Lecture 14.4

Topics

1. Data Validation – Brief
2. Sorting – Non-Recursive

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1. Data Validation – Brief

Recall that writing a computer program is to provide a solution to some given problem. A general computer program execution may be depicted in **Figure 1** below.

The **Data Validation** block will validate the input data before being sent to the **Processing** block. If designed properly in applications, incorrect data will be rejected and new set of input data may be re-entered or selected and then validated again.

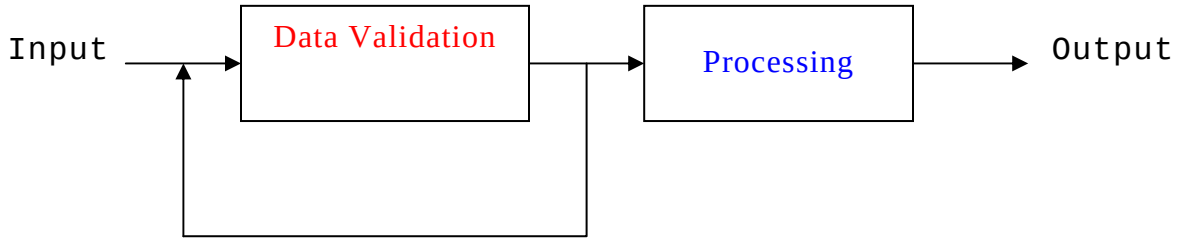


Figure 1 Input/output and data processing

Using the input data, the processing block has all the algorithms and steps to produce the desired result (i.e., output). The processing block(s) will be designed and implemented specifically for individual applications.

The most general form of input data would be **typed** through keyboard or given as character strings (or just strings). These strings should be validated and converted to numerical values. What kinds of numerical values are they convertible to? We will discuss and work on this "soon".

Next, let's consider a general memory model when the applications are running in a system.

2. Sorting – Non-Recursive

There are two different techniques of implementing the sorting

- Recursive sorts, and
- Non-recursive sorts

We will look at some of non-recursive sorts here.

2.1 Bubble Sort

It is easiest and least efficient!

Below would be the code.

```
int sortBubble(int iAry[], int iSize) {
  int i, j;
  int iTemp;

  iSize = MAX_ARY_SIZE;
  for (i = 0; i < iSize; i++) {
    for (j = i + 1; j < iSize; j++) {
```

```
        if (iAry[i] < iAry[j]) {
          iTemp = iAry[i];
          iAry[i] = iAry[j];
          iAry[j] = iTemp;
        }
      }
    }

    return 0;
}
```

2.2 Insertion Sort

Insertion sort is an algorithm that will also work with data that are in two groups:

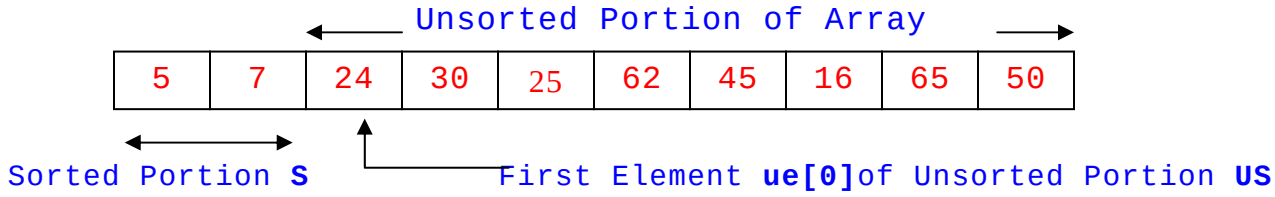
(1) Sorted sequence (**S**), and

(2) Unsorted sequence (**US**).

The sorting will be done in several passes just as the bubble sort or selection sort – There are **(N-1)** passes for a given sequence of **N** values.

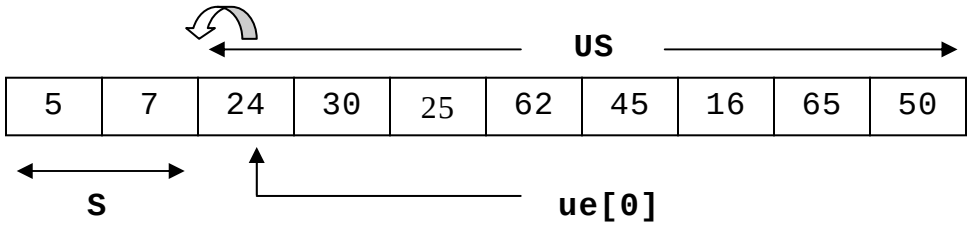
For each pass,

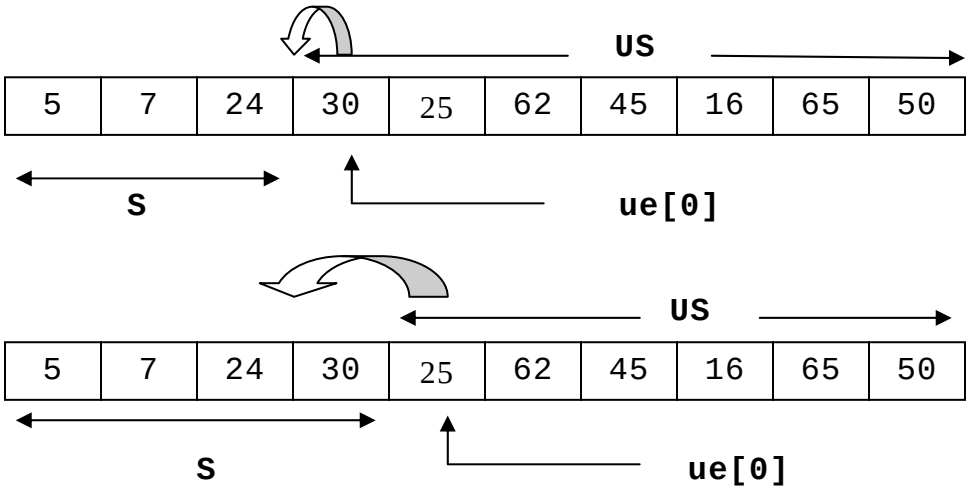
- The first element **ue[0]** from the unsorted sequence **US** will be moved to the sorted sequence **S**.
- This **ue[0]** element will be inserted at the appropriate place in the **S** sequence so that all elements in **S** sequence will be sorted.



In the above, it was assumed that the **insertion sort** was performed up to and including the first 2 elements

The subsequence passes are illustrated as follows,





Final Pass

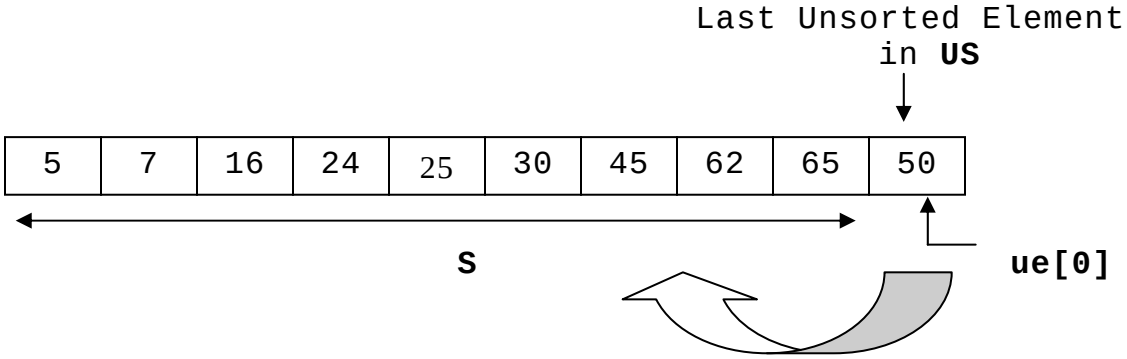


Figure 2 Insertion Sort

Example 1

```
/* FILE #1 */
/**
 *Program Name: cis27Lec1441Driver.c
 *Discussion:   Insertion Sort
 */
#include <stdio.h>
#include "cis27Lec1441.h"

int main() {
  int i;
  int iSize;
  int iAry[MAX_ARY_SIZE] = {89, 72, 3, 15, 21,
                            57, 61, 44, 19, 98,
                            5, 77, 39, 59, 61};

  printf("Unsorted array: ");
  for (i = 0; i < MAX_ARY_SIZE; i++)
    printf("%3d", iAry[i]);

  iSize = MAX_ARY_SIZE;
  sortInsertion(iAry, iSize);

  printf("\nSorted array:   ");
  for (i = 0; i < MAX_ARY_SIZE; i++)
    printf("%3d", iAry[i]);
```

```
  printf("\n");

  return 0;
}

/* FILE #2 */
/**
 *Program Name: cis27Lec1441.h
 *Discussion:   Insertion Sort
 */
#include <stdio.h>
#define MAX_ARY_SIZE 15

/**
 *Function Name:  sortInsertion()
 *Description:    Insertion sort
 *Pre:            Unsorted integer Array and its size
 *Post:           Sorted integer array
 */
int sortInsertion(int [], int);

/* FILE #3 */
/**
 *Program Name: cis27Lec1411.c
 *Discussion:   Insertion Sort
 */
#include "cis27Lec1441.h"

int sortInsertion(int iAry[], int iSize) {
  int i, j;
  int iSorted;
  int iTemp;

  iSize = MAX_ARY_SIZE;
  for (i = 1; i < iSize; i++) {
    iSorted = 0;
    iTemp = iAry[i];

    for (j = i - 1; j >= 0 && !iSorted;) {
      if (iTemp < iAry[j]) {
        iAry[j + 1] = iAry[j];
        j--;
      } else {
        iSorted = 1;
      }
    }

    iAry[j + 1] = iTemp;
  }

  return 0;
}
```

OUTPUT

```
Unsorted array:  89 72  3 15 21 57 61 44 19 98  5 77 39 59 61
Sorted array:     3  5 15 19 21 39 44 57 59 61 61 72 77 89 98
```

2.3 Selection Sort

In this selection sort, the data are stored in an array and two values are compared to each other to produce the index information.

- Assuming that an ascending sort is desired, for the array of size **N**, there will be **(N – 1)** passes.
- And in each pass, the values are processed (compared) so that the index of the smallest value will be determined.
- This index information is then used to swap the values appropriately.

In each pass, the array is divided into two halves. One half has all sorted values and the other half has the unsorted values (the position of the unsorted values may not be the same as the original one).

After the first pass is done, there will be one sorted element in the sorted half and (N – 1) elements in the unsorted half. After the second pass, there will be two elements in the sorted half and (N – 2) in the unsorted half. In total, there will be (N – 1) passes to be performed.

Consider the following array,

16	30	24	7	25	62	45	5	65	50

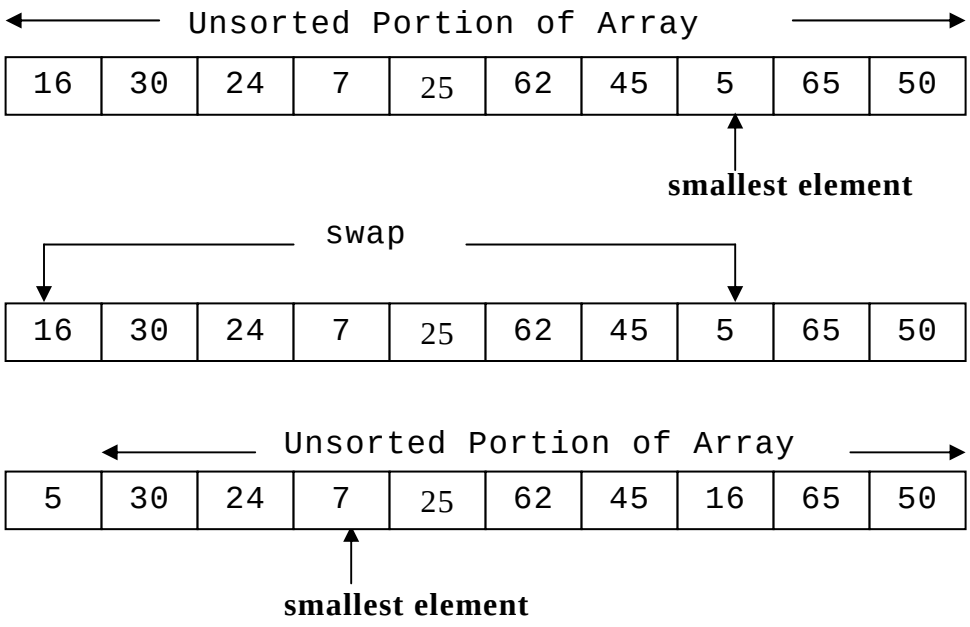
Let's assume that an ascending sort is being applied to the array. The selection sort will

(a) Select the smallest element from the unsorted array (or portion of the array that is unsorted), and then

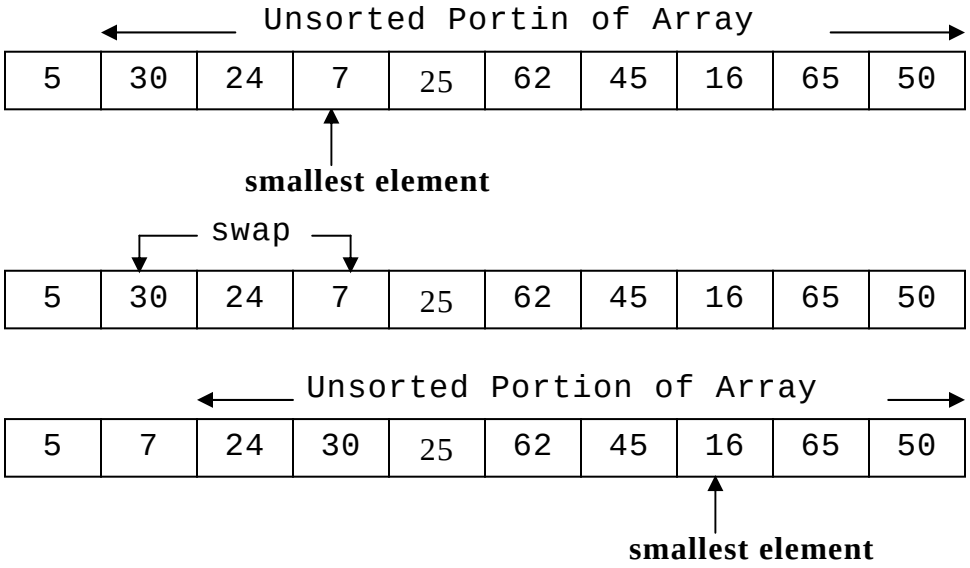
(b) Swap this smallest element to the beginning of the unsorted array (or to become the last element in the sorted portion of the array).

The first time around, the smallest element is found for the entire list. The second time around, the smallest element is located in the remaining portion of the array starting from the second element on. This process stops when there is one element left from the array.

First Pass:



Second Pass:



Continue the above steps until all elements are placed in correct order. Note that the process stop **when the unsorted portion of the array is reduced to just one element.**

The code and example are listed below; it is the copy from a textbook. Some functions are added to provide options or alternatives to the existing code.

Example 2

```
/*
 *Program Name: cis27L1442.c
 *Discussion:   Selection Sort
*/
/*    ****************************************************************
      **  This program is provided to the professors and students   **
      **  using "Computer Science: A Structured Approach Using C,   **
      **  Second Edition." All reprints in any form must cite this  **
      **  copyright.                                                **
      **                                                          **
      **  Copyright(c) 2001 by Brooks/Cole                          **
      **  A division of Thomson Learning                            **
      ****************************************************************
*/

/*    Test driver for sorting.
         Written by:
         Date:
*/
#include <stdio.h>

#define MAX_ARY_SIZE 15

/*    Prototype Declarations */
void selectionSort(int list[], int last);
void exchangeSmallest(int list[], int first, int last);

int main() {
  /* Local Declarations */
  int i;
```

```
  int ary[MAX_ARY_SIZE] = {89, 72,  3, 15, 21,
                           57, 61, 44, 19, 98,
                           5, 77, 39, 59, 61};
  /*Statements */
  printf("Unsorted array: ");
  for (i = 0; i < MAX_ARY_SIZE; i++)
    printf("%3d", ary[i]);

  selectionSort(ary, MAX_ARY_SIZE - 1);

  printf("\nSorted array:   ");
  for (i = 0; i < MAX_ARY_SIZE; i++)
    printf("%3d", ary[i]);
  printf("\n");
  return 0;
} /* main */

/*    ==================== selectionSort ====================
      Sorts by selecting smallest element in unsorted portion
      of array and exchanging it with element at the
      beginning of the unsorted list.
         Pre   list must contain at least one item
               last contains index to last element in list
         Post  list rearranged smallest to largest
*/
void selectionSort(int list[], int last) {
  /*Local Definitions */
  int current;

  /*Statements */
  for (current = 0; current < last; current++)
    exchangeSmallest (list, current, last);

  return;
} /* selectionSort */

/*    ================== exchangeSmallest ==================
      Given array of integers, place smallest element into
      position in array.
         Pre   list must contain at least one element
               current is beginning of array (not always 0)
               last element in array must be >= current
         Post  returns index of smallest element in array
*/
void exchangeSmallest(int list[], int current, int last) {
  /*Local Definitions*/
  int walker;
  int smallest;
  int tempData;

  /*Statements*/
  smallest = current;
  for (walker = current + 1; walker <= last; walker++)
    if (list[walker] < list[smallest])
      smallest = walker;

  /* Smallest selected: exchange with current element */
  tempData        = list[current];
  list[current]   = list[smallest];
```

```
  list[smallest]  = tempData;

  return;
} /* exchangeSmallest */

/*    Results:
      Unsorted array:  89 72  3 15 21 57 61 44 19 98  5 77 39 59 61
      Sorted array:     3  5 15 19 21 39 44 57 59 61 61 72 77 89 98
*/
```