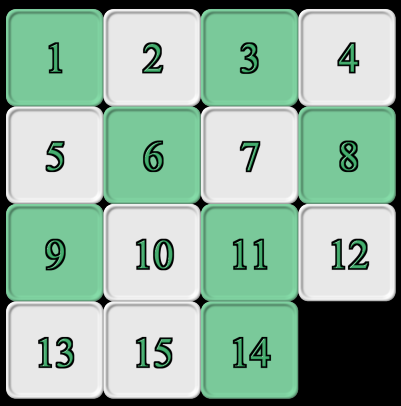
CS302

Assignment 1: 15 Puzzle



Description

For this assignment, you will implement a game board in which the game 15 puzzle can be played. The following link allows you to get an idea of how the game is played http://lorecioni.github.io/fifteen-puzzle-game/. The idea of the game is you have a 4 x 4 grid with 15 tiles and one blank spot. Each tile is labeled with a number between 1 and 15. The a tile to the left, above, the right, and below can be moved to fill the gap which then creates a new gap based on which tile was moved. The goal is to get the tiles arranged from 1 - 15, such that the first row contains tiles 1-4, the second row contains tiles 5- 8, the third row contains tiles 9-12, and the last row contains tiles 13-15 and the bottom right spot contains the gap.

Of course we could use a a 2D array to implement a grid (or board), but to make things a bit more interesting we will use an array of linked lists to implement a 2D grid. Since it is a 15 puzzle, we will have an array of 4 linked lists and each linked list will have 4 nodes, each node will be labelled 0 - 15, where the number 0 represents the gap in the puzzle. The following header file must be implemented.

```
template <class Type>
class LL
{
  struct node
  {
    Type item;
    node * next;
    node * prev;
  };
public:
  class iterator
  {
  public:
    friend class LL;
    iterator();
    iterator(node*);
    Type operator*();
    iterator operator++(int);
    iterator operator--(int);
    bool operator==(const iterator&) const;
    bool operator!=(const iterator&) const;
  private:
    node * current;
  };

  LL();
  LL(const LL&);
  const LL& operator=(const LL&);
  ~LL();
  iterator begin() const;
  iterator end() const;
  void headRemove();
  void tailRemove();
  void removeNode(const iterator&);
  bool isEmpty() const;
  void headInsert(const Type&);
  void tailInsert(const Type&);
  void update(const iterator&, const Type&);
private:
  node * head;
  node * tail;
};
```

Each member of the iterator class contains/implements the following:

- `node * current` - a points to a node in the linked list
- `LL<Type>::iterator::iterator()` - default constructor that sets `current` to `NULL`
- `LL<Type>::iterator::iterator(node * pointer)` - constructor that assigns `current` with `pointer`
- `Type LL<Type>::iterator::operator*()` - returns the `item` field of the node that `current` points to
- `typename LL<Type>::iterator LL<Type>::iterator::operator++(int)` - moves the iterator object over to the next node in the linked list, i.e. sets `current` pointer over to the next node

- `typename LL<Type>::iterator LL<Type>::iterator::operator--(int)` - moves the iterator object over to the previous node in the linked list, i.e. sets `current` pointer over to the previous node
- `bool LL<Type>::iterator::operator==(const iterator& rhs) const` - returns `true` if `*this` iterator points to the same node as the `rhs` object, returns `false` otherwise
- `bool LL<Type>::iterator::operator!=(const iterator& rhs) const` - returns `false` if `*this` iterator points to the same node as the `rhs` object, returns `true` otherwise

For the `LL` class, you are implementing a doubly linked list, element of the list is of type `struct node` where each node contains some data in its `item` field and contains a pointer `next` to the node to the right and a pointer `prev` that points to the node to the left, the rest of the class contains/implements the following:

- `node * head` - pointer that points to the beginning of the linked list
- `node * tail` - pointer that points to the end of the linked list
- `LL<Type>::LL()` - default constructor that assigns `NULL` to both `head` and `tail`
- `LL<Type>::LL(const LL& copy)` - copy constructor, performs a deep copy of the `copy` object to the `*this` object
- `const LL<Type>& LL<Type>::operator=(const LL& rhs)` - assignment operator, performs a deep copy of the `rhs` object into the `*this` object (aka the left hand side object)
- `LL<Type>::~LL()` - destructor, deallocates the linked list
- `typename LL<Type>::iterator LL<Type>::begin() const` - returns an `iterator` object whose `current` pointer is assigned with the address in the `head` pointer
- `typename LL<Type>::iterator LL<Type>::end() const` - returns an `iterator` object whose `current` pointer is assigned with the address in the `tail` pointer
- `void LL<Type>::removeNode(const iterator& it)` - removes the node from the linked list that the `iterator` that is passed into the function is pointing to
- `void LL<Type>::headRemove()` - removes the front node
- `void LL<Type>::tailRemove()` - removes the end node
- `bool LL<Type>::isEmpty() const` - returns `true` if the list is empty and returns `false` if the list is not empty
- `void LL<Type>::headInsert(const Type& element)` - inserts a new node to the front of the linked list
- `void LL<Type>::tailInsert(const Type& element)` - inserts a new node to the end of the linked list
- `void LL<Type>::update(const LL<Type>::iterator& it, const Type& element)` - assigns the `item` field of the node that the `iterator` object points to with the element passed into the function

Contents of main

1. Ask the user for an input file, repeat this step as long as an invalid file is given
2. Once a valid file is given, read the contents of the file and build the linked list, the file contains 4 rows where each row contains 4 numbers separated by a space and each line is terminated with an end of line character
3. Output the puzzle (refer to the sample output for formatting)

4. Ask the user to make a move L for left, R for right, U for up, D for down, or Q for quit (the input will be a single character and your program should be case insensitive), repeat this step if invalid input given
5. If Q was read, quit the program
6. If L was read, find where the gap resides in the structure (the node that contains 0), and exchange its value with the node on the right (so we are moving the node to the right of the gap to the left), if the gap is on the rightmost position in the row then do nothing
7. If R was read, find where the gap resides in the structure (the node that contains 0), and exchange its value with the node on the left (so we are moving the node to the left of the gap to the right), if the gap is on the leftmost position in the row then do nothing
8. If U was read, find where the gap resides in the structure (the node that contains 0), and exchange its value with the node below (so we are moving the node below the gap up a level), if the gap is on the bottom row then do nothing
9. If D was read, find where the gap resides in the structure (the node that contains 0), and exchange its value with the node above (so we are moving the node above the gap down a level), if the gap is on the top row then do nothing
10. Output the puzzle after making a move
11. If the game is not over, i.e. user didn't complete the puzzle go back to step 4
12. If the game is over, output that the user won ask them if they wish to continue, they must enter Y or N (case insensitive), repeat this step if Y or N is not entered
13. If N was entered, terminate the program, if Y was entered go to step 1

Specifications

- Comment your code and your functions
- No global variables
- Make sure your program is memory leak free

Sample Run

A test input file is given that you can use linux redirection, this leads to a winning configuration that is shown in the second run

```
$ g++ main.cpp

$./a.out

Enter puzzle file: 15puzzle.txt
Enter puzzle file: board.txt
Enter puzzle file: scrambled.txt

  5   1   -   7
 11   3   8   2
 14  10  12  13
  4  15   9   6

Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit: u
```

```
  5   1   8   7
 11   3   -   2
 14  10  12  13
  4  15   9   6

Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit: r

  5   1   8   7
 11   -   3   2
 14  10  12  13
  4  15   9   6

Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit: r

  5   1   8   7
  -  11   3   2
 14  10  12  13
  4  15   9   6

Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit: r

  5   1   8   7
  -  11   3   2
 14  10  12  13
  4  15   9   6

Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit: r

  5   1   8   7
  -  11   3   2
 14  10  12  13
  4  15   9   6

Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit: d

  -   1   8   7
  5  11   3   2
 14  10  12  13
 4  15   9   6

Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit: d

  -   1   8   7
  5  11   3   2
 14  10  12  13
  4  15   9   6

Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit: f

Invalid selection!

Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit: g

Invalid selection!
```

```
Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit: v

Invalid selection!

Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit: q

Quitter...

-----------------------------------------------------------------
SECOND RUN (YOU DON'T HAVE TO OUTPUT THIS, THIS IS JUST FYI)
-----------------------------------------------------------------

$ ./a.out

Enter puzzle file: scrambled.txt

  5   1   -   7
 11   3   8   2
 14  10  12  13
  4  15   9   6

Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit:  u

  5   1   8   7
 11   3   -   2
 14  10  12  13
  4  15   9   6

Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit:  r

  5   1   8   7
 11   -   3   2
 14  10  12  13
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Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit:  r

  5   1   8   7
  -  11   3   2
 14  10  12  13
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Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit:  d

  -   1   8   7
  5  11   3   2
 14  10  12  13
  4  15   9   6

Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit:  l

  1   -   8   7
  5  11   3   2
```

```
 14  10  12  13
  4  15   9   6

Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit:  l

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Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit:  l

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Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit:  r
```

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  1   2   -  11
```

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Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit:  u

  1   2   3   4
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 12  13   7   6
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Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit:  r

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Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit:  d

  1   2   3   4
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Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit:  l

  1   2   3   4
  5   8  10  11
 12  13   6   -
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```

```
Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit:  d

  1   2   3   4
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  1   2   3   4
  5   8   -  10
 12  13   6  11
 15  14   7   9

Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit:  u

  1   2   3   4
  5   8   6  10
 12  13   -  11
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  1   2   3   4
  5   6   -  10
 12   8  13  11
 15  14   7   9

Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit:  u

  1   2   3   4
  5   6  13  10
 12   8   -  11
 15  14   7   9

Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit:  r

  1   2   3   4
  5   6  13  10
```

```
 12   -   8  11
 15  14   7   9

Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit:  u

  1   2   3   4
  5   6  13  10
 12  14   8  11
 15   -   7   9

Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit:  l

  1   2   3   4
  5   6  13  10
 12  14   8  11
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Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit:  l

  1   2   3   4
  5   6  13  10
 12  14   8  11
 15   7   9   -

Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit:  d

  1   2   3   4
  5   6  13  10
 12  14   8   -
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Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit:  d

  1   2   3   4
  5   6  13   -
 12  14   8  10
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Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit:  r

  1   2   3   4
  5   6   -  13
 12  14   8  10
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Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit:  u

  1   2   3   4
  5   6   8  13
 12  14   -  10
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Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit:  r
```

```
  1   2   3   4
  5   6   8  13
 12   -  14  10
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Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit:  u

  1   2   3   4
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  1   2   3   4
  5   6   8  13
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  1   2   3   4
  5   6   8  13
 12   7   -  10
 15   9  14  11

Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit:  r

  1   2   3   4
  5   6   8  13
 12   -   7  10
 15   9  14  11

Please make your choice, (L)eft, (R)ight, (U)p, (D)own, (Q)uit:  u

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 12   9   7  10
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  1   2   3   4
  5   6   7   8
  9  10  11  12
 13  14  15   -

You win!!!

Play again? (Y/N): n

Yeah I don't blame you for not wanting to play anymore
This game is like league...except it actually makes sense :D
```

Submission

Upload your header file (.h file) and your main.cpp file onto webcampus by or before the deadline

References

- Link to image(s) can be found at $https://upload.wikimedia.org/wikipedia/commons/thumb/b/bd/15-Puzzle_2.svg/1024px-15-Puzzle_2.svg.png$