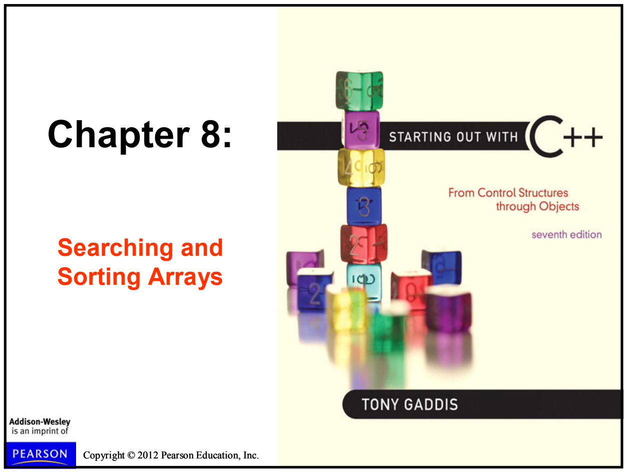
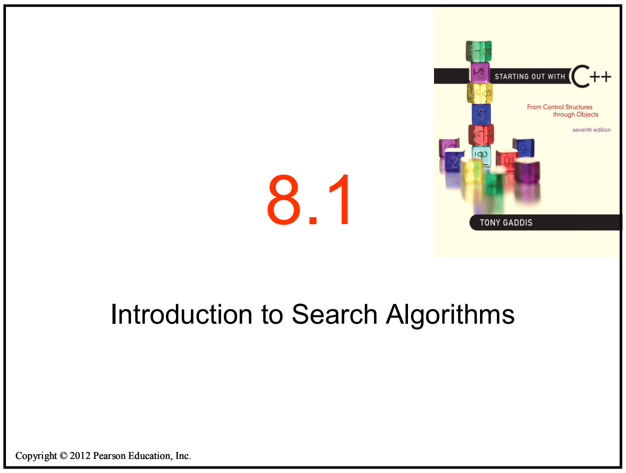


Chapter 8:

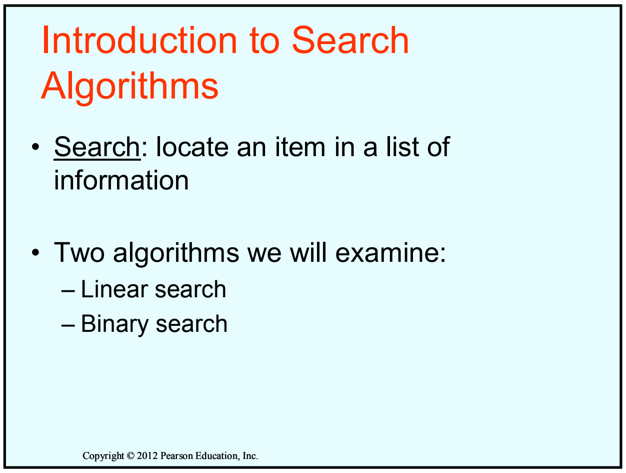
Searching and Sorting Arrays

Addison-Wesley is an imprint of PEARSON



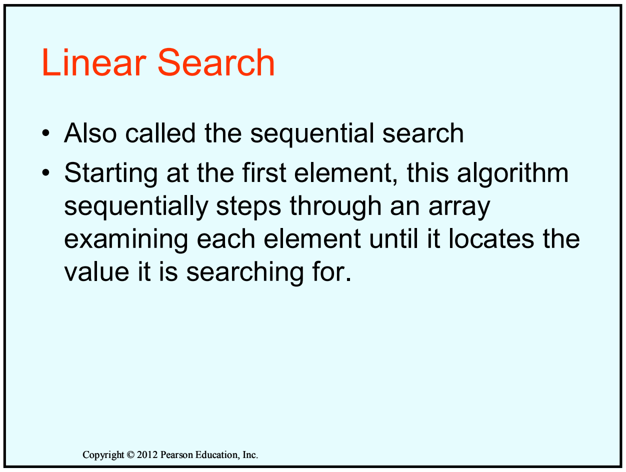
8.1

Introduction to Search Algorithms



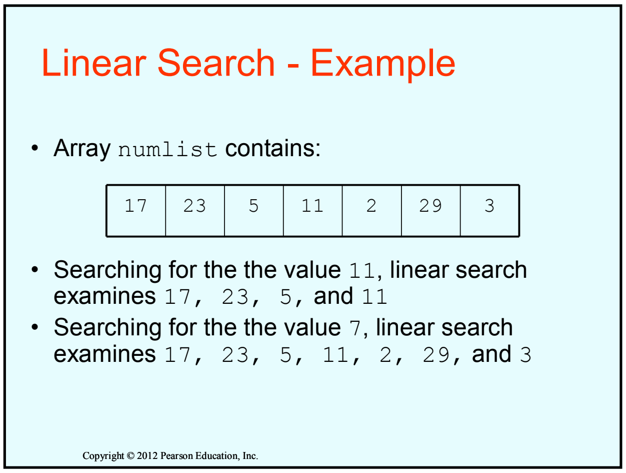
Introduction to Search Algorithms

- Search: locate an item in a list of information
- Two algorithms we will examine:
  - Linear search
  - Binary search



Linear Search

- Also called the sequential search
- Starting at the first element, this algorithm sequentially steps through an array examining each element until it locates the value it is searching for.

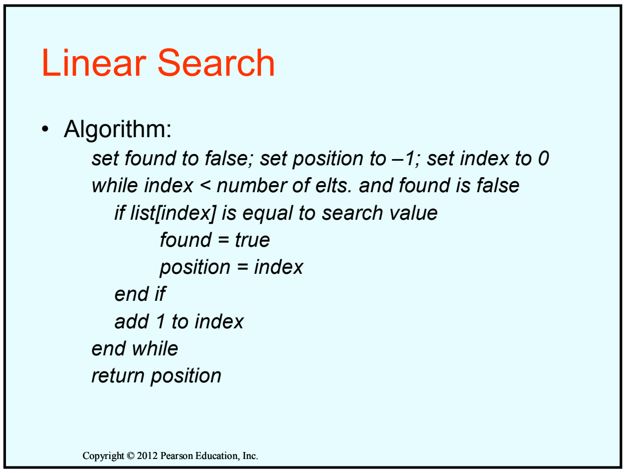


Linear Search - Example

- Array `numlist` contains:

17	23	5	11	2	29	3

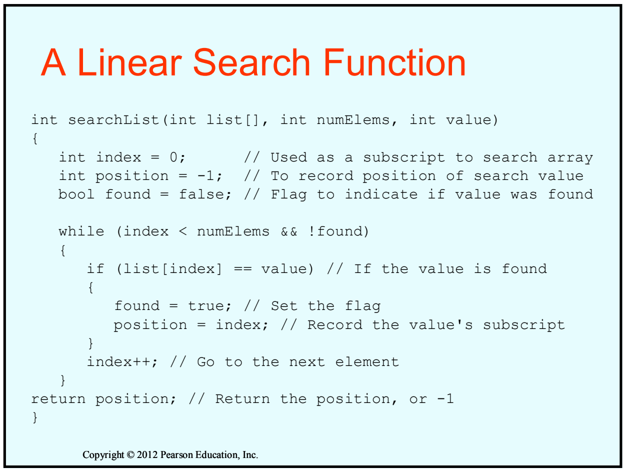
- Searching for the the value `11`, linear search examines `17, 23, 5`, and `11`
- Searching for the the value `7`, linear search examines `17, 23, 5, 11, 2, 29`, and `3`



Linear Search

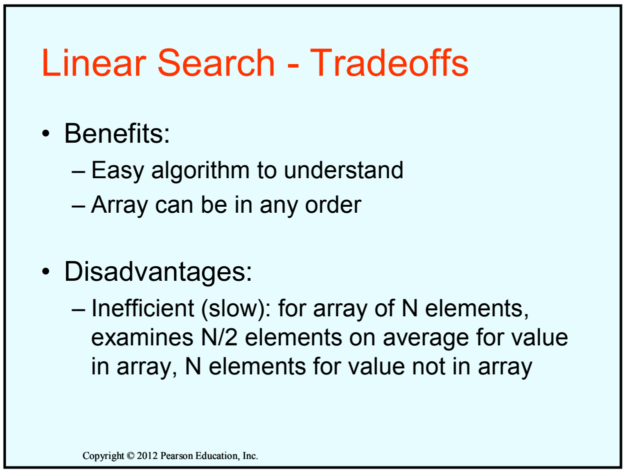
- Algorithm:

```
set found to false; set position to –1; set index to 0
while index < number of elts. and found is false
   if list[index] is equal to search value
         found = true
         position = index
   end if
   add 1 to index
end while
return position
```



A Linear Search Function

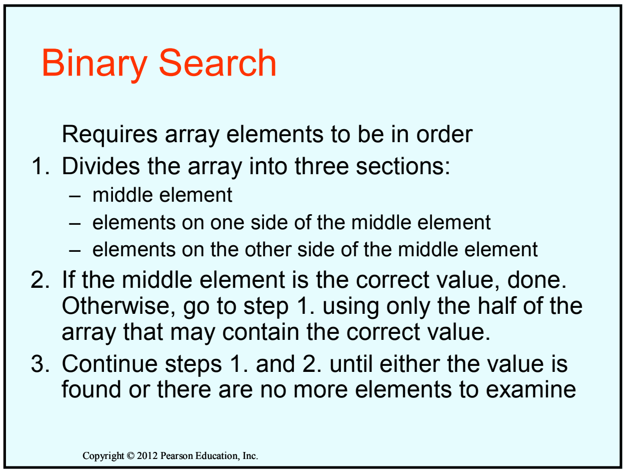
```
int searchList(int list[], int numElems, int value)
{
   int index = 0;      // Used as a subscript to search array
   int position = -1;  // To record position of search value
   bool found = false; // Flag to indicate if value was found

   while (index < numElems && !found)
   {
      if (list[index] == value) // If the value is found
      {
         found = true; // Set the flag
         position = index; // Record the value's subscript
      }
      index++; // Go to the next element
   }
return position; // Return the position, or -1
}
```



Linear Search - Tradeoffs

- Benefits:
  - Easy algorithm to understand
  - Array can be in any order

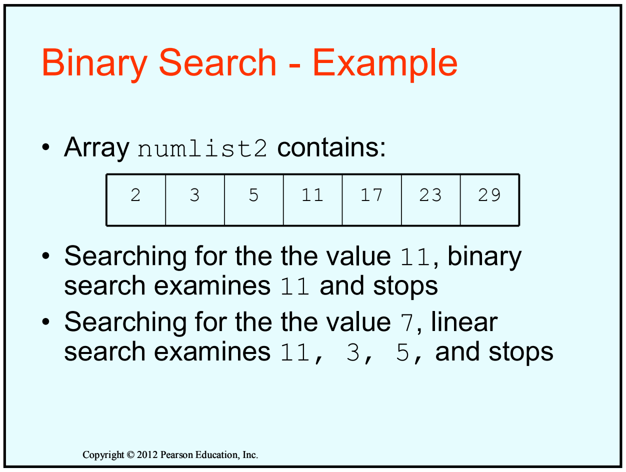
- Disadvantages:
  - Inefficient (slow): for array of N elements, examines N/2 elements on average for value in array, N elements for value not in array



Binary Search

Requires array elements to be in order

1. Divides the array into three sections:
   - middle element
   - elements on one side of the middle element
   - elements on the other side of the middle element
2. If the middle element is the correct value, done. Otherwise, go to step 1. using only the half of the array that may contain the correct value.
3. Continue steps 1. and 2. until either the value is found or there are no more elements to examine

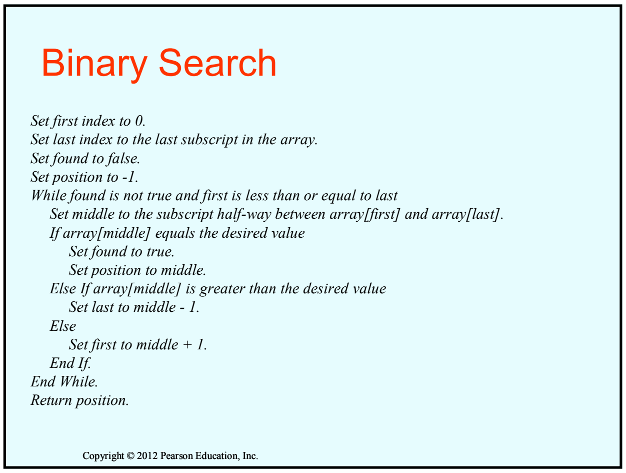


Binary Search - Example

- Array `numlist2` contains:

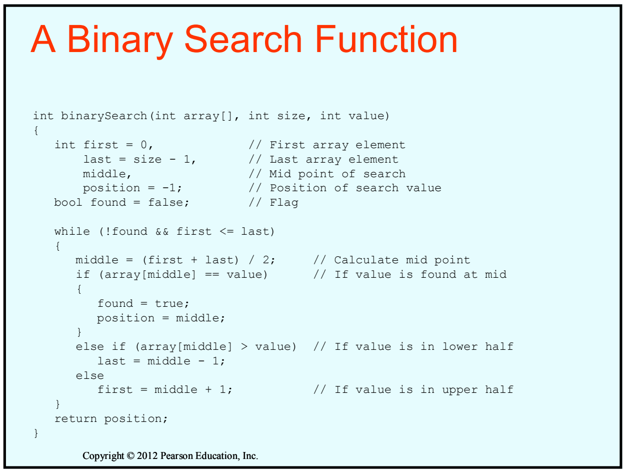
2	3	5	11	17	23	29

- Searching for the the value `11`, binary search examines `11` and stops
- Searching for the the value `7`, linear search examines `11, 3, 5,` and stops



Binary Search

```
Set first index to 0.
Set last index to the last subscript in the array.
Set found to false.
Set position to -1.
While found is not true and first is less than or equal to last
    Set middle to the subscript half-way between array[first] and array[last].
    If array[middle] equals the desired value
        Set found to true.
        Set position to middle.
    Else If array[middle] is greater than the desired value
        Set last to middle - 1.
    Else
        Set first to middle + 1.
    End If.
End While.
Return position.
```

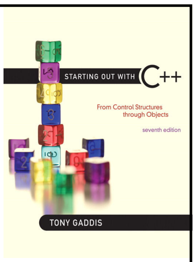


A Binary Search Function

```
int binarySearch(int array[], int size, int value)
{
   int first = 0,             // First array element
       last = size - 1,       // Last array element
       middle,                // Mid point of search
       position = -1;         // Position of search value
   bool found = false;        // Flag

   while (!found && first <= last)
   {
      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;
}
```

Binary Search - Tradeoffs

- Benefits:
  - Much more efficient than linear search. For array of N elements, performs at most log_2N comparisons
- Disadvantages:
  - Requires that array elements be sorted



8.3

Introduction to Sorting Algorithms

Introduction to Sorting Algorithms

- Sort: arrange values into an order:
  - Alphabetical
  - Ascending numeric
  - Descending numeric
- Two algorithms considered here:
  - Bubble sort
  - Selection sort

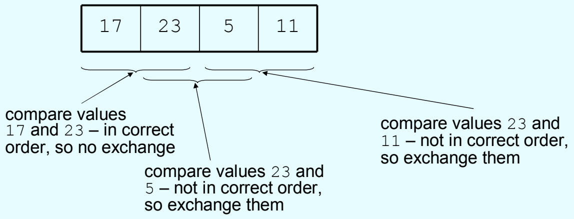
Bubble Sort

Concept:

- Compare 1st two elements
  - If out of order, exchange them to put in order
- Move down one element, compare 2nd and 3rd elements, exchange if necessary. Continue until end of array.
- Pass through array again, exchanging as necessary
- Repeat until pass made with no exchanges

Example – First Pass

Array `numlist3` contains:



17	23	5	11

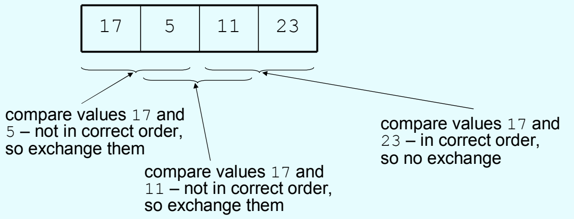
compare values `17` and `23` – in correct order, so no exchange

compare values `23` and `5` – not in correct order, so exchange them

compare values `23` and `11` – not in correct order, so exchange them

Example – Second Pass

After first pass, array `numlist3` contains:



17	5	11	23

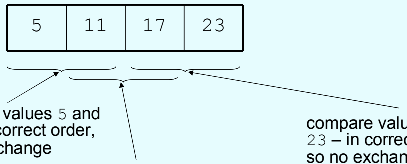
compare values `17` and `5` – not in correct order, so exchange them

compare values `17` and `11` – not in correct order, so exchange them

compare values `17` and `23` – in correct order, so no exchange

Example – Third Pass

After second pass, array `numlist3` contains:



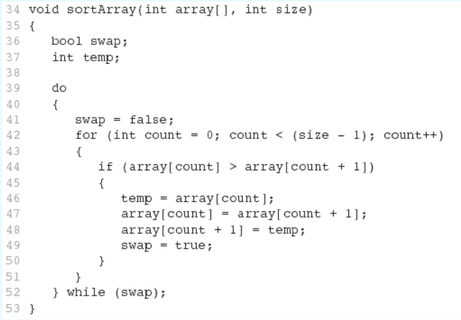
compare values `5` and `11` – in correct order, so no exchange

compare values `11` and `17` – in correct order, so no exchange

compare values `17` and `23` – in correct order, so no exchange

No exchanges, so array is in order

A Bubble Sort Function – From Program 8-4



```
void sortArray(int array[], int size)
{
   bool swap;
   int temp;

   do
   {
      swap = false;
      for (int count = 0; count < (size - 1); count++)
      {
         if (array[count] > array[count + 1])
         {
            temp = array[count];
            array[count] = array[count + 1];
            array[count + 1] = temp;
            swap = true;
         }
      }
   } while (swap);
}
```

Bubble Sort - Tradeoffs

- Benefit:
  - Easy to understand and implement
- Disadvantage:
  - Inefficient: slow for large arrays

Selection Sort

- Concept for sort in ascending order:
  - Locate smallest element in array. Exchange it with element in position 0
  - Locate next smallest element in array. Exchange it with element in position 1.
  - Continue until all elements are arranged in order

Selection Sort - Example

Array `numlist` contains:

11	2	29	3

1. Smallest element is `2`. Exchange `2` with element in 1st position in array:

2	11	29	3

Example (Continued)

2. Next smallest element is `3`. Exchange `3` with element in 2nd position in array:

2	3	29	11

3. Next smallest element is `11`. Exchange `11` with element in 3rd position in array:

2	3	11	29

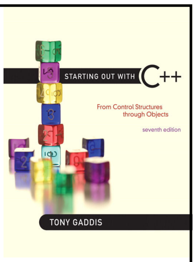
A Selection Sort Function – From Program 8-5

```
void selectionSort(int array[], int size)
{
   int startScan, minIndex, minValue;

   for (startScan = 0; startScan < (size - 1); startScan++)
   {
      minIndex = startScan;
      minValue = array[startScan];
      for(int index = startScan + 1; index < size; index++)
      {
         if (array[index] < minValue)
         {
            minValue = array[index];
            minIndex = index;
         }
      }
      array[minIndex] = array[startScan];
      array[startScan] = minValue;
   }
}
```

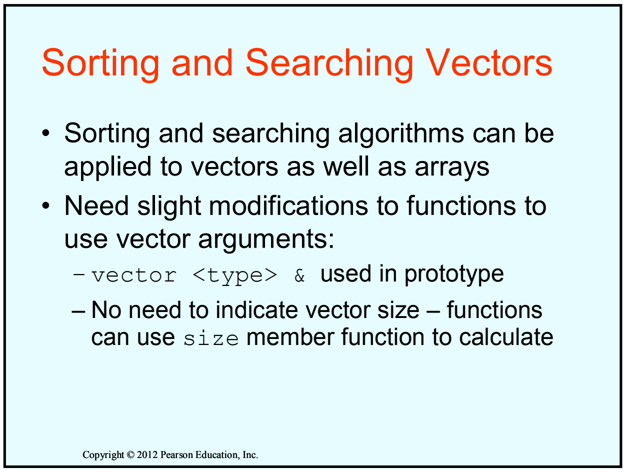
Selection Sort - Tradeoffs

- Benefit:
  - More efficient than Bubble Sort, since fewer exchanges
- Disadvantage:
  - May not be as easy as Bubble Sort to understand

8.5



Sorting and Searching Vectors



Sorting and Searching Vectors

- Sorting and searching algorithms can be applied to vectors as well as arrays
- Need slight modifications to functions to use vector arguments:
  - `vector <type> &` used in prototype
  - No need to indicate vector size – functions can use `size` member function to calculate