List ADT:

Linked lists vs. Arrays

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Abstract Data Type

- A data type for which:
  - only the properties of the data and the operations to be performed on the data are specific,
  - how the data will be represented or how the operations will be implemented is unspecified.
- An ADT may be implemented using various specific data types or data structures, in many ways and in many programming languages.
- Examples:
  - Stacks and Queues (implemented using arrays+LL)
  - string class   (not sure how it's implemented)

The Abstract List Data Type

- A List is an ordered collection of items of some type T:
  - each element has a position in the list
  - duplicate elements are allowed
- List is not a C++ data type. It is conceptual. It can be implemented in various ways
- We have implemented it using a linked list (NumberList).
- Now we are going to use an array to implement the list.

Common List operations

- Basic operations over a list:
  - **create** a new, empty list
  - **append** a value to the end of the list
  - **insert** a value within the list
  - **delete** a value (remove it from the list)
  - **display** the values in the list
  - **delete/destroy** the list
    (if it was dynamically allocated)

Declaring the List data type

- We will be defining a class called NumberList to represent a List data type.
  - ours will store values of type double, using an array.
- The class will implement the basic operations over lists on the previous slide.
- In the private section of the class we will:
  - define an array of double to store the elements in the list.
  - define a count variable that keeps track of how many elements are currently in the list.

NumberList class declaration

NumberList.h

```
class NumberList
{
   private:
      static const int SIZE = 100;
      double array[SIZE];
      int count;

   public:
      NumberList();  // creates an empty list
//   ~NumberList();  // not needed, no dynamic allocation

      void appendNode(double);
      void insertNode(double);
      void deleteNode(double);
      void displayList();
};
```

- This has the same public interface as it does when using linked lists.

Operation:
Create the empty list

- Constructor: sets up empty list

NumberList.cpp

```
#include "NumberList.h"


NumberList::NumberList()
{
   count = 0;
}
```

Operation:
append value to end of list

- appendNode: adds new value to end of list
- Algorithm: Make sure the list isn't full.
  Put new element in array at position count.
  Increment count.

in NumberList.cpp

```
void NumberList::appendNode(double num) {
    if (count < SIZE) {
        array[count] = num;
        count++;
    } else
        cout << "Error: cannot append value, list is full"
             << endl;
        //maybe we should add isFull/isEmpty?
}
```

Operation: **display** the list

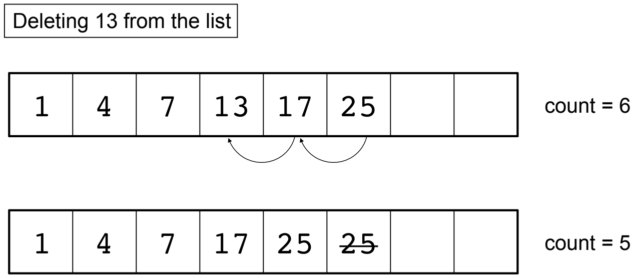
- Use a for loop
- Stop at count, not SIZE

in NumberList.cpp

```
void NumberList::displayList() {

    for (int i=0; i<count; i++) {
        cout << array[i] << " ";
    }
    cout << endl;

}
```

Operation: **delete** a node from the list

- deleteNode: removes a given value from list
- We need to shift elements over to fill the gap.



Deleting 13 from the list

1	4	7	13	17	25			count = 6
1	4	7	17	25	~~25~~			count = 5

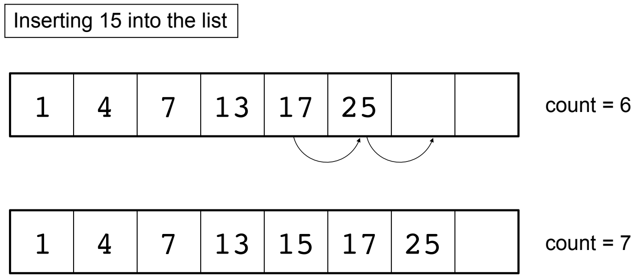
deleteNode code

in NumberList.cpp

```
void NumberList::deleteNode(double num) {

    int i=0;
    while (i<count && array[i]!=num) {
        i++;
    }

    if (i<count) {  //found at i
        count--;

        //shift left to close gap
        while (i<count) {
            array[i] = array[i+1];
            i++;
        }
    }
}
```

Operation: **insert** a value into a list

- Inserts a new value into the middle of a list.
- We'll assume the list is sorted, and insert before first number greater than this value.
- We need to shift elements over to produce a gap.



Inserting 15 into the list

1	4	7	13	17	25			count = 6
1	4	7	13	15	17	25		count = 7

insertNode code

in NumberList.cpp

```
void NumberList::insertNode(double num) {

    //keep the list sorted
    int i=0;
    while (i<count && array[i]<num) {
        i++;
    }

    count++;

    //shift right to open up a spot in the array
    int j= count-1;
    while (j>i) {
        array[j]=array[j-1];
        j--;
    }
    array[i] = num;
}
```

Driver to demo NumberList

in ListDriver.cpp

```
int main() {

   // set up the list
   NumberList list;
   list.appendNode(2.5);
   list.appendNode(7.9);
   list.appendNode(12.6);
   list.displayList();

   list.insertNode (8.5);
   list.displayList();

   list.insertNode (1.5);
   list.displayList();

   list.insertNode (21.5);
   list.displayList();

//continued on next slide
```

This is the same Driver we used for the Linked List-based NumberList. We should confirm that we get the same exact output for this array-based implementation.

```
Output:
2.5   7.9   12.6
2.5   7.9   8.5   12.6
1.5   2.5   7.9   8.5   12.6
1.5   2.5   7.9   8.5   12.6   21.5
```

Driver to demo NumberList

in ListDriver.cpp

```
    cout << "remove 7.9:" << endl;
    list.deleteNode(7.9);
    list.displayList();

    cout << "remove 8.9: " << endl;
    list.deleteNode(8.9);
    list.displayList();

    cout << "remove 2.5: " << endl;
    list.deleteNode(2.5);
    list.displayList();

    cout <<"remove 12.6: " << endl;
    list.deleteNode(12.6);
    list.displayList();
}
```

```
remove 7.9:
1.5 2.5 8.5 12.6 21.5

remove 8.9:
1.5 2.5 8.5 12.6 21.5

remove 2.5:
1.5 8.5 12.6 21.5

remove 12.6:
1.5 8.5 21.5
```

linked lists vs arrays: space issues

- Linked list is never full (if there’s more memory)
  - For arrays we need to predict the largest possible size.
- The amount of memory used to store the linked list version is always proportional to the number of elements in the list (it grows+shrinks)
  - For arrays, the amount of memory used is often much more than is required by the actual elements in the list.
- Arrays do not require extra storage for links
  - linked lists are impractical for lists of characters or booleans (pointer value is bigger than data value).

linked lists vs arrays: time issues

- When a value is inserted into or deleted from a linked list, none of the other nodes have to be moved.
  - Array elements must be shifted to make room or close a gap.

- Arrays allow random access to elements: array[i]
  - for arrays this is pointer arithmetic
  - linked lists must be traversed to get to i’th element.