School of Computer Science

COMP SCI 1103/2103 Algorithm Design & Data Structure

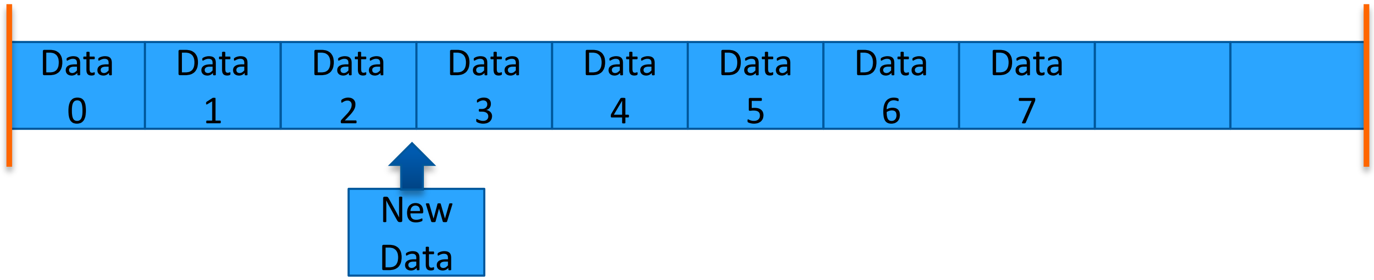
Complexity – Linked Lists

Overview

- Case Study - Linked list
  - Impact of data structure choices on run time

Impact on Complexity of Data Structures

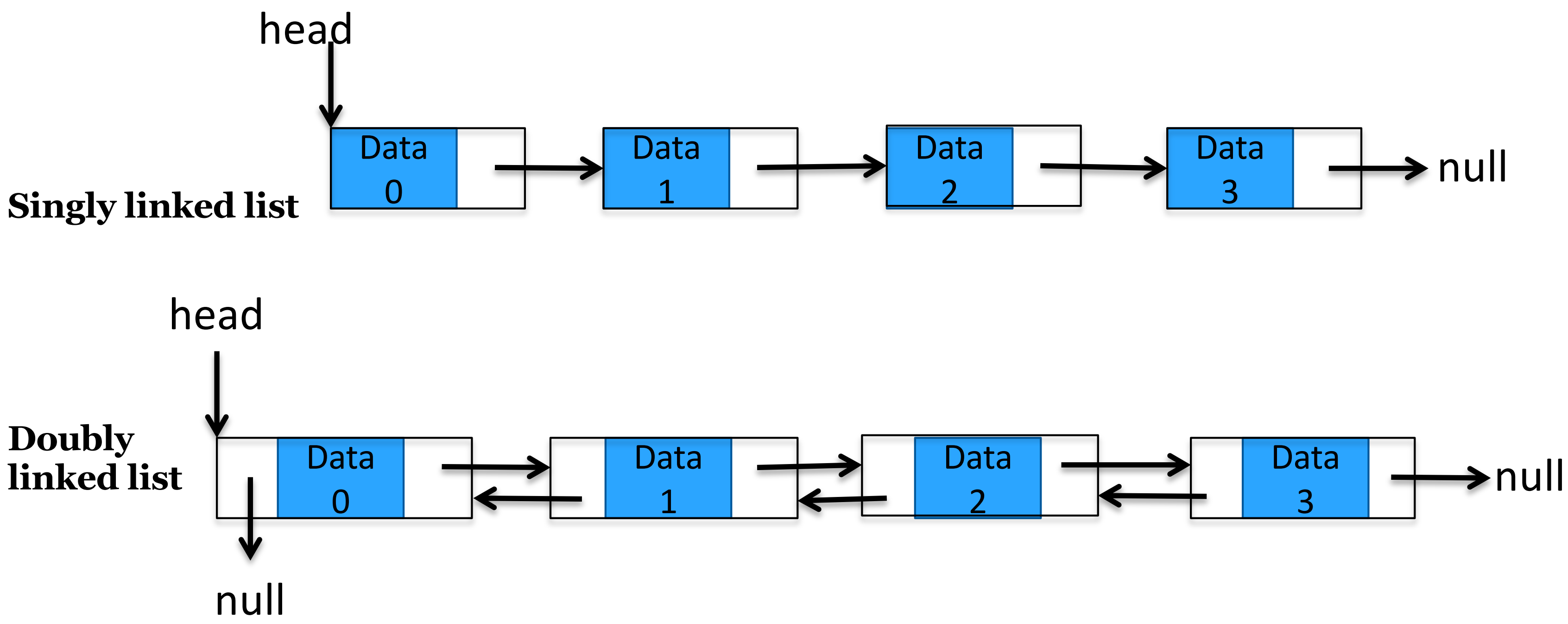
- In an array
  - the items are placed in consecutive places in the memory
    - Some operations in the middle of the list are costly
      - Insert
      - Delete



- Static structure with a fixed total size
- How much does it take to add an item at the end?
- Insert at the end takes O(1)
- But when there is not enough room, it takes O(n)
  because the whole array needs to be moved to a larger space

Linked Lists

- A dynamic data structure for representing a list, in which each item of the list is stored in a separate object called *Node*
- Linked Lists have faster **insert/delete**, slower **access** compared to arrays.
- Nodes consist of an item and a reference to the next Node.
- We need a reference to the first node called head

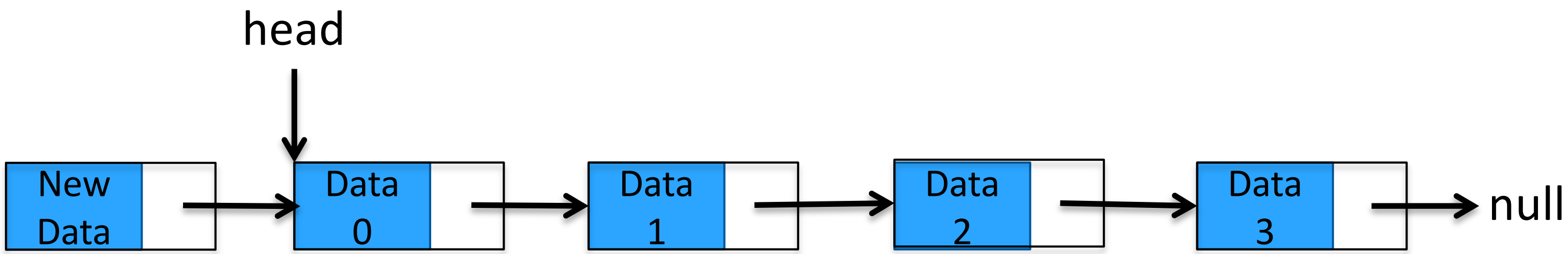


Node Struct and Methods

We need a structure for nodes and a number of methods

```
Struct Node{
   Type data;
   Pointer nextNode;
}
Class LinkedList{
  Pointer head;
// methods including insert, delete, search and traverse
  InsertAtFront(newData);
  Pointer Search(item);
  InsertAfter(newData, itemBefore);
 }
```

InsertAtFront method

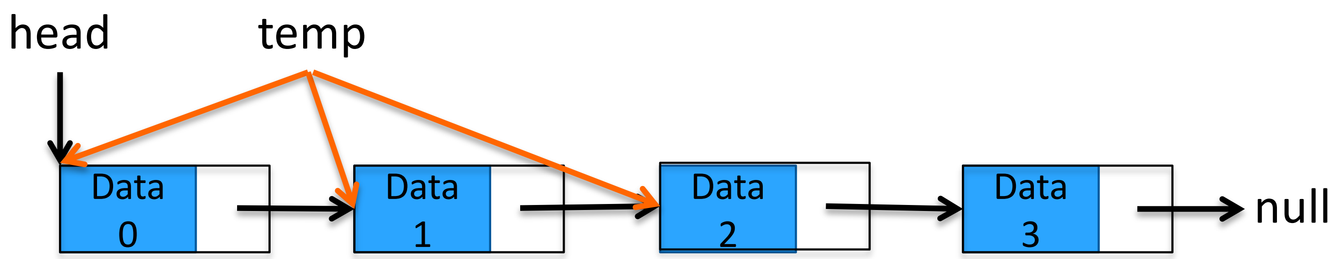



```
InsertAtFront(newData){
        newNode= new Node()
        newNode.data= newData
        newNode.nextNode= head
        head =  addressOf(newNode)
}
```

Complexity?

Takes O(1) time steps

Search method

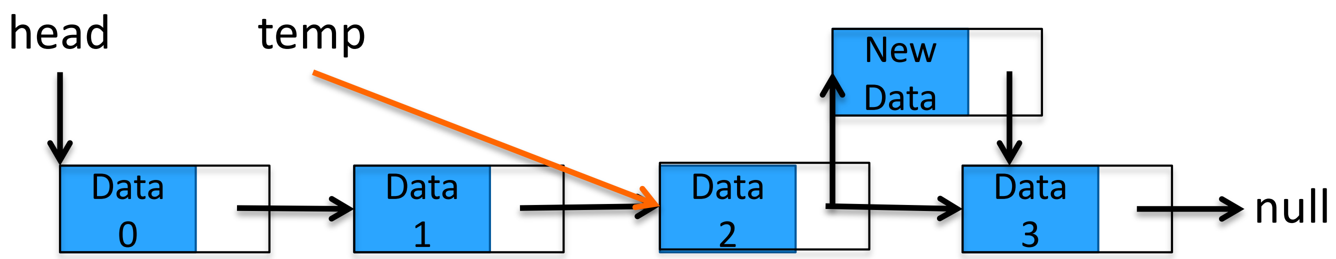



```
pointer Search(item){
        temp=head
        while(temp!=null and temp.data!=item)
                temp= temp.nextNode
        return temp
}
```

Complexity?

Takes O(n) time steps

InsertAfter method




```
InsertAfter(newData, itemBefore){
        temp=Search(itemBefore)
        if (temp=null)
                error: item not found
        newNode= new Node()
        newNode.data= newData
        newNode.nextNode= temp.nextNode
        temp.nextNode=  addressOf(newNode)
}
```

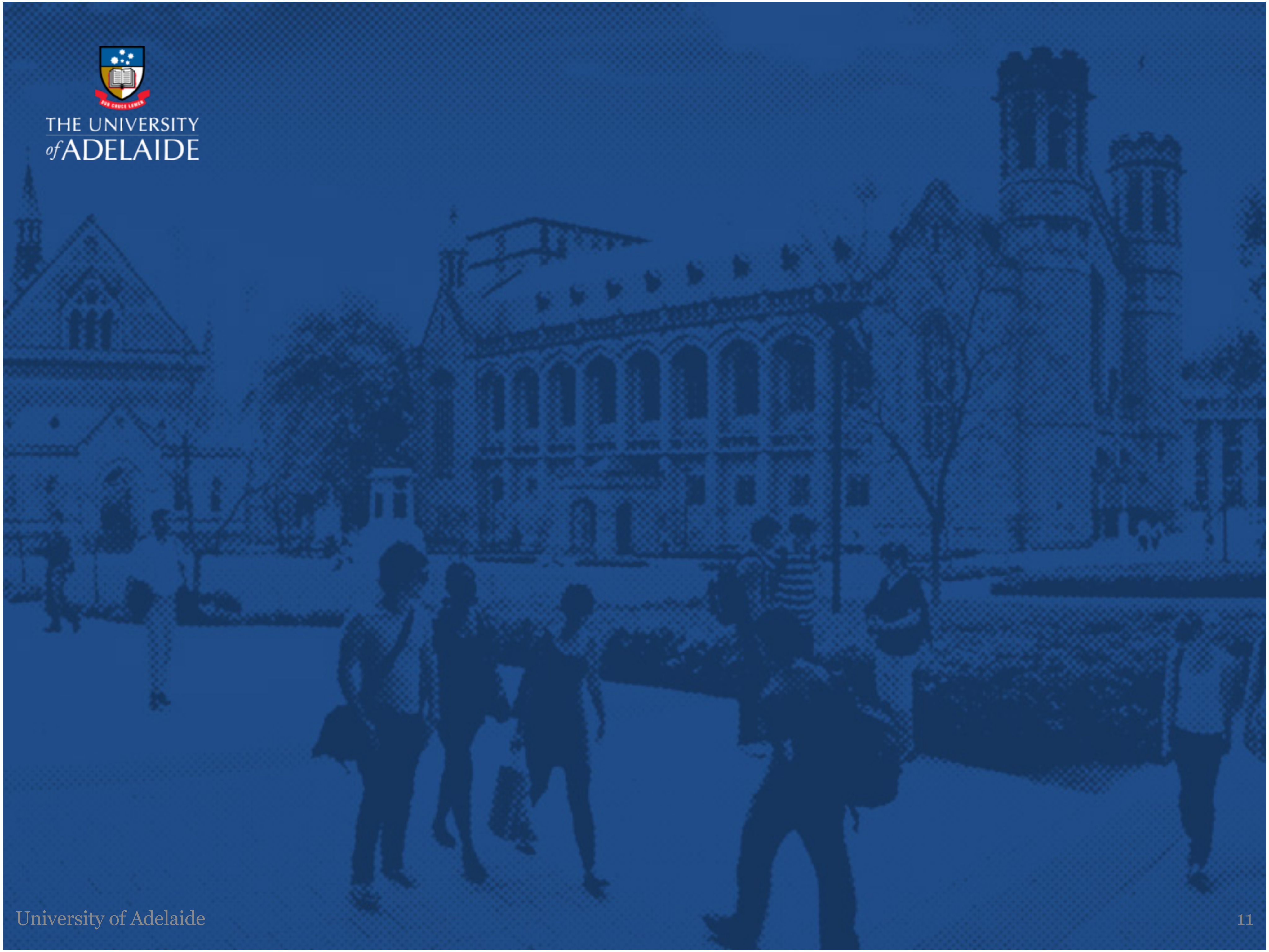
Takes O(n) time steps

Question for Discussion

- What affect does having a doubly linked list have on insert, search, delete…?
- When would it be preferable to use:
  - An array
  - A singly linked list
  - A doubly linked list

Summary on Linked lists

- We learned situations where array is not a good choice for representing lists
- We defined linked lists and learned a few methods for doing operations on linked lists
- Arrays:
  - Add at the end if enough space: O(1)
  - Due to fixed size, adding a new item at the end may take O(n)
  - Direct access to items by index number :O(1)
  - Shifts data when an item is added in the middle of the list or deleted from it: O(n)
- Linked Lists:
  - Dynamically grows or shrinks: add and remove take O(1)
  - No direct access by index number; Links should be followed: O(n)
  - Adding and removing items from the middle of the list include search: O(n), but not as costly as shifting the data


THE UNIVERSITY of ADELAIDE