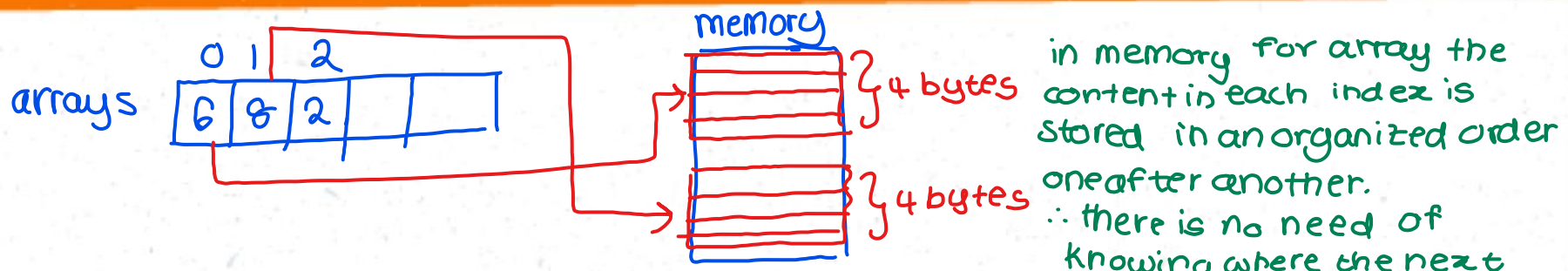
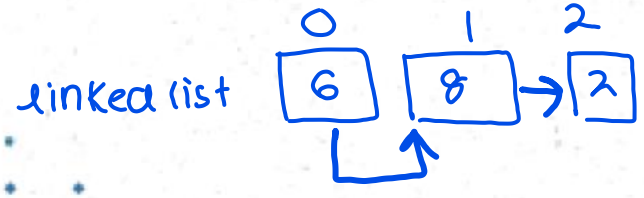


in memory for array the content in each index is stored in an organized order one after another.
∴ there is no need of knowing where the next element is



in linked list these elements are stored in different memory locations ∴ we should know how/where the next element is in the memory

Linked Lists

in circular queues / linear queues and stacks
1.we can't expand
2.hard to shrink
3.Cant access inner elements

introduced to avoid limitations of arrays

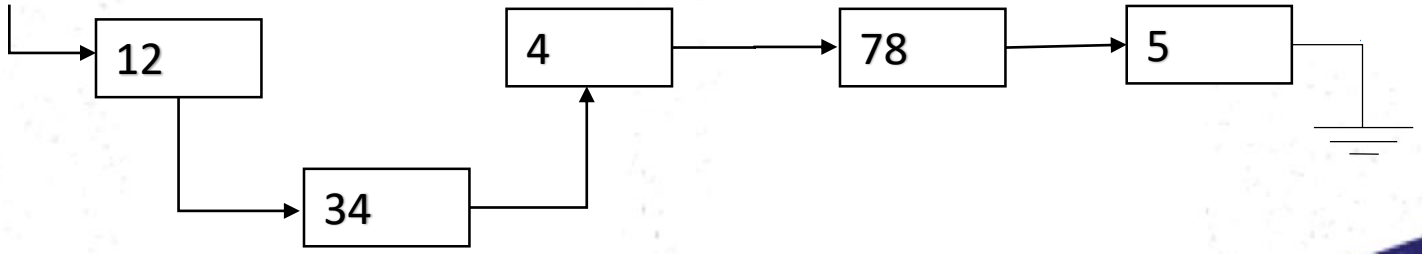
Ways in which linked lists differ from arrays

Array – each item occupies a particular position and can be directly accessed using an index number.

Linked list – need to follow along the chain of element to find a particular element.
A data item cannot be accessed directly.

Array →

Linked List →



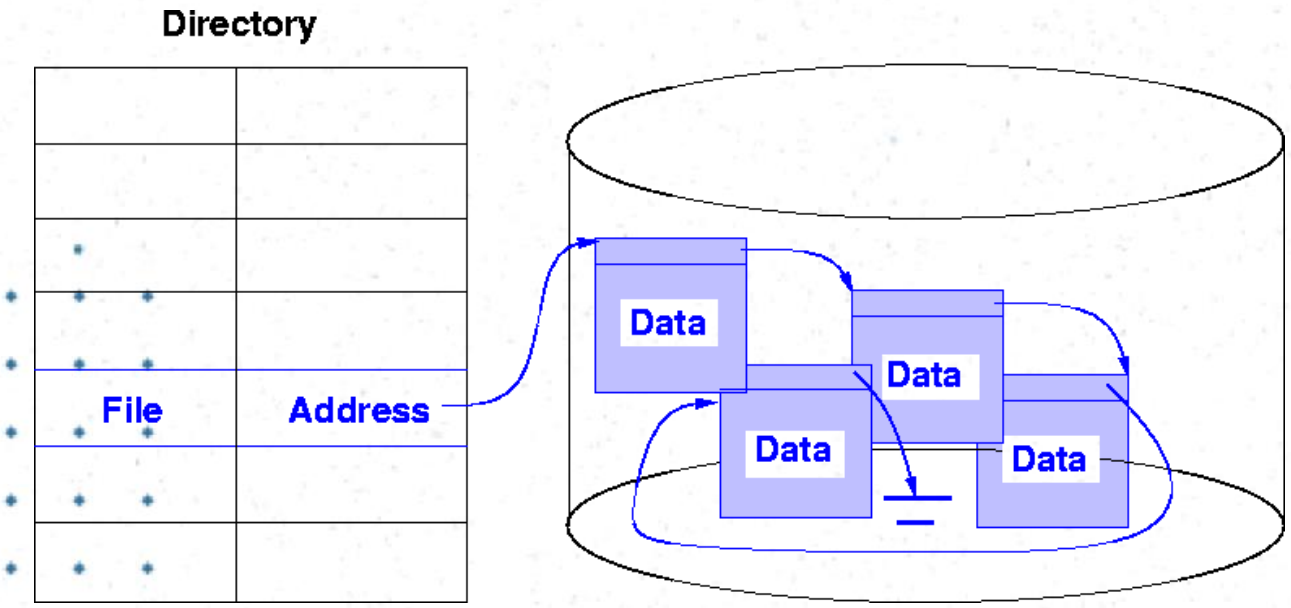
Applications of linked list in real world-

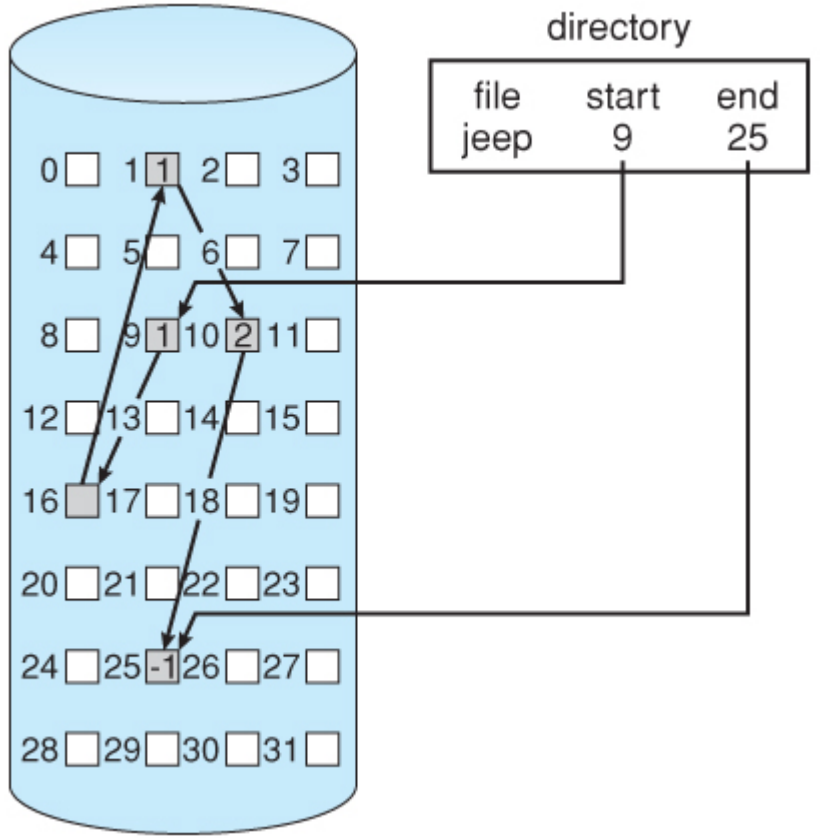
- *Image viewer* – Previous and next images are linked, hence can be accessed by next and previous button.
- *Previous and next page in web browser* – We can access previous and next url searched in web browser by pressing back and next button since, they are linked as linked list.
- *Music Player* – Songs in music player are linked to previous and next song. you can play songs either from starting or ending of the list.

Applications of linked list in computer science –

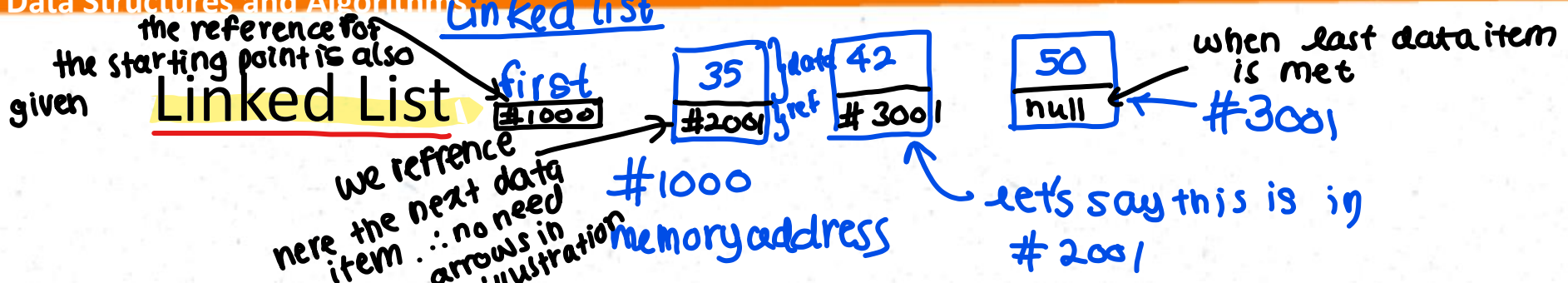
- Implementation of stacks and queues
- Implementation of graphs : Adjacency list representation of graphs is most popular which is uses linked list to store adjacent vertices.
- Dynamic memory allocation : We use linked list of free blocks.
- Maintaining directory of names

Linked Allocation in File System



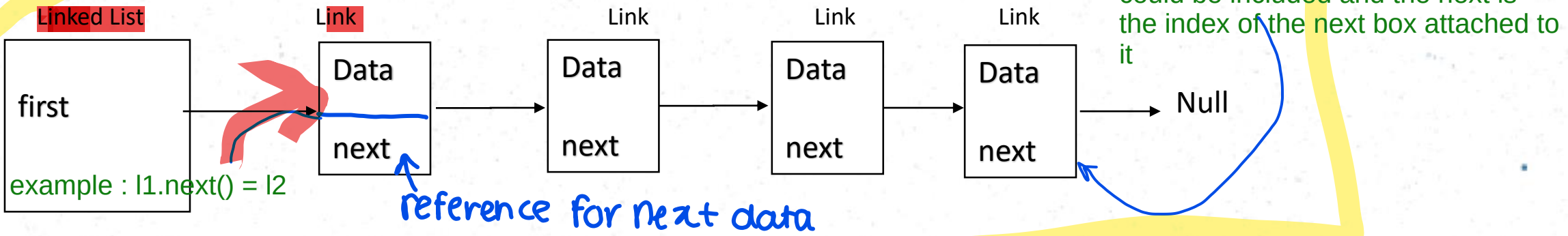


Linked List



Linked lists are probably the second most commonly used general purpose storage structures after arrays.

array is the first commonly used



- In a linked list each data item is embedded in a link.
- There are many similar links.

this reference could be a part of the data(later may discuss)

- Each link object contains a reference to the next link in the list.
- In a typical application there would be many more data items in a link.

we must not break the connection(the indexes)

Operations

things we can do with a linked list

we have to classes here as linked list and link

- Mainly the following operations can be performed on a linked list.

here to refer an integer we need to have a integer reference
this integer key word in this theory changes according to the data type
like wise in order to refer a link we need to have a link reference

- Find

  Find a link with a specified key value.

- Insert

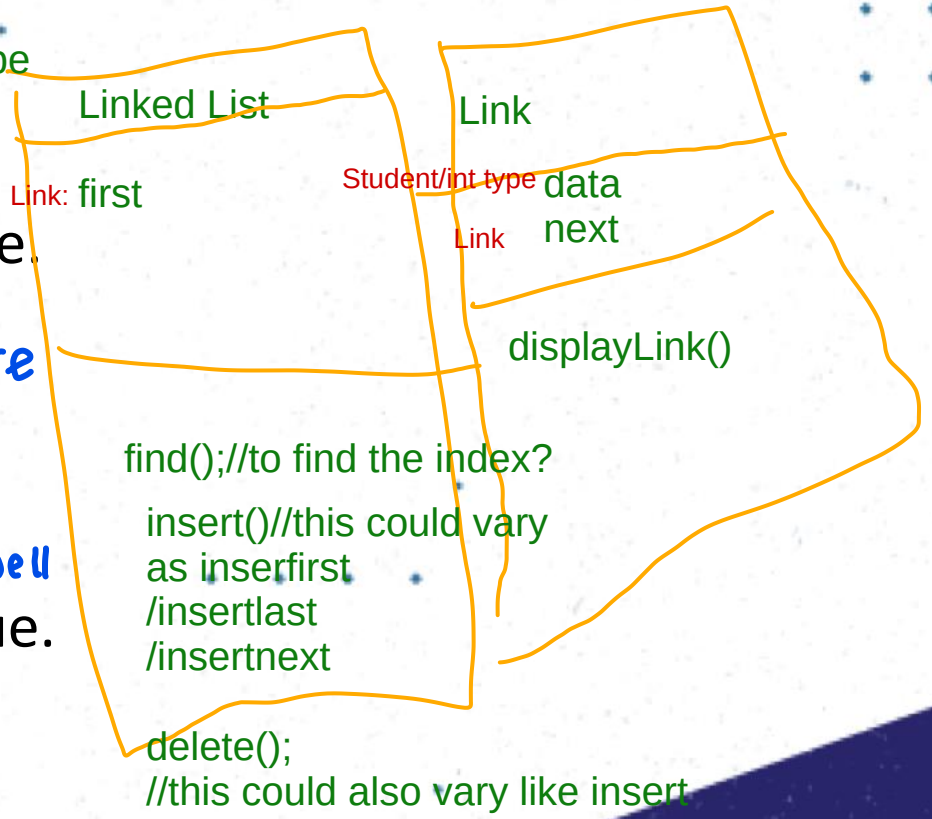
  → we can insert anywhere

  Insert links anywhere in the list.

- Delete

  → delete from anywhere aswell

  Delete a link with the specified value.



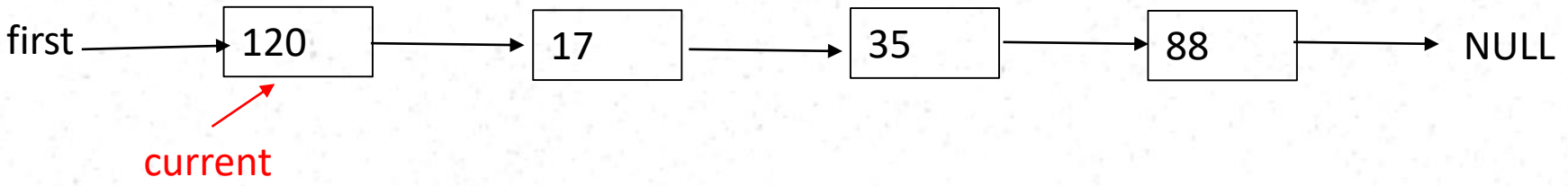
displayList()/this method should display all the data in the entire list

Operations - Find

Start with the first item, go to the second link, then the third, until you find what you are looking for.

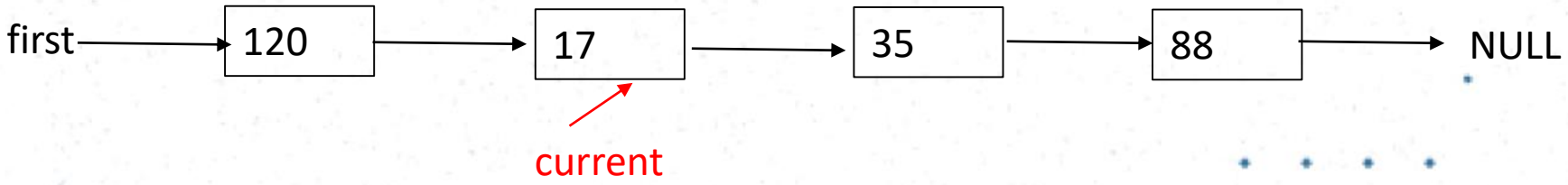
Ex: **Find Item 35**

Step 1 :



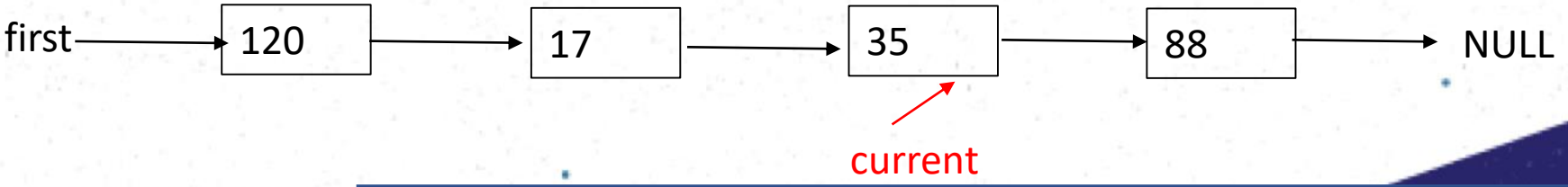
Found ?
No

Step 2 :



Found ?
No

Step 3 :



Found ?
Yes

Operations – Insert

we can insert anywhere

insertfirst

insertLast

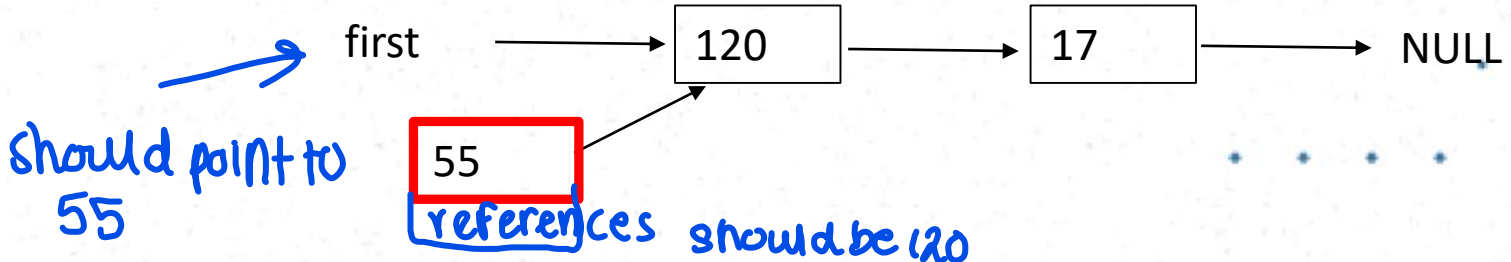
insertNext()

Inserting an item at the beginning of the list

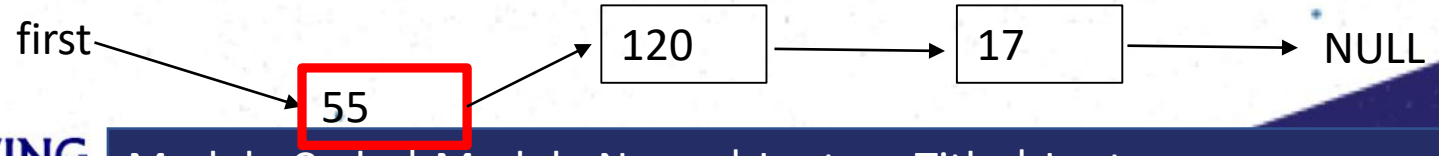
Before inserting

Step 1 : create a new link

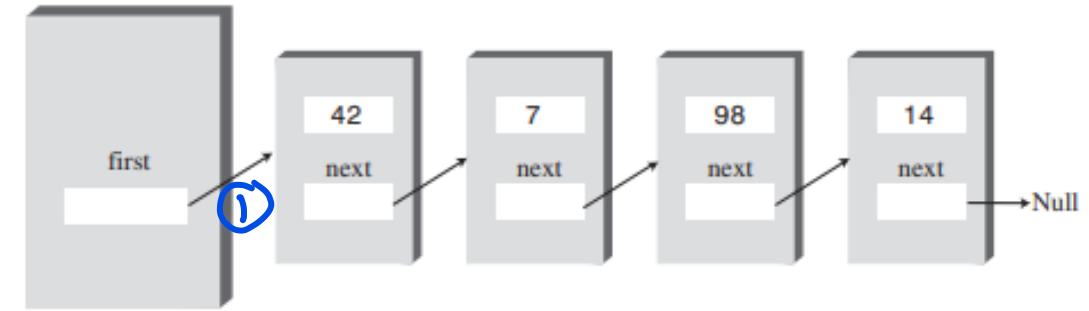
Step 2 : 'next' field of the new link points to the old first link



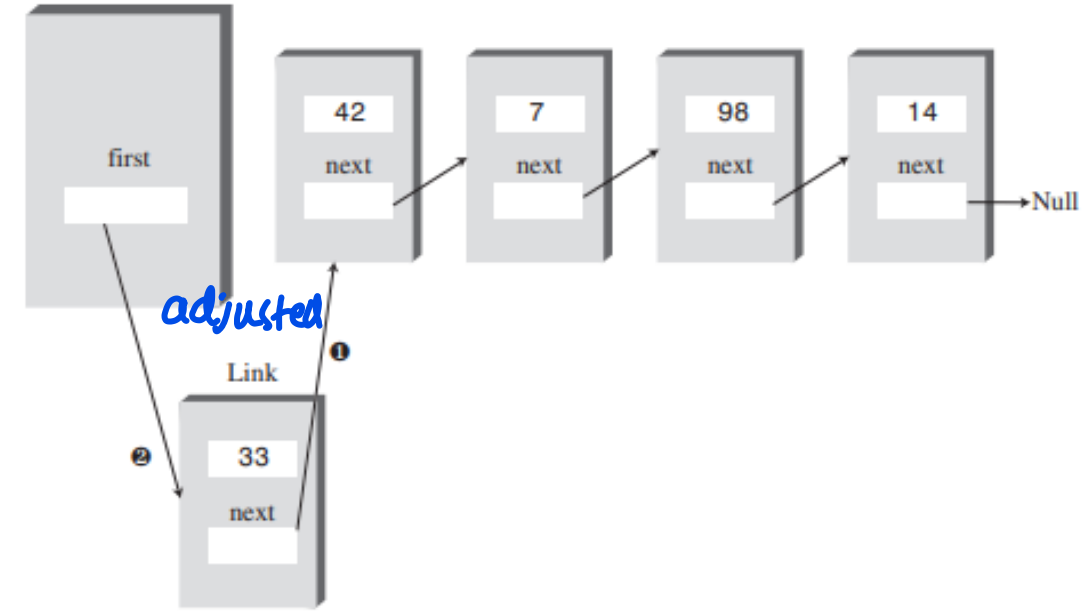
Step 3 : 'first' points to the newly created link



InsertFirst() → inserting for the first place



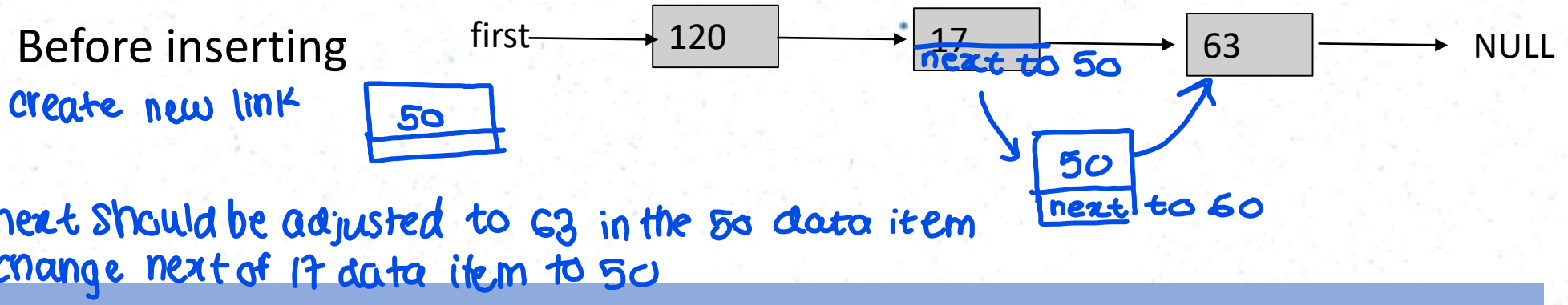
a) Before Insertion



b) After Insertion

Operations - Insert

Inserting an item in the middle of the list



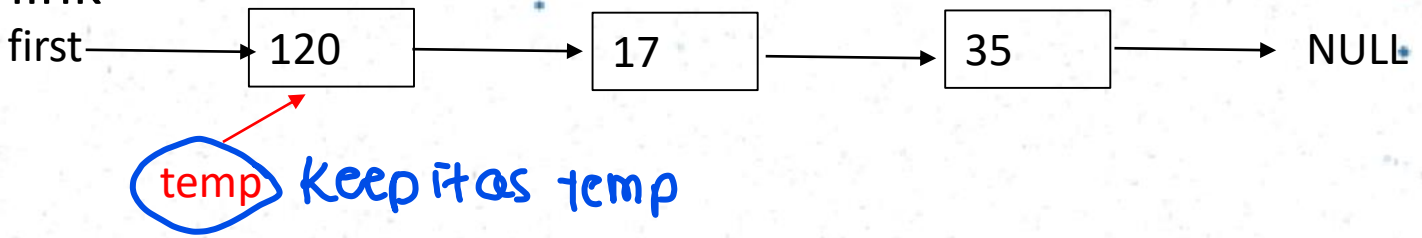
Question:

What steps need to be followed if a new link is inserted after the link '17' ?

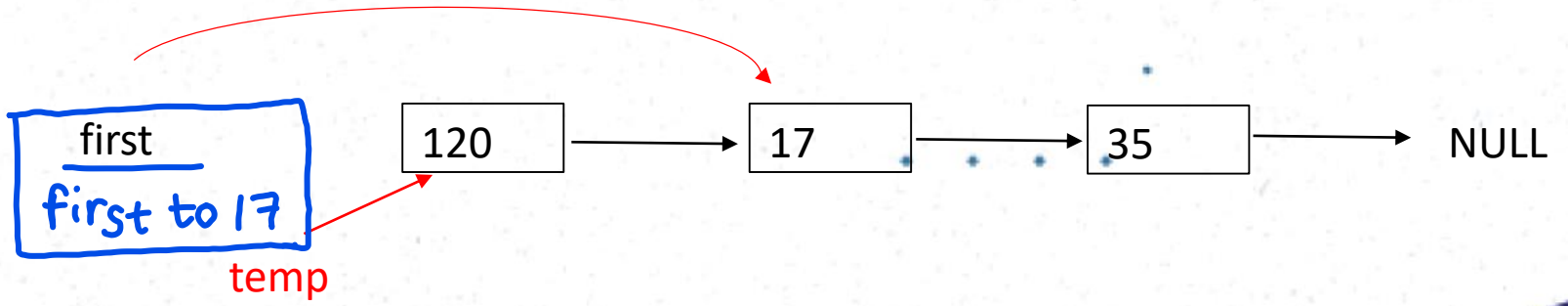
Operations - Delete

Deleting an item from the beginning of the list

Step 1 : Save reference to first link

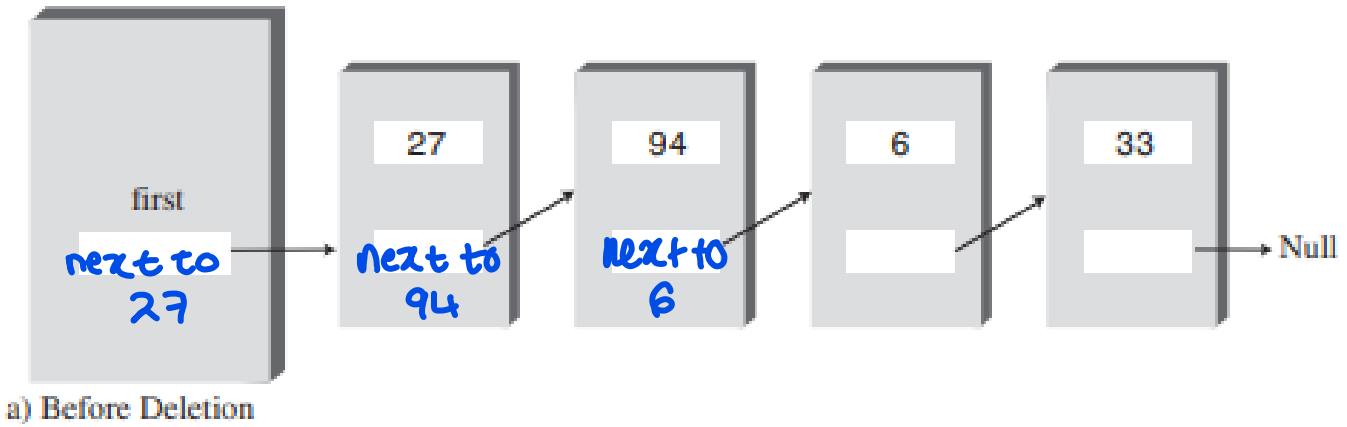


Step 2 : Disconnect the first link by rerouting first to point to the second link

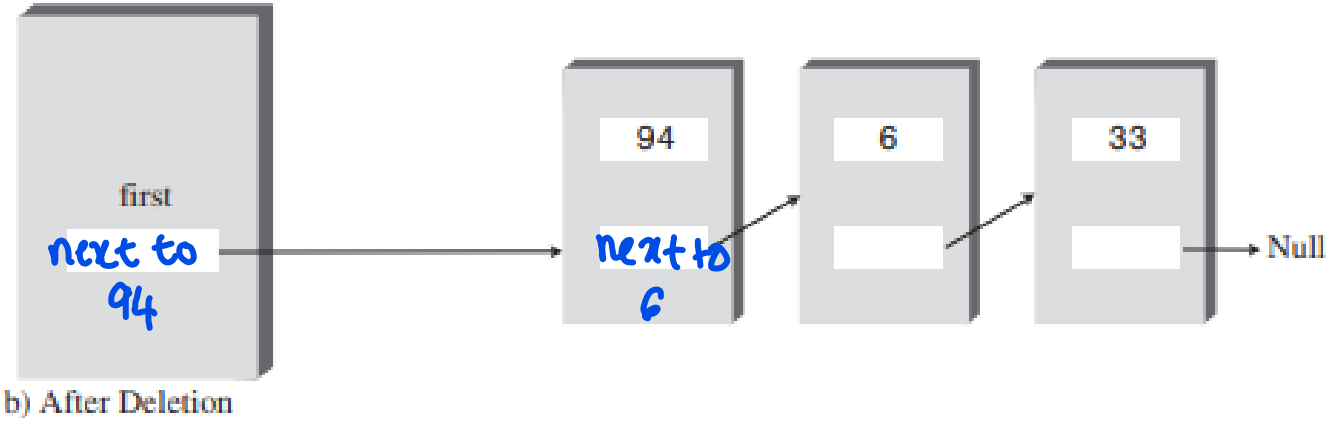


Step 3 : Return the deleted link (temp)

deleteFirst()



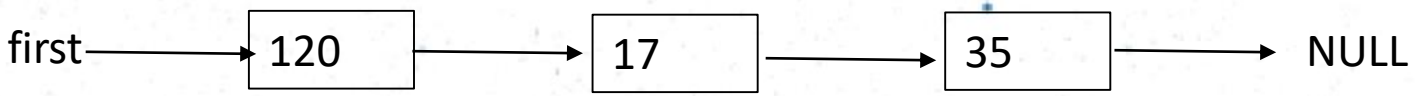
a) Before Deletion



b) After Deletion

Operations - Delete

Deleting a given item from the list



- find link of 17 save it as temp
- change 120 next to 17 to 120 next to 35

Question:

What steps need to be followed to delete the link '17' ?

Linked List - Implementation

Link Class

- In a linked list, a link is an object of a class called something like "**Link**".
- There are many similar links in a linked list.
- Each link contains Data Items and a reference to the next link in the list.

create linked list

```
class Link {
    public int iData;    // data item
    public Link next;    // reference to the next link

    public Link(int id) { // constructor

            iData = id;
            next  = null;
     }
     public void displayLink() {  // display data item

            System.out.println(iData);
     }
}
```

Linked List - Implementation

LinkList class is implemented because in LinkList we should be careful when linking items. ∴ to avoid making errors we create this .Link list handles all connections

Link List Class

check example

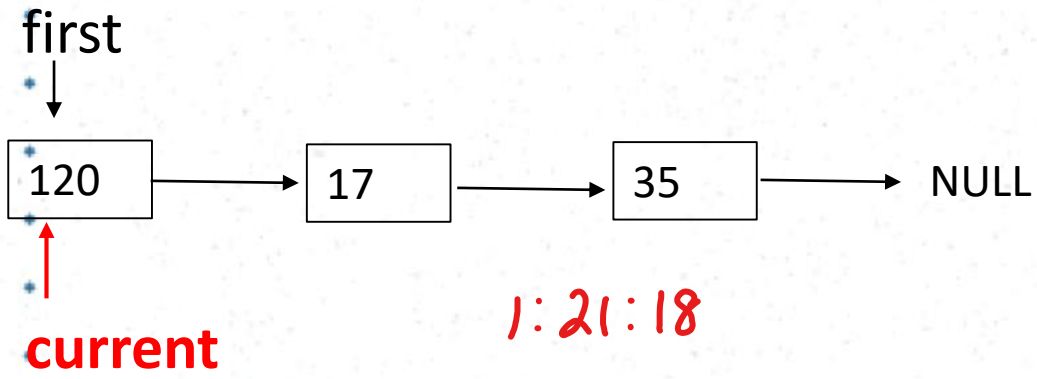
- The LinkList class contains only one data item, a reference to the first link on the list called **'first'**.

- It is possible to find the other links by following the chain of references from '**first**', using each link's next field.

```
class LinkList {
    private Link first;

    public LinkList() {     //constructor

            first = null;
    }
    public boolean isEmpty() {  // true if list is empty

            return (first == null);
    }
    // ……….....        other methods
}
```

Linked List - Implementation

Link List Class – Contd.



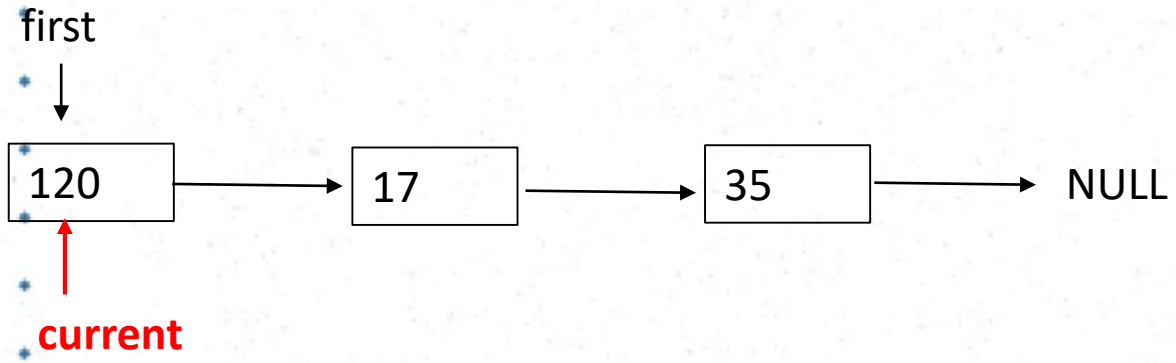
1:21:18

Display List code

```
class LinkList {
    private Link first;
    public  LinkList() { //constructor
                first = null;
    }
    public boolean isEmpty() {  // true if list is empty
                return (first == null);
    }
     public void displayList()    {
                Link current = first;
                while (current != null) {
                      current.displayLink();
                      current = current.next;
                }
                System.out.println(" ");
     }
}
```

Linked List - Implementation

Link List Class – Contd.




```
class LinkList {
    private Link first;
    public LinkList()  {  //constructor
            first == null;
    }
    public boolean isEmpty()  { // true if list is empty
            return (first == null);
    }
     public void displayList() {
            Link current = first;
            while (current != null) {
                current.displayLink();
                current = current.next;
            }
            System.out.println(" ");
     }
}
```

Linked List - Implementation

Link List Class – Contd.

```
class LinkList {
    private Link first;
    public LinkList() {  //constructor

            first = null;
    }
    public boolean isEmpty() { // true if list is empty

            return (first == null);
    }
    public void displayList() {

        Link current = first;
        while (current != null) {

            current.displayLink();
            current = current.next;
        }
        System.out.println(" ");
    }
```

method to insert items to first

```
// insertFirst Method
public void insertFirst(int id) {
        Link newLink = new Link(id);
        newLink.next = first;
        first = newLink;
  }
```

method to delete first item

```
// deleteFirst Method
public Link deleteFirst()  {
        Link temp = first;
        first = first.next;
        return temp;
  }
}
```

Question 1

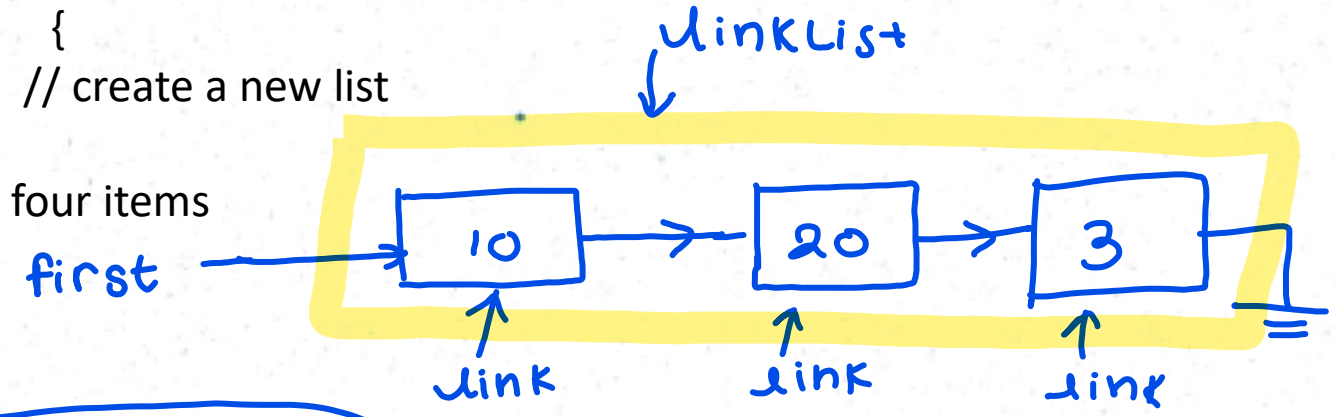
Write a program to

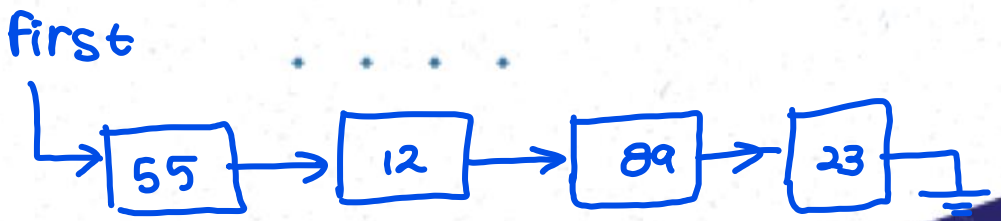
i) Create a new linked list and insert four new links.
ii) Display the list.
iii) Remove the items one by one until the list is empty.

(Use the LinkList class created)

Answer1

```
class  myList {
      public static void main(String[] args)       {
            LinkList theList  = new LinkList();    // create a new list

             theList.insertFirst(23);    // insert four items
             theList.insertFirst(89);
             theList.insertFirst(12);
             theList.insertFirst(55);

            theList.displayList();          //display the list

            while( !theList.isEmpty() ) {   // delete item one by one

                        Link aLink = theList.deleteFirst();
                        System.out.print("Deleted ");
                        aLink.displayLink();

            }
}
}
```

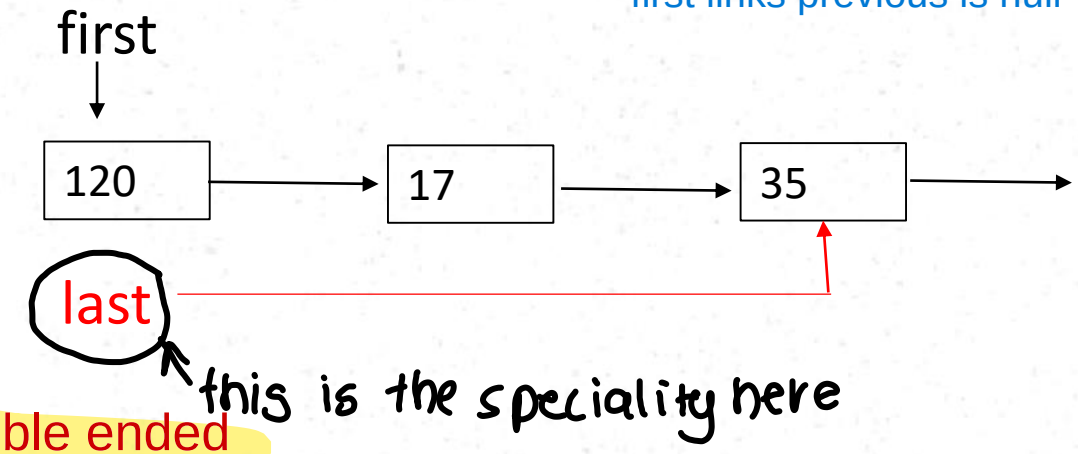




Double-Ended List

A double-ended list is similar to an ordinary linked list with an additional reference to the last link.

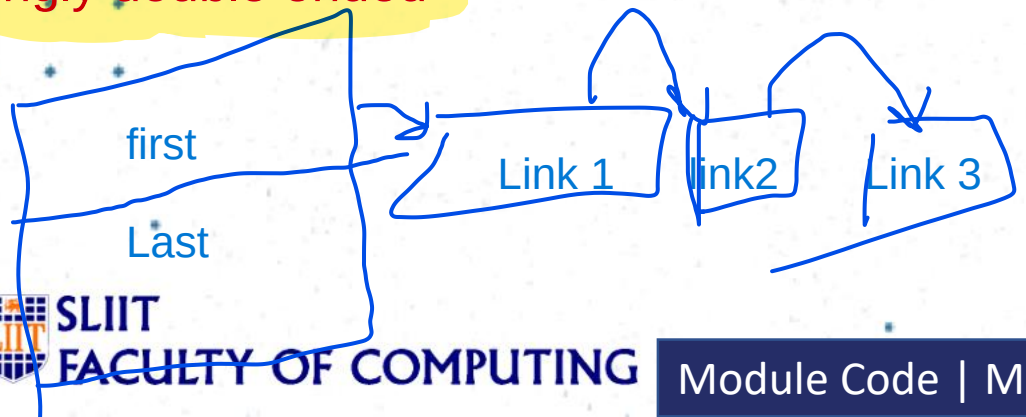
last links next is null
first links previous is null



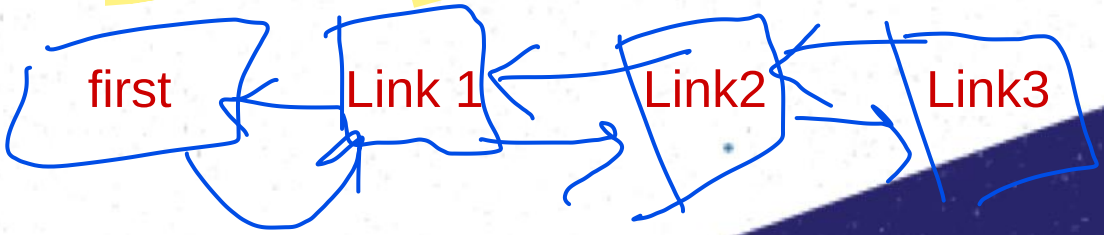
*when you don't have anything both last and first = null once an item is added last = first

in the double ended list we have additionly insertLast() and deleteLast() methods

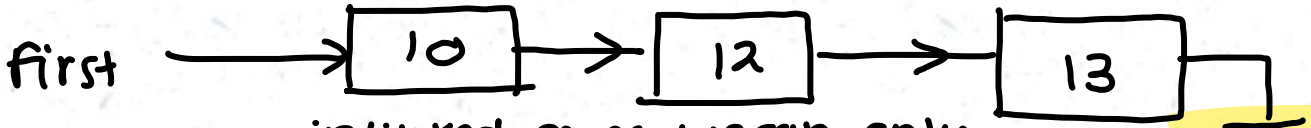
singly double ended



doubly double ended



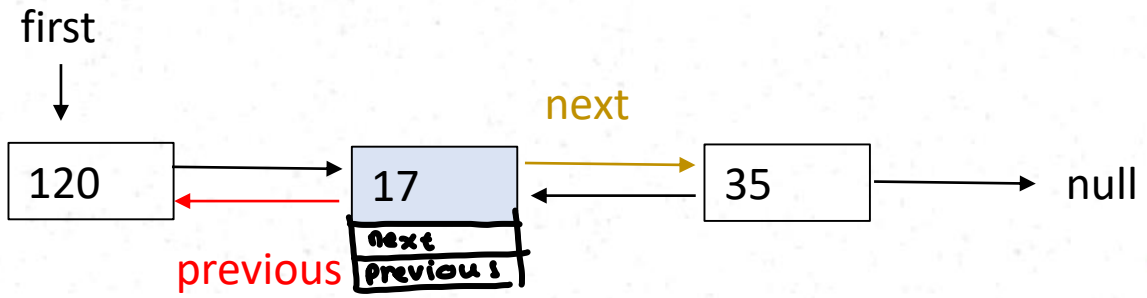
Doubly Linked List



in linked class we can only go for ward with next but here we can go backward and forward both

A doubly linked list allows to traverse backwards as well as forward through the list.

Each link has two references.



∴ in a link there are two references pointing to both previous address and next address

References

Mitchell Waite, Robert Lafore, Data Structures and Algorithms in Java, 2nd Edition, Waite Group Press,1998.