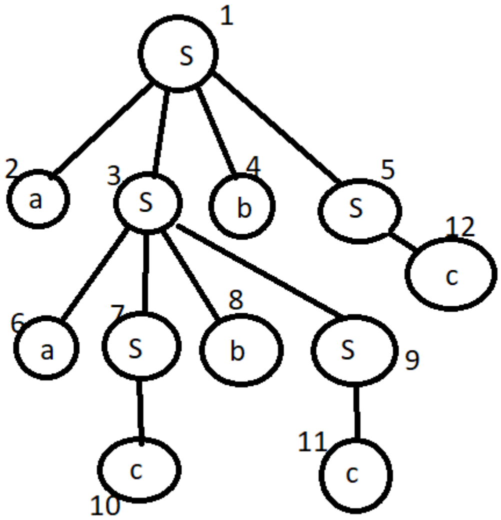
Sequence: aacbcbc



```
[Checking sequence ...]
(aacbcbc$ , S$ , )
[PUSH]
(aacbcbc$ , aSbS$ , 1)
[POP]
(acbcbc$ , SbS$ , 1)
[PUSH]
(acbcbc$ , aSbSbS$ , 11)
[POP]
(cbcbc$ , SbSbS$ , 11)
[PUSH]
(cbcbc$ , cbSbS$ , 112)
[POP]
(bcbc$ , bSbS$ , 112)
[POP]
(cbc$ , SbS$ , 112)
[PUSH]
(cbc$ , cbS$ , 1122)
[POP]
(bc$ , bS$ , 1122)
[POP]
(c$ , S$ , 1122)
[PUSH]
(c$ , c$ , 11222)
[POP]
($ , $ , 11222)
[ACCEPT]
Sequence: 1 1 2 2 2
```

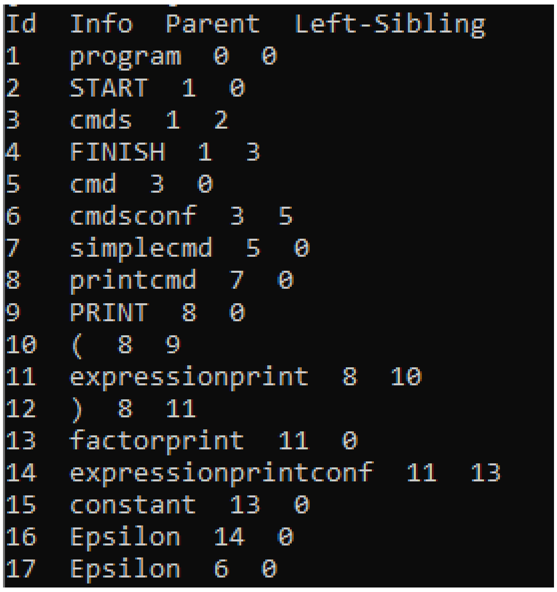


```
[Table ...]
Id  Info  Parent  Left-Sibling
1   S  0  0
2   a  1  0
3   S  1  2
4   b  1  3
5   S  1  4
6   a  3  0
7   S  3  6
8   b  3  7
9   S  3  8
10  c  7  0
11  c  9  0
12  c  5  0
[... done]
```

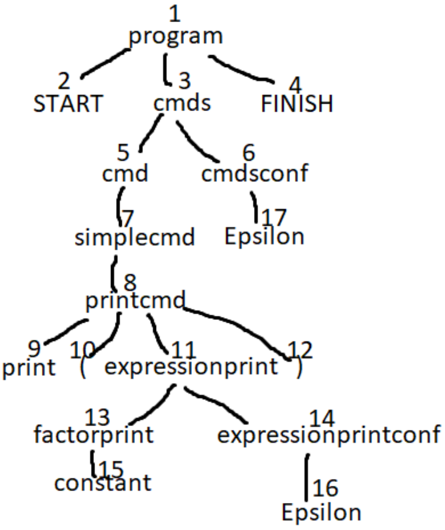


p4.in

```
START
PRINT("Hello world")
FINISH
```



```
Id  Info  Parent  Left-Sibling
1   program  0  0
2   START  1  0
3   cmds  1  2
4   FINISH  1  3
5   cmd  3  0
6   cmdsconf  3  5
7   simplecmd  5  0
8   printcmd  7  0
9   PRINT  8  0
10  (  8  9
11  expressionprint  8  10
12  )  8  11
13  factorprint  11  0
14  expressionprintconf  11  13
15  constant  13  0
16  Epsilon  14  0
17  Epsilon  6  0
```


1
program
2
START
3
cmds
4
FINISH
5
cmd
6
cmdsconf
7
simplecmd
17
Epsilon
8
printcmd
9
print
10
(
11
expressionprint
12
)
13
factorprint
14
expressionprintconf
15
constant
16
Epsilon