CS1FC16 Spring Term Coursework - Card Sorting by Algorithms and Tree

Module Title: Fundamentals of Computer Science

Assignment report Title: Card Sorting by Algorithms and Tree

Module Code: CS1FC16

Student Number: 30021591

Git Repository: https://csgitlab.reading.ac.uk/il021591/cs1fc16_card_sorting_algo.git

Lecturer responsible: Prof Richard Mitchell

Weighting of the Assignment: 7.5%

Due in Date: 17th March 2022 @ 12

Actual hrs spent for the assignment: 8 hrs

Assignment evaluation : Deeper understand of sorting algorithms and binary sorted tree. Helped increase confidante to program in C and C++.

Usage

Download the repo using the following command

```
git clone https://csgitlab.reading.ac.uk/il021591/cs1fc16_card_sorting_algo.git
```

To compile the sorting algorithms and run type this in the terminal

```
make sort
```

To compile the tree algorithms and run type this in the terminal

```
make tree
```

Introduction

The objective of this coursework was to understand sorting algorithms and binary sorted tree using playing cards. To sort the cards individuals had to use the code provided to create algorithms that used the bubble sort and quick sort method. Furthermore, a separate piece of code was also needed to be produced to utilise binary sorted tree structure to store and interact with the cards.

Sorting Program

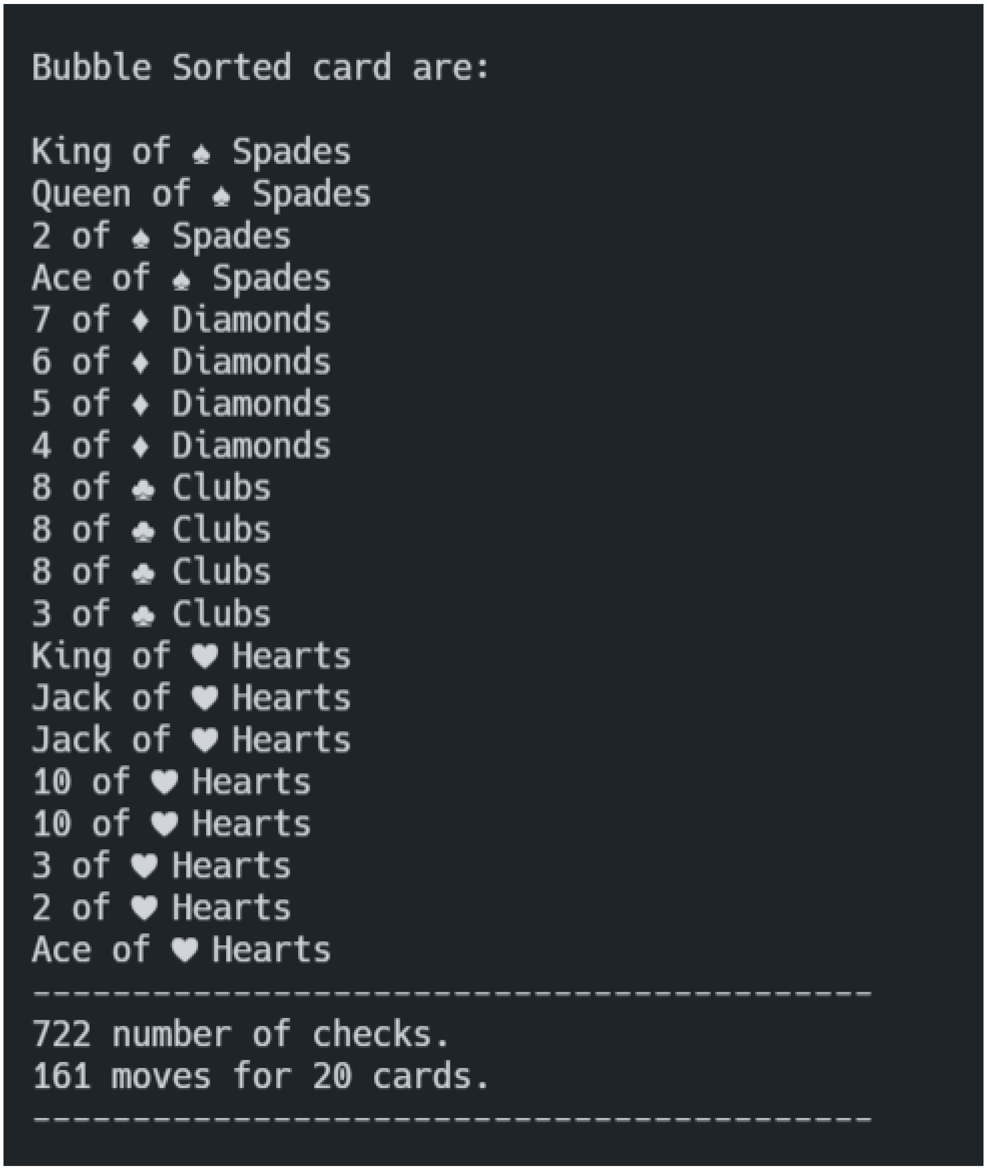
As Stated in the introduction two sorting algorithms will be used and tested to demonstrate the performance of the different sorting algorithms and its time complexity. A simple counter that measures the number of times each algorithm checks and moves cards has also been implemented.

Bubble Sort

The Algorithm used to sort the stack of cards is by looping an if statement in `maxCard-1` iteration of I and j using it calls the swap function and swaps the current item in the stack and the next item if its larger. Finally returning the stack.

```
aCard* bubbleSort(aCard c[], bool val)                // bubbleSort algorithm which retur
{

    for (int j = 0; j < (maxCard-1); j++)             // for i in maxCard-1 and for j in
    {
        for (int i = 0; i < (maxCard-1); i++)
        {
            if (corOrder(c[i], c[i+1], val) == 1)    // used the checker function to che
            {
                swap( c[i], c[i + 1]);
                sortCounter++;                        // sort counter increments yet agai
            }
        }
    }
    return c;                                         // return a pointer of the array of
}
```

Bubble Sort Output



```
Bubble Sorted card are:

King of ♠ Spades
Queen of ♠ Spades
2 of ♠ Spades
Ace of ♠ Spades
7 of ♦ Diamonds
6 of ♦ Diamonds
5 of ♦ Diamonds
4 of ♦ Diamonds
8 of ♣ Clubs
8 of ♣ Clubs
8 of ♣ Clubs
3 of ♣ Clubs
King of ♥ Hearts
Jack of ♥ Hearts
Jack of ♥ Hearts
10 of ♥ Hearts
10 of ♥ Hearts
3 of ♥ Hearts
2 of ♥ Hearts
Ace of ♥ Hearts
------------------------------------------
722 number of checks.
161 moves for 20 cards.
------------------------------------------
```

The Swap function

This function is used by both sorting algorithms and essentially initiates an `aCard` struct `x` to temporarily store the card that's being worked on and then set the first position in the card to `x` . then setting the value of the card in the second position to the value of the card in the first position. Finally, setting the value of `x` to the value of the card in the second position.

```
void swap(aCard c[], int pos1, int pos2){          // swap function to swap 2 cards in a
 aCard x;                                         // temporary variable to store the car
 x = c[pos1];                                     // setting the value of the card in po
 c[pos1] = c[pos2];                               // Setting the value of the card in po
 c[pos2] = x;                                     // setting the value of the card in po
}
```

The Compare function

The Compare Function takes in three arguments, two `aCards` , and a Boolean value to ether compare by `cardVal` or `cardSuit` . If value is 0(False) it sorts by `cardSuit` if its 1(True) it sorts by `cardVal` it returns true if a is bigger, then `B` and returns False if `B` is bigger than `A` .

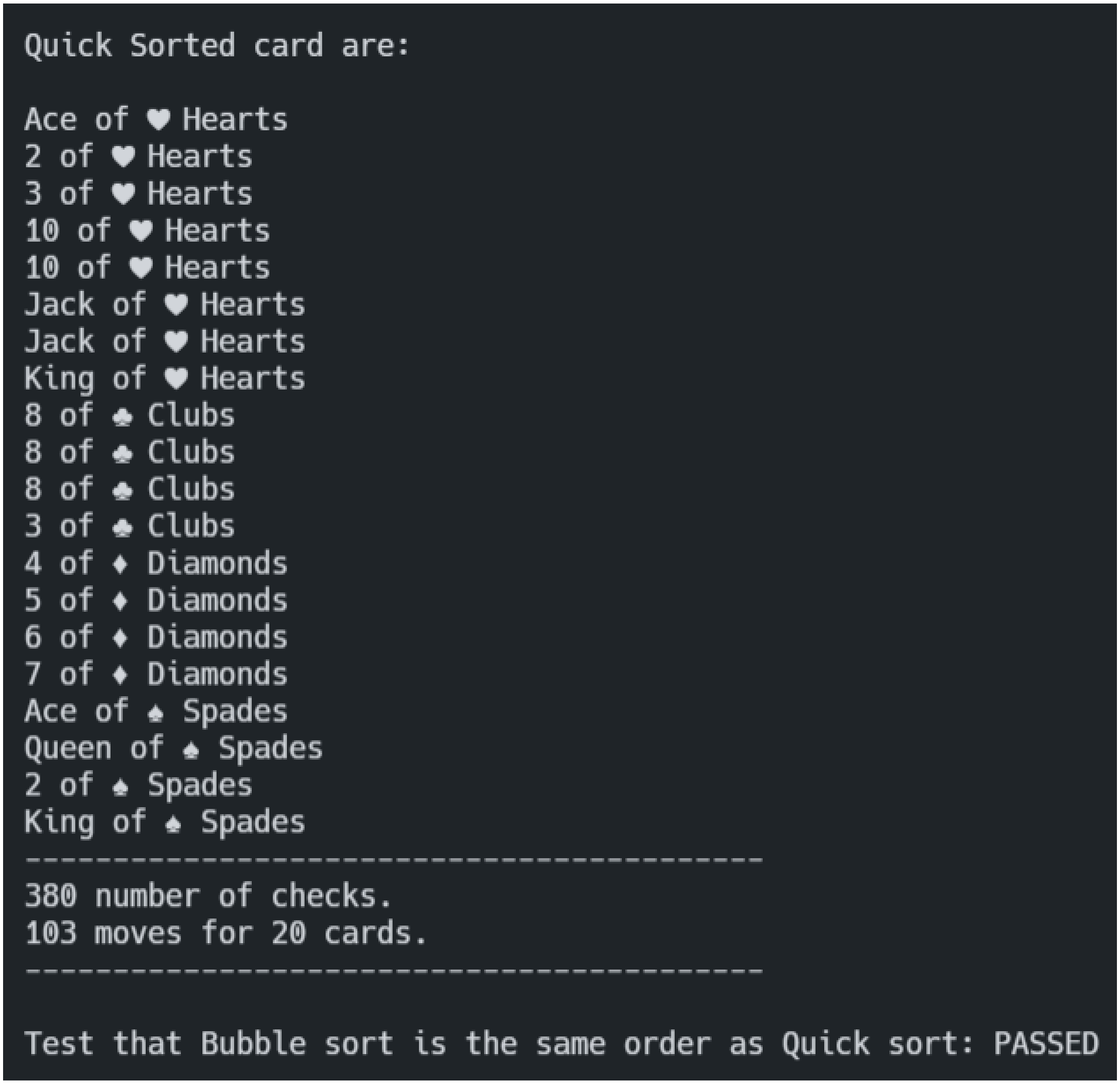
```
int corOrder(aCard a, aCard b, int val)             // checker function that returns tru
{
    corOrderCounter++;                              // checker function counter incremen

    if (val != 0)                                   //if value of card is what requested
    {
        if (a.cardVal < b.cardVal){return true;}    // returns true if cardVal of a is s
        else return false;
    }
    else if(val != 1)                               // does the same but with cardSuit
    {
        if (a.cardSuit < b.cardSuit){return true;}
        else return false;
    }
    return -1;
}
```

Quick Sort and the partitioning Function

As the time complexity of bubble sort is `O(N^2)` it's not expected to be the optimum way of sorting list Quick sort is often used. The Quicksort algorithm consists of two functions the quicksort function which is called recursively until the last two items are sorted and a partition function which finds the pivot and devise the list. Here the swap function is also used to swap the card in the current iteration with the left integer.

```
aCard* quickSort(aCard c[], int left, int right, bool val) // quickSort function will re
{
    if (left >= right) return c;                     // if left is less than ore equal t
    int piv;                                         // inital pivot

    piv = partition(c, left, right, val);            // pivot is the output of the parti

    quickSort(c, left, (piv-1), val);               // recursively call quickSort with t
    quickSort(c, (piv+1), right, val);              // recursively call quickSort with t
    return c;
}

int partition(aCard c[], int left, int right, int val) // function used to determine the
{
    aCard x;                                           // Temporary variable x to hold c

    for (int i = left+1; i <= right; i++)              // for the left integer plus 1, u
    {
        if (corOrder(c[i], c[left], val) == 1)         // if the left integer is greater
        {
            swap(c[i], c[left]);
            sortCounter++;                            // sort counter increments yet aga
        }
    }

    return left;                                     // return the left integer for recu
}
```

Quick sort Output



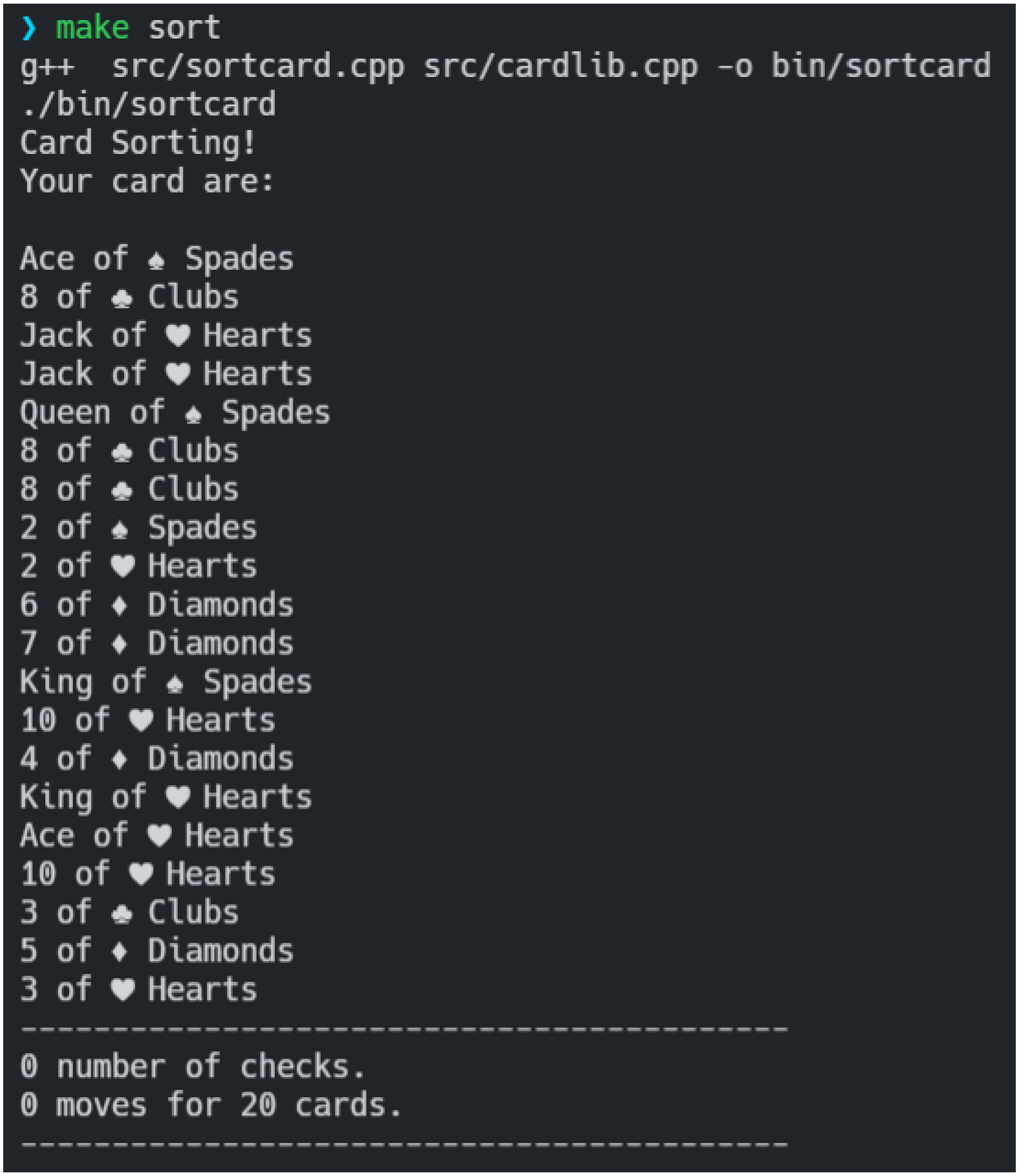
```
Quick Sorted card are:

Ace of ♥ Hearts
2 of ♥ Hearts
3 of ♥ Hearts
10 of ♥ Hearts
10 of ♥ Hearts
Jack of ♥ Hearts
Jack of ♥ Hearts
King of ♥ Hearts
8 of ♣ Clubs
8 of ♣ Clubs
8 of ♣ Clubs
3 of ♣ Clubs
4 of ♦ Diamonds
5 of ♦ Diamonds
6 of ♦ Diamonds
7 of ♦ Diamonds
Ace of ♠ Spades
Queen of ♠ Spades
2 of ♠ Spades
King of ♠ Spades
------------------------------------------
380 number of checks.
103 moves for 20 cards.
------------------------------------------

Test that Bubble sort is the same order as Quick sort: PASSED
```

Card Print Function

This simple function prints out each card int the array using the value name (e.g.: 12 as queen) as well as the suit names instead of 0,1,2 or 3. Output Example.: King of ♠ Spades

```
void printPack(aCard c[], string msg)               // Neatly print the cards using the
{
    string suiteNames[] = {"♥ Hearts", "♣ Clubs", "♦ Diamonds", "♠ Spades"}; // list of
    string cardValue[] = {"-", "Ace", "2", "3", "4", "5", "6", "7", "8", "9", "10", "Jac

    cout << msg << "\n" << endl;                        // msg defined if the cards are sort

    for (int i=0; i < maxCard; i++)                     // print each card in the pack using
    {
        cout << cardValue[c[i].cardVal] << " of " << suiteNames[c[i].cardSuit] << endl;
    }
            // V print out the number of cards checked and the number of cards moved.
    cout << "------------------------------------------\n" << corOrderCounter << " numbe
}
```

Print Output



```
❯ make sort
g++  src/sortcard.cpp src/cardlib.cpp -o bin/sortcard
./bin/sortcard
Card Sorting!
Your card are:

Ace of ♠ Spades
8 of ♣ Clubs
Jack of ♥ Hearts
Jack of ♥ Hearts
Queen of ♠ Spades
8 of ♣ Clubs
8 of ♣ Clubs
2 of ♠ Spades
2 of ♥ Hearts
6 of ♦ Diamonds
7 of ♦ Diamonds
King of ♠ Spades
10 of ♥ Hearts
4 of ♦ Diamonds
King of ♥ Hearts
Ace of ♥ Hearts
10 of ♥ Hearts
3 of ♣ Clubs
5 of ♦ Diamonds
3 of ♥ Hearts
------------------------------------------
0 number of checks.
0 moves for 20 cards.
------------------------------------------
```

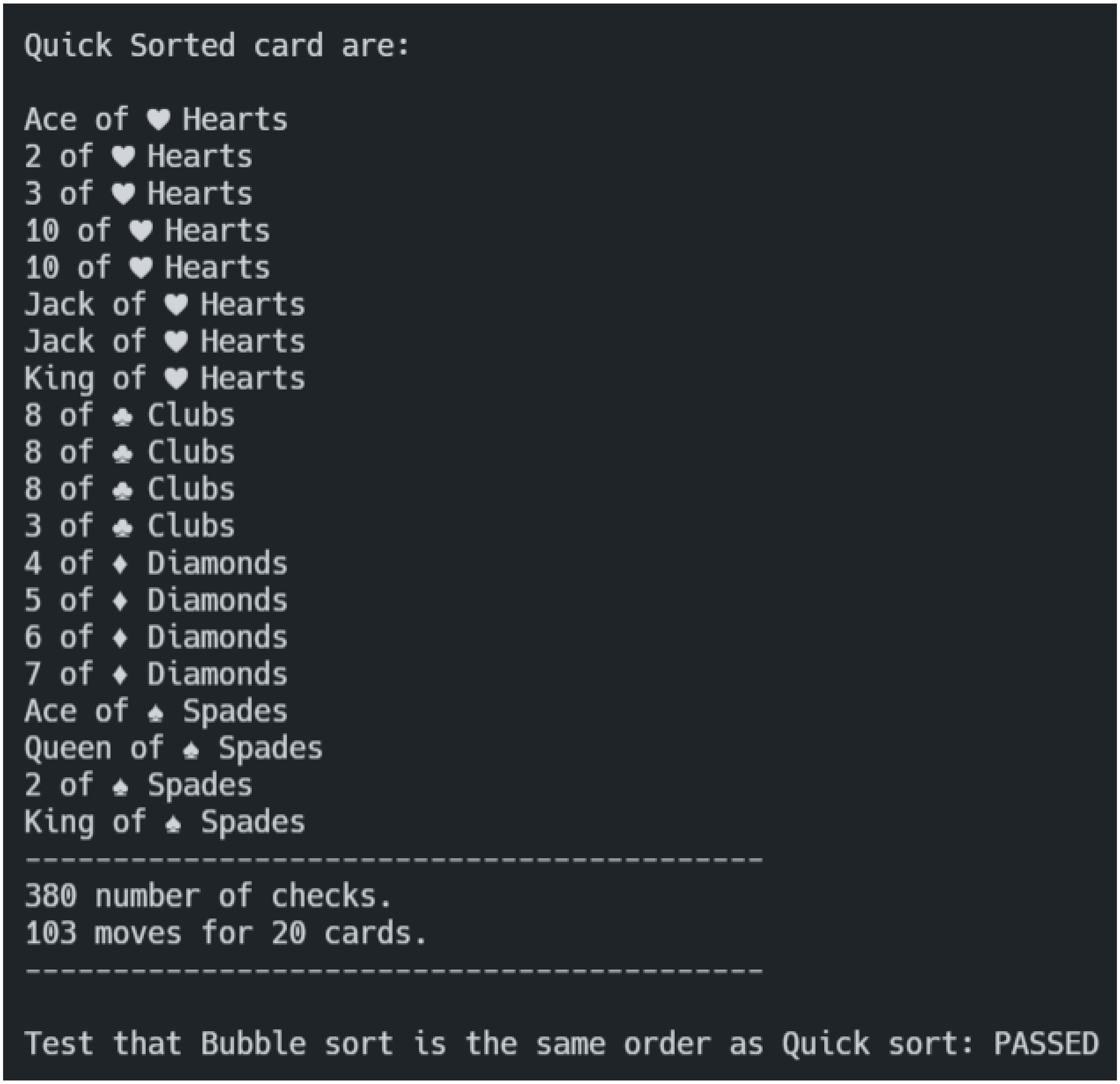
Tesing the Sorting Algorithms

```
string testSortingAlgos(aCard a[], aCard b[]){      // test sorting algorithms by compar
    for (int i = 0; i < maxCard; i++)
    {
        if ((corOrder(a[i-maxCard], b[i],1)==1) && (corOrder(a[i-maxCard], b[i], 0)==1))
        {
            return "PASSED"; // return "PASSED or FAILED";
        }
    }
    return "FAILED";
}
```

Main Function for the Sorting Algorithms

```
int main()
{
    cout << "Card Sorting!\n";

    for (int ct = 0; ct < maxCard; ct++)      // looping through maxCard to get the defi
    {
        thePack[ct] = getCard("30021591");    // change to your student number
    }

    printPack( thePack, "Your card are: ");   // print the cards given by the getCard fu

    aCard* bubbleSortedCards;                 // define the bubble sort and quickSort aC
    aCard* quickSortedCards;

    bubbleSortedCards = bubbleSort(thePack, 1); // sort the cards by their value (using
    bubbleSortedCards = bubbleSort(bubbleSortedCards, 0); // sort the cards by their sui
    printPack(bubbleSortedCards, "Bubble Sorted card are: "); // print the cards given b

    sortCounter = 0;            //reset counters for quickSort
    corOrderCounter = 0;

    quickSortedCards = quickSort(thePack, 0, (maxCard-1), 1);// sort the cards by their
    quickSortedCards = quickSort(quickSortedCards, 0, (maxCard-1), 0);// sort the cards
    printPack(quickSortedCards, "Quick Sorted card are: ");// print the cards given by t

    // test that Bubble and Quick sort are the same order
    cout << "Test that Bubble sort is the same order as Quick sort: " << testSortingAlgc
}
```

Quick Sort Output



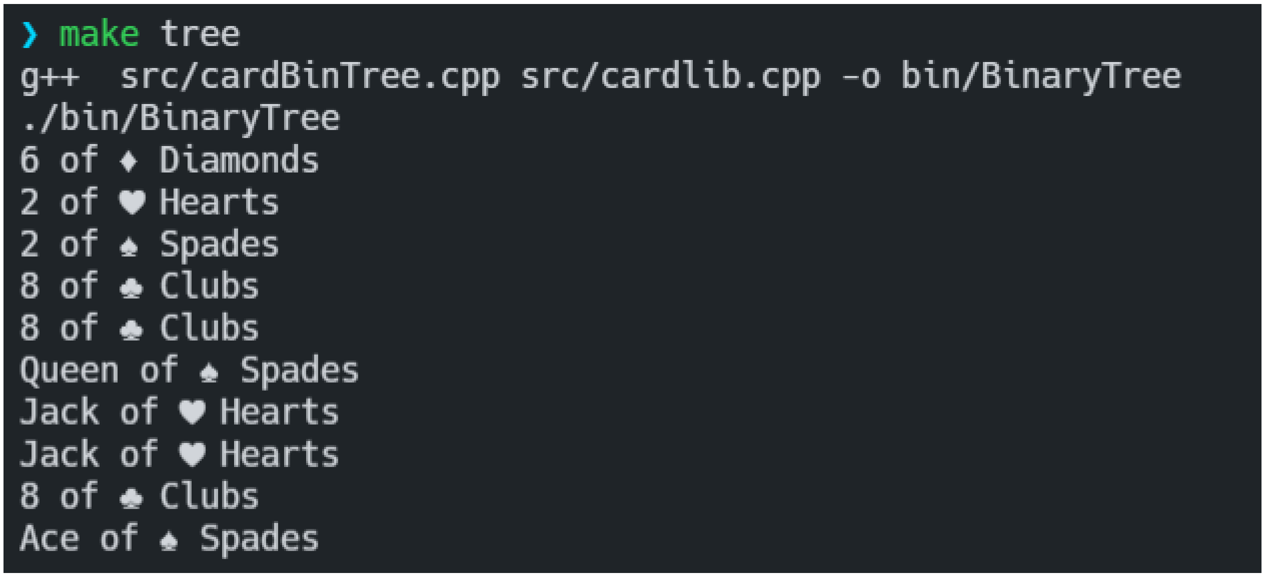
```
Quick Sorted card are:

Ace of ♥ Hearts
2 of ♥ Hearts
3 of ♥ Hearts
10 of ♥ Hearts
10 of ♥ Hearts
Jack of ♥ Hearts
Jack of ♥ Hearts
King of ♥ Hearts
8 of ♣ Clubs
8 of ♣ Clubs
8 of ♣ Clubs
3 of ♣ Clubs
4 of ♦ Diamonds
5 of ♦ Diamonds
6 of ♦ Diamonds
7 of ♦ Diamonds
Ace of ♠ Spades
Queen of ♠ Spades
2 of ♠ Spades
King of ♠ Spades
------------------------------------------
380 number of checks.
103 moves for 20 cards.
------------------------------------------

Test that Bubble sort is the same order as Quick sort: PASSED
```

Tree Program

The tree program could be broken down into … components, the struct which used `aCard` as the data and two pointer nodes one the less side and the other on the more side. The `insertTree` creates a node and allow to append a card to the tree. `cfstring` function is used to compares two cards and returns -1,0,1. `cardNewNode` create a new node and returns a pointer. The `printTree` function prints out all the items in the tree.

```
#include <string>
#include <iostream>
using namespace std;
#include "cardlib.h"

struct cardTreeNode {
    aCard card;
    cardTreeNode* less, * more;
};

cardTreeNode* cardNewNode(cardTreeNode* l, aCard a) {       // create a new node with da
    cardTreeNode* pos = new cardTreeNode;     // create space for node
    pos->card = a;                       // add data
    pos->less = NULL;                    // pointers less and more are set to NULL
    pos->more = NULL;
    return pos;                          // return pointer to this new node
}

int cfstring(aCard c1, aCard c2) {
    // compares two cards and  returns -1,0,1
    if (c1.cardVal <= c2.cardVal) return -1;
    else if (c1.cardVal >= c2.cardVal) return 1;
    else return 0;
}

cardTreeNode *insertTree(cardTreeNode* l, aCard a) {
    // insert string s searching from node p, returns pointer to this node (normally unc
    cardTreeNode* ans = l;
    if (l == NULL) ans = cardNewNode(l, a);    // if found NULL pointer, create new node
    else if (cfstring(l->card, a) >= 0) l->less = insertTree(l->less, a);    // insert i
    else if (cfstring(l->card, a) <= 0) l->more = insertTree(l->more, a);    // insert i
        // change above line if want repeat items in tree
    return ans;         // return pointer to new node, or to this node, as appropriate
}

void printTree(cardTreeNode* l){
    if (l == NULL) return;
    string suteNames[] = {"♥ Hearts", "♣ Clubs", "♦ Diamonds", "♠ Spades"};
    string cardValue[] = {"-", "Ace", "2", "3", "4", "5", "6", "7", "8", "9", "10", "Jac
    printTree(l->less);
    // then recur on right subtree

    printTree(l->more);
    // now deal with the node
    cout << cardValue[l->card.cardVal] << " of " << suteNames[l->card.cardSuit] << endl;
}

int main(){
    struct cardTreeNode* stack = NULL;
    aCard c;
    for(int i = 0; i < 10; i++)
    {
        c = getCard("30021591");
        stack = insertTree(stack, c);
    }
    printTree(stack);
    return 0;
}
```

Tree Output



```
❯ make tree
g++  src/cardBinTree.cpp src/cardlib.cpp -o bin/BinaryTree
./bin/BinaryTree
6 of ♦ Diamonds
2 of ♥ Hearts
2 of ♠ Spades
8 of ♣ Clubs
8 of ♣ Clubs
Queen of ♠ Spades
Jack of ♥ Hearts
Jack of ♥ Hearts
8 of ♣ Clubs
Ace of ♠ Spades
```

Reflection

In Conclusion we learned two different methods of storing items in a list. Although The Bubble sort algorithm is not efficient it gives a good incite on how things could be sorted and was easy to program. The Quick sort programs widened upon that knowledge to optimize sorting for further applications. The tree algorithm helped understand how algorithms are used in real like software systems such as databases and spreadsheets.