

Exercise 4-2:

Maximilian Fernaldy - C2TB1702

Exercise 4-2: Inversion of bubble sort sort_bubble2.c

- Modify sort_bubble1.c to create a program sort_bubble2.c that starts the comparison from the back of the array and replaces the smaller elements in the forward.

ex)
""" Before the reference element
"<" Before the element to be compared
[Comparison count] and
[Replacement count] are displayed at the
beginning of the array.

```
[ 1][ 0] 8 2 7 4 5 6 9 0 <1 *3  
[ 2][ 0] 8 2 7 4 5 6 3 <0 *1 3  
[ 3][ 0] 8 2 7 4 5 6 <9 *0 1 3  
[ 4][ 1] 8 2 7 4 5 <6 *0 9 1 3  
[ 5][ 2] 8 2 7 4 <5 *0 6 9 1 3  
[ 6][ 3] 8 2 7 <4 *0 5 6 9 1 3  
[ 7][ 4] 8 2 <7 *0 4 5 6 9 1 3  
[ 8][ 5] 8 <2 *0 7 4 5 6 9 1 3  
[ 9][ 6] <8 *0 2 7 4 5 6 9 1 3  
[10][ 7] 0 8 2 7 4 5 6 9 <1 *3  
[11][ 7] 0 8 2 7 4 5 6 <9 *1 3  
...  
[40][26] 0 1 2 3 4 5 8 6 <7 *9  
[41][26] 0 1 2 3 4 5 8 <6 *7 9  
[42][26] 0 1 2 3 4 5 <8 *6 7 9  
[43][27] 0 1 2 3 4 5 6 8 <7 *9  
[44][27] 0 1 2 3 4 5 6 <8 *7 9  
[45][28] 0 1 2 3 4 5 6 7 <8 *9
```

To start the sort from the end of the array, we only need to replace the values used in the loops, and reuse almost all the code from exercise 4-1. We need to modify these lines in particular:

```
sort_bubble1.c ↔ sort_bubble2.c — pip  
lec04 > ex4-2 > C sort_bubble2.c > main()  
35 for (j = 0; j < NUM-1; j++) {  
36     comparisons++;  
37     printf("[%d][%d] ", comparisons, swaps); //  
38     // Display the number of comparisons and swaps done  
39     for (int k = 0; k < NUM; k++) {  
40         if (k == j) {  
41             printf("%d ", A[k]);  
42         } else if (k == j + 1) {  
43             printf(">%d ", A[k]);  
44         } else {  
45             printf("%d ", A[k]);  
46         }  
47  
48         // Insert new line if k reaches the end of  
49         the array  
50         if (k == NUM - 1) {  
51             printf("\n");  
52         }  
53  
54         // If compared number is smaller than reference  
55         number, swap them  
56         if (A[j] > A[j+1]) {  
57             temp = A[j];  
58             A[j] = A[j+1];  
59             A[j+1] = temp;  
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61     }  
62 }  
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```

Next, we need to modify the `for` loop that prints the array. The element that is being referenced is still the `j`-th element, so we don't need to change that part. However, the element it is being compared to is now the `j-1`-th element, as opposed to `j+1` from earlier. Therefore, we should change the condition of the `else if` operator to execute the block if `k` matches `j-1` instead. We also change the symbol shown beside the number to "<" instead of ">".

```
} else if (k == j - 1) {  
    printf("<%d ", A[k]);  
}
```

Finally, we of course need to change the code that swaps the numbers around. If the compared number is larger than the referenced one, they should be swapped around.

```
if (A[j-1] > A[j]) {  
    temp = A[j];  
    A[j] = A[j-1];  
    A[j-1] = temp;  
  
    swaps++;  
}
```

Running the compiled program gives:

```
-zsh
max ~ % cdpip && cd lec04/ex4-2 && ./sort_bubble2
Array before sorting:
8 2 7 4 5 6 9 0 1 3

Bubble sorting...
Loop 1:
[1][0] 8 2 7 4 5 6 9 0 <1 *3
[2][0] 8 2 7 4 5 6 9 <0 *1 3
[3][0] 8 2 7 4 5 6 <9 *0 1 3
[4][1] 8 2 7 4 5 <6 *0 9 1 3
[5][2] 8 2 7 4 <5 *0 6 9 1 3
[6][3] 8 2 7 <4 *0 5 6 9 1 3
[7][4] 8 2 <7 *0 4 5 6 9 1 3
[8][5] 8 <2 *0 7 4 5 6 9 1 3
[9][6] <8 *0 2 7 4 5 6 9 1 3

Loop 2:
[10][7] 0 8 2 7 4 5 6 9 <1 *3
[11][7] 0 8 2 7 4 5 6 <9 *1 3
[12][8] 0 8 2 7 4 5 <6 *1 9 3
[13][9] 0 8 2 7 4 <5 *1 6 9 3
[14][10] 0 8 2 7 <4 *1 5 6 9 3
[15][11] 0 8 2 <7 *1 4 5 6 9 3
[16][12] 0 8 <2 *1 7 4 5 6 9 3
[17][13] 0 <8 *1 2 7 4 5 6 9 3

Loop 3:
[18][14] 0 1 8 2 7 4 5 6 <9 *3
[19][15] 0 1 8 2 7 4 5 <6 *3 9
[20][16] 0 1 8 2 7 4 <5 *3 6 9
[21][17] 0 1 8 2 7 <4 *3 5 6 9
[22][18] 0 1 8 2 <7 *3 4 5 6 9
[23][19] 0 1 8 <2 *3 7 4 5 6 9
[24][19] 0 1 <8 *2 3 7 4 5 6 9

Loop 4:
[25][20] 0 1 2 8 3 7 4 5 <6 *9
[26][20] 0 1 2 8 3 7 4 <5 *6 9
[27][20] 0 1 2 8 3 7 <4 *5 6 9
[28][20] 0 1 2 8 3 <7 *4 5 6 9
[29][21] 0 1 2 8 <3 *4 7 5 6 9
[30][21] 0 1 2 <8 *3 4 7 5 6 9

Loop 5:
[31][22] 0 1 2 3 8 4 7 5 <6 *9
[32][22] 0 1 2 3 8 4 7 <5 *6 9
[33][22] 0 1 2 3 8 4 <7 *5 6 9
[34][23] 0 1 2 3 8 <4 *5 7 6 9
[35][23] 0 1 2 3 <8 *4 5 7 6 9

Loop 6:
[36][24] 0 1 2 3 4 8 5 7 <6 *9
[37][24] 0 1 2 3 4 8 5 <7 *6 9
[38][25] 0 1 2 3 4 8 <5 *6 7 9
[39][25] 0 1 2 3 4 <8 *5 6 7 9

Loop 7:
[40][26] 0 1 2 3 4 5 8 6 <7 *9
[41][26] 0 1 2 3 4 5 8 <6 *7 9
[42][26] 0 1 2 3 4 5 <8 *6 7 9

Loop 8:
[43][27] 0 1 2 3 4 5 6 8 <7 *9
[44][27] 0 1 2 3 4 5 6 <8 *7 9

Loop 9:
[45][28] 0 1 2 3 4 5 6 7 <8 *9

Sorted array:
0 1 2 3 4 5 6 7 8 9
45 comparisons, 28 replacements made
max ex4-2 %
```