CAUSWE Compiler, 2021

Compiler Project #1 Documentation

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Definition of Tokens

Signed integer

<SIGNED INTEGER> – for non-empty sequence of digit, starting from a non-zero digit or minus sign symbol. And single zero digit e.g 0, 11, -123

Single character

<CHARACTER> – for a single digit. English letter, block or any symbol starting from and terminating with ' e.g `0', `a'

Boolean string

<BOOLSTR> – for true and false

Literal string

<LITERAL STRING> – for any combination of digits, letters, blank. starting from and terminating with " e.g "Hello"

An idetifier of variables and functions

<ID> – for a non-empty sequence of English letters, digits, and underscore starting from an English letter or a underscore e.g i, j, _func_,

Keywords for special statements

<KEYWORD> – for `if', `else', `while', `class', `return' keword

Arithmetic operators

<ARITHMETICOP> – for `+', `-', `*', `/' operator

Assignment operator

<OP> – for assign operator `='

Comparison operator

<COMPARISON> – for compare operator `>', `>=', `<', `<=', `==', `!='

A terminating symbol of statements,

A pair of symbols for defining area/scope of variables and functions, for indicating a function/statement, for using an array, for seperating input arguments in functions.

<SYMBOL> – for `;', `{', `}', `(', `)', `[', `]', `,'

Regular Expression

Regular expression

<VARTYPE> = int | char | boolean | String

DIGIT = 0 | 1 | 2 | ... | 8 | 9

LETTER = a | b | ... | y | z | A | B | ... | Y | Z

OTHER : any other symbol ex) `$', ` ', `~'

<SIGNEDINTEGER> = (− | ε)(DIGIT^{+})

<CHARACTER> = ` DIGIT | LETTER | OTHER '

<BOOLSTR> = true | false

<LITERALSTRING> = "(DIGIT | LETTER)*"

<ID> = (LETTER | _)(LETTER | DIGIT | _)*

<KEYWORD> = if | else | while | class | return

<ARITHMETICOP> = + | − | * | /

<OP> = =

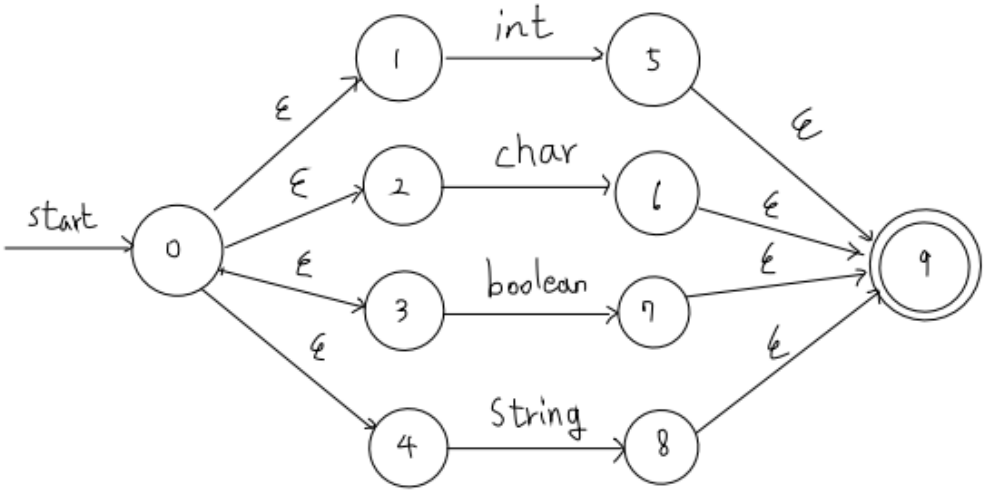
<COMPARISON> = ((> | <)(= | ε)) | ((! | =) =)

<SYMBOL> = ; | ε | } | (|) | [|] | .

NFAs

- **<VARTYPE>**

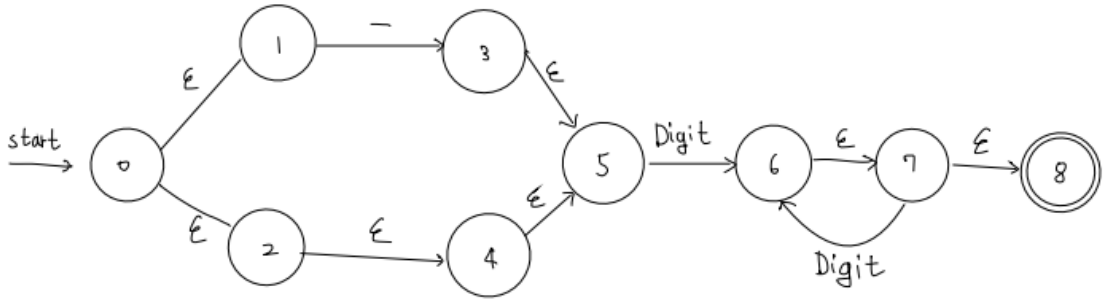
<VARTYPE> = int | char | boolean | String



- **<SIGNED INTEGER>**

Digit = 0 | 1 | ··· | 8 | 9

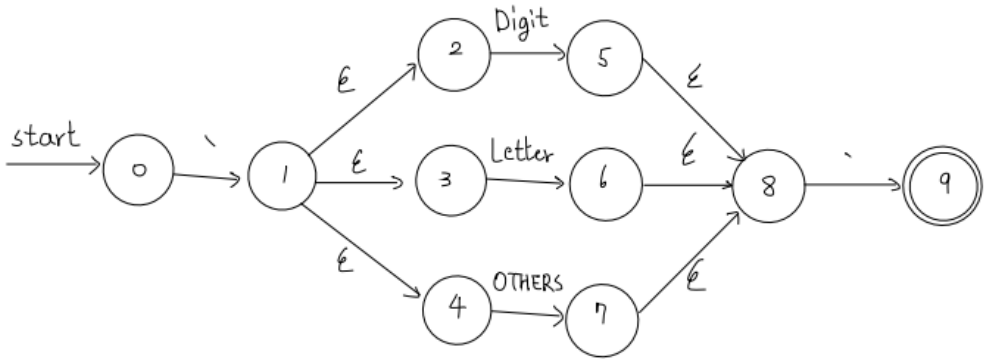
<SIGNEDINTEGER> = (-|ε) Digit^{+}



- **<CHARACTER>**

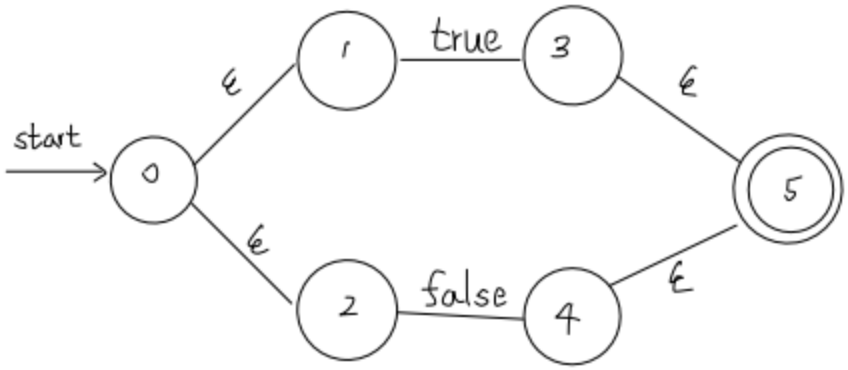
Digit = 0|1|···|8|9
Letter = a|b|···|y|z|A|B|···|Y|Z
<CHARACTER> = '(Digit|Letter|OTHERS)'

OTHERS: any symbol (e.g. ' ', '$', '%')



- **<BOOLSTR>**

<BOOLSTR> = true|false

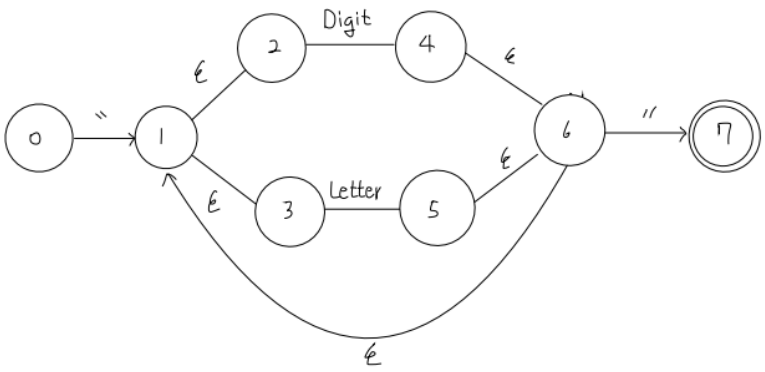


- **<LITERAL STRING>**

Digit = 0|1|2|...|8|9

Letter = a|b|...|z|A|B|...|Z

<LITERALSTRING> = " (Digit|Letter)$^{+}$ "

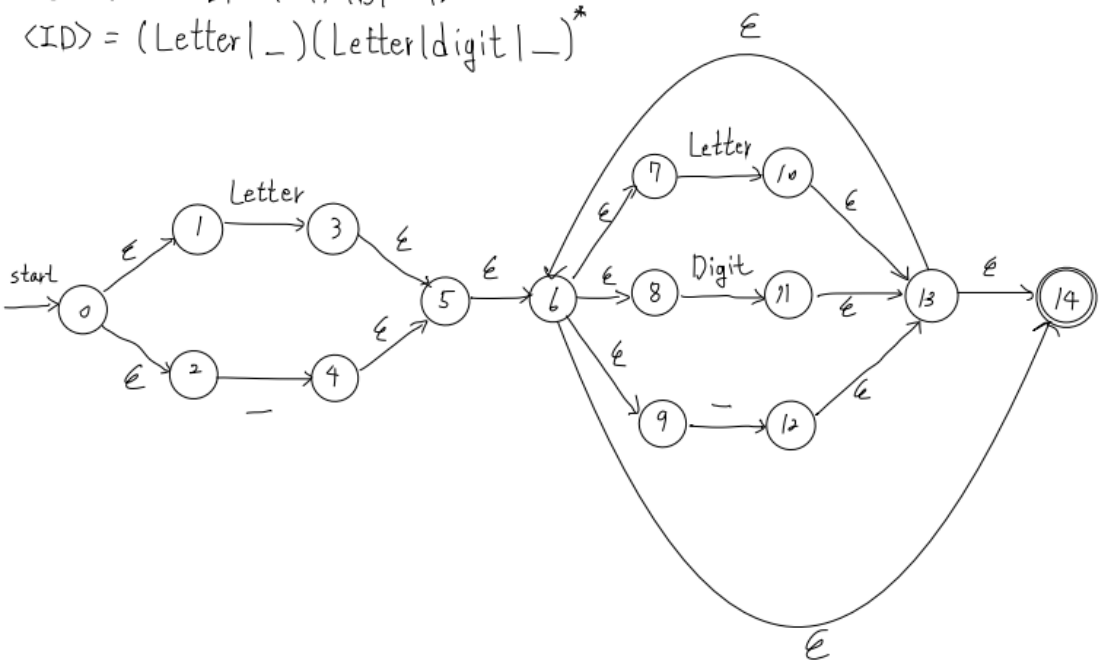


- **<ID>**

Digit = 0|1|...|9

Letter = a|b|...|z|A|B|...|Z

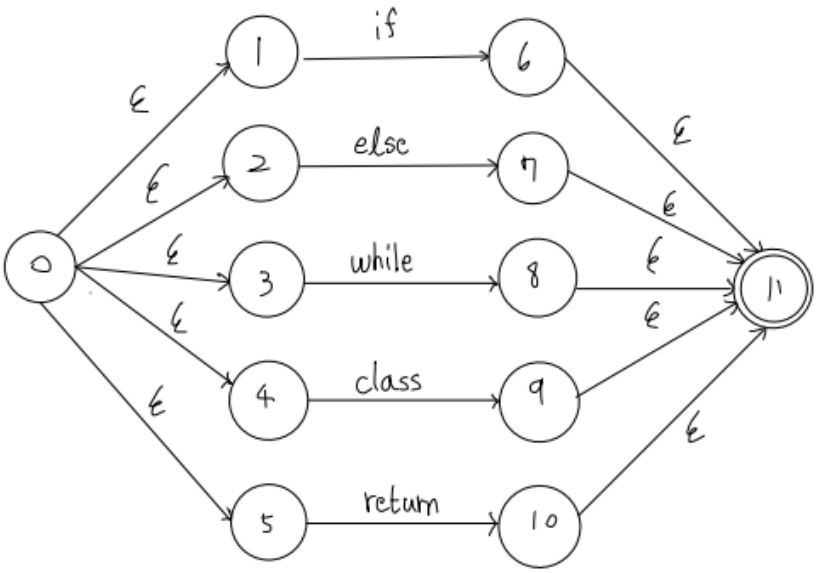
<ID> = (Letter|_)(Letter|digit|_)*



- **<KEYWORD>**

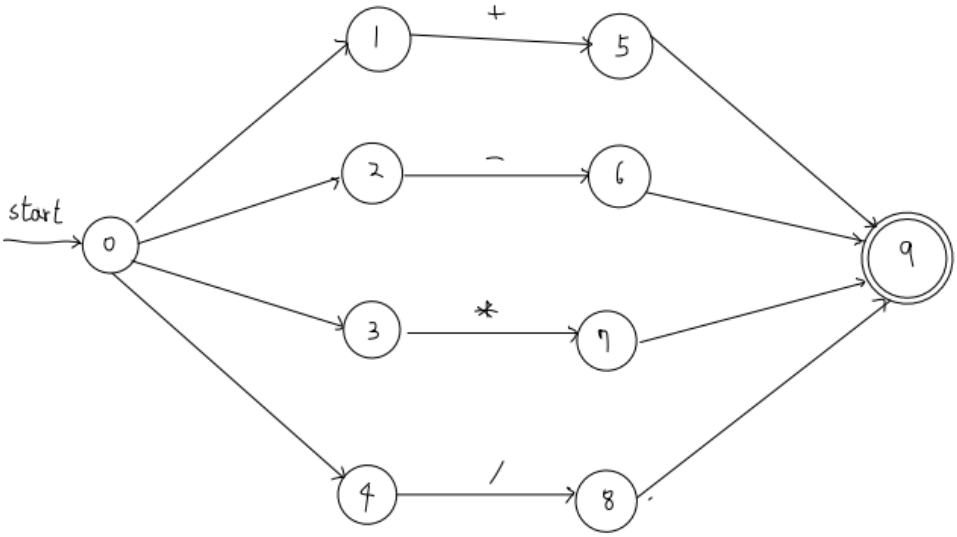
<KEYWORD> NFA

<KEYWORD> = if | else | while | class | return



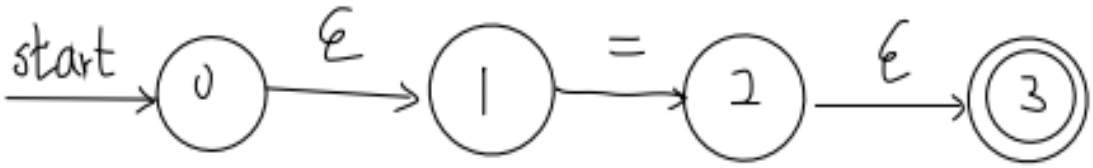
- **<ARITHMETIC OP>**

<ARITHMETICOP> = + | - | * | /



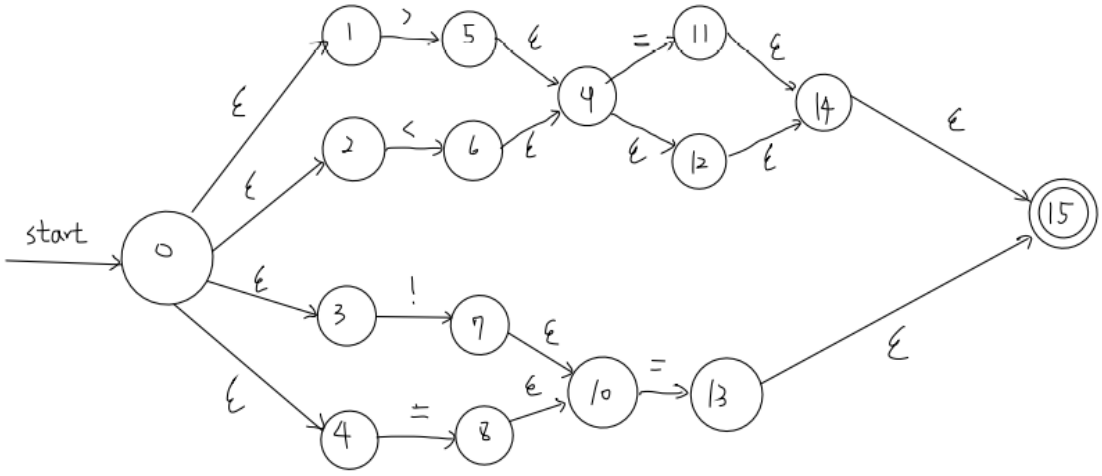
- **<OP>**

<OP> = =

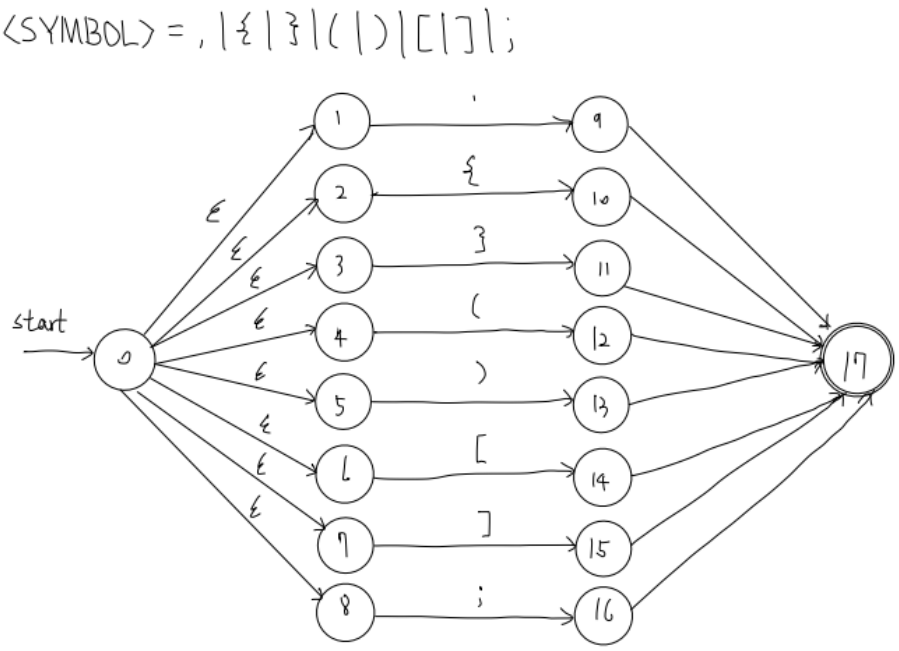


- **<COMPARISON>**

<COMPARISON> = (<|>|(=|ε))|((!|=)=)



- **<SYMBOL>**



DFAs and Transition table

- **<VARTYPE>**

$T_0 = \varepsilon\text{-closure}(0) = \{0, 1, 2, 3, 4\}$

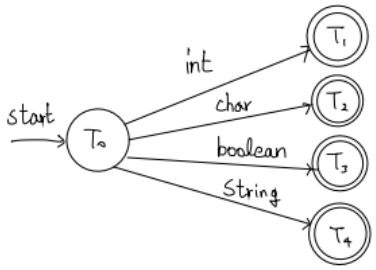
$T_1 = \varepsilon\text{-closure}(\delta(T_0, \text{int})) = \varepsilon\text{-closure}(1) = \{1, 5, 9\}$

$T_2 = \varepsilon\text{-closure}(\delta(T_0, \text{char})) = \varepsilon\text{-closure}(2) = \{2, 6, 9\}$

$T_3 = \varepsilon\text{-closure}(\delta(T_0, \text{boolean})) = \varepsilon\text{-closure}(3) = \{3, 7, 9\}$

$T_4 = \varepsilon\text{-closure}(\delta(T_0, \text{String})) = \varepsilon\text{-closure}(4) = \{4, 8, 9\}$

	int	char	boolean	String
T_0	T_1	T_2	T_3	T_4
T_1	$\emptyset$	$\emptyset$	$\emptyset$	$\emptyset$
T_2	$\emptyset$	$\emptyset$	$\emptyset$	$\emptyset$
T_3	$\emptyset$	$\emptyset$	$\emptyset$	$\emptyset$



- **<SIGNED INTEGER>**

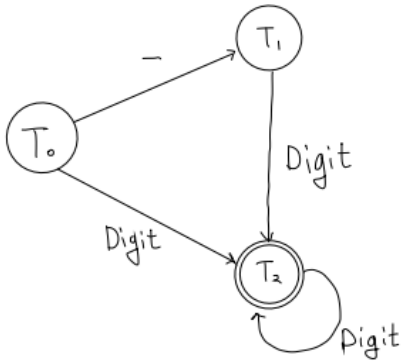
$T_0 = \varepsilon\text{-closure}(0) = \{0, 1, 2, 4, 5\}$

$T_1 = \varepsilon\text{-closure}(\delta(T_0, -)) = \varepsilon\text{-closure}(3) = \{3, 5\}$

$T_2 = \varepsilon\text{-closure}(\delta(T_0, \text{Digit})) = \varepsilon\text{-closure}(6) = \{6, 7, 8\}$

$= \varepsilon\text{-closure}(\delta(T_1, \text{Digit})) = \varepsilon\text{-closure}(6) = \{6, 7, 8\} = T_2$

	−	Digit
T_0	T_1	T_2
T_1	$\emptyset$	T_2
T_2	$\emptyset$	T_2



- **<CHARACTER>**

$T_0 = \varepsilon\text{-closure}(0) = \{0\}$

$T_1 = \varepsilon\text{-closure}(\delta(T_0, \text{'}\backslash\text{'})) = \varepsilon\text{-closure}(1) = \{1,2,3,4\}$

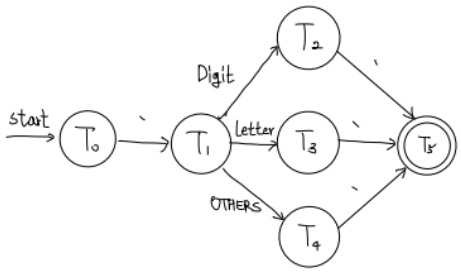
$T_2 = \varepsilon\text{-closure}(\delta(T_1, \text{Digit})) = \varepsilon\text{-closure}(5) = \{5,8\}$

$T_3 = \varepsilon\text{-closure}(\delta(T_1, \text{Letter})) = \varepsilon\text{-closure}(6) = \{6,8\}$

$T_4 = \varepsilon\text{-closure}(\delta(T_1, \text{OTHERS})) = \varepsilon\text{-closure}(7) = \{7,8\}$

$T_5 = \varepsilon\text{-closure}(\delta(T_2, \text{'}\backslash\text{'})) = \varepsilon\text{-closure}(8) = \{8,9\}$

	\	Digit	Letter	OTHERS
T_0	T_1	$\emptyset$	$\emptyset$	$\emptyset$
T_1	$\emptyset$	T_2	T_3	T_4
T_2	T_5	$\emptyset$	$\emptyset$	$\emptyset$
T_3	T_5	$\emptyset$	$\emptyset$	$\emptyset$
T_4	T_5	$\emptyset$	$\emptyset$	$\emptyset$
T_5	$\emptyset$	$\emptyset$	$\emptyset$	$\emptyset$



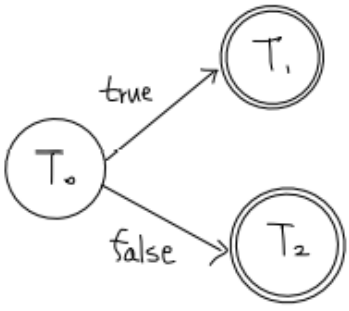
- **<BOOLSTR>**

$T_0 = \varepsilon\text{-closure}(0) = \{0,1,2\}$

$T_1 = \varepsilon\text{-closure}(\delta(T_0, \text{true})) = \varepsilon\text{-closure}(3) = \{3,5\}$

$T_2 = \varepsilon\text{-closure}(\delta(T_0, \text{false})) = \varepsilon\text{-closure}(4) = \{4,5\}$

	true	false
T_0	T_1	T_2
T_1	$\emptyset$	$\emptyset$
T_2	$\emptyset$	$\emptyset$



- **<LITERAL STRING>**

$T_0 = \varepsilon\text{-closure}(0) = \{0\}$

$T_1 = \varepsilon\text{-closure}(\delta(T_0, \text{"}")) = \varepsilon\text{-closure}(1) = \{1, 2, 3\}$

$T_2 = \varepsilon\text{-closure}(\delta(T_1, \text{Digit})) = \varepsilon\text{-closure}(4) = \{1, 2, 3, 4, 6\}$

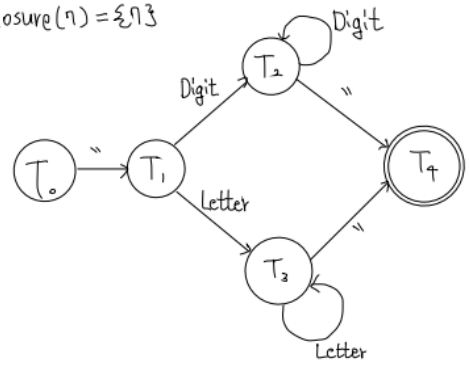
$T_3 = \varepsilon\text{-closure}(\delta(T_1, \text{Letter})) = \varepsilon\text{-closure}(5) = \{1, 2, 3, 5, 6\}$

$\varepsilon\text{-closure}(\delta(T_2, \text{Digit})) = T_2 \quad \varepsilon\text{-closure}(\delta(T_2, \text{Letter})) = T_3$

$\varepsilon\text{-closure}(\delta(T_3, \text{Digit})) = T_2 \quad \varepsilon\text{-closure}(\delta(T_3, \text{Letter})) = T_3$

$T_4 = \varepsilon\text{-closure}(\delta(T_2, \text{"}")) = \varepsilon\text{-closure}(7) = \{7\}$

	"	Digit	Letter
T_0	T_1	$\emptyset$	$\emptyset$
T_1	$\emptyset$	T_2	T_3
T_2	T_4	T_2	T_3
T_3	T_4	T_2	T_3
T_4	$\emptyset$	$\emptyset$	$\emptyset$



- **<ID>**

<ID> NFA to DFA

$T_0 = \varepsilon\text{-closure}(0) = \{0, 1, 2\}$

$T_1 = \varepsilon\text{-closure}(\delta(T_0, \text{Letter})) = \varepsilon\text{-closure}(3) = \{3, 5, 6, 7, 8, 9, 14\}$

$T_2 = \varepsilon\text{-closure}(\delta(T_0, \_)) = \varepsilon\text{-closure}(4) = \{4, 5, 6, 7, 8, 9, 14\}$

$T_3 = \varepsilon\text{-closure}(\delta(T_1, \text{Letter})) = \varepsilon\text{-closure}(10) = \{6, 7, 8, 9, 10, 13, 14\}$

$T_4 = \varepsilon\text{-closure}(\delta(T_1, \text{Digit})) = \varepsilon\text{-closure}(11) = \{6, 7, 8, 9, 11, 13, 14\}$

$T_5 = \varepsilon\text{-closure}(\delta(T_1, \_)) = \varepsilon\text{-closure}(12) = \{6, 7, 8, 9, 12, 13, 14\}$

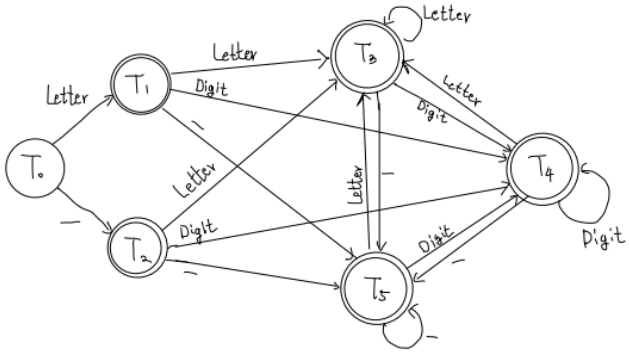
$\varepsilon\text{-closure}(\delta(T_2, \text{Letter})) = T_3 \quad \varepsilon\text{-closure}(\delta(T_2, \text{Digit})) = T_4 \quad \varepsilon\text{-closure}(\delta(T_2, \_)) = T_5$

$\varepsilon\text{-closure}(\delta(T_3, \text{Letter})) = T_3 \quad \varepsilon\text{-closure}(\delta(T_3, \text{Digit})) = T_4 \quad \varepsilon\text{-closure}(\delta(T_3, \_)) = T_5$

$\varepsilon\text{-closure}(\delta(T_4, \text{Letter})) = T_3 \quad \varepsilon\text{-closure}(\delta(T_4, \text{Digit})) = T_4 \quad \varepsilon\text{-closure}(\delta(T_4, \_)) = T_5$

$\varepsilon\text{-closure}(\delta(T_5, \text{Letter})) = T_3 \quad \varepsilon\text{-closure}(\delta(T_5, \text{Digit})) = T_4 \quad \varepsilon\text{-closure}(\delta(T_5, \_)) = T_5$

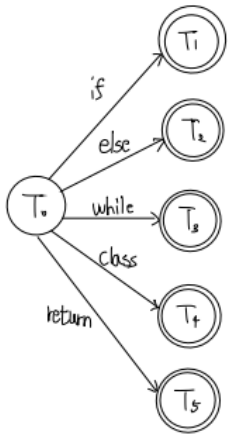
	Letter	Digit	_
T_0	T_1	$\emptyset$	T_2
T_1	T_3	T_4	T_5
T_2	T_3	T_4	T_5
T_3	T_3	T_4	T_5
T_4	T_3	T_4	T_5
T_5	T_3	T_4	T_5



- **<KEYWORD>**

$T_0 = \varepsilon\text{-closure}(0) = \{0, 1, 2, 3, 4, 5\}$
$T_1 = \varepsilon\text{-closure}(\delta(T_0, if)) = \varepsilon\text{-closure}(6) = \{6, 11\}$
$T_2 = \varepsilon\text{-closure}(\delta(T_0, else)) = \varepsilon\text{-closure}(7) = \{7, 11\}$
$T_3 = \varepsilon\text{-closure}(\delta(T_0, while)) = \varepsilon\text{-closure}(8) = \{8, 11\}$
$T_4 = \varepsilon\text{-closure}(\delta(T_0, class)) = \varepsilon\text{-closure}(9) = \{9, 11\}$
$T_5 = \varepsilon\text{-closure}(\delta(T_0, return)) = \varepsilon\text{-closure}(10) = \{10, 11\}$

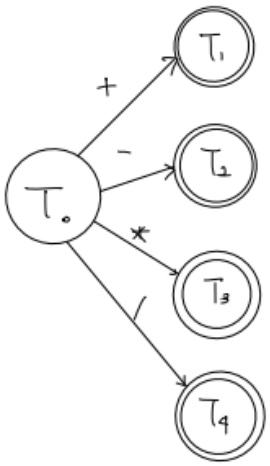
	if	else	while	class	return
T_0	T_1	T_2	T_3	T_4	T_5
T_1	$\emptyset$	$\emptyset$	$\emptyset$	$\emptyset$	$\emptyset$
T_2	$\emptyset$	$\emptyset$	$\emptyset$	$\emptyset$	$\emptyset$
T_3	$\emptyset$	$\emptyset$	$\emptyset$	$\emptyset$	$\emptyset$
T_4	$\emptyset$	$\emptyset$	$\emptyset$	$\emptyset$	$\emptyset$
T_5	$\emptyset$	$\emptyset$	$\emptyset$	$\emptyset$	$\emptyset$



- **<ARITHMETIC OP>**

$T_0 = \varepsilon\text{-closure}(0) = \{0, 1, 2, 3, 4\}$
$T_1 = \varepsilon\text{-closure}(\delta(T_0, +)) = \varepsilon\text{-closure}(1) = \{5, 9\}$
$T_2 = \varepsilon\text{-closure}(\delta(T_0, -)) = \varepsilon\text{-closure}(2) = \{6, 9\}$
$T_3 = \varepsilon\text{-closure}(\delta(T_0, *)) = \varepsilon\text{-closure}(3) = \{7, 9\}$
$T_4 = \varepsilon\text{-closure}(\delta(T_0, /)) = \varepsilon\text{-closure}(4) = \{8, 9\}$

	+	−	*	/
T_0	T_1	T_2	T_3	T_4
T_1	$\emptyset$	$\emptyset$	$\emptyset$	$\emptyset$
T_2	$\emptyset$	$\emptyset$	$\emptyset$	$\emptyset$
T_3	$\emptyset$	$\emptyset$	$\emptyset$	$\emptyset$
T_4	$\emptyset$	$\emptyset$	$\emptyset$	$\emptyset$

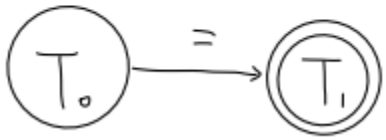


- **<OP>**

$T_0 = \varepsilon\text{-closure}(0) = \{0, 1\}$

$T_1 = \varepsilon\text{-closure}(\delta(T_0, =)) = \varepsilon\text{-closure}(2) = \{2, 3\}$

	=
T_0	T_1
T_1	$\emptyset$



- **<COMPARISON>**

<COMPARISON> NFA to DFA

$T_0 = \varepsilon\text{-closure}(0) = \{0, 1, 2, 3\}$

$T_1 = \varepsilon\text{-closure}(\delta(T_0, >)) = \varepsilon\text{-closure}(5) = \{5, 9, 12, 14, 15\}$

$T_2 = \varepsilon\text{-closure}(\delta(T_0, <)) = \varepsilon\text{-closure}(6) = \{6, 9, 12, 14, 15\}$

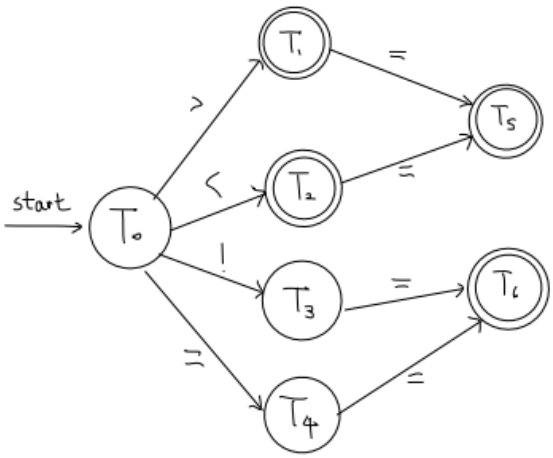
$T_3 = \varepsilon\text{-closure}(\delta(T_0, !)) = \varepsilon\text{-closure}(7) = \{7, 10\}$

$T_4 = \varepsilon\text{-closure}(\delta(T_0, =)) = \varepsilon\text{-closure}(8) = \{8, 10\}$

$T_5 = \varepsilon\text{-closure}(\delta(T_1, =)) = \varepsilon\text{-closure}(11) = \{11, 14, 15\}$

$T_6 = \varepsilon\text{-closure}(\delta(T_3, =)) = \varepsilon\text{-closure}(13) = \{13, 15\}$

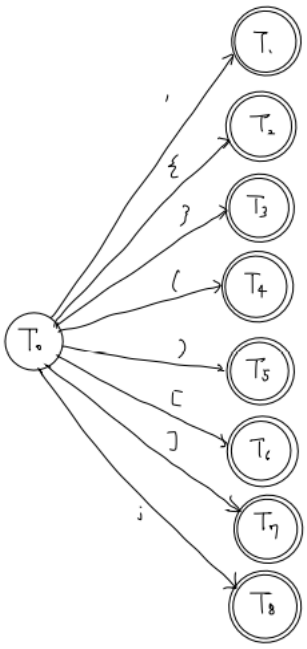
	>	<	!	=
T_0	T_1	T_2	T_3	T_4
T_1	$\emptyset$	$\emptyset$	$\emptyset$	T_5
T_2	$\emptyset$	$\emptyset$	$\emptyset$	T_5
T_3	$\emptyset$	$\emptyset$	$\emptyset$	T_6
T_4	$\emptyset$	$\emptyset$	$\emptyset$	T_6
T_5	$\emptyset$	$\emptyset$	$\emptyset$	$\emptyset$
T_6	$\emptyset$	$\emptyset$	$\emptyset$	$\emptyset$



- **<SYMBOL>**

$T_0 = \varepsilon\text{-closure}(0) = \{0, 1, 2, 3, 4, 5, 6, 7, 8\}$
$T_1 = \varepsilon\text{-closure}(\delta(T_0, ,)) = \varepsilon\text{-closure}(9) = \{9, 17\}$
$T_2 = \varepsilon\text{-closure}(\delta(T_0, \{)) = \varepsilon\text{-closure}(10) = \{10, 17\}$
$T_3 = \varepsilon\text{-closure}(\delta(T_0, \})) = \varepsilon\text{-closure}(11) = \{11, 17\}$
$T_4 = \varepsilon\text{-closure}(\delta(T_0, ()) = \varepsilon\text{-closure}(12) = \{12, 17\}$
$T_5 = \varepsilon\text{-closure}(\delta(T_0,))) = \varepsilon\text{-closure}(13) = \{13, 17\}$
$T_6 = \varepsilon\text{-closure}(\delta(T_0, [)) = \varepsilon\text{-closure}(14) = \{14, 17\}$
$T_7 = \varepsilon\text{-closure}(\delta(T_0,])) = \varepsilon\text{-closure}(15) = \{15, 17\}$
$T_8 = \varepsilon\text{-closure}(\delta(T_0, ;)) = \varepsilon\text{-closure}(16) = \{16, 17\}$

	,	{	}	(	)	[	]	;
T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
T_1	∅	∅	∅	∅	∅	∅	∅	∅
T_2	∅	∅	∅	∅	∅	∅	∅	∅
T_3	∅	∅	∅	∅	∅	∅	∅	∅
T_4	∅	∅	∅	∅	∅	∅	∅	∅
T_5	∅	∅	∅	∅	∅	∅	∅	∅
T_6	∅	∅	∅	∅	∅	∅	∅	∅
T_7	∅	∅	∅	∅	∅	∅	∅	∅
T_8	∅	∅	∅	∅	∅	∅	∅	∅



How This Lexical Analyzer Work?

Requirements

- Python >= 3.8.2
- Ubuntu or MacOS

Architecture

There's a DFA_Graph class. This class contains a token's DFA Informations and current_state. If it gets a symbol as an input, current_state changes and returns its value. Of course, If it got a wrong symbol, current_state changes to None and returns it until it resets.

There are syntaces as DFA_Graph class in this code.

For the main function,

1. it reads a file by a single symbol.
2. Then pass it into every token DFA_Graph's input.
3. Repeat it until every DFA_Graph returns None.
4. Print token's information that returned a number until last time.
   If there were several tokens, choose the first one.
5. From the last symbol, do 2 and repeat until a file ends.

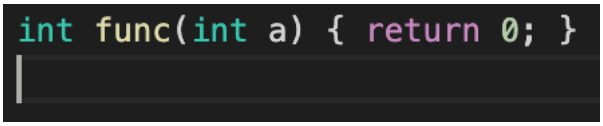
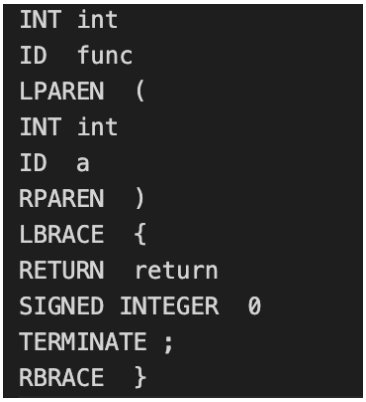
And If parsing ends up with an error, it reports where the error occurred.
(Error Message is not written at output file.)

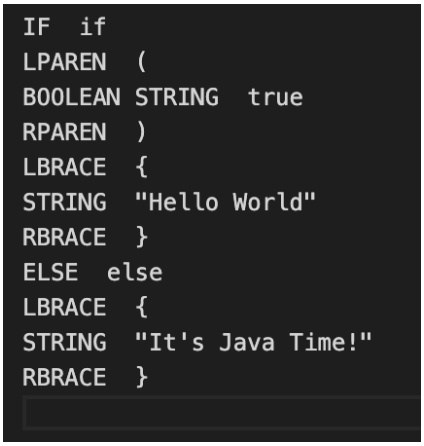
Running Table

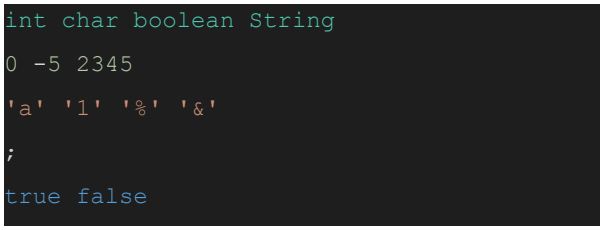
This table shows what happens for each symbol input.

		i	n	t		t	e	s	t	
DFA_ Graph	INT .current_state	1	1	2(f)	None →None	None →None	None	None	None	None →None
	ID .current_state	2(f)	2(f)	2(f)	None →None	None →1(f)	1(f)	1(f)	1(f)	None →None
	WS .current_state	None	None	None	None →1(f)	None →None	None	None	None	None →1(f)
		Every states becomes None↑ print INT(priority)								
					↑ print WS					
									↑ print ID	

Sample Result

input (sample2.java)	output (sample2.java_output.txt)
	

input (sample5.java)	output (sample5.java_output.txt)
	

input (sample_final.java)	output (sample_final.java_output.txt)
	


```
INT        int
CHAR       char
BOOLEAN            boolean
STRING     String
SIGNED INTEGER     0
SIGNED INTEGER     -5
SIGNED INTEGER     2345
SINGLE CHARACTER           'a'
SINGLE CHARACTER           '1'
```

```
"Hello Java World"
class Foo
a+b
b-c
1-5
-17
int foo = -3;
int _bar_123 = 4;
if(true) {
"Hello World";
}else{
"It's Java Time!";
}
int func(int a) {return a}
int[] a = {1,2,3};
class compiler {
  String Teacher;
  char Grade;
}
3 > 5
3 >= 5
3 < 5
3 <= 5
3 != 5
3 == 5
int b = 3 * 5
b = 3 / 5
int i = 4;
while(i < 5){
 i = 10;
}
"ddddsdfasdfasdf"
ghfhhdh"
This Line is made for Error
```

```
SINGLE CHARACTER        '%'
SINGLE CHARACTER        '&'
TERMINATE       ;
BOOLEAN STRING  true
BOOLEAN STRING  false
STRING  "Hello Java World"
CLASS   class
ID      Foo
ID      a
OP_ARITHMATIC   +
ID      b
ID      b
OP_ARITHMATIC   -
ID      c
SIGNED INTEGER  1
OP_ARITHMATIC   -
SIGNED INTEGER  5
SIGNED INTEGER  -17
INT     int
ID      foo
OP_ASSIGNMENT   =
SIGNED INTEGER  -3
TERMINATE       ;
INT     int
ID      _bar_123
OP_ASSIGNMENT   =
SIGNED INTEGER  4
TERMINATE       ;
IF      if
LPAREN  (
BOOLEAN STRING  true
RPAREN  )
LBRACE  {
STRING  "Hello World"
TERMINATE       ;
RBRACE  }
ELSE    else
LBRACE  {
STRING  "It's Java Time!"
TERMINATE       ;
RBRACE  }
INT     int
ID      func
LPAREN  (
INT     int
ID      a
RPAREN  )
LBRACE  {
RETURN  return
ID      a
RBRACE  }
INT     int
LBRACKET        [
RBRACKET        ]
ID      a
OP_ASSIGNMENT   =
LBRACE  {
SIGNED INTEGER  1
SEPARATE        ,
SIGNED INTEGER  2
SEPARATE        ,
SIGNED INTEGER  3
RBRACE  }
TERMINATE       ;
CLASS   class
```

	ID compiler LBRACE { STRING String ID Teacher TERMINATE ; CHAR char ID Grade TERMINATE ; RBRACE } SIGNED INTEGER 3 OP_COMPARISON >= SIGNED INTEGER 5 SIGNED INTEGER 3 OP_COMPARISON >= SIGNED INTEGER 5 SIGNED INTEGER 3 OP_COMPARISON < SIGNED INTEGER 5 SIGNED INTEGER 3 OP_COMPARISON <= SIGNED INTEGER 5 SIGNED INTEGER 3 OP_COMPARISON != SIGNED INTEGER 5 SIGNED INTEGER 3 OP_COMPARISON == SIGNED INTEGER 5 INT int ID b OP_ASSIGNMENT = SIGNED INTEGER 3 OP_ARITHMATIC * SIGNED INTEGER 5 ID b OP_ASSIGNMENT = SIGNED INTEGER 3 OP_ARITHMATIC / SIGNED INTEGER 5 INT int ID i OP_ASSIGNMENT = SIGNED INTEGER 4 TERMINATE ; WHILE while LPAREN (ID i OP_COMPARISON < SIGNED INTEGER 5 RPAREN) LBRACE { ID i OP_ASSIGNMENT = SIGNED INTEGER 10 TERMINATE ; RBRACE } STRING "ddddsdfasdfasdf" ID ghfhhdh Lexical Analyzer Error : Cannot Parse at line 39