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C Programming Basic – week 11

Sorting II

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Topics of this week

- Advanced Sorting Algorithm
 - Quick sort
 - Merge sort
 - Recursive processing
- Exercises



Quicksort Algorithm

Given an array of n elements (e.g., integers):

- If array only contains one element, return
- Else
 - pick one element to use as *pivot*.
 - Partition elements into two sub-arrays:
 - Elements less than or equal to pivot
 - Elements greater than pivot
 - Quicksort two sub-arrays
 - Return results



Example

- We are given array of n integers to sort:

40	20	10	80	60	50	7	30	100
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Quick Sort (Hoare)

- Given $(R_0, R_1, \dots, R_{n-1})$
 K_i : pivot key
 if K_i is placed in $S(i)$,
 then $K_j \leq K_{S(i)}$ for $j < S(i)$,
 $K_j \geq K_{S(i)}$ for $j > S(i)$.
- $R_0, \dots, R_{S(i)-1}, R_{S(i)}, R_{S(i)+1}, \dots, R_{S(n-1)}$

two partitions

Partitioning Array

- Given a pivot, partition the elements of the array such that the resulting array consists of:
 - 1. One sub-array that contains elements \geq pivot
 - 2. Another sub-array that contains elements $<$ pivot
- The sub-arrays are stored in the original data array.
- Partitioning loops through, swapping elements below/above pivot.

Partition Result

7	20	10	30	40	50	60	80	100
[0]	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
← ≤ data[pivot]					→ > data[pivot]			

Recursion: Quicksort Subarrays

7	20	10	30	40	50	60	80	100
[0]	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
← ≤ data[pivot]					→ > data[pivot]			

Example for Quick Sort

R0	R1	R2	R3	R4	R5	R6	R7	R8	R9	left	right
{ 26	5	37	1	61	11	59	15	48	19 }	0	9
{ 11	5	19	1	15 }	26	{ 59	61	48	37 }	0	4
{ 1	5 }	11	{ 19	15 }	26	{ 59	61	48	37 }	0	1
{ 1	5	11	15	19	26	{ 59	61	48	37 }	3	4
1	5	11	15	19	26	{ 48	37 }	59	{ 61 }	6	9
1	5	11	15	19	26	37	48	59	{ 61 }	6	7
1	5	11	15	19	26	37	48	59	61	9	9
1	5	11	15	19	26	37	48	59	61		

Quick Sort

```

void quicksort(element list[], int left,
               int right)
{
    int pivot, i, j;
    element temp;
    if (left < right) {
        i = left;      j = right+1;
        pivot = list[left].key;
        do {
            do i++; while (list[i].key < pivot);
            do j--; while (list[j].key > pivot);
            if (i < j) SWAP(list[i], list[j], temp)
        } while (i < j);
        SWAP(list[left], list[j], temp);
        quicksort(list, left, j-1);
        quicksort(list, j+1, right);
    }
}

```



Exercise 11-1: Quick sort

- We assume that you make a mobile phone's address book.
- At the very least, you should declare the structure that can store "name", "phone number" and "e-mail address". And, you should declare the array that can store about 100 data that have this structure.
- You write a program that reads about 10 data from an input file to the array and writes the data to an output file after sorting in ascending order for name.
- You must use Quick sort for sorting.



Exercise 11-2

- Initiate an array of n random integers. n is entered by user.
- Sort the array with the insertion sort
- And using quicksort
- Compare the execution time of two algorithms.
- Run the program with various values of n to view the effect.



Exercise 11-3 Combination of quick sort and insertion sort

- When a program sorts a little number of the data, a program using insertion sort is faster than a program using quick sort and so on. So, a program sorts efficiently, if a program changes sorting algorithms by the number of data.
- You write a function that selects sorting algorithms – If number of the data is more than x numbers, the function selects quick sort. If not so, it selects insertion sort.
- Note: get the number " x " as the program argument.
- Read the text file that has more than 100 characters, sort the first 100 characters, and show the result by standard output.



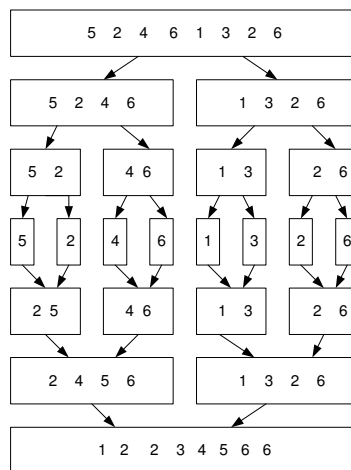
Merge Sort

- Problem: Given n elements, sort elements into non-decreasing order
- Apply divide-and-conquer to sorting problem
 - If $n=1$ terminate (every one-element list is already sorted)
 - If $n>1$, partition elements into two sub-arrays; sort each; combine into a single sorted array

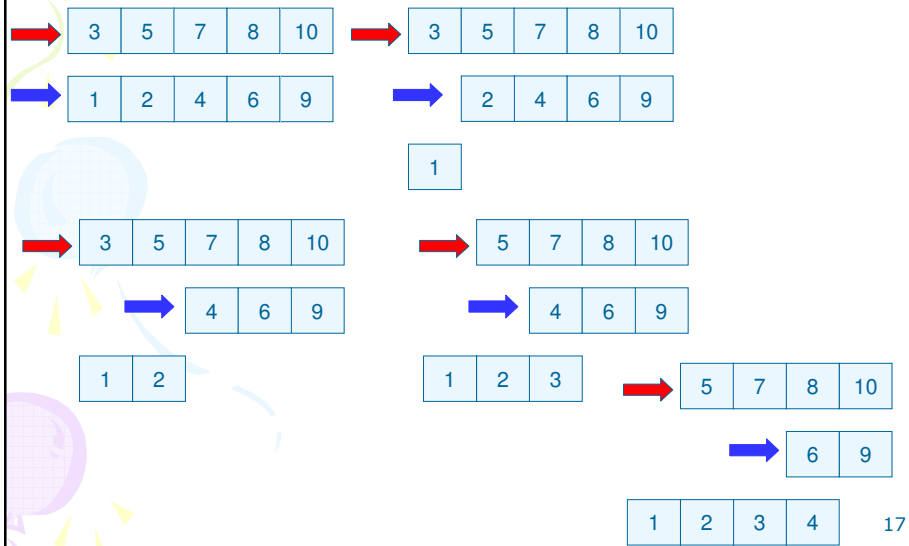
Algorithm

```
MergeSort (E[ 0 .. N])  
  if N < threshold  
    InsertionSort ( E[0..N] )  
  else  
    copy E[0.. N/2] to U[0.. N/2]  
    copy E[N/2 .. N] to V[0 .. N-N/2]  
    MergeSort(U[0 .. N/2])  
    MergeSort(V[0 .. N-N/2])  
    Merge( U[0 .. N/2], V[0 .. N-N/2], E[0  
    .. N] )
```

Merge Sort: Example



Process of merge



Merge algorithm

```
Merge(U[0..m], V[0..n], E[0..n+m])
```

```
  i = 0 , j = 0
```

```
  k = 0
```

```
  while k < n+m
```

```
    if U[i] < V[j]
```

```
      E[k] = U[i] , i++
```

```
    else
```

```
      E[k] = V[j] , j++
```

```
    k++
```



Exercise: 11-3 Merge sort

- We assume that you make a mobile phone's address book.
- At the very least, you should declare the structure that can store "name", "phone number" and "e-mail address". And, you should declare the singly-linked list that can store about 100 data that have this structure.
- You write a program that reads about 10 data from an input file to the list and writes the data to an output file after sorting in ascending order for name.
- You must use Merge sort for sorting.



Exercise: Recursive Processing

- Write a recursive algorithm for dealing a deck of cards. The parameters should be (i) the deck of undealt cards, and (ii) the person who is to receive the next card. Assume:
 - the players are seated around a table;
 - dealing begins with the player to the dealer's left;
 - each dealing step involves dealing one card to a player, then the dealer's attention moves to the next player to the left; and
 - dealing continues until no cards are left in the deck.



Hint

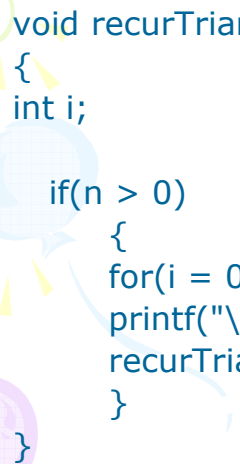
```
function dealCards (deck, person)
{
    if (deck is empty)
        return;
    deal top card from deck to person;
    dealCards (rest of deck, personLeftOf(person));
}
```



Exercise: Recursive Processing

- Write a recursive function **void recurTriangle (int n, char ch)** which prints out an upside-down triangle. The parameter *ch* is the character to be used for drawing the triangle, and *n* is the number of characters on the first row. For example, if *n* is 7 and *ch* is '+', then the output of the function should be:

```
+++++++
+++++++
+++++++
+++++
++++
+++
++
+
```

Three colorful balloons (green, blue, and purple) with yellow streamers are positioned on the left side of the slide.

```
void recurTriangle(int n, char ch)
{
    int i;

    if(n > 0)
    {
        for(i = 0; i < n; i++) printf("%c", ch);
        printf("\n");
        recurTriangle(n-1, ch);
    }
}
```

Three colorful balloons (green, blue, and purple) with yellow streamers are positioned on the left side of the slide.

Exercise 11-4: String sorting

- Write a program that sorts strings with quick sort by alphabetical order based on the following instructions.

I. Compare the character strings

- Write the function "preceding()" to search which of two character strings comes before by alphabetical order.

```
int preceding(char *first, char *second)
```

- A return value is by alphabetical order
 - Case that the character string of the argument "first" is before the character string of the argument "second" : 1
 - Case that the character string of the argument "first" is equal to the character string of the argument "second" : 0
 - Case that the character string of the argument "first" is after the character string of the argument "second" : -1

II. Input the character string from the file

- Write the function "setup_nameList()" to read the name of more than 2 persons and less than 25 persons from the file and set them to the array "nameList[]" of a character string (in fact, the array of the pointer to the character string)

```
int setup_nameList(char *namelist[], char *filename)
```



III. Implement Quicksort

- Write the function "qsort_name()" to sort the character string of the array "namelist[]" by alphabetical order with quick sort using the function you made ever.



Homework

- Write a quicksort function to sort a singly linked list. Add this function to the linked list library.
- Hint: You should have a function
 - *for getting the Nth element in the linked list*
 - *Swapping two nodes in listed*