CMPSC 24: Lecture 5
Abstract Data Type: Lists

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Announcements

- Programming Assignment 1:
  - Due Friday April 16, 2010
- CMPSC 24 HelpDesk:
  - Sunday through Thursday: 7PM-9PM
  - Send mail to cs24@cs
  - One of the TAs will be on-call to answer queries
  - Intended primarily for debugging help
- HelpDesk versus Office Hours:
  - discuss

LINKED LISTS C++ CLASS: PUTTING IT TOGETHER

Example linkedlist.h

```
#include <iostream>     // compiler directives
using namespace std;   // compile directives
Class linkedlist{
      private:
         struct node{
            int data;
            node *link;
         } *list;
      public:
        linkedlist();                    // Constructor
        void append( int num );  // append a node with "num"
        void delete( int num );    // delete the node containing "num"
        bool find( int num );       // TRUE if "num" exists in the list
        ~linkledist();                  // Destructor (to ensure no memory leak)
};
```


Skeleton of linkedlist.cpp

```
linkedlist::linkedlist()
{
      p=NULL;
}

void linkedlist::append(int num)
{
    // the code we developed goes in here
    .
    .
}

void linkedlist::delete(int num)
{
      // the code we developed goes in here
}
```


Skeleton of linkedlist.cpp

```
bool linkedlist::find(int num)
{
      // the code we developed goes in here
      .
      .
}

Linkedlist::~linkedlist()
{
      // ask the students what should happen here?
      .
      .
}
```

Usage of linkedlist Class

```
int main()
{
    linkedlist myList;

    myList.append(35);
    myList.append(45);
    myList.append(37);
    if myList.find(36) cout<<"36 on the list????"<endl;
    else cout<<"36 not on the list!!!"<<endl;

    // you should get the idea…
    // would it be nice to have myList.display() ??? Left as an exercise!!!
}
```


Recap

- Abstract Data Types
  - Specification (What?)
  - Implementation (How?)

LIST ADT

Sorted and Unsorted List ADTs

UNSORTED LIST

Elements are placed into the list in no particular order.

SORTED LIST

List elements are in a sorted order---either numerically or alphabetically by the elements themselves, or by a component of the element (called a KEY member).

Name some possible keys

ADT Unsorted List

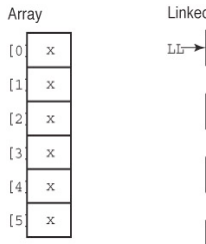
- **Transformers**
  - MakeEmpty
  - InsertItem
  - DeleteItem
- **Observers**
  - IsFull
  - GetLength
  - RetrieveItem
- **Iterators**
  - ResetList
  - GetNextItem

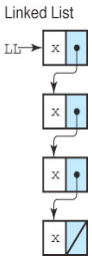
change state

observe state

process all

ADT Unsorted List





Two implementations

Common vocabulary

location accesses a particular element
Node(location) is all data of element
Info(location) is the user's data at location
Info(last) is the user's data at the last location
Next(location) is the node following Node(location)

Specification

```
// SPECIFICATION FILE      ( unsortedType.h )
#include "ItemType.h"

class  UnsortedType     // declares a class data type
{
public :            // 8 public member functions
  UnsortedType();
  void MakeEmpty( );
  bool IsFull( ) const;
  int  GetLength( ) const;  // returns length of list
  void RetrieveItem( ItemType&  item, bool&  found );
  void InsertItem( ItemType  item );
  void DeleteItem( ItemType  item );
  void ResetList( );
  void GetNextItem( ItemType&  item );
}
```

What is ItemType?

Public declarations are the same for both implementations; only private data changes

Generic Data Type

- A type for which the operations are defined but the types of the items being manipulated are not defined
- *How can we make the items on the list generic?*
- List items are of class `ItemType`, which has a `ComparedTo` function that returns (`LESS`, `GREATER`, `EQUAL`)

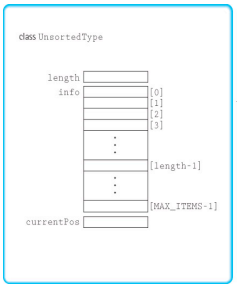
Array-Based Implementation

Private data members for array-based implementation

```
private
  int length;
  ItemType info[MAX_ITEMS];
  int currentPos;
};
```

Where does MAX_ITEMS come from?

Array-Based Implementation



Array-based implementation

Notice the difference between the array and the list stored in the array

Constructor

A special member function of a class that is implicitly invoked when a class object is defined

What should the constructor do?

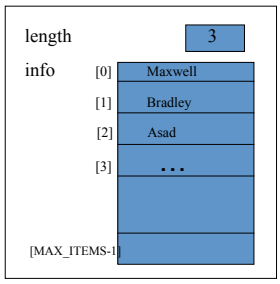
```
UnsortedType::UnsortedType()
{
 length = 0;
}
```


Checking for full and empty lists

- *What is a full list? An empty list?*

```
bool UnsortedType::IsFull()
  {
   return (length == MAX_ITEMS);
  }
bool UnsortedType::IsEmpty()
  {
   return (length == 0);
  }
```

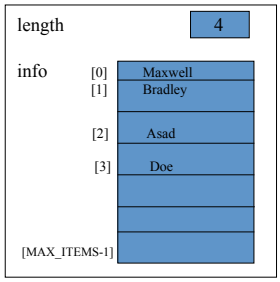
Insert



insert("Doe");

If the list is unsorted, where should the next element go ?

Insert



insert("Doe");

That was easy! Can you code it ?

Insert

```
void UnsortedType::InsertItem(ItemType
item)
// Post: item is in the list.
{
  info[length] = item;
  length++;
}
```

RetrieveItem

How would you go about finding an item in the list?

Cycle through the list looking for the item

What are the two ending cases?

The item is found

The item is not in the list

How do we compare items?

We use function ComparedTo in class ItemType

Pseudocode for RetrieveItem

```
Initialize location to position of first item
Set found to false
Set moreToSearch to (have not examined Info(last))
while moreToSearch AND NOT found
    if (item.ComparedTo(Info(location))) == EQUAL)
      { Set found to true
        Set item to Info(location)
      }
      else
      { Set location to Next(location)
        Set moreToSearch to (have not examined Info(last))
      }
```

Replace bold general statements with array-based code

C++ code for RetrieveItem

```
void UnsortedType::RetrieveItem(ItemType& item, bool& found)
// Pre:  Key member(s) of item is initialized.
// Post: If found, item's key matches an element's key in the
//       list and a copy of that element has been stored in item;
//       otherwise, item is unchanged.
{ bool moreToSearch;
  int location = 0;
  found = false;
  moreToSearch = (location < length);
  while (moreToSearch && !found){
    if (item.ComparedTo(info[location]) == EQUAL){
      found = true;
      item = info[location];}
    else {
      location++;
      moreToSearch = (location < length);
    }
  }
}
```

C++ code for RetrieveItem

```
void UnsortedType::RetrieveItem(ItemType& item, bool& found)
// Pre:  Key member(s) of item is initialized.
// Post: If found, item's key matches an element's key in the
//       list and a copy of that element has been stored in item;
//       otherwise, item is unchanged.
{
  bool moreToSearch;
  int location = 0;
  found = false;
  moreToSearch = (location < length);
  while (moreToSearch && !found)
  {
    if (item.ComparedTo(info[location]) == EQUAL)
    {found = true;
     item = info[location];
    }
    else
    { location++;
      moreToSearch = (location < length);
    }
  }
}
```

Loop invariant:
(location <= length) **and**
moreToSearch == (location < length) **and**
(!found → (ItemType.key **not in** Info [0..location-1])) **and**
found → ItemType.key == Info[location].key

Delete

How do you delete an item?

First you find the item

Yes, but how do you delete it?

Move those below it up one slot, or

Replace it with another item

What other item?

How about the item at info[length-1]?

C++ code for delete

```
void UnsortedType::DeleteItem ( ItemType  item )
// Pre: item's key has been inititalized.
//   An element in the list has a key that matches item's.
// Post: No element in the list has a key that matches item's.
{
  int  location  =  0 ;
  while (item.ComparedTo (info[location])  !=  EQUAL)
    location++;
  // move last element into position where item was located
  info [location] = info [length - 1 ] ;
  length-- ;
}
```

Why don't we have to check for end of list?

C++ code for delete

```
void UnsortedType::DeleteItem ( ItemType  item )
// Pre: item's key has been initialized.
//   An element in the list has a key that matches item's.
// Post: No element in the list has a key that matches item's.
{
  int  location  =  0 ;
  while (item.ComparedTo (info[location])  !=  EQUAL)
    location++;
  // move last element into position where item was located
  info [location] = info [length - 1 ] ;
  length-- ;
}
```

Loop invariant:
(location < length) **and**
(item.key **in** Info[location..length-1])

Why don't we have to check for end of list?

PrintList

```
void PrintList(ofstream& dataFile, UnsortedType list)
// Pre:  list has been initialized.
//       dataFile is open for writing.
// Post: Each component in list has been written.
//       dataFile is still open.
{
  int length;
  ItemType item;

  list.ResetList();
  length = list.GetLength();
  for (int counter = 1; counter <= length; counter++)
  {
    list.GetNextItem(item);
    item.Print(dataFile);
  }
}
```

How do ResetList and GetNextItem work?

ResetList and GetNextItem

```
void UnsortedType::ResetList ( )
// Pre:  List has been initialized.
// Post: Current position is prior to first element.
{
  currentPos  =  -1 ;
}
void UnsortedType::GetNextItem ( ItemType&  item )
// Pre:  List has been initialized. Current position is
//   defined.
//       Element at current position is not last in list.
// Post: Current position is updated to next position.
//       item is a copy of element at current position.
{
  currentPos++  ;
  item = info [currentPos] ;
}
```

Class **ItemType**

```
//  SPECIFICATION FILE itemtype.h

const int  MAX_ITEM = 5;
enum  RelationType { LESS, EQUAL, GREATER };

class  ItemType       // declares class data type
{
  public :          // 3 public member functions
  RelationType ComparedTo( ItemType )  const;
  void Print( )  const;
  void Initialize( int  number );

  private :         // one private data member
    int value;        // could be any type
} ;
```


Class ItemType

```
//  IMPLEMENTATION FILE ( itemtype.cpp )
//  Implementation depends on the  data type of value.

#include "itemtype.h"
#include <iostream>

RelationType ComparedTo( ItemType  otherItem ) const
{
  if ( value  <  otherItem.value )
    return  LESS;
  else if ( value  > otherItem.value )
    return  GREATER;
  else  return  EQUAL;
}
void Print( ) const
{
  using namespace std;
  cout  <<  value  <<  endl;
}
void Initialize( int number )
{
  value  =  number;
}
```

How would this class change if the items on the list were strings rather than integers?

UML Diagram