ARRAYS SEARCHING

NATIONAL UNIVERSITY OF TECHNOLOGY (NUTECH)

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ANALYSIS OF ARRAYS

- How to insert an item?
 - How many steps in terms of N (number of elements in array)?
 - N steps at maximum (move items to insert at given location)
- How to delete an item?
 - How many steps in terms of N (number of elements in array)?
 - N steps at maximum (move items back to take place of deleted item)

ANALYSIS OF ARRAYS

- How to search an item?
 - Linear Search
 - Binary Search

SEARCHING ARRAYS

REFERENCE: DATA STRUCTURES

(BY LIPSCHUTZ P4.12 – 4.18)

INTRODUCTION TO SEARCH ALGORITHMS

- A search algorithm is a method of locating a specific item of information in a larger collection of data. This section discusses two algorithms for searching the contents of an array.
 - Linear Search
 - Binary Search

THE LINEAR SEARCH

- This is a very simple algorithm.
- It uses a loop to sequentially step through an array, starting with the first element.
- It compares each element with the value being searched for and stops when that value is found or the end of the array is reached.

LINEAR SEARCH

```
// The searchList function performs a linear search on an
// integer array. The array list, which has a maximum of numElems
// elements, is searched for the number stored in value. If the
// number is found, its array subscript is returned. Otherwise,
// -1 is returned indicating the value was not in the array.
int searchList(int list[], int numElems, int value)
 int index = 0; // Used as a subscript to search array
 int position = -1; // To record position of search value
 bool found = false; // Flag to indicate if the value was found
  while (index < numElems && !found)</pre>
           if (list[index] == value)
           found = true;
           position = index;
         index++;
  return position;
```

```
8
```

```
// This program demonstrates the searchList function, which
// performs a linear search on an integer array.
#include <iostream>
// Function prototype
int searchList(int [], int, int);
const int arrSize = 5;
void main(void)
 int tests[arrSize] = \{87, 75, 98, 100, 82\};
 int result;
```

```
result = searchList(tests, arrSize, 100);
if (result == -1)
      cout << "You did not earn 100 points on any test\n";
else
{
      cout << "You earned 100 points on test ";
      cout << (result + 1) << endl;
}</pre>
```

PROGRAM OUTPUT

You earned 100 points on test 4

EFFICIENCY OF THE LINEAR SEARCH

- The advantage is its simplicity.
 - It is easy to understand
 - Easy to implement
 - Does not require the array to be in order
- The disadvantage is its inefficiency
 - If there are 20,000 items in the array and what you are looking for is in the 19,999th element, you need to search through the entire list.

BINARY SEARCH

- The binary search is much more efficient than the linear search.
- It requires the list to be in order.
- The algorithm starts searching with the middle element.
 - If the item is less than the middle element, it starts over searching the first half of the list.
 - If the item is greater than the middle element, the search starts over starting with the middle element in the second half of the list.
 - It then continues halving the list until the item is found.

BINARY SEARCH

```
// The binarySearch function performs a binary search on an integer array. Array,
// which has a maximum of numElems elements, is searched for the number
// stored in value. If the number is found, its array subscript is returned.
// Otherwise, -1 is returned indicating the value was not in the array.
int binarySearch(int array[], int numelems, int value)
  int first = 0, last = numelems - 1, middle, position = -1;
  bool found = false;
  while (!found && first <= last)</pre>
          middle = (first + last) / 2; // Calculate mid point
          if (array[middle] == value) // If value is found at mid
         { found = true;
              position = middle;
           else if (array[middle] > value) // If value is in lower half
            last = middle - 1;
           else
               first = middle + 1;  // If value is in upper half
  return position;
```

```
// This program demonstrates the binarySearch function, which
// performs a binary search on an integer array.
#include <iostream>
// Function prototype
int binarySearch(int [], int, int);
const int arrSize = 20;
void main(void)
int empIDs[arrSize] = \{101, 142, 147, 189, 199, 207, 222,
                      234, 289, 296, 310, 319, 388, 394,
                      417, 429, 447, 521, 536, 600};
```

PROGRAM CONTINUES

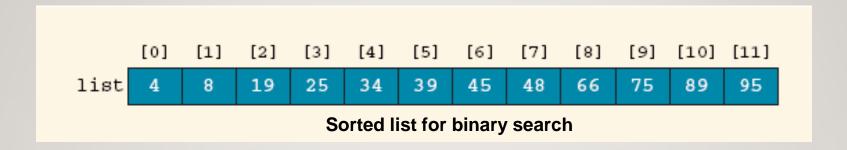
```
int result, empID;
cout << "Enter the Employee ID you wish to search for: ";
cin >> empID;
result = binarySearch(empIDs, arrSize, empID);
if (result == -1)
     cout << "That number does not exist in the array.\n";
else
     cout << "That ID is found at element " << result;</pre>
     cout << " in the array\n";</pre>
```

PROGRAM OUTPUT WITH EXAMPLE INPUT

Enter the Employee ID you wish to search for: 199

That ID is found at element 4 in the array.

BINARY SEARCH



| key | = 89 | | | |
|-----------|-------|------|-----|-------------------|
| Iteration | first | last | mid | list[mid] |
| 1 | 0 | 11 | 5 | 39 |
| 2 | 6 | 11 | 8 | 66 |
| 3 | 9 | 11 | 10 | 89 Value is found |

| key = 34 | | | | | | |
|-----------|-------|------|-----|-------------------|--|--|
| Iteration | first | last | mid | list[mid] | | |
| 1 | 0 | 11 | 5 | 39 | | |
| 2 | 0 | 4 | 2 | 19 | | |
| 3 | 3 | 4 | 3 | 25 | | |
| 4 | 4 | 4 | 4 | 34 Value is found | | |

EFFICIENCY OF THE BINARY SEARCH

- Much more efficient than the linear search.
- How long does this take (worst case)?
- If the list has 8 elements
 - It takes 3 steps $(2^3 = 8)$
- If the list has 16 elements
 - It takes 4 steps $(2^4 = 16)$
- If the list has 64 elements
 - It takes 6 steps (2⁶ = 64)
- Similarly, if the list has n elements
 - It takes $\log_2 n$ steps