Program Design

Garrett Wells
CS121
3-4-19

Bank Simulation Application File:

This takes an input bank file of the format:

Entry Time   Name   Activity   Transactions

The program then uses the data in the file to calculate how long the customers in the bank are in the bank and in what order they finish their transactions.

Return Type	Name	Function Description
int	main(void)	Takes in an input file of customers, runs a simulation using the data, then prints the results
void	printOutput()	Prints the results of the simulation calculations
bool	linesEmpty(Queue line1, Queue line2, Queue line3)	Returns true if all the lines are empty
void	printCustomer(Node customer, int exitTime)	Prints the information for a customer leaving the bank, including exit time
void	AddToLine(Node customer)	Adds a customer to the end of the shortest line
void	PrintLines()	Prints the customers currently in the bank and what line they are in
void	runTests()	Prints test results of LinkedList and Queue

Tester Class:

Tests the implementation of Queue and LinkedList classes.

Return Type	*Name*	*Function Description*
(Constructor)	Tester()	Runs and prints the results from testing the queue and linked list implementation
int	testLinkedList()	Tests the various add, remove, and print functions of LinkedList

int	testQueue()	Tests Enqueue() and Dequeue() functions of Queue class

LinkedList Class:

Return Type	**Name**	**Function Description**
(Constructor)	LinkedList()	Creates a new, empty Linked List object.
void	AddToEnd(string name, char line, int num)	Creates a new Node and adds it to the end of the Linked List
void	AddToFront(string name, char line, int num)	Creates a new Node and adds it to the front of the Linked List
Node	RemoveFromFront()	Removes a node from the front of the Linked List and returns the name of the customer
Node	RemoveFromBack()	Removes a node from the back of the Linked List and returns the name of the customer
Node	Peek()	Returns a pointer to the Node at the front of the line
int	getSize()	Returns how many Nodes are in the list
void	Print()	Prints the Nodes in the list

Queue Class:

Return Type	Name	Function Description
(Constructor)	Queue()	Creates a new, empty Queue object
void	Enqueue(string name, char line, int num)	Adds a new customer to the end of the Queue
Node	Remove()	Remove a customer from the end of the line and return their name
Node	Dequeue()	Remove a customer from the front of the Queue and return their name
int	getSize()	Returns the number of customers in line
void	Print()	Prints the contents of the Queue

Programming Log:

2-27-19

1hr – Created program design and implemented LinkedList and Queue classes

2-28-19

2hr – Refined program design and rewrote LinkedList and Queue implementation. Also wrote code for Tester Class and debugged LinkedList and Queue.

3-1-19

0.75hr – Began implementing Bank Simulation.

3-2-19

4hrs – Finished debugging logical errors and formatting program output

Estimated Time to Complete = 6hrs

Total Required Time = 8hrs

```
/*

  Application File for Bank
  @author: Garrett Wells
  @date: 3-4-19

*/

#include "queue.cpp"
#include "tester.cpp"
#include <fstream>

bool linesEmpty(Queue line1, Queue line2, Queue line3);
void printCustomer(Node customer, int exitTime);
void AddToLine(Node nextUp);
void runTests(void);
void PrintLines(void);

Queue expressLine;
Queue line2;
Queue line3;
Queue waiting;

int main(void){
  // Run Tests
  //runTests();

  //Run Bank Simulation
  // temporary variables to hold data
  int entryTime;
  string customerName;
  char transactionType;
  int numTrans;

  // Read from file --------------------------------
  ifstream input("/Users/garrettwells/Documents/2018-
19_UofI/2nd_Semester/CS121/Projects/Project#3/bank1.dat");
  while(!input.eof() && input.is_open()){
    for(int i = 0; i < 4; i++){
      if(i == 0)
        input >> entryTime;
      if(i == 1)
        input >> customerName;
      if(i == 2)
        input >> transactionType;
      if(i == 3)
        input >> numTrans;

    }
    waiting.Enqueue(entryTime, customerName, transactionType, numTrans);
  }

  input.close();


  // Banking Loop -----------------------------------
  int clk = 0;
  int expressLineStart = 0;
  int line2Start = 0;
  int line3Start = 0;
  while((waiting.getSize() > 0) || !linesEmpty(expressLine, line2, line3)){

    bool someLineEmpty = expressLine.getSize() == 0 || line2.getSize() == 0
                         || line3.getSize() == 0;
    bool someLineExcess = (expressLine.getSize() > 1) || (line2.getSize() > 1)
                          || (line3.getSize() > 1);

    // If there is an empty line, and there is some line with more than 1 node, then
transfer a node from the longest line to the shortest
    while(someLineEmpty && someLineExcess){

      bool line2IsLongest = (line2.getSize() > line3.getSize())
                            && (line3.getSize() > expressLine.getSize());
      bool line3IsLongest = ((line3.getSize() > line2.getSize())
                            && (line3.getSize() > expressLine.getSize()));
      bool expressIsLongest = !line2IsLongest && !line3IsLongest;

      bool line2Shortest = (line2.getSize() < line3.getSize())
                           && (line2.getSize() < expressLine.getSize());
      bool line3Shortest = (line3.getSize() < line2.getSize())
                           && (line3.getSize() < expressLine.getSize());
      bool expressShortest = !line2Shortest && !line3Shortest;

      // Get the node to transfer to the empty line
      // Check if shortest line is express, if it is we need to put some restrictions
on the transfer
      if(expressShortest) {
        // Add the node to the empty line

        Node temp;
        if(line2IsLongest){
          temp = line2.Remove();

        }else if(line3IsLongest){
          temp = line3.Remove();

        }else {
          temp = expressLine.Remove();

        }

        bool validTrans = ((temp.transactionType == 'C')
                          || (temp.transactionType == 'D'));

        if(validTrans){
          // Add the node
          AddToLine(temp);

        }else{ // Look for another possible transfer
          /*If second longest line has more than 2 nodes and the node has valid
transaction - > transfer it*/
          // Move from second longest to express line
          if(line2IsLongest && (line3.getSize() > 1)){
            validTrans = (line3.Peek().transactionType == 'C')
                         || (line3.Peek().transactionType == 'D');
            if(validTrans) AddToLine(line3.Remove());

          }else if(line2.getSize() > 1){
```

```
        // Try line 2
        validTrans = (line2.Peek().transactionType == 'C')
                     || (line2.Peek().transactionType == 'D');
        if(validTrans) AddToLine(line2.Remove());

      }else{
        // No alternative transfer
        break;
      }
    }

  }else{
    // Add the node to whatever the shortest line is
    Node temp;
    if(line2IsLongest){
      temp = line2.Remove();

    }else if(line3IsLongest){
      temp = line3.Remove();

    }else {
      temp = expressLine.Remove();

    }
    AddToLine(temp);
  }


  someLineEmpty = expressLine.getSize() == 0 || line2.getSize() == 0
                  || line3.getSize() == 0;
  someLineExcess = (expressLine.getSize() > 1) || (line2.getSize() > 1)
                   || (line3.getSize() > 1);

}

// Add new customer to line
if(waiting.getSize() > 0){
  Node first = waiting.Peek();

  if(first.entryTime == clk) {

    while (first.entryTime == clk) {
      cout << "-------------------------------------"
           << "\n"
           << "| Adding New Customer to Line: " << waiting.Peek().name
           << " |\n" << endl
           << "-------------------------------------" << endl << endl;

      AddToLine(waiting.Dequeue());


      if(waiting.getSize() > 0) {
        first = waiting.Peek();
      }else break;
    }
  }

}
```

```
    // Check for the customers who have completed their transactions
    // Remove the customers who are done
    // Print their information
    if(linesEmpty(expressLine, line2, line3)){clk++; continue;}

    if(expressLine.getSize() > 0){
      Node expressLineFront = expressLine.Peek();

      bool transactionsCompleted = (expressLineFront.entryTime
                                    + (expressLineFront.transactions * 2) == clk);

      if(transactionsCompleted) {
        expressLineFront = expressLine.Dequeue();
        printCustomer(expressLineFront, clk);
      }
    }

    if(line2.getSize() > 0){
      Node line2Front = line2.Peek();

      bool transactionsCompleted = (line2Front.entryTime
                                    + (line2Front.transactions * 4) == clk);

      if(transactionsCompleted){
        line2Front = line2.Dequeue();
        printCustomer(line2Front, clk);
      }
    }

    if(line3.getSize() > 0){
      Node line3Front = line3.Peek();

      bool transactionsCompleted = (line3Front.entryTime
                                    + (line3Front.transactions * 4) == clk);

      if(transactionsCompleted){
        line3Front = line3.Dequeue();
        printCustomer(line3Front, clk);
      }
    }

    clk+=1;
  }
}

// Run Tests
void runTests(void){
  Tester a;
}

// Check if lines are empty and returns true if all customers have finished their
transactions
bool linesEmpty(Queue line1, Queue line2, Queue line3){
  return ((line1.getSize() == 0) && (line2.getSize() == 0) && (line3.getSize() == 0));
}

// Print data stored by the customer
void printCustomer(Node customer, int exitTime){
  cout << "          |---------- Customer Leaving ----------" << endl
       << "          |Name: " << customer.name << endl
       << "          |Entry Time: " << customer.entryTime << endl
       << "          |Transaction Type: " << customer.transactionType << endl
       << "          |Number of Transactions: " << customer.transactions << endl
       << "          |Exit Time: " << exitTime << endl
       << "          |--------------------------------------" << endl << endl;
}

// Print Lines
void PrintLines(void){
  cout << "--------- Express Line: -----------" << endl;
  expressLine.Print();

  cout << "----------- Line 2: ----------" << endl;
  line2.Print();

  cout << "----------- Line 3: ----------" << endl;
  line3.Print();

}

// Find shortest line to add Node to
void AddToLine(Node nextUp){

  int expressLength = expressLine.getSize();
  int line2Length = line2.getSize();
  int line3Length = line3.getSize();

  bool expressShortest = (expressLength <= line2Length)
                         && (expressLength <= line3Length);
  bool expressEligible = (nextUp.transactionType == 'C'
                         || nextUp.transactionType == 'D');

  if(expressEligible && expressShortest) {
    // Add node to expressLine
    expressLine.Enqueue(nextUp.entryTime, nextUp.name, nextUp.transactionType,
nextUp.transactions);

  }else if((line2Length < line3Length)){
    // Add node to line2
    line2.Enqueue(nextUp.entryTime, nextUp.name, nextUp.transactionType,
nextUp.transactions);

  }else{
    // Add node to line3
    line3.Enqueue(nextUp.entryTime, nextUp.name, nextUp.transactionType,
nextUp.transactions);

  }
}
```

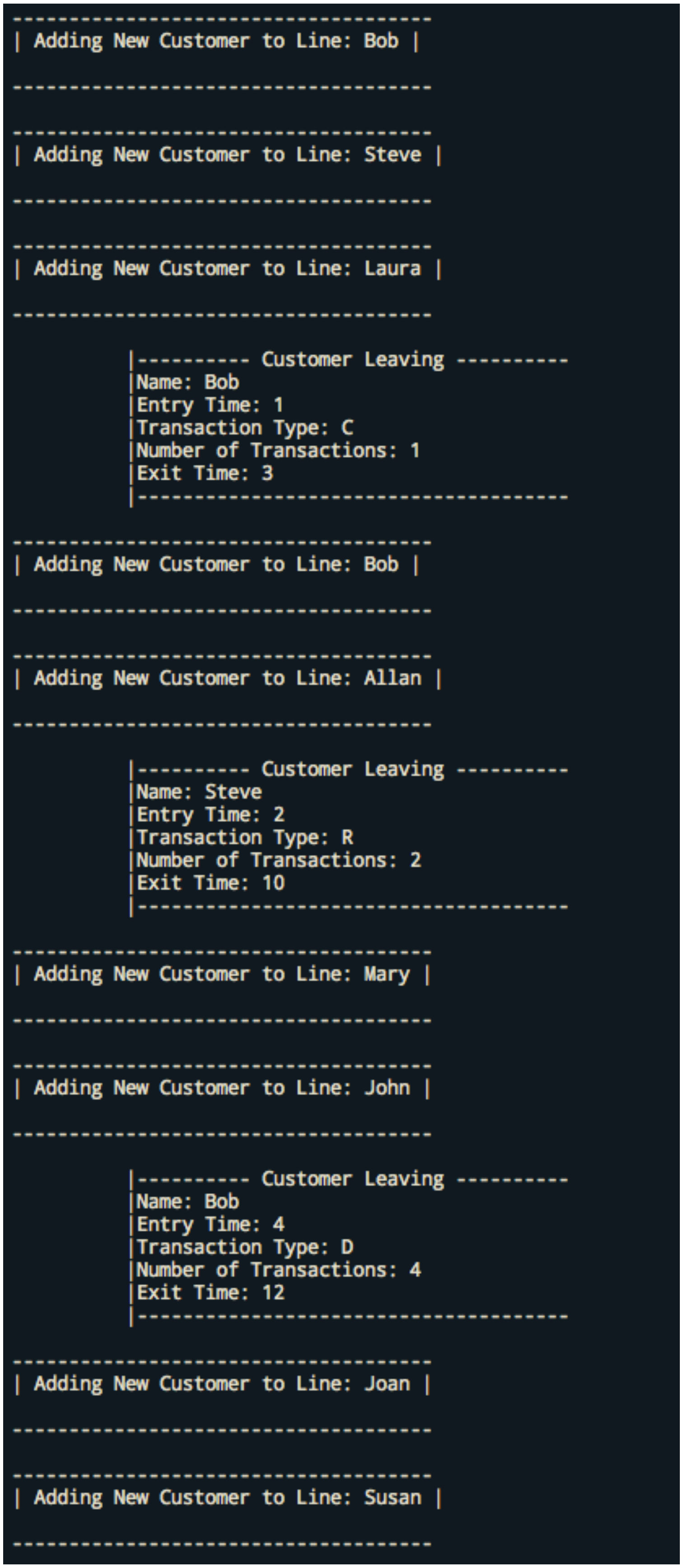
```
/*

  Interface for Queue
  @author: Garrett Wells
  @date: 3-1-19

*/

#ifndef QUEUE_H
#define QUEUE_H

#include "linkedlist.cpp"

class Queue{
private:
    LinkedList list;

public:
  Queue(void); // Create new queue

  // Add customer to queue end of queue
  void Enqueue(int entryTime, string name, char transactionType, int numTransactions);

  Node Remove(void); // Remove the customer at the end of the queue
  Node Dequeue(void); // Remove the customer at the front of the queue

  Node Peek(void); // Return a pointer to the Node at the front of the queue
  int getSize(void); // Return the number of Nodes in the list
  void Print(void); // Print details of all nodes in the list
};

#endif
```

```
/*

  Implementation file for queue
  @author: Garrett Wells
  @date: 3-2-19

*/

#include "queue.h"

// Create new queue
Queue::Queue(void){
}

// Add customer to queue
void Queue::Enqueue(int entryTime, string name, char transactionType,
                    int numTransactions){

  list.AddToEnd(entryTime, name, transactionType, numTransactions);

}

// Remove the customer at the end of the queue
Node Queue::Remove(void){
  return list.RemoveFromBack();
}

 // Remove the customer at the front of the queue
Node Queue::Dequeue(void){
  return list.RemoveFromFront();
}

// Return the number of Nodes in the list
int Queue::getSize(void) {
  return list.getSize();
}

// Call LinkedList.Print()
void Queue::Print(void){
  if(list.getSize() != 0){
    list.Print();
  }
}

// Return the first node in the line
Node Queue::Peek(void) {
    return list.Peek();
}
```

```
/*

   Linked List Interface file
   @author: Garrett Wells
   @date: 3-4-19

*/

#ifndef LINKEDLIST_H
#define LINKEDLIST_H

#include <string>
#include <iostream>
using namespace std;

//----------

struct Node{
  string name; // Name of the customer
  int transactions; // Number of transactions the customer is conducting
  char transactionType; // Checking, Deposit, New Account, Reconcile Account
  int entryTime; // Entry time of customer
  struct Node* next; // Pointer to the next node in the list
};

typedef struct Node Node;
typedef Node* Nodeptr;

//----------

class LinkedList{
private:
  Nodeptr head; // First Node in the list
  int size; // Number of elements in the list

public:
  LinkedList(void); // Creates new empty list

  void AddToEnd(int entryTime, string name, char transactionType, int
numTransactions); // Adds node to end of list
  void AddToFront(int entryTime, string name, char transactionType, int
numTransactions); // Adds node to front of list

  Node RemoveFromFront(void); // Remove the node from the front, return name
  Node RemoveFromBack(void); // Remove the node from the back and return name

  void Print(void); // Print contents of list
  Node Peek(void); // Return a pointer to the first Node in the list
  int getSize(void); // Return the number of Nodes in the list
};

#endif
```

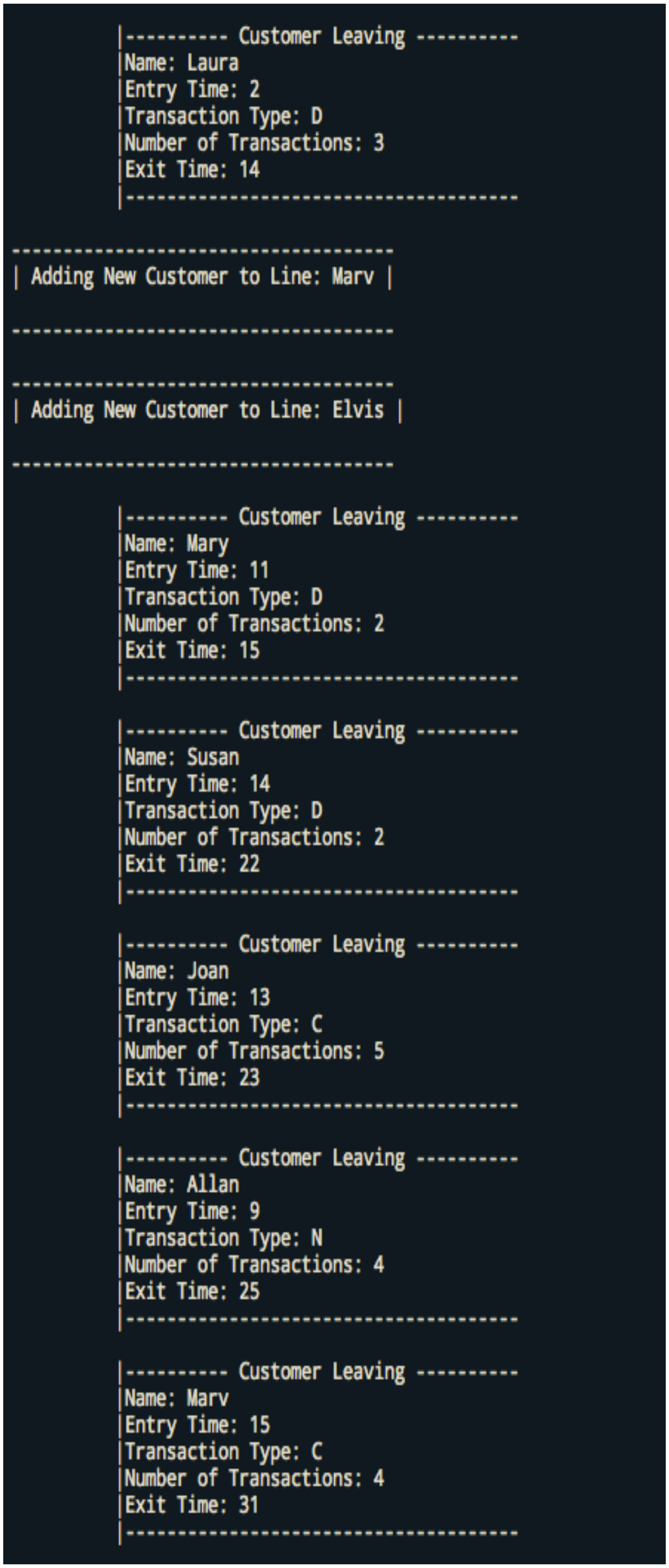
```
/*

  Implementation file for LinkedList
  @author: Garrett Wells
  @date: 2-24-19

*/

#include "linkedlist.h"

 // Creates new empty list
LinkedList::LinkedList(void){
  head = NULL;
  size = 0;
}

// Adds node to end of list
void LinkedList::AddToEnd(int entryTime, string name, char transactionType,
                 int numTransactions)
{

  Nodeptr ptr = new Node();
  ptr->entryTime = entryTime;
  ptr->name = name;
  ptr->transactions = numTransactions;
  ptr->transactionType = transactionType;
  ptr->next = NULL;

  if(head == NULL){
    head = ptr;
  }else{
    Nodeptr itr = head;

    while(itr->next != NULL){
      itr = itr->next;
    }

    itr->next = ptr;
  }

  size++;
}

// Adds node to front of list
void LinkedList::AddToFront(int entryTime, string name, char transactionType,
                 int numTransactions)
{
  Nodeptr ptr = new Node();
  ptr->entryTime = entryTime;
  ptr->name = name;
  ptr->transactions = numTransactions;
  ptr->transactionType = transactionType;
  ptr->next = NULL;

  if(head == NULL){
    head = ptr;
  }else{
    ptr->next = head;
    head = ptr;
  }
  size++;
}

// Remove the node from the front, return name
Node LinkedList::RemoveFromFront(void){
  if(head != NULL){
    Nodeptr ptr = head;
    head = head->next;

    Node temp = *ptr; // Save value in the Node
    delete ptr; // Delete the Node pointer

    size--;

    return temp;

  }else{
    size = 0;
    cout << "[ERROR]: empty list" << endl;
    return *head;
  }
}

// Remove the node from the back and return name
Node LinkedList::RemoveFromBack(void){
  if(head != NULL){
    // Traverse list and return last Node
    Nodeptr ptr = head;
    Nodeptr itr = head;

    while(ptr->next != NULL){
      itr = ptr;
      ptr = ptr->next;
    }

    Node temp = *ptr; // Save values stored by last Node
    delete ptr; // Delete the Node
    itr->next = NULL; // Break link

    size--;

    return temp;

  }else{
    size = 0;
    cout << "[ERROR]: empty list" << endl;
    return *head;
  }
}

// Returns head
Node LinkedList::Peek(void){
  return *head;
}

// Returns the number of Nodes in the list
int LinkedList::getSize(void){
  return size;
}

void LinkedList::Print(void){
  if(head != NULL){
    Nodeptr itr = head;

    while(itr->next != NULL){
      cout << itr->name << endl
           << "Entry Time: " << itr->entryTime << endl
           << "Transactions: " << itr->transactions << endl
           << "Transaction Type: " << itr->transactionType << endl;

      itr = itr->next;
    }

    cout << itr->name << endl
         << "Entry Time: " << itr->entryTime << endl
         << "Transactions: " << itr->transactions << endl
         << "Transaction Type: " << itr->transactionType << endl;

  }else{
    cout << "\n";
  }
}
```

```
/*

    Tester Interface and Implementation file
    @author: Garrett Wells
    @date: 3-4-19

*/

#ifndef TESTER_H
#define TESTER_H

class Tester{
private:
  int numTestsPassed;
  int numTests;

public:
  Tester(void);

  int testQueue(void);
  int testLinkedList(void);
};

Tester::Tester(void){
  numTests = 3;
  numTestsPassed = 0;

  numTestsPassed += testLinkedList();
  numTestsPassed += testQueue();
  numTestsPassed += testBankSim();

  std:cout << "----- Test Results -----" << endl
           << "Tests Passsed: " << numTestsPassed << "/" << numTests << endl;
}

int Tester::testLinkedList(void){
  LinkedList list;

  list.AddToEnd(1, "adam", 'C', 2);
  list.AddToEnd(2, "barry", 'D', 1);
  list.AddToEnd(3, "calum", 'N', 3);

  list.Print();

  Node temp;

  temp = list.RemoveFromFront();
  if(temp.name != "adam")
  {
    return 0;
  }

  temp = list.RemoveFromBack();
  if(temp.name != "calum")
  {
    return 0;
  }

  temp = list.RemoveFromFront();
  if(temp.name != "barry")
  {
    return 0;
  }

  return 1;
}

int Tester::testQueue(void){
  // Create new Queue of customers and remove them and print their data
  Node ptr;
  Queue line;

  line.Enqueue(1, "adam", 'C', 2);
  line.Enqueue(2, "barry", 'D', 1);
  line.Enqueue(3, "calum", 'N', 3);

  cout << "---------- Printing Queue ----------" << endl;
  // Print Queue contents
  line.Print();

  cout << "---------- Dequeueing Contents ----------" << endl;
  // Dequeue contents and print in order
  ptr = line.Dequeue();
  if(ptr.name != "adam"){return 0;}

  ptr = line.Dequeue();
  if(ptr.name != "barry"){return 0;}

  ptr = line.Dequeue();
  if(ptr.name != "calum"){return 0;}

  cout << "---------- Dequeueing Successful ----------" << endl;

  return 1;
}

#endif
```



```
-------------------------------------
| Adding New Customer to Line: Bob |

-------------------------------------

-------------------------------------
| Adding New Customer to Line: Steve |

-------------------------------------

-------------------------------------
| Adding New Customer to Line: Laura |

-------------------------------------

          |---------- Customer Leaving ----------
          |Name: Bob
          |Entry Time: 1
          |Transaction Type: C
          |Number of Transactions: 1
          |Exit Time: 3
          |--------------------------------------

-------------------------------------
| Adding New Customer to Line: Bob |

-------------------------------------

-------------------------------------
| Adding New Customer to Line: Allan |

-------------------------------------

          |---------- Customer Leaving ----------
          |Name: Steve
          |Entry Time: 2
          |Transaction Type: R
          |Number of Transactions: 2
          |Exit Time: 10
          |--------------------------------------

-------------------------------------
| Adding New Customer to Line: Mary |

-------------------------------------

-------------------------------------
| Adding New Customer to Line: John |

-------------------------------------

          |---------- Customer Leaving ----------
          |Name: Bob
          |Entry Time: 4
          |Transaction Type: D
          |Number of Transactions: 4
          |Exit Time: 12
          |--------------------------------------

-------------------------------------
| Adding New Customer to Line: Joan |

-------------------------------------

-------------------------------------
| Adding New Customer to Line: Susan |

-------------------------------------
```

Program Output



```
          |---------- Customer Leaving ----------
          |Name: Laura
          |Entry Time: 2
          |Transaction Type: D
          |Number of Transactions: 3
          |Exit Time: 14
          |--------------------------------------

-------------------------------------
| Adding New Customer to Line: Marv |

-------------------------------------

-------------------------------------
| Adding New Customer to Line: Elvis |

-------------------------------------

          |---------- Customer Leaving ----------
          |Name: Mary
          |Entry Time: 11
          |Transaction Type: D
          |Number of Transactions: 2
          |Exit Time: 15
          |--------------------------------------

          |---------- Customer Leaving ----------
          |Name: Susan
          |Entry Time: 14
          |Transaction Type: D
          |Number of Transactions: 2
          |Exit Time: 22
          |--------------------------------------

          |---------- Customer Leaving ----------
          |Name: Joan
          |Entry Time: 13
          |Transaction Type: C
          |Number of Transactions: 5
          |Exit Time: 23
          |--------------------------------------

          |---------- Customer Leaving ----------
          |Name: Allan
          |Entry Time: 9
          |Transaction Type: N
          |Number of Transactions: 4
          |Exit Time: 25
          |--------------------------------------

          |---------- Customer Leaving ----------
          |Name: Marv
          |Entry Time: 15
          |Transaction Type: C
          |Number of Transactions: 4
          |Exit Time: 31
          |--------------------------------------
```