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Implementing Stack and Queue from scratch

CSC10004 – DATA STRUCTURES AND ALGORITHMS

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1 Result Screenshots

1.1 Stack (Array version)

‘push’ operation

```
-----  
| Stack max size: 3  
| Stack size: 2  
| Stack elements: 1 2  
-----  
  
>>> Stack Lib  
1. Push  
2. Pop  
0. Exit  
  
=: Enter your choice: 1  
  
=: Enter value to be pushed: 3  
  
?: Continue: Yes(1) - No(0)
```

(a) Normal test cases

```
-----  
| Stack max size: 3  
| Stack size: 3  
| Stack elements: 1 2 3  
-----  
  
>>> Stack Lib  
1. Push  
2. Pop  
0. Exit  
  
=: Enter your choice: 1  
  
=: Enter value to be pushed: 4  
!: Stack is full! Please pop before pushing  
  
?: Continue: Yes(1) - No(0)
```

(b) When the stack is full

```
StackArray  
>• cpp main  
-----  
| Stack is not initialized.  
-----  
  
>>> Stack Lib  
1. Push  
2. Pop  
0. Exit  
  
=: Enter your choice: 1  
  
!: Stack is not initialized.  
?: Do you want to initialize the stack? Yes(1) - No(0)  
1  
  
=: Enter stack max size: 3  
  
=: Enter value to be pushed: 1  
  
?: Continue: Yes(1) - No(0)
```

(c) When the stack is uninitialized

Figure 1: Screenshots of Stack (Array version) ‘push’ operation.

‘pop’ operation

```
-----  
| Stack max size: 3  
| Stack size: 0  
| Stack elements:  
-----  
>>> Stack Lib  
1. Push  
2. Pop  
0. Exit  
  
=: Enter your choice: 2  
  
!: Stack is empty! Please push before popping  
  
?: Continue: Yes(1) - No(0)
```

(a) When the stack is empty

```
-----  
| Stack max size: 3  
| Stack size: 3  
| Stack elements: 1 2 3  
-----  
>>> Stack Lib  
1. Push  
2. Pop  
0. Exit  
  
=: Enter your choice: 2  
  
>>> Popped value: 3  
  
?: Continue: Yes(1) - No(0)
```

(b) Normal test cases

Figure 2: Screenshots of Stack (Array version) ‘pop’ operation.

1.2 Stack (Linked List version)

‘push’ operation

```
StackLinkedList
>• cpp main
-----
| Stack is not initialized.
-----
>>> Stack Lib
1. Push
2. Pop
0. Exit

=: Enter your choice: 1

!: Stack is not initialized.
?: Do you want to initialize the stack? Yes(1) - No(0)
1
=: Enter value to be pushed: 1
?: Continue: Yes(1) - No(0)
```

(a) When the stack is uninitialized

```
-----
| Stack elements: 1
-----
>>> Stack Lib
1. Push
2. Pop
0. Exit

=: Enter your choice: 1

=: Enter value to be pushed: 2
?: Continue: Yes(1) - No(0)
```

(b) Normal test cases

Figure 3: Screenshots of Stack (Linked List version) ‘push’ operation.

‘pop’ operation

```
-----
| Stack elements:
-----
>>> Stack Lib
1. Push
2. Pop
0. Exit

=: Enter your choice: 2

!: Stack is empty! Please push before popping
?: Continue: Yes(1) - No(0)
```

(a) When the stack is empty

```
-----
| Stack elements: 3 2 1
-----
>>> Stack Lib
1. Push
2. Pop
0. Exit

=: Enter your choice: 2

>>> Popped value: 3
?: Continue: Yes(1) - No(0)
```

(b) Normal test cases

Figure 4: Screenshots of Stack (Linked List version) ‘pop’ operation.

1.3 Queue (Array version)

‘enqueue’ operation

```

-----
| Queue max size: 3
| Queue size: 1
| Queue elements: 1
-----
>>> Queue Lib
1. Enqueue
2. Dequeue
0. Exit

=: Enter your choice: 1

=: Enter value to be pushed: 2

?: Continue: Yes(1) - No(0)

```

(a) Normal test cases

```

-----
| Queue max size: 3
| Queue size: 3
| Queue elements: 1 2 3
-----
>>> Queue Lib
1. Enqueue
2. Dequeue
0. Exit

=: Enter your choice: 1

=: Enter value to be pushed: 4
!: Queue is full! Please dequeue before enqueueing

?: Continue: Yes(1) - No(0)

```

(b) When the queue is full

```

QueueArray
>• cpp main
-----
| Queue is not initialized.
-----
>>> Queue Lib
1. Enqueue
2. Dequeue
0. Exit

=: Enter your choice: 1

!: Queue is not initialized.
?: Do you want to initialize the queue? Yes(1) - No(0)
1

=: Enter queue max size: 3

=: Enter value to be pushed: 1

?: Continue: Yes(1) - No(0)

```

(c) When the queue is uninitialized

Figure 5: Screenshots of queue (Array version) ‘push’ operation.

‘dequeue’ operation

```

-----
| Queue max size: 3
| Queue size: 0
| Queue elements:
-----
>>> Queue Lib
1. Enqueue
2. Dequeue
0. Exit

=: Enter your choice: 2

!: Queue is empty! Please enqueue before dequeuing

?: Continue: Yes(1) - No(0)

```

(a) When the queue is empty

```

-----
| Queue max size: 3
| Queue size: 3
| Queue elements: 1 2 3
-----
>>> Queue Lib
1. Enqueue
2. Dequeue
0. Exit

=: Enter your choice: 2

>>> Front value: 1

?: Continue: Yes(1) - No(0)

```

(b) Normal test cases

Figure 6: Screenshots of queue (Array version) ‘pop’ operation.

1.4 Queue (Linked List version)

‘enqueue’ operation

```

QueueLinkedList
>• cpp main
-----
| Queue is not initialized.
-----
>>> Queue Lib
1. Enqueue
2. Dequeue
0. Exit

=: Enter your choice: 1

!: Queue is not initialized.
?: Do you want to initialize the queue? Yes(1) - No(0)
1
=: Enter value to be pushed: 1

?: Continue: Yes(1) - No(0)

```

(a) When the queue is uninitialized

```

-----
| Queue elements: 1
-----
>>> Queue Lib
1. Enqueue
2. Dequeue
0. Exit

=: Enter your choice: 1

=: Enter value to be pushed: 2

?: Continue: Yes(1) - No(0)

```

(b) Normal test cases

Figure 7: Screenshots of queue (Linked List version) ‘push’ operation.

‘dequeue’ operation

```

-----
| Queue elements:
-----
>>> Queue Lib
1. Enqueue
2. Dequeue
0. Exit

=: Enter your choice: 2

!: Queue is empty! Please enqueue before dequeuing

?: Continue: Yes(1) - No(0)

```

(a) When the queue is empty

```

-----
| Queue elements: 1 2 3
-----
>>> Queue Lib
1. Enqueue
2. Dequeue
0. Exit

=: Enter your choice: 2

>>> Front value: 1

?: Continue: Yes(1) - No(0)

```

(b) Normal test cases

Figure 8: Screenshots of queue (Linked List version) ‘pop’ operation.

2 Recursive versions

2.1 Stack

Recursion Stack (Array version)

- **Theoretical Time Complexity:** Both implementations have the same theoretical time complexity of $O(1)$ for push and $O(n)$ for copy operations.
- **Practical Performance:**
 - Loop-based implementations are generally faster in practice because they avoid the overhead of function calls and recursion.
 - But in the below screenshot, the copy operation with recursive version seems to be faster than the loop version with 10^8 elements.

```

StackArray
>• cpp metrics
Push 10000000 elements
    Push with loop version: 0.156227s
    Push with recursive version: 0.153887s
Copy stack (100000000 elements)
    Copy stack with loop version: 1.48e-05s
    Copy stack with recursive version: 9.6e-06s

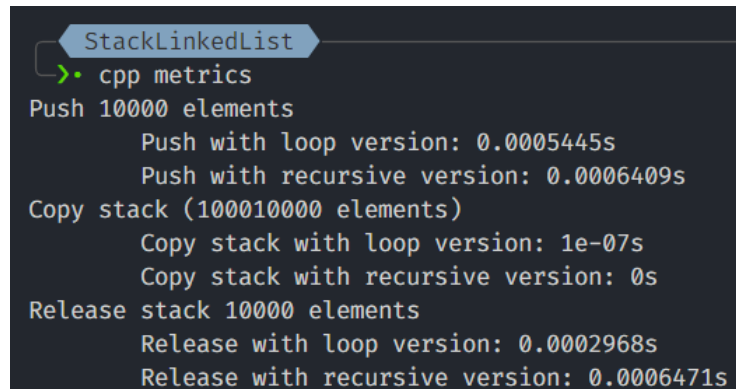
```

Figure 9: Recursive and loop version comparison of Stack (Array version)

Recursion Stack (Linked List version)

- **Theoretical Time Complexity:** Both implementations have the same theoretical time complexity of $O(1)$ for push, $O(n)$ for copy and release operations.
- **Practical Performance:**

- Loop-based implementations are generally faster in practice because they avoid the overhead of function calls and recursion.



```

StackLinkedList
>• cpp metrics
Push 10000 elements
    Push with loop version: 0.0005445s
    Push with recursive version: 0.0006409s
Copy stack (100010000 elements)
    Copy stack with loop version: 1e-07s
    Copy stack with recursive version: 0s
Release stack 10000 elements
    Release with loop version: 0.0002968s
    Release with recursive version: 0.0006471s

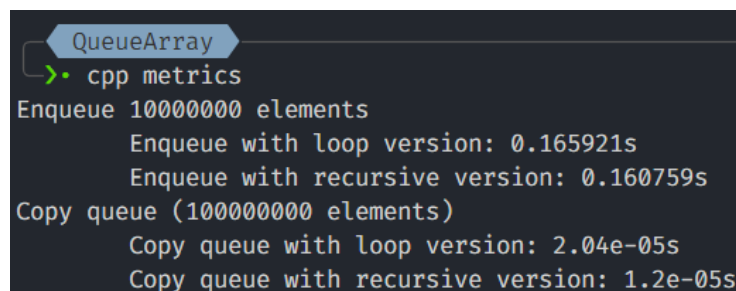
```

Figure 10: Recursive and loop version comparison of Stack (Linked List version)

2.2 Queue

Recursion Queue (Array version)

- **Theoretical Time Complexity:** Both implementations have the same theoretical time complexity of $O(1)$ for **enqueue** and $O(n)$ for **copy** operations.
- **Practical Performance:**
 - Loop-based implementations are generally faster in practice because they avoid the overhead of function calls and recursion.
 - But in the below screenshot, the copy operation with recursive version seems to be faster than the loop version with 10^8 elements.



```

QueueArray
>• cpp metrics
Enqueue 10000000 elements
    Enqueue with loop version: 0.165921s
    Enqueue with recursive version: 0.160759s
Copy queue (100000000 elements)
    Copy queue with loop version: 2.04e-05s
    Copy queue with recursive version: 1.2e-05s

```

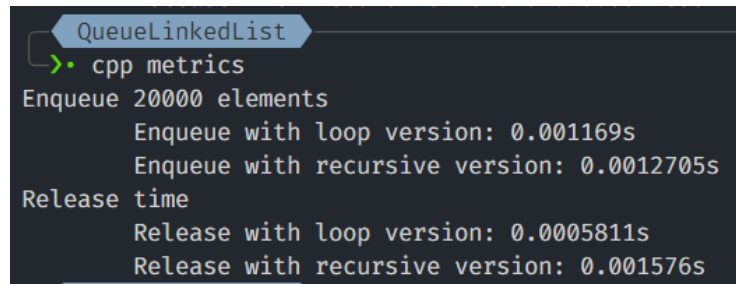
Figure 11: Recursive and loop version comparison of Queue (Array version)

- However the recursive version doesn't work with large data sets because of stack overflow.

Recursion Queue (Linked List version)

- **Theoretical Time Complexity:** Both implementations have the same theoretical time complexity of $O(1)$ for **enqueue** and $O(n)$ for **release** operations.
- **Practical Performance:**

- Loop-based implementations are generally faster in practice because they avoid the overhead of function calls and recursion.



A screenshot of a terminal window with a dark background. At the top, a blue header bar contains the text 'QueueLinkedList'. Below this, a green prompt character is followed by the command 'cpp metrics'. The output shows two sections: 'Enqueue 20000 elements' and 'Release time'. Each section contains two lines of performance data comparing loop and recursive versions.

```
QueueLinkedList
>• cpp metrics
Enqueue 20000 elements
    Enqueue with loop version: 0.001169s
    Enqueue with recursive version: 0.0012705s
Release time
    Release with loop version: 0.0005811s
    Release with recursive version: 0.001576s
```

Figure 12: Recursive and loop version comparison of Queue (LinkedList version)

3 Self-evaluation

No.	Details	Score
1	Stack (Array version)	100%
2	Stack (Linked List version)	100%
3	Queue (Array version)	100%
4	Queue (Linked List version)	100%
5	Recursive versions	100%
6	Report	100%

4 Exercise Feedback

4.1 What I learned

Because almost the things could be done easily, I have learned nothing new from this exercise.

4.2 What I found challenging

This exercise is quite simple and easy, so I have no difficulties to finish this task.

4.3 What I have used in this exercise

- I used C++ to implement the data structures and the test cases.
- I also used \LaTeX to write this report.
- All the source code and the report are available in [my github repo](#)