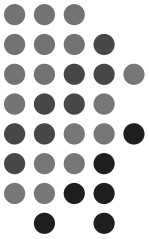
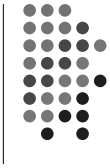
OOP
A Deeper Look

4B

Iterators,
The Collection Hierarchy



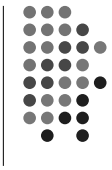


Iterating over a list

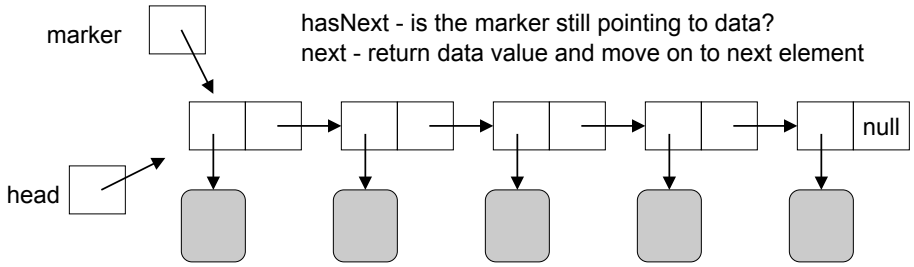
```
SinglyLinkedList<type> list =
       new SinglyLinkedList<type>();
...
for (int i=0; i<list.size(); i++) {
  type nextElement = list.get(i);
  // do something with nextElement
}
```

If the list has n elements, what is the order of complexity of this iteration? _____

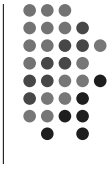
Iterators



- An iterator implements a "marker" in the list to keep track of the last element accessed so we can examine the next element quickly.



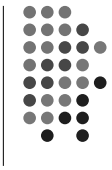
Iterators



```
Iterator<type> iter = list.iterator();
while (iter.hasNext()) {
  type nextElement = iter.next();
  // do something with nextElement
}
```

If the list has n elements, what is the order of complexity of this iteration? _____

The `Iterator` interface



`boolean hasNext()`

Returns `true` if there is another element to process.

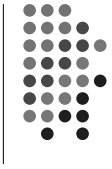
`E next()`

Returns the next element. If there are no more elements, throws the `NoSuchElementException`.

`void remove()`

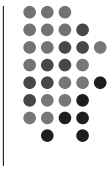
Removes the last element returned by the `next` method. (must be preceded by a call to `next`)

Using `Iterator` interface



- If we say `SinglyLinkedList` implements `Iterator`, we can only have one iterator for the list.
  - That is, the singly linked list acts as the iterator itself.
- Instead, we can create an iterator as an inner class.
  - We can have more than one iterator for a list.

Creating iterators



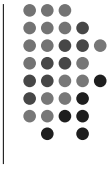
To use an iterator on a collection of data, we must supply an `iterator` method that returns an `Iterator` on this object.

Example: in `SinglyLinkedList` class

```
public Iterator<E> iterator() {
  return new SLLIterator();
}
```

implementation later

Using iterators



Example: Use an iterator to remove all integers in a singly-linked list of integers that are even.

```
SinglyLinkedList<Integer> list =
      new SinglyLinkedList<Integer>();
...
Iterator<Integer> iter = list.iterator();
while (iter.hasNext()) {
  int num = iter.next();
  if (num % 2 == 0) iter.remove();
}
```

The `ListIterator<E>` interface

- `ListIterator` is an extension of `Iterator`
- The `LinkedList` class implements the `List<E>` interface using a doubly-linked list.
- Methods in `LinkedList` that return a list iterator:

```
public ListIterator<E> listIterator()
public ListIterator<E> listIterator(int index)
```

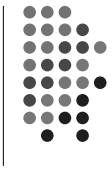
- Methods in the `ListIterator` interface:
  - `add`, `hasNext`, `hasPrevious`, `next`, `previous`, `nextIndex`, `previousIndex`, `remove`, `set`

Example

- Replace the first occurrence of `target` in `LinkedList aList` of strings with `newItem` :

```
ListIterator<String> iter =
                aList.listIterator();
while (iter.hasNext()) {
    if (target.equals(iter.next())) {
         iter.set(newItem);
         break;
    }
}
```

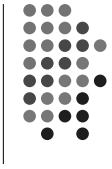
Example



- Count the number of times `target` appears in `LinkedList aList` of strings :

```
int count = 0;
ListIterator<String> iter =
                aList.listIterator();
while (iter.hasNext()) {
    if (target.equals(iter.next())) {
        count++;
    }
}
```


Example
(using the enhanced `for` loop)

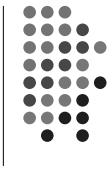


- Count the number of times `target` appears in `LinkedList aList` of strings :

```
int count = 0;
for (String nextStr : aList) {
    if (target.equals(nextStr)) {
        count++;
    }
}
```

implicitly calls the `hasNext` and `next` methods; `remove` is not available

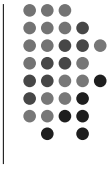
Example
(using the enhanced `for` loop)



- Enhanced `for` loops can also be used with arrays.

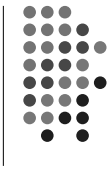
```
int[] dataArray = new int[1000];
...
int total = 0;
for (int nextInt : dataArray) {
    total += nextInt;
}
```


Iterable<T> interface



- Specifies an `iterator` method.
  - `Iterator<T> iterator()`
    Returns an iterator over a set of elements of type T.
- Implemented by the `Collection` interface.
- All classes that implement the `Collection` interface must include an `iterator` method that returns an Iterator for that collection.
- The enhanced `for` statement can then be used to "traverse" the collection one element at a time easily.

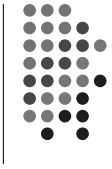
Example



- Let `myList` be an `ArrayList` of `Integer`.
- Since `myList` is an `ArrayList`, and `ArrayList` is a subclass of `Collection`, it must have an `iterator` method that returns an iterator for the collection.

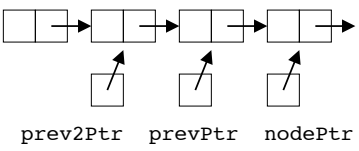
```
int total = 0;
for (int nextInt : myList)
    total += nextInt;
```


Implementing an iterator

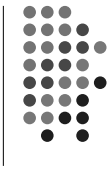


Inside the `SinglyLinkedList` class:

```
private class SLLIterator implements Iterator<E>
{
  private Node<E> nodePtr;
  private Node<E> prevPtr;
  private Node<E> prev2Ptr;
  private boolean okToRemove;
  ...
  // constuctor and
  // required methods
}
```



Implementing an iterator

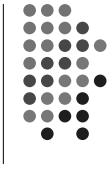


Constructor for the `SLLIterator`:

```
private SLLIterator()  {
  nodePtr = head;
  prevPtr = null;
  prev2Ptr = null;
  okToRemove = false;
}
```

We can only `remove` if we call `next` first.

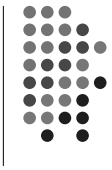
Implementing an iterator



Required methods for `SLLIterator`:
`hasNext`, `next`, `remove`

```
public boolean hasNext() {
  return nodePtr != null;
}
```

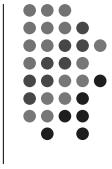
Implementing an iterator



```
public E next() {
  if (nodePtr == null)
      throw new NoSuchElementException();
  E result = nodePtr.data;
  prev2Ptr = prevPtr;
  prevPtr = nodePtr;
  nodePtr = nodePtr.next;
  okToRemove = true;
  return result;
}
```

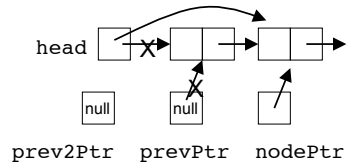
shift three references forward one position

Implementing an iterator



```
public void remove() {
  if (!okToRemove)
   throw new IllegalStateException();
  if (prev2Ptr == null)
   head = nodePtr;
  else
   prev2Ptr.next = nodePtr;
  prevPtr = prev2Ptr;
  okToRemove = false;
}
```

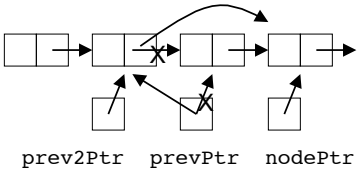
removing head node



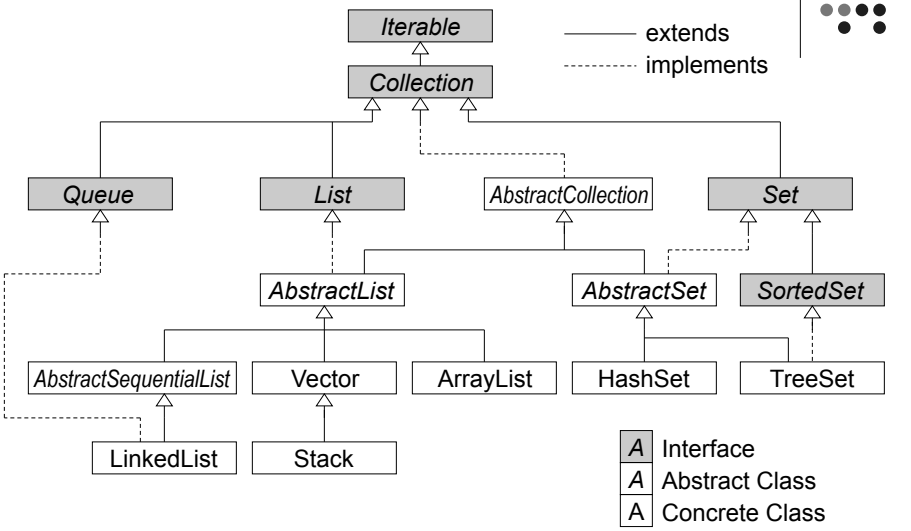
Does this method work if you remove the tail node?

What if the list only has 1 node?

removing non-head node



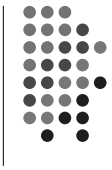
The `Collection` Hierarchy



Properties of All Collections

- Collections grow in size as needed.
- Collections always hold references to objects.
- Collections must have at least two constructors:
  - A constructor to create an empty collection (no parameters).
  - A constructor to make a copy of another collection (one parameter of type Collection).

AbstractCollection

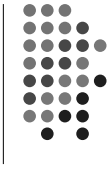


- The `AbstractCollection` class helps us define a collection.
- This `abstract` class contains implementations of most methods except `size` and `iterator`.
- To create a collection, we only have to `extend` this class, provide methods for `size` and `iterator`, and include an inner class to implement the `Iterator` interface.

```
public class SinglyLinkedList<E>
    extends AbstractCollection<E> {...}
```

  - From the Java API: To implement a modifiable collection, the programmer must additionally override this class's `add` method (which otherwise throws an `UnsupportedOperationException`), and the iterator returned by the `iterator` method must additionally implement its `remove` method.

AbstractList



- The `AbstractList` class helps us define a list.
- This `abstract` class contains implementations of most methods except `add`, `get`, `remove`, `set`, and `size`.
- To create a list, we only have to `extend` `AbstractList`, provide the missing methods above.
  - used for collections that can be accessed randomly
  - how does it return an iterator?

```
public class CMUArrayList<E>
   extends AbstractList<E> {...}
```

`AbstractSequentialList`

- The `AbstractSequentialList` class helps us define a sequential list.
- This `abstract` class contains implementations of most methods except `listIterator` and `size`, and provide an inner class that implements the `ListIterator` interface.
- To create a list, we only have to `extend` `AbstractListCollection`, provide the missing methods above.
  - used for collections accessed sequentially