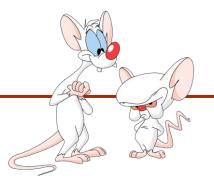
# Assiste MPc 250 Help INTRODUC https://eduassistpro.gTER.SCIENCE

Week \$43. Doubledu assist pro

Giulia Alberini, Fall 2020

#### WHAT ARE WE GOING TO DO IN THIS VIDEO?



Doubly Linked Listsignment Project Exam Help

https://eduassistpro.github.io/

Add WeChat edu\_assist\_pro



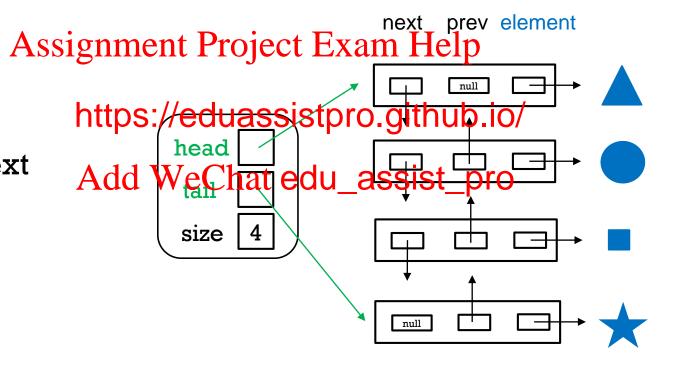
#### **IMPLEMENTATIONS**

There are different implementations of a list:

- Array list Assignment Project Exam Help
- Singly linked list https://eduassistpro.github.io/n the list are linked using poi
- Doubly linked list Add WeChat edu\_assist\_pro

#### Doubly Linked List

Each node has a reference to the next node and to the previous node.



#### DOUBLY LINKED LIST NODE

```
Shape element signment Project Exam Help

DNode next;

DNode prev; https://eduassistpro.github.io/

Add WeChat edu_assist_pro
```

```
DNode myNode = new DNode();
n.element = new Shape( );
```

#### DOUBLY LINKED LIST

```
public class DLinkedList {
                                                                      element
                                                          next
                                                                prev
   private DNode head;
                                                                 null
   private DNode tail;
                      Assignment Project Exam Help
   private int size;
                            https://eduassistpr<del>b.g</del>ithub.io/
   private class DNode {
                            Add We Chat edu_assist_pro
      Shape element;
      DNode next;
      DNode prev;
                                                          null
```

```
DLinkedList list = new DLinkedList();
:
```

# DOUBLY LINKED LIST – removeLast()

```
prev
                                                                        element
                                                            next
tail = tail.prev;
                                                                   null
tail.next.prev = null; // not necessary
Assignment Project Exam Help
tail.next = null;
                             https://eduassistprb.github.io/
size = size - 1;
                            Add We Chat edu_assist_pro
// to return the element,
// you need to do a bit more work
// edge cases for size = 0 and 1 to be added
                                                            null
```

# DOUBLY LINKED LIST - removeLast()

```
element
                                                             next
tail = tail.prev;
                                                                   prev
                                                                    null
tail.next.prev = null; // not necessary
Assignment Project Exam Help
tail.next = null;
                             https://eduassistprb.github.io/
size = size - 1;
                            Add We Chat edu_assist_pro
// to return the element,
// you need to do a bit more work
// edge cases for size = 0 and 1 to be added
                                                             null
    For a doubly linked list, removing the last
                                                            null
    element is much faster.
```

# WORSE CASE TIME COMPLEXITY (N = LIST SIZE)

	array list	SLinkedList	DLinkedList
addFirst()	Assignment Proj	ect Exam Help	O(1)
removeFirst()	https://eduassistpro.github.io/ O(N) Add WeChat edu_assist_pro		O(1)
addLast()	O(1)	O(1)	O(1)
removeLast()	O(1)	O(N)	O(1)

#### OTHER LIST OPERATIONS

Many list operations require access to a specific node in Assignment Project Exam Help

get(i)

set(i,e)

add(i,e)

remove(i)

https://eduassistpro.github.io/

Add WeChat edu\_assist\_pro

#### **LINKED LISTS**

Suppose we want to access general node i in a linked list.

Two issues arise: Assignment Project Exam Help

https://eduassistpro.github.io/

Edge cases (i = 0, i = size - 1) r ra code.

Add WeChat edu\_assist\_pro

This is a pain and can lead to co

How long does it take to access node i?

#### AVOID EDGE CASES WITH "DUMMY NODES"

```
public class DLinkedList {
                                      // empty list
   private DNode dummyHead;
  private DNode dummyTAissignment Project Exam Help
   private int size;
                           https://eduassistpro.github.io/
   public DLinkedList() {
                                                                   prev element
                                                              next
      dummyHead = new DNode Add WeChat edu_assist_pro
                                                                       null
                                                                   null
      dummyTail = new DNode();
                                              dummyHead
      dummyHead.next = dummyTail;
                                              dummyTail
      dummyTail.prev = dummyHead;
                                      list
                                                                        null
                                                              null
                                                  size
      size = 0;
```

#### AVOID EDGE CASES WITH "DUMMY NODES"

```
DLinkedList list = new DLinkedList();
public class DLinkedList {
                                        // add 2 elements...
   private DNode dummyHead;
   private DNode dummy TAis signment Project Exam Help
                                                                     prev element
                                                               next
   private int size;
                                                                     null
                                                                          null
                             https://eduassistpro.github.io/
   public DLinkedList() {
      dummyHead = new DNode Add WeChat edu_assist p
      dummyTail = new DNode();
                                               dummyTail
                                      list
      dummyHead.next = dummyTail;
                                                   size 2
      dummyTail.prev = dummyHead;
      size = 0;
                                                                null
                                                                          null
```

# HOW DO WE ACCESS A NODE? – get()

```
public Shape get(int i) {
   DNode node = getNode(i);
   return node.element: Assignment Project Exam Help
                                                                      prev element
                                                                next
                                                                      null
                                                                           null
                             https://eduassistpro.github.io/
private DNode getNode(int iAdd WeChat edu_assist_p
   // verify that 0<=i<size omitted</pre>
                                                dummyTail
                                       list
   DNode node = dummyHead.next;
                                                    size 2
   for (int k=0; k<i; k++)
      node = node.next;
   return node;
                                                                 null
                                                                           null
```

# CAN WE SPEED THIS UP? – getNode()

```
private DNode getNode(int i) {
   // verify that 0<=i<size omitted</pre>
   DNode node;
   if (i < size/2) { Assignment Project Exam Help
                                                                 next
                                                                      prev element
      node = dummyHead.next;
                                                                      null
                                                                           null
      for (int k=0; k<i; k++) https://eduassistpro.github.io/
          node = node.next;
                              Add WeChat edu_assist_p
   else {
                                                dummyTail
                                       list
      node = dummyTail.prev;
                                                    size 2
      for (int k=size -1; k>i; k--)
          node = node.prev;
                                                                 null
                                                                           null
   return node;
```

#### JAVA LINKEDLIST CLASS

https://docs.oracle.com/javase/8/docs/api/java/util/LinkedList.html

It uses a doubly linked list as the underlying data structure.

Assignment Project Exam Help

It has some methods thahttps://eduassistpro.github.io/

addFirst()

- Add WeChat edu\_assist\_pro
- removeFirst()
- addLast()
- removeLast()

Why?

```
DLinkedList list = new DLinkedList();

Assignment Project Exam Help

for (k = 0; k some constant

li https://eduassistpro.github.io/

Add WeChat edu_assist_pro
```

```
DLinkedList list = new DLinkedList();

Assignment Project Exam Help

for (k = 0; k some constant

li https://eduassistpro.github.io/

Add WeChat edu_assist_pro
```

A: 
$$1 + 1 + 1 + \dots 1 = N \Rightarrow O(N)$$

where '1' means constant.

```
for (k = 0; k < list.size(); k ++) // size == N

Assignment Project Exam Help
```

https://eduassistpro.github.io/

Assuming here that Assuming here the Assuming here that Assuming here the Assuming here that Assuming here the Assuming here the Assumi

https://eduassistpro.github.io/

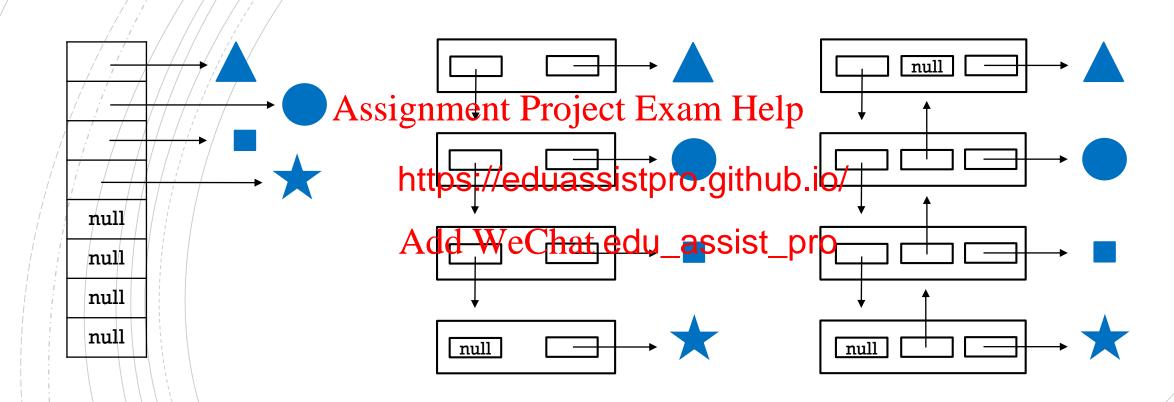
Assuming here that Assuming here the Assuming here that Assuming here that Assuming here the Assuming h

A: 
$$1+2+3+....N$$

$$= \frac{N(N+1)}{2} \Rightarrow O(N^2)$$

In 3 weeks we'll talk about a more efficient way to iterate through elements in a (Java) LinkedList!

## WHAT ABOUT "SPACE COMPLEXITY"?



All three data structures use space O(N) for a list of size N. But linked lists use 2x (single) or 3x (double).

## ARRAY LIST VERSUS LINKED LIST ?

Array lists and linked lists both take O(N) time to add or remove from an signiment Position in the Help

In practice and whttps://eduassistpro.github.jo/aster. But the reasons are subtle wechat edu\_assist\_promputer memory works, in particular, exploit contiguous memory allocation. You will learn about that topic in COMP 273.

#### DO YOU EVER NEED LINKED LISTS?

Yes. Even is young refer Phojev Listsany of still need to understand Li are special cases of a general a https://eduassistpro.gitcubeicalled a tree which we will be discus sively.

Add WeChat edu\_assist\_pro



Assignment Project Exam Help In the next

- Quadrat https://eduassistpro.github.io/
- Asymptotic notations

  Add WeChat edu\_assist\_pro