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CSC 212: Data Structures and Abstractions

11: Linked Lists

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THINK BIG WE DO™

Practice

- Assuming that a character array starts at address `0x0100`
  - label the memory addresses of all elements

'h'	'e'	'l'	'l'	'o'	0				

- Assuming that an integer array starts at address `0x0100`
  - label the memory addresses of all elements

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Practice

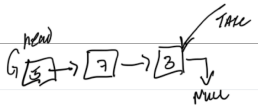
- Assume a dynamic array and efficient implementations
  - what is the cost of inserting 1 element at the end?
    O(1) - AMORTIZED
  - what is the cost of inserting 1 element at the front?
    O(N)
  - what is the cost of inserting 1 element at index `idx`?
    O(N)
  - what is the cost of performing deletions at those same locations?
    SAME THING

Linked lists

Linked list

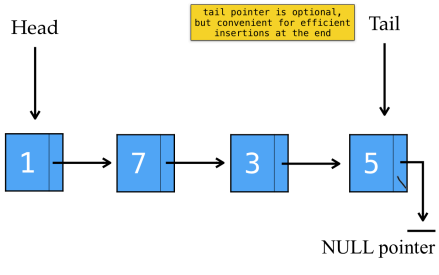
- Definition
  - a linked list is a **linear data structure** that consists of a sequence of elements stored at **non-contiguous** locations in memory
- Typical operations
  - **insert**: add a new node to the list (rear, front, at index, by value)
  - **delete**: remove a node from the list (rear, front, at index, by value)
  - **search**: find a node with a specific value
  - **get**: get a value at an specific index
  - **traverse**: "visit" each node in the list – PRINT etc.

Linked lists

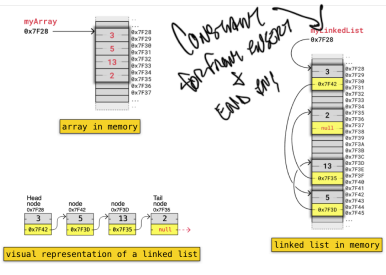


- Types of linked lists
  - **singly-linked list**: each node has a pointer to the next node
  - **doubly-linked list**: each node has a pointer to the next and previous nodes
  - **circular-linked list**: the last node has a reference to the first node
- Singly-linked list
  - each element is a **node** that contains a value and a pointer to a next node
  - the last node has a reference to **null**
  - the first node is called the **head**
  - the last node is called the **tail**
  - the length of the linked list is the number of nodes

Singly-linked list



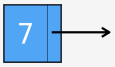
Singly-linked list and memory



https://www.w3schools.com/dsa/dsa_theory_linkedlists_memory.php

Implementing a linked list

Representing a node




```
struct Node {
    T data;
    Node *next;
    Node(const T& value) {
        data = value; next = nullptr;
    }
};
```

`struct` representing a node in a linked list using templates. It contains a value of type T, a pointer to the next node, and a constructor that initializes the value and sets the next pointer to `nullptr`

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Representing a singly-linked list

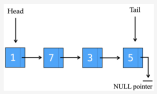
```
template <typename T>
class SLList {

    private:
        struct Node {
            T data;
            Node *next;
            Node(const T& value) { data = value; next = nullptr; }
        };

        Node *head;
        Node *tail;
        size_t size;

    public:
        SLList() { head = tail = nullptr; size = 0; }
        ~SLList() { clear(); }

        size_t get_size() { return size; }
        bool empty() { return size == 0; }
        void clear();
        T& front();
        T& back();
        void push_front(const T& value);
        void pop_front();
        void push_back(const T& value);
        void pop_back();
        void print();
};
```



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Methods

- Constructor
- Destructor
- clear

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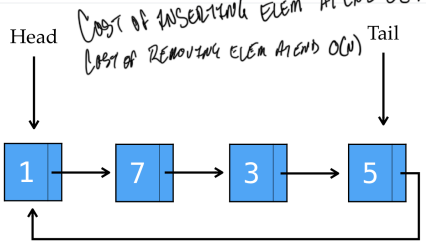
Other types of linked lists

Circular singly linked list



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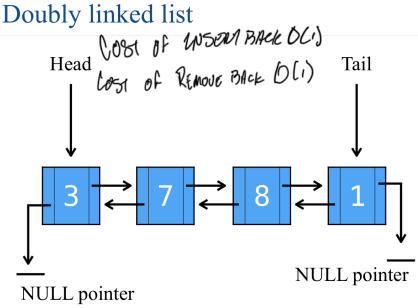
Doubly linked list



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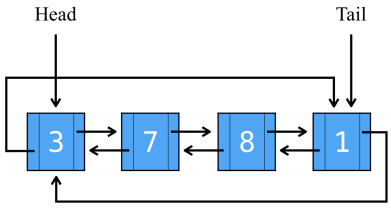
Circular doubly linked list



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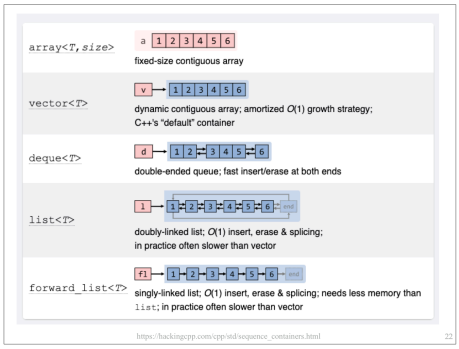
Linked lists in the STL



Others

Linked lists and other data structures

- Stacks
  - insert and remove from the same end
  - constant time complexity for both operations
- Queues
  - insert at one end and remove from the other end
  - constant time complexity for both operations
- Deques
  - insert and remove from both ends
  - constant time complexity for all insert/remove operations

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