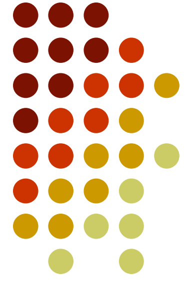
Inserting a Node into a Specified Position of a Linked List



- To create a node for the new item

```
newNode = new Node(item);
```

- To insert a node between two nodes

```
newNode.setNext(curr);
prev.setNext(newNode);
```

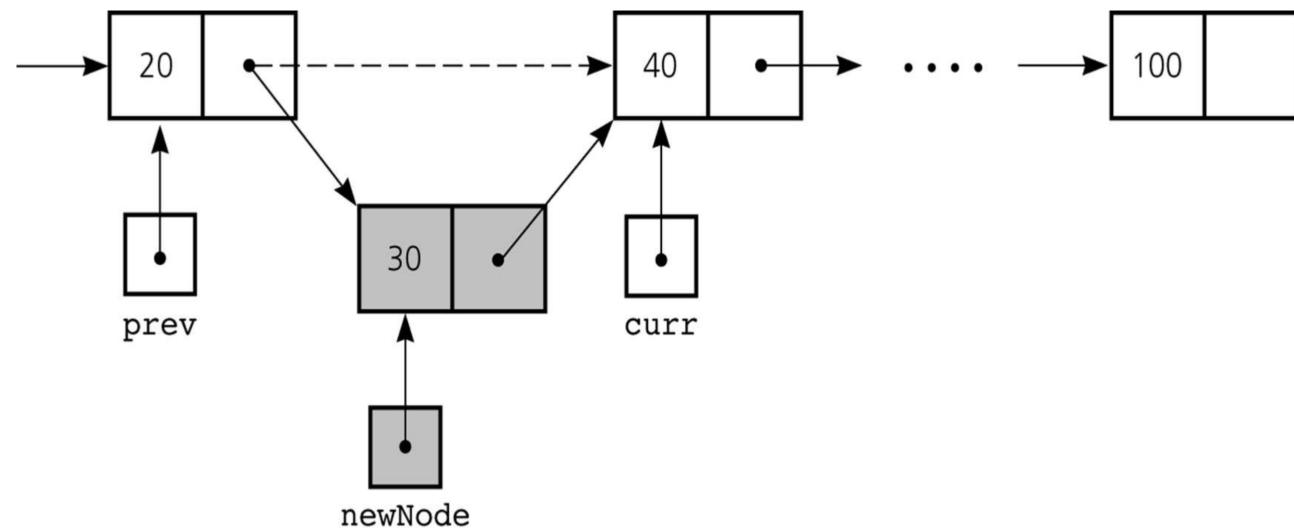
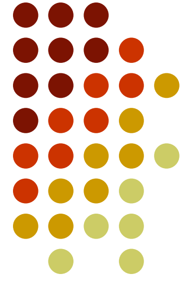


Figure 5-13

Inserting a new node into a linked list

Inserting a Node into a Specified Position of a Linked List



- To insert a node at the beginning of a linked list

```
newNode.setNext(head);
head = newNode;
```

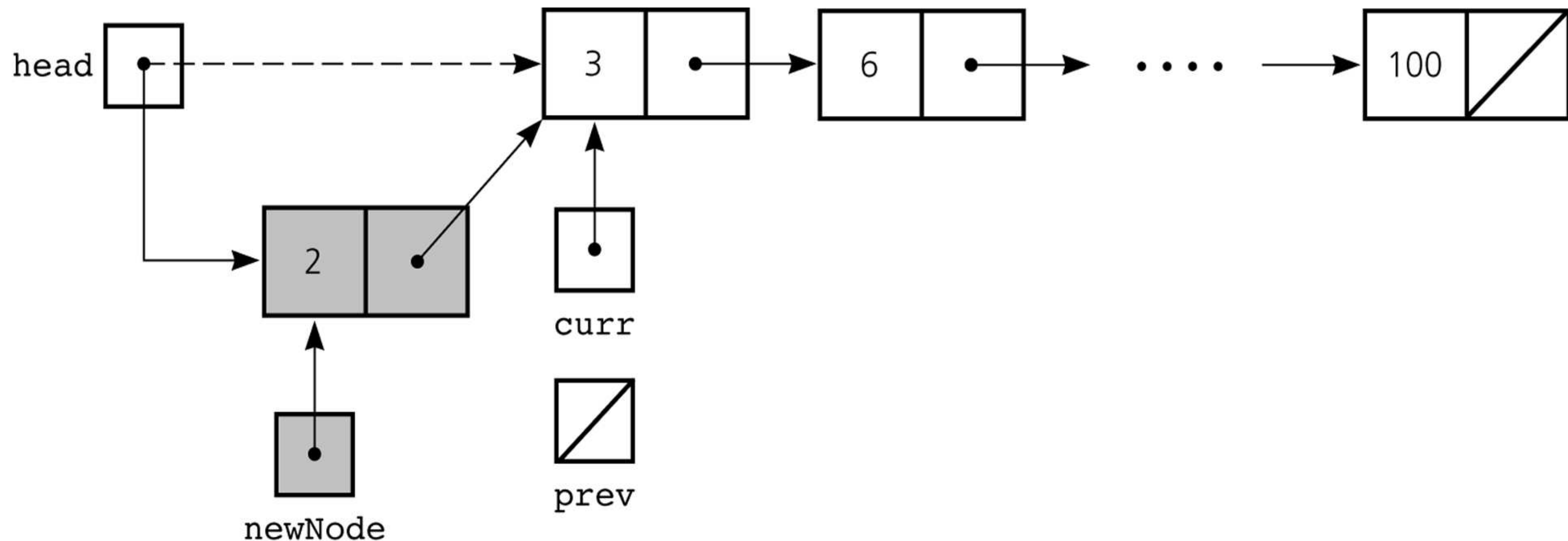
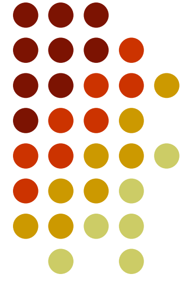


Figure 5-14

Inserting at the beginning of a linked list

Inserting a Node into a Specified Position of a Linked List



- Inserting at the end of a linked list is not a special case if `curr` is `null`

```
newNode.setNext(curr);
prev.setNext(newNode);
```

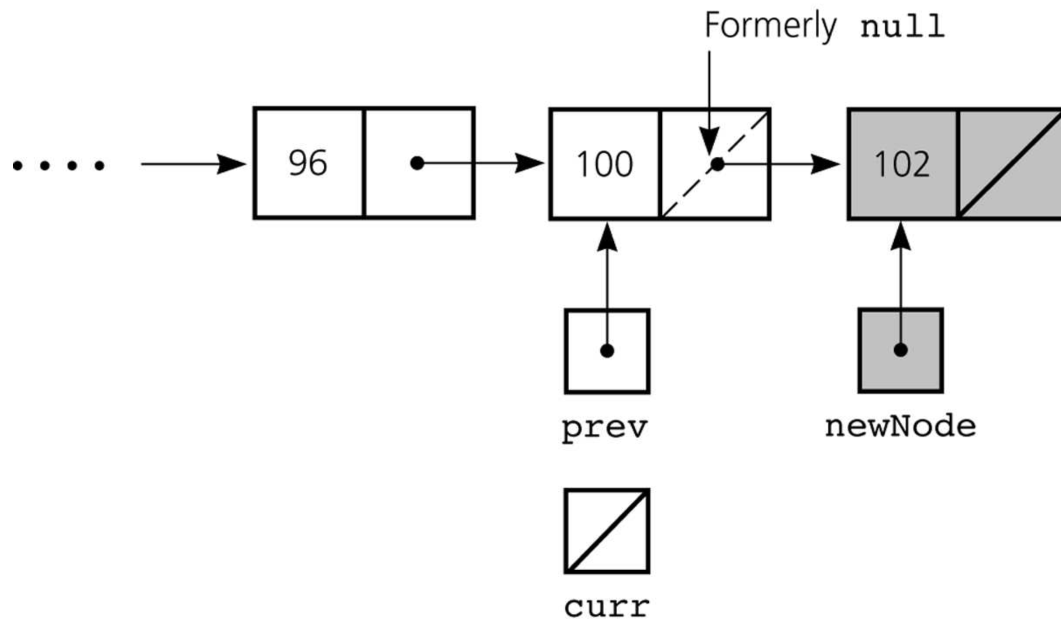
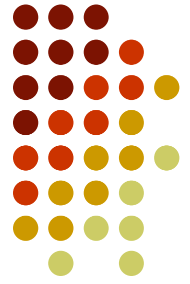


Figure 5-15

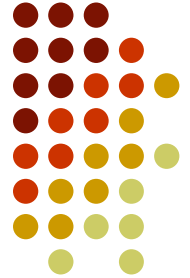
Inserting at the end of a linked list

Inserting a Node into a Specified Position of a Linked List



- Three steps to insert a new node into a linked list
  - Determine the point of insertion
  - Create a new node and store the new data in it
  - Connect the new node to the linked list by changing references

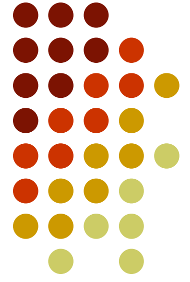
Determining `curr` and `prev`



- Determining the point of insertion or deletion for a sorted linked list of objects
  - assume we have `newValue` which should inserted (deleted)

```
for ( prev = null, curr = head;
          (curr != null) &&
          (newValue.compareTo(curr.getItem()) > 0);
          prev = curr, curr = curr.getNext() ) {
} // end for
```

A Reference-Based Implementation of the ADT List



- A reference-based implementation of the ADT list
  - Does not shift items during insertions and deletions
  - Does not impose a fixed maximum length on the list

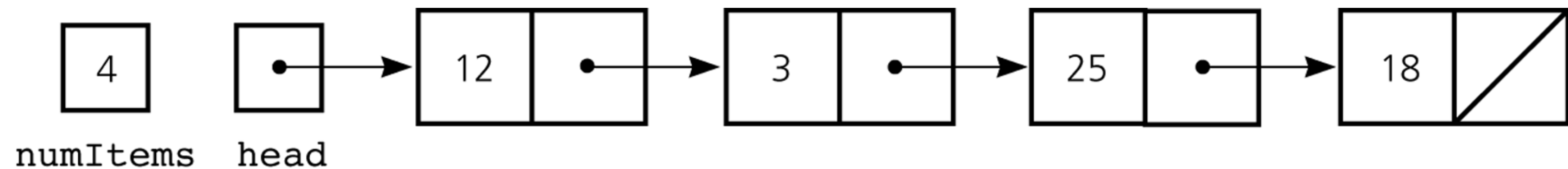
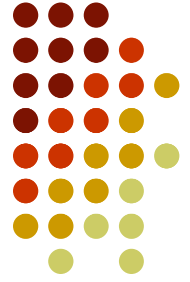


Figure 5-18

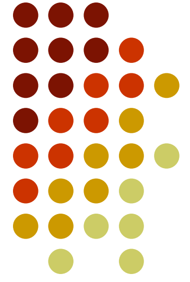
A reference-based implementation of the ADT list

A Reference-Based Implementation of the ADT List



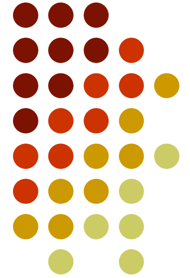
- Default constructor
  - Initializes the data fields `numItems` and `head`
- List operations
  - Public methods
    - isEmpty
    - size
    - add
    - remove
    - get
    - removeAll
  - Private method
    - find

Reference-based Implementation of ADT List



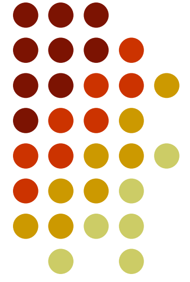
```
public boolean isEmpty() {
    return numItems == 0;
  }  // end isEmpty

  public int size() {
    return numItems;
  }  // end size
```

Reference-based Implementation of ADT List



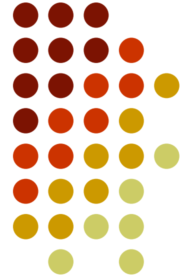
```
private Node find(int index) {
 // --------------------------------------------------
 // Locates a specified node in a linked list.
 // Precondition: index is the number of the desired
 // node. Assumes that 1 <= index <= numItems+1
 // Postcondition: Returns a reference to the desired
 // node.
 // --------------------------------------------------
   Node curr = head;
   for (int skip = 1; skip < index; skip++) {
     curr = curr.getNext();
   } // end for
   return curr;
 } // end find
```

Reference-based Implementation of ADT List



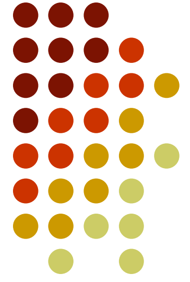
```java
public Object get(int index)
              throws ListIndexOutOfBoundsException {
  if (index >= 1 && index <= numItems) {
    // get reference to node, then data in node
    Node curr = find(index);
    Object dataItem = curr.getItem();
    return dataItem;
  }
  else {
    throw new ListIndexOutOfBoundsException(
                 "List index out of bounds on get");
  } // end if
} // end get
```

Reference-based Implementation of ADT List



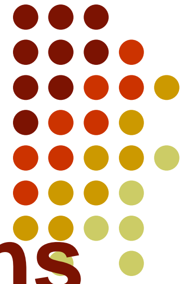
```
public void add(int index, Object item)
                  throws ListIndexOutOfBoundsException {
    if (index >= 1 && index <= numItems+1) {
      if (index == 1) {
        // insert the new node containing item at
        // beginning of list
        Node newNode = new Node(item, head);
        head = newNode;
      }
      else {
        Node prev = find(index-1);
        // insert the new node containing item after
        // the node that prev references
        Node newNode = new Node(item, prev.getNext());
        prev.setNext(newNode);
      } // end if
      numItems++;
    }
    else {
      throw new ListIndexOutOfBoundsException(
                  "List index out of bounds on add");
    } // end if
  }  // end add
```

Reference-based Implementation of ADT List



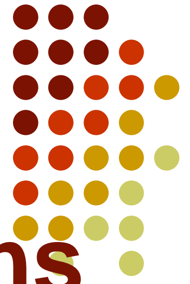
```
public void remove(int index)
                     throws ListIndexOutOfBoundsException {
    if (index >= 1 && index <= numItems) {
      if (index == 1) {
        // delete the first node from the list
        head = head.getNext();
      }
      else {
        Node prev = find(index-1);
        // delete the node after the node that prev
        // references, save reference to node
        Node curr = prev.getNext();
        prev.setNext(curr.getNext());
      } // end if
      numItems--;
    } // end if
    else {
      throw new ListIndexOutOfBoundsException(
                 "List index out of bounds on remove");
    } // end if
  }   // end remove
```

Comparing Array-Based and Referenced-Based Implementations



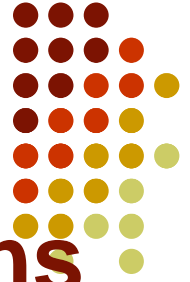
- Size (number of elements stored)
  - Array-based
    - Fixed size
      - Can you predict the maximum number of items in the ADT?
      - Will an array waste storage?
    - Resizable array
      - Increasing the size of a resizable array can waste storage and time
  - Reference-based
    - Do not have a fixed size
      - Do not need to predict the maximum size of the list
      - Will not waste storage (for data)

Comparing Array-Based and Referenced-Based Implementations



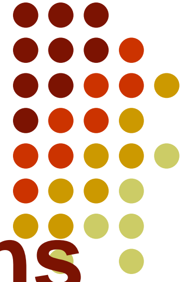
- Storage requirements
  - Array-based
    - Requires less memory than a reference-based implementation
      - There is no need to store explicitly information about where to find the next data item
  - Reference-based
    - Requires more storage
      - An item explicitly references the next item in the list

Comparing Array-Based and Referenced-Based Implementations



- Access time
  - Array-based
    - Constant access time
  - Reference-based
    - The time to access the ith node depends on I
- But when processing all elements: both implementations require constant time on average

Comparing Array-Based and Referenced-Based Implementations



- Insertion and deletions
  - Array-based
    - Require you to shift the data
  - Reference-based
    - Do not require you to shift the data
    - Require a list traversal