Project 4: Infix and Postfix Notation

CSE3333

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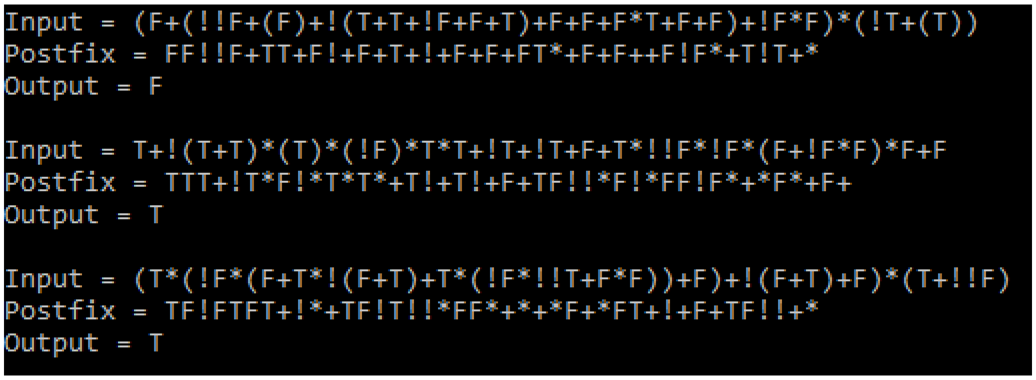
Read Me:

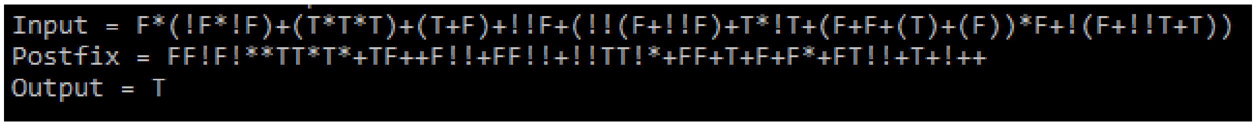
The program has the functions and their descriptions in the header file EvalBool.h. The file project4.cpp (changed to Infix and Postfix Notation.cpp) contains the main function where the program is executed. The program was executed using visual studios, and using the C++ STL template for stacks.

On the worksheet Testing Cases for proof that the postfix evaluation of Boolean characters is correct:

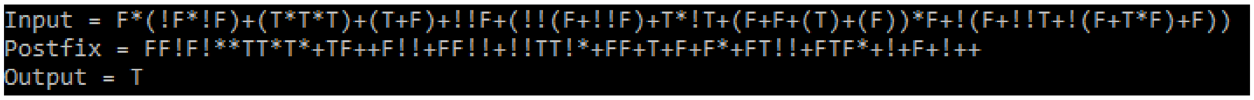
Original test runs on Project 4 worksheet evaluated:



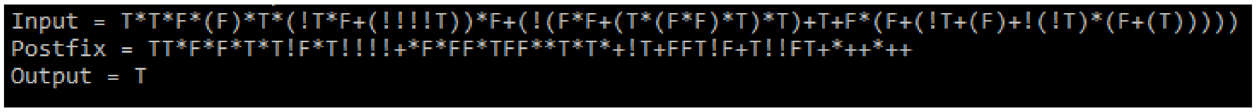
```
Input = (F+(!!F+(F)+!(T+T+!F+F+T)+F+F+F*T+F+F)+!F*F)*(!T+(T))
Postfix = FF!!F+TT+F!+F+T+!+F+F+FT*+F+F++F!F*+T!T+*
Output = F

Input = T+!(T+T)*(T)*(!F)*T*T+!T+!T+F+T*!!F*!F*(F+!F*F)*F+F
Postfix = TTT+!T*F!*T*T*+T!+T!+F+TF!!*F!*FF!F*+*F*+F+
Output = T

Input = (T*(!F*(F+T*!(F+T)+T*(!F*!!T+F*F))+F)+!(F+T)+F)*(T+!!F)
Postfix = TF!FTFT+!*+TF!T!!*FF*+*+*F+*FT+!+F+TF!!+*
Output = T
```



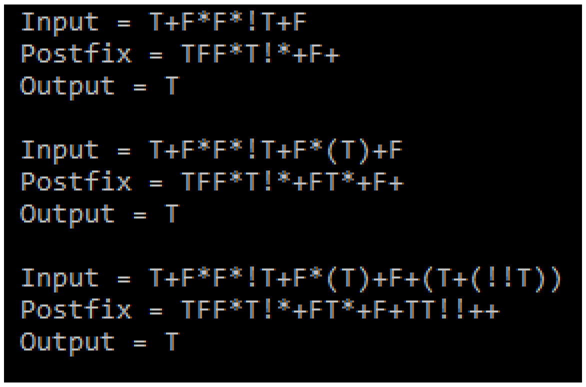
```
Input = F*(!F*!F)+(T*T*T)+(T+F)+!!F+(!!(F+!!F)+T*!T+(F+F+(T)+(F))*F+!(F+!!T+T))
Postfix = FF!F!**TT*T*+TF++F!!+FF!!+!!TT!*+FF+T+F+F*+FT!!+T+!++
Output = T
```



```
Input = F*(!F*!F)+(T*T*T)+(T+F)+!!F+(!!(F+!!F)+T*!T+(F+F+(T)+(F))*F+!(F+!!T+!(F+T*F)+F))
Postfix = FF!F!**TT*T*+TF++F!!+FF!!+!!TT!*+FF+T+F+F*+FT!!+FTF*+!+F+!++
Output = T
```

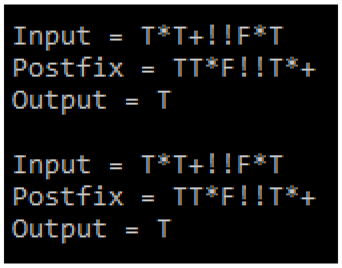


```
Input = T*T*F*(F)*T*(!T*F+(!!!!T))*F+(!(F*F+(T*(F*F)*T)*T)+T+F*(F+(!T+(F)+!(!T)*(F+(T)))))
Postfix = TT*F*F*T*T!F*T!!!!+*F*FF*TFF**T*T*+!T+FFT!F+T!!FT+*++*++
Output = T
```



```
Input = T+F*F*!T+F
Postfix = TFF*T!*+F+
Output = T

Input = T+F*F*!T+F*(T)+F
Postfix = TFF*T!*+FT*+F+
Output = T

Input = T+F*F*!T+F*(T)+F+(T+(!!T))
Postfix = TFF*T!*+FT*+F+TT!!++
Output = T
```

Testing for smaller cases shows that the EvaluateBooleanPostfix function correctly evaluates the operands based on precedence.

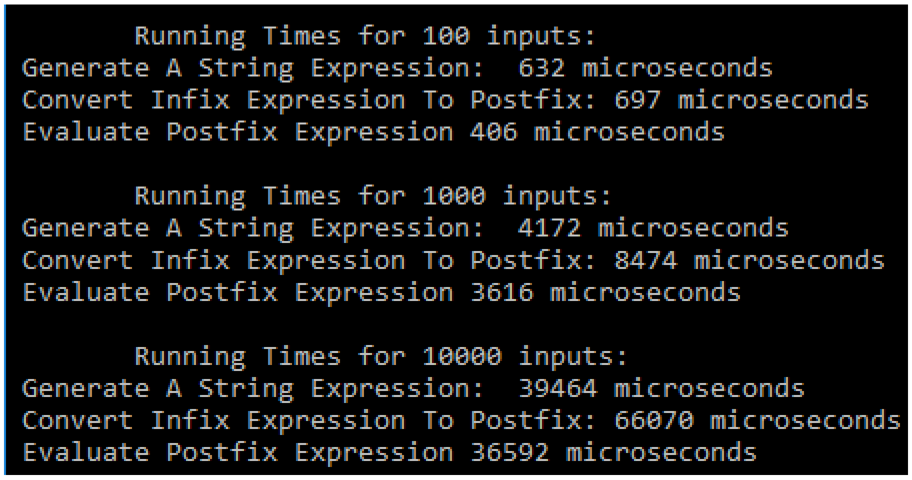


```
Input = T*T+!!F*T
Postfix = TT*F!!T*+
Output = T

Input = T*T+!!F*T
Postfix = TT*F!!T*+
Output = T
```

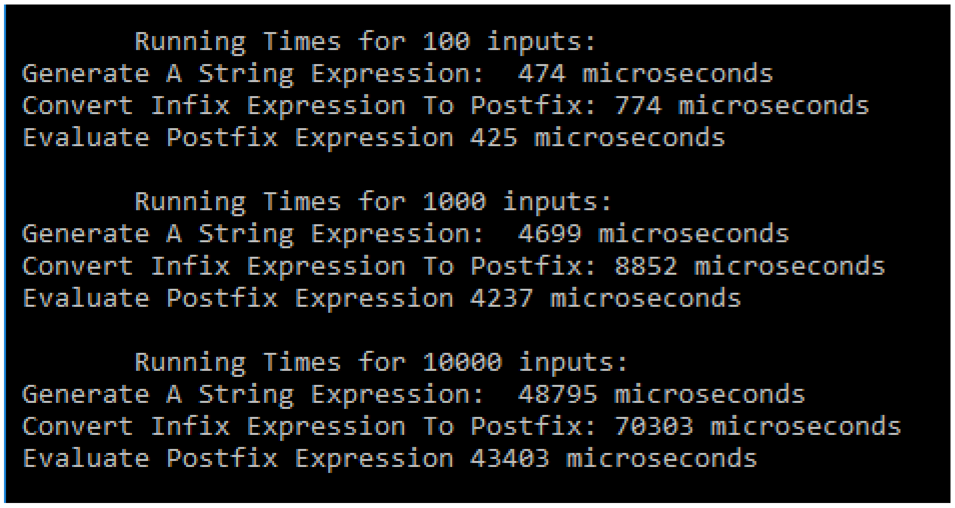
Larger Input Sizes:

Now that the evaluations have shown to be correct, the running times for larger input sizes can be evaluated.

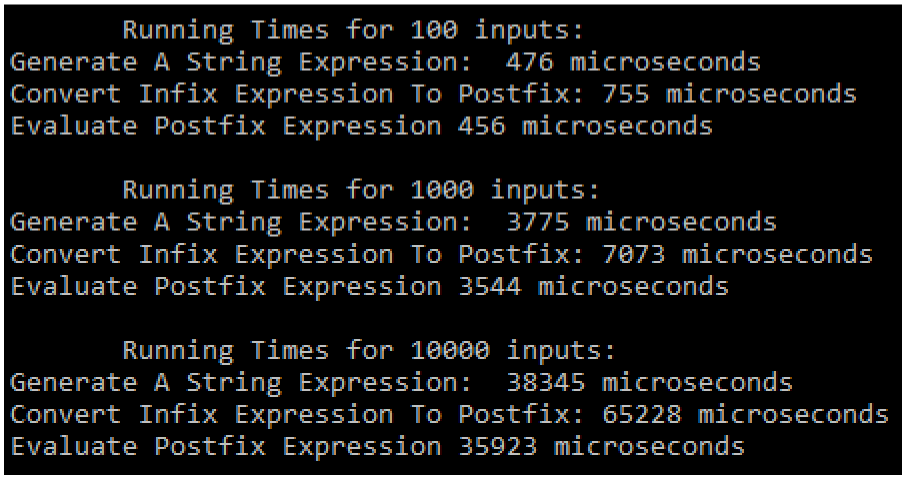
Below are the running times for 3 different sets of trials of input sizes 100, 1000, and 10000:



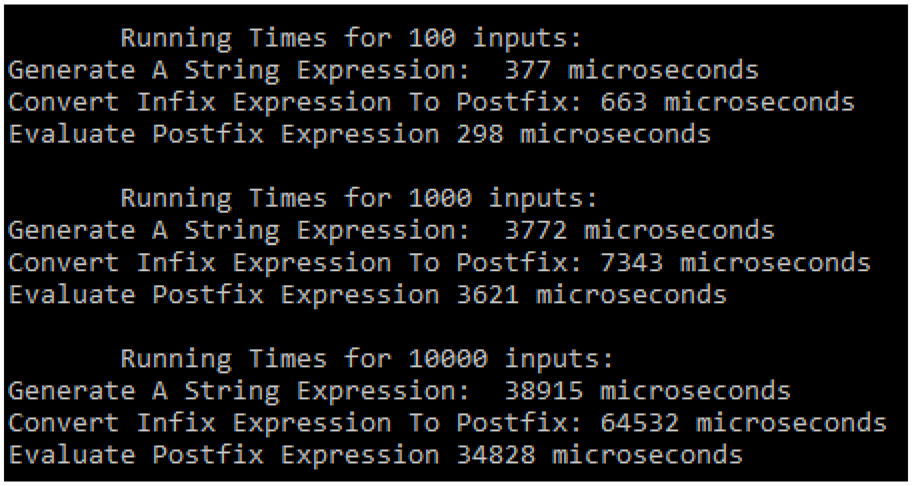
```
       Running Times for 100 inputs:
Generate A String Expression:  632 microseconds
Convert Infix Expression To Postfix: 697 microseconds
Evaluate Postfix Expression 406 microseconds

       Running Times for 1000 inputs:
Generate A String Expression:  4172 microseconds
Convert Infix Expression To Postfix: 8474 microseconds
Evaluate Postfix Expression 3616 microseconds

       Running Times for 10000 inputs:
Generate A String Expression:  39464 microseconds
Convert Infix Expression To Postfix: 66070 microseconds
Evaluate Postfix Expression 36592 microseconds
```



```
       Running Times for 100 inputs:
Generate A String Expression:  474 microseconds
Convert Infix Expression To Postfix: 774 microseconds
Evaluate Postfix Expression 425 microseconds

       Running Times for 1000 inputs:
Generate A String Expression:  4699 microseconds
Convert Infix Expression To Postfix: 8852 microseconds
Evaluate Postfix Expression 4237 microseconds

       Running Times for 10000 inputs:
Generate A String Expression:  48795 microseconds
Convert Infix Expression To Postfix: 70303 microseconds
Evaluate Postfix Expression 43403 microseconds
```



```
       Running Times for 100 inputs:
Generate A String Expression:  476 microseconds
Convert Infix Expression To Postfix: 755 microseconds
Evaluate Postfix Expression 456 microseconds

       Running Times for 1000 inputs:
Generate A String Expression:  3775 microseconds
Convert Infix Expression To Postfix: 7073 microseconds
Evaluate Postfix Expression 3544 microseconds

       Running Times for 10000 inputs:
Generate A String Expression:  38345 microseconds
Convert Infix Expression To Postfix: 65228 microseconds
Evaluate Postfix Expression 35923 microseconds
```



```
       Running Times for 100 inputs:
Generate A String Expression:  377 microseconds
Convert Infix Expression To Postfix: 663 microseconds
Evaluate Postfix Expression 298 microseconds

       Running Times for 1000 inputs:
Generate A String Expression:  3772 microseconds
Convert Infix Expression To Postfix: 7343 microseconds
Evaluate Postfix Expression 3621 microseconds

       Running Times for 10000 inputs:
Generate A String Expression:  38915 microseconds
Convert Infix Expression To Postfix: 64532 microseconds
Evaluate Postfix Expression 34828 microseconds
```

Data:

Running Times in microseconds for Trials:

Input Size (N)	**Trial 1**		**Trial 2**		**Trial 3**		**Trial 4**	
	Infix To Postfix	**Postfix Evaluation**	**Infix To Postfix**	**Postfix Evaluation**	**Infix To Postfix**	**Postfix Evaluation**	**Infix To Postfix**	**Postfix Evaluation**
100	697 µs	406 µs	774 µs	425 µs	755 µs	456 µs	663 µs	298 µs
1000	8474 µs	3616 µs	8852 µs	4237 µs	7073 µs	35923µs	7343 µs	3621µs
10000	66070 µs	36592 µs	70303 µs	43403 µs	65228 µs	35923µs	64532 µs	34828 µs

Report:

An infix notation reads an expression from left to right and performs an evaluation on the operands based on the precedence of the operators. The operators are usually in between the operands. For this reason, infix expressions are usually harder to evaluate for computers because they must decide on the precedence of the operators before they perform a calculation, and so it takes a longer time.

This same way of calculating an infix expression is represented by the InfixToPostfix function, where a Boolean expression is converted to its equivalent postfix. Thus, the function will evaluate the expression based on the order of operations, and then output the solution, where the precedence of the operators are placed in the right hand side of the expression to make a postfix notation. For this reason, it may be said that the InfixToPostfix function simulates an infix calculation. The running time of this function is of O(N).

Total: N*O(N)(for loop) + O(8) (if else statements) = O(N)

Postfix notation is a lot easier for computers to process because the order of operations is not needed to evaluate the expression. In postfix notation, the operands are pushed to a stack, and when there is an operator, then the process for that operator evaluates the two elements from the stack, and the result is pushed back into the stack. Hence, postfix notation does not deal with precedence as an infix notation does. The process is much more straightforward, simpler, and faster.

The EvaluateBooleanPostfix function will take the postfix string, evaluate the boolean expression and return a char for the result. The running time for this function is O(N).

Total: N*O(N) (for loop) + O(2)(if statements) = O(N)

Results:

Even if both expressions are of O(N) running time, the differences in efficiency between infix and postfix notations are very clear by the results. In every trial, the time to evaluate a postfix expression was quicker by more than half the time of an infix evaluation. For example, an infix calculation took 6948 microseconds to process, and the postfix calculation took 3592 microseconds. Thus, the actual results are corresponded with the theoretical analysis.