Data structure and algorithms lab

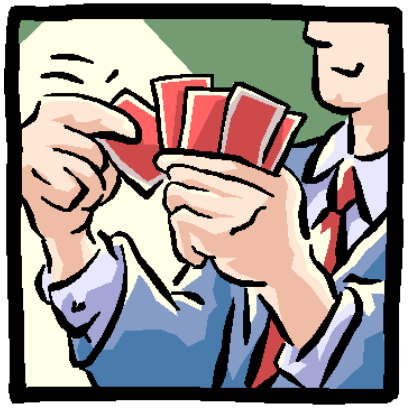
SORTING I

Lecturers : Cao Tuan Dung
dungct@soict.hust.edu.vn
Dept of Software Engineering
Hanoi University of Science and Technology

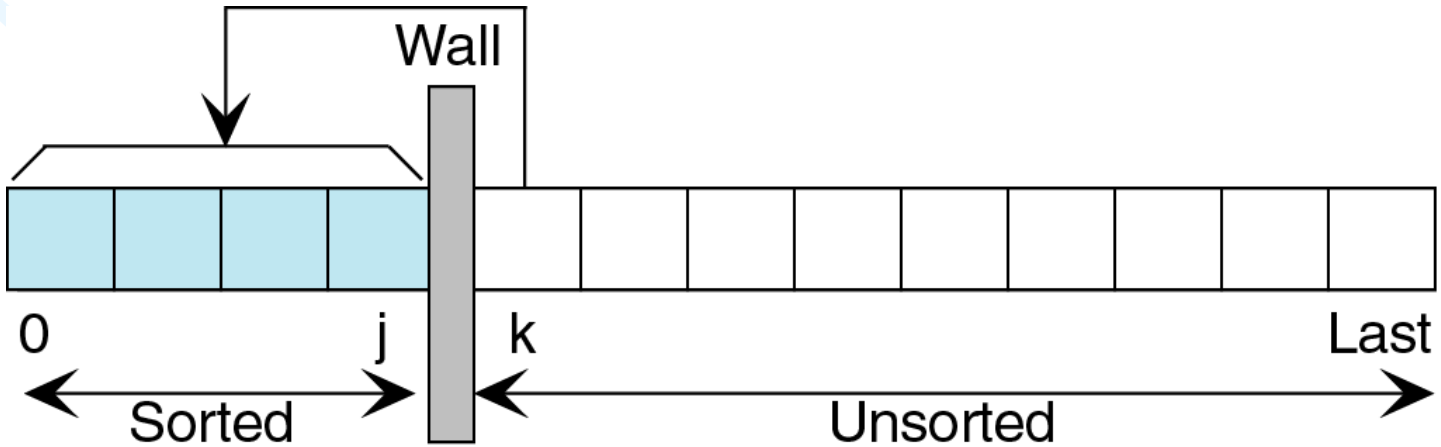
Topics of this week

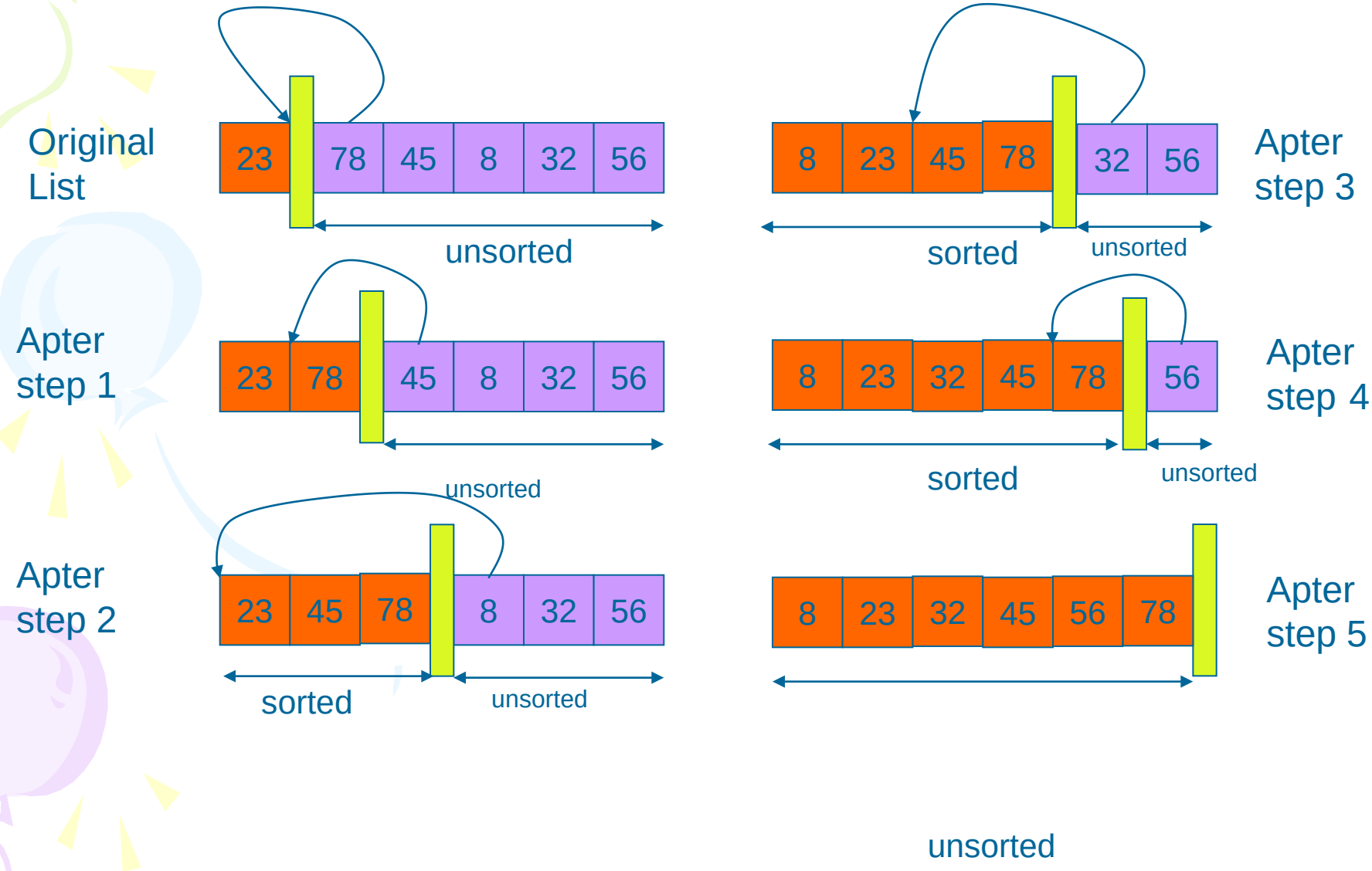
- Elementary Sorting Algorithm
  - Insertion
  - Selection
  - Bubble (exchange)
- Heap sort Algorithm

Insertion sort



- Strategy of Card Players
- Sorts list by
  - Finding first unsorted element in list
  - Moving it to its proper position
  - Efficiency: O(n^2)



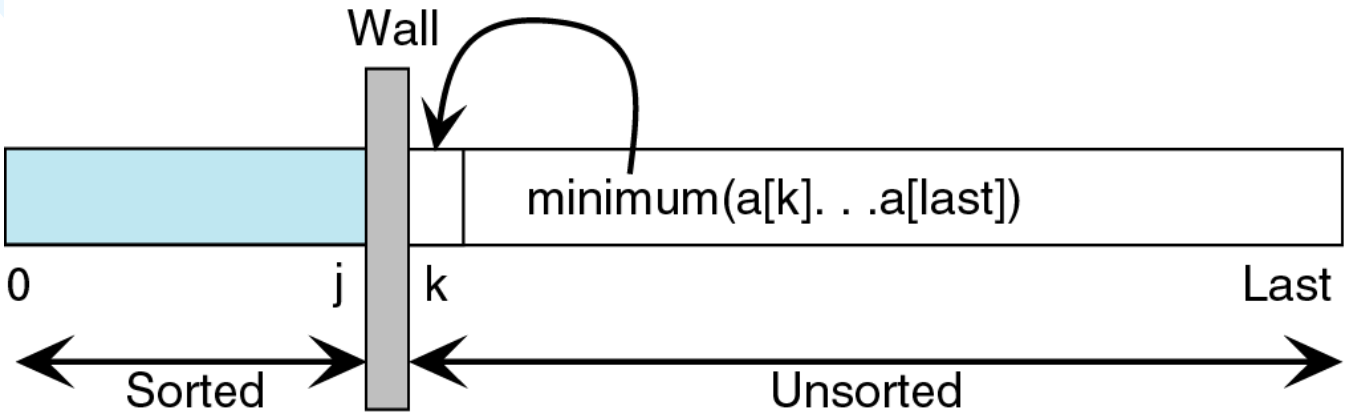

Original List
23
78
45
8
32
56
unsorted
Apter step 1
23
78
45
8
32
56
unsorted
Apter step 2
23
45
78
8
32
56
sorted
unsorted
Apter step 3
8
23
45
78
32
56
sorted
unsorted
Apter step 4
8
23
32
45
78
56
sorted
unsorted
Apter step 5
8
23
32
45
56
78
unsorted

Insertion Sort

```
void insertion_sort(element list[], int n)
{
   int i, j;
   element next;
   for (i=1; i<n; i++) {
      next= list[i];
      for (j=i-1;j>=0 && next.key< list[j].key;
           j--)
        list[j+1] = list[j];
      list[j+1] = next;
   }
}
```

Selection sort

- Sorts list by
  - Finding smallest (or equivalently largest) element in the list
  - Moving it to the beginning (or end) of the list by swapping it with element in beginning (or end) position



Selection sort

```
void selection(element a[], int n)
   { int i, j, min, tmp;
     for (i = 0; i < n-1; i++){
         min = i;
         for (j = i+1; j <=n-1 ; j++)
             if ( a[j].key < a[min].key)
                 min = j;
         tmp= a[i];
         a[i]= a[min]);
         a[min] = tmp;
       }
   }
```

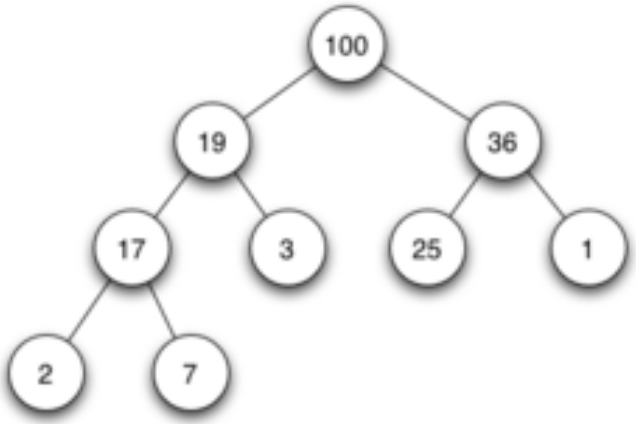
Exercise

- We assume that you make a mobile phone's address book.
- At least, we want to write a program that can store about 100 structure data with name and phone number and e-mail address.
- Read about 10 data from an input file to this structure, and write the data that is sorted in ascending order into an output file.
- Use the insertion sort and selection sort

- (1) Write a program that uses array of structure
- (2) Write a program that uses singly-linked list or doubly-linked list.
- In both program, print out the number of comparisons made during the sorting process of each algorithm.

Heap sort

- Heap: a binary tree which
  - The root is guaranteed to hold largest node in tree
  - Smaller values can be on either right or left sub-tree
  - The tree is complete or nearly complete
  - Key value of each node is >= to key value in each descendent

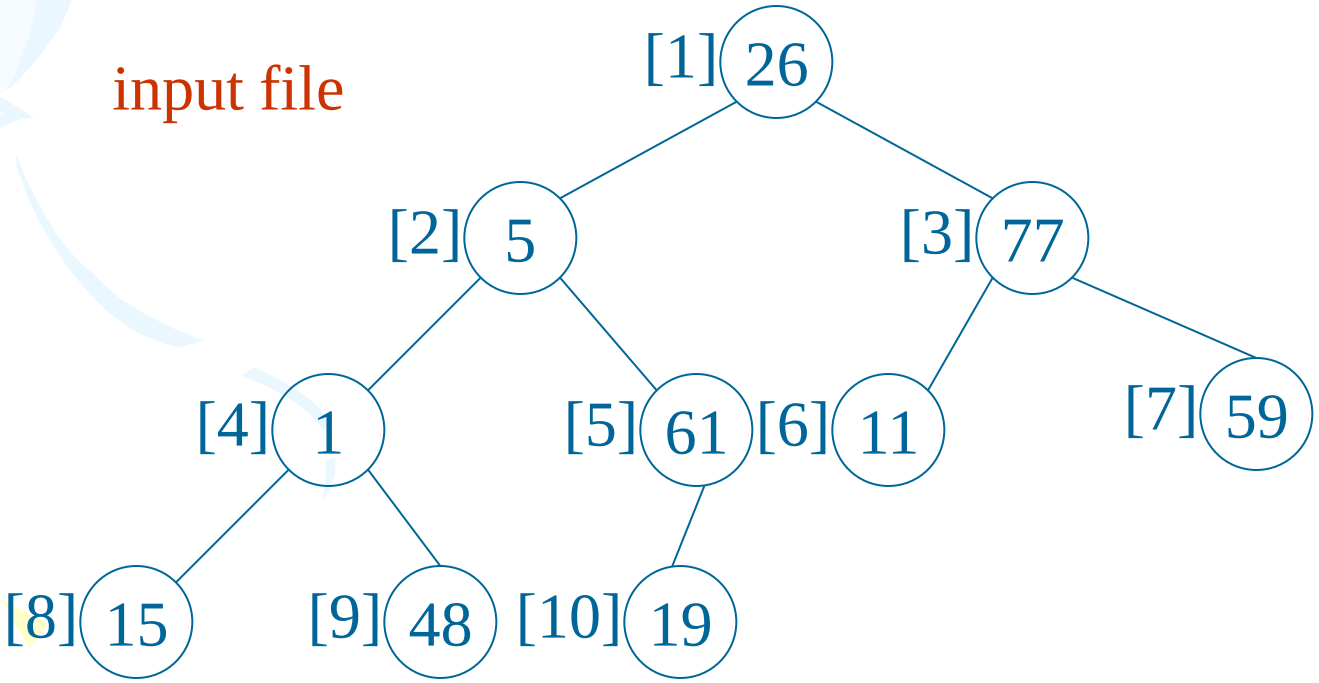


Heap sort

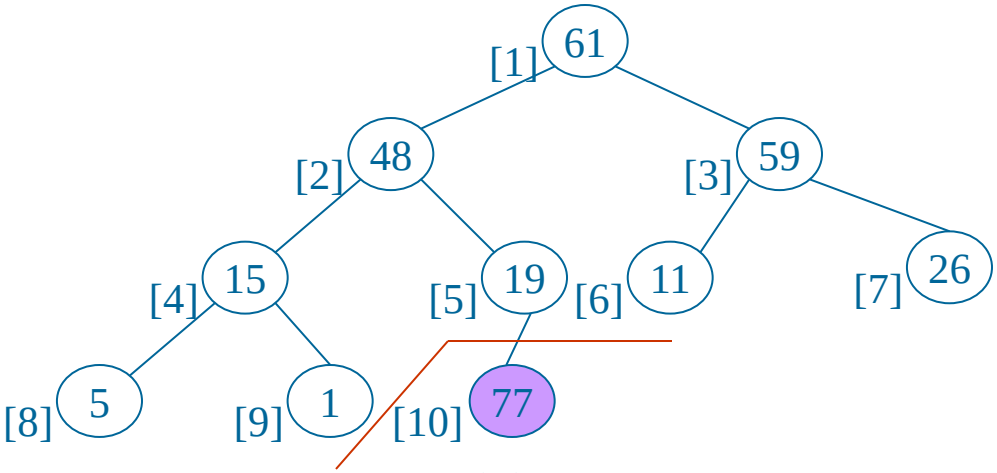
Array interpreted as a binary tree

1	2	3	4	5	6	7	8	9	10
26	5	77	1	61	11	59	15	48	19

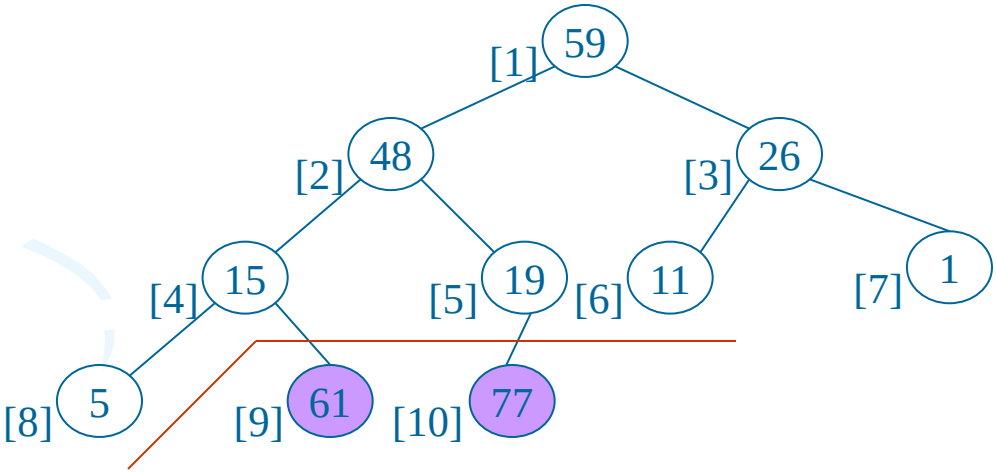
input file



Heap sort illustration

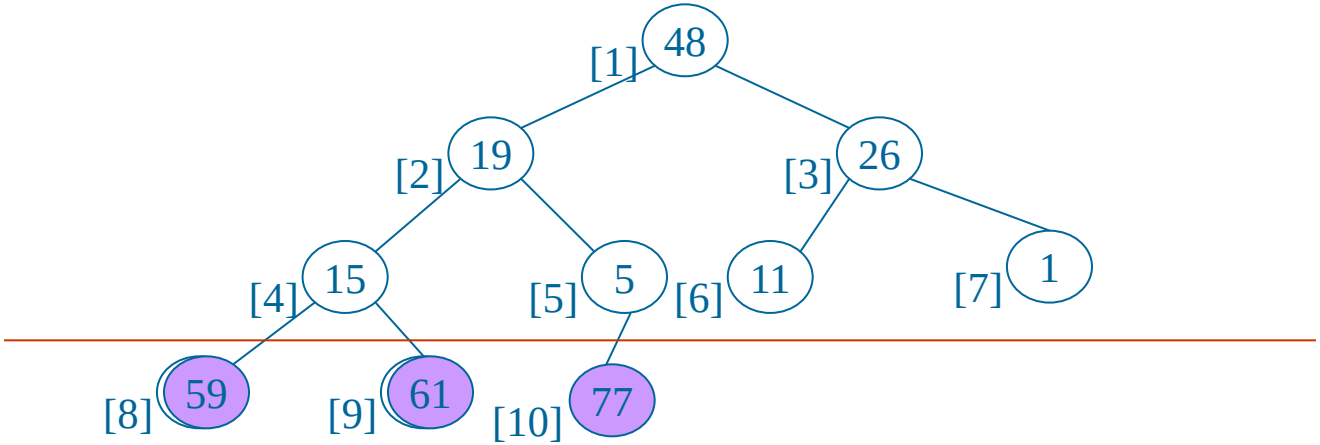


(a)

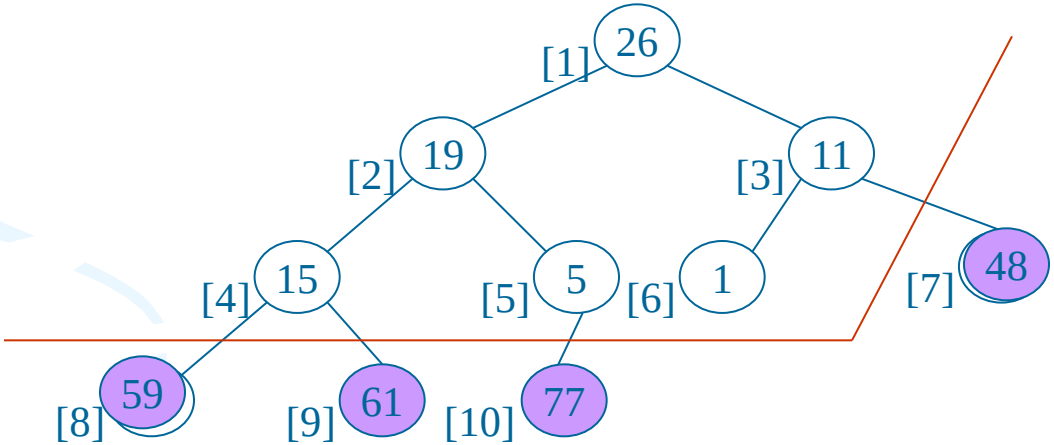


(b)

Heap sort illustration



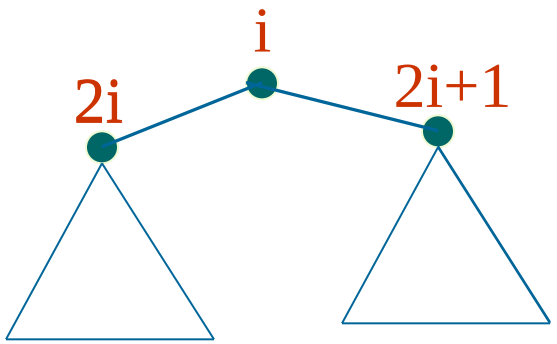
(c)



(d)

Heap sort

```
void adjust(element list[], int root, int n)
{
  int child, rootkey;   element temp;
  temp=list[root];      rootkey=list[root].key;
  child=2*root;
  while (child <= n) {
    if ((child < n) &&
        (list[child].key < list[child+1].key))
           child++;
    if (rootkey > list[child].key) break;
    else {
      list[child/2] = list[child];
      child *= 2;
    }
  }
  list[child/2] = temp;
}
```



Heap sort

```
void heapsort(element list[], int n)
{
    int i, j;
    element temp;
    for (i=n/2; i>0; i--) adjust(list, i, n);
    for (i=n-1; i>0; i--) {
        SWAP(list[1], list[i+1], temp);
        adjust(list, 1, i);
    }
}
```

ascending order (max heap)

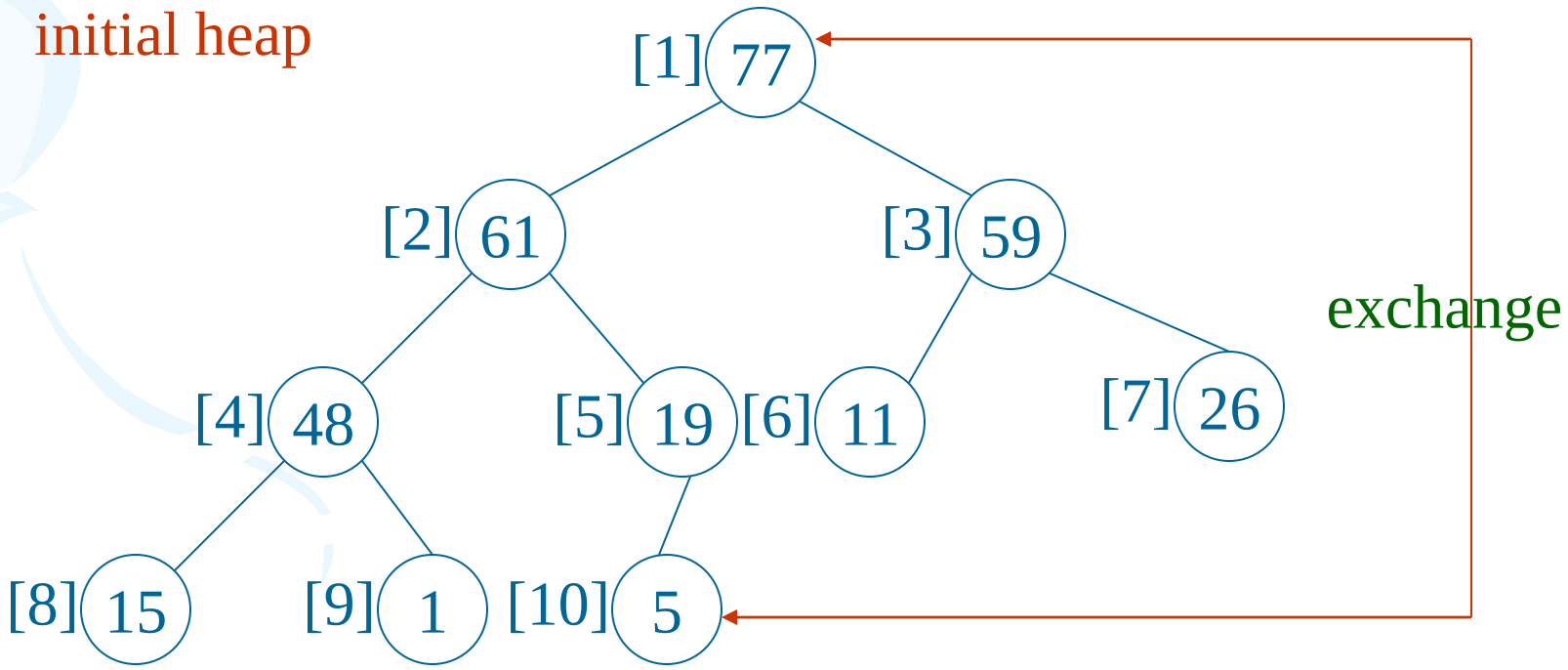
bottom-up

n-1 cylces

top-down

Heap sort

Max heap following first **for** loop of *heapsort*



Exercise

- We assume that you make a mobile phone's address book.
- At least, we want to write a program that can store the declared about 100 structure data with name and phone number and e-mail address.
- Read the about 10 data from an input file to this structure, and write the data that is sorted in ascending order into an output file.
- Use the heap sort. Print out the number of comparisons.

Exercise: Comparison of running time

- Write a program to initiate an array of 100000 integers by using random function.
- Sort this array using insertion sort and heap sort. Calculate the running time of program in each case and print out the results.

Help

- function for generating random numbers: `srand(time(NULL))and rand()`
- Time functions

```
#include <time.h>
time_t t1,t2;
time(&t1);
/* Do something */
time(&t2);
durationinseconds = (int) t2 -t1;
```

Help

- Time functions

```
#include <time.h>

 clock_t tic = clock();
 dosomething();
 clock_t toc = clock();
 printf("Elapsed: %f seconds\n",
   (double)(toc - tic) / CLOCKS_PER_SEC);
```

Exercise

- Input 10 words from the standard input, and load them to a character type array.
- Sort the array by insertion sort, and output the sorted array into the standard output.

Hints

- You can write a program that processes in the following order.
  - 1. Declare char data[10].
  - 2. Read every 1 word from the standard input by fgetc( ) function and load it on the array “data”.
  - 3. Do the insertion sort to the array “data”
  - 4. Output every 1 word of the value of the sorted array ”sort” by fputc( ) function.

Homework

- Create a dynamically allocated array of 2 million integers. Generate randomly value for the array's elements.
- Implement menu-driven program
- Sorting Algorithms Comparison
  - 1. Create dataset (Generate integers)
  - 2. Insertion Sort
  - 3. Selection Sort
  - 4. Bubble Sort
  - 5. Heap Sort
- For each sorting algorithm, display the execution time in seconds.

Homework

- From unsorted PhoneDB.dat, sort the data by the field of phone model using Heapsort and display the result in the screen.

Homework

- Implement Heapsort for your Student list data for both ascending and descending order.