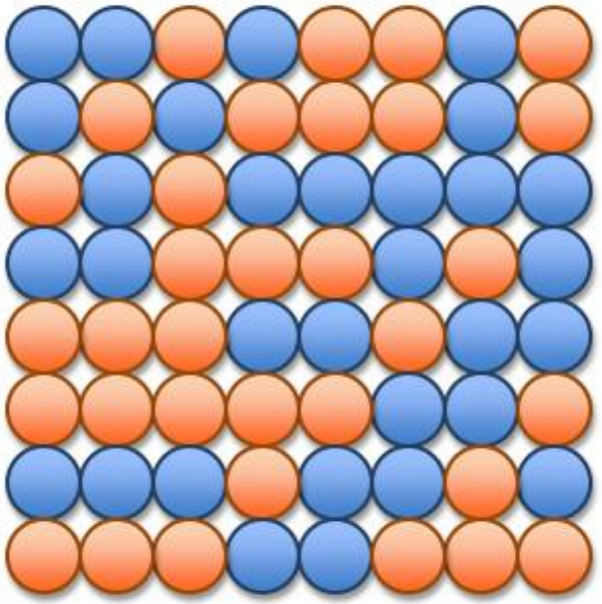
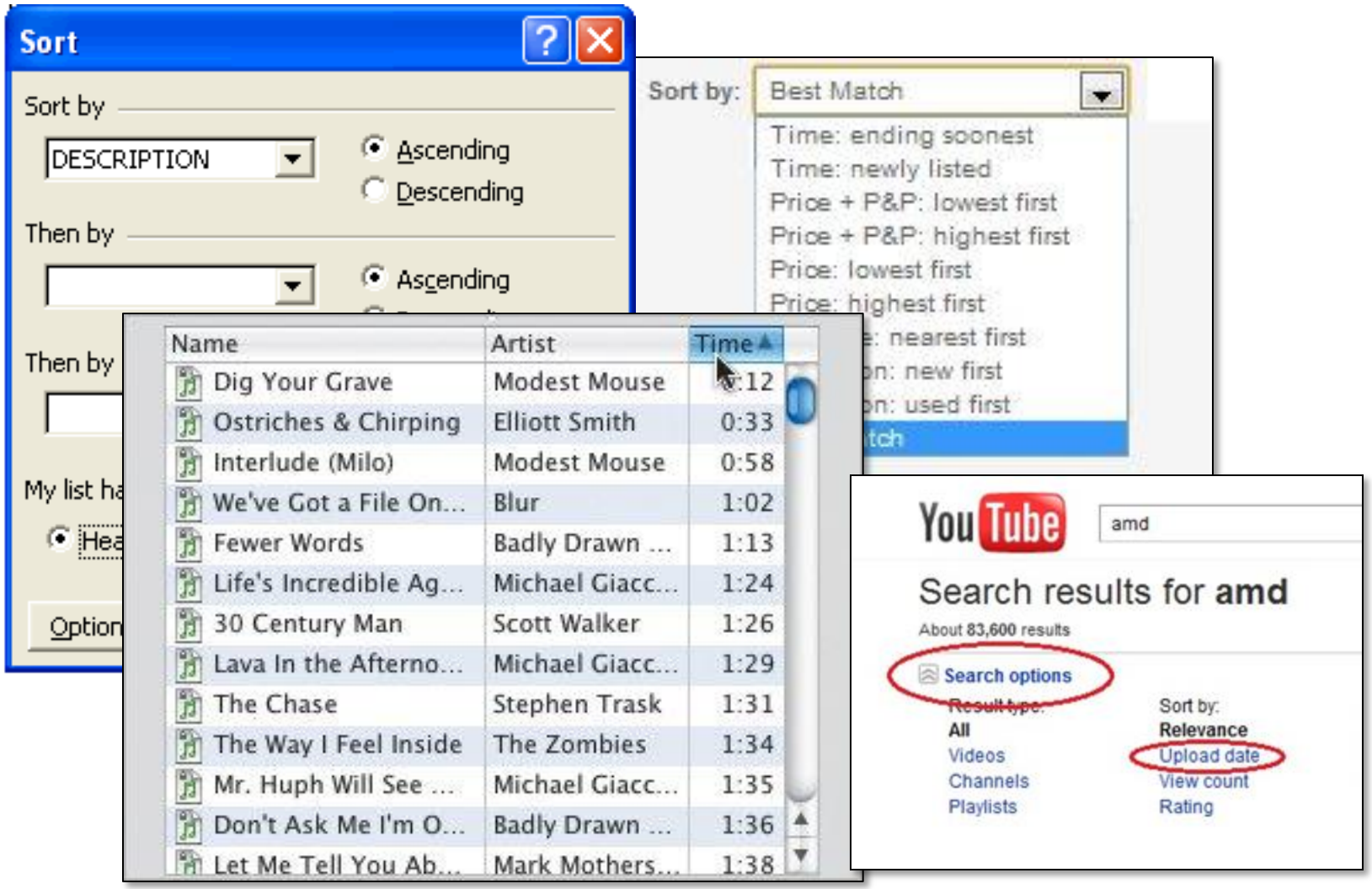


UNIT 4
Iteration: Sorting and Scalability

Sorting


Sort
Sort by
DESCRIPTION
Ascending
Descending
Then by
Ascending
Then by
My list ha
Hea
Option
Sort by:
Best Match
Time: ending soonest
Time: newly listed
Price + P&P: lowest first
Price + P&P: highest first
Price: lowest first
Price: highest first
: nearest first
on: new first
on: used first
tch
Name
Artist
Time
Dig Your Grave
Modest Mouse
:12
Ostriches & Chirping
Elliott Smith
0:33
Interlude (Milo)
Modest Mouse
0:58
We've Got a File On...
Blur
1:02
Fewer Words
Badly Drawn ...
1:13
Life's Incredible Ag...
Michael Giacc...
1:24
30 Century Man
Scott Walker
1:26
Lava In the Afterno...
Michael Giacc...
1:29
The Chase
Stephen Trask
1:31
The Way I Feel Inside
The Zombies
1:34
Mr. Huph Will See ...
Michael Giacc...
1:35
Don't Ask Me I'm O...
Badly Drawn ...
1:36
Let Me Tell You Ab...
Mark Mothers...
1:38
YouTube
amd
Search results for amd
About 83,600 results
Search options
Result type:
All
Videos
Channels
Playlists
Sort by:
Relevance
Upload date
View count
Rating

Insertion Sort

Given an array a of length n, n > 0.

1. Set i = 1.
2. While i is not equal to n, do the following:

   a. Insert a[i] into its correct position in a[0..i].

   b. Add 1 to i.
3. Return the array a which will now be sorted.

Example

```
a = [53, 26, 76, 30, 14, 91, 68, 42]
i =       1
```

Insert a[1] into its correct position in a[0..1]
and then add 1 to i:

53 moves to the right,

26 is inserted back into the array

```
a = [26, 53, 76, 30, 14, 91, 68, 42]
i =           2
```

Example

```
a = [26, 53, 76, 30, 14, 91, 68, 42]
i =          2
```

Insert a[2] into its correct position in a[0..2]
and then add 1 to i:

76 is already in the correct place in a[0..2]

```
a = [26, 53, 76, 30, 14, 91, 68, 42]
i =              3
```

Example

```
a = [26, 53, 76, 30, 14, 91, 68, 42]
i =              3
```

Insert a[3] into its correct position in a[0..3]
and then add 1 to i:

76 moves to the right, then 53 moves to the right,

now 30 is inserted back into the array

```
a = [26, 30, 53, 76, 14, 91, 68, 42]
i =                   4
```

Look Closer at Insertion Sort

Given an array a of length n, n > 0.

1. Set i = 1.
2. While i is not equal to n, do the following:

   Precondition for each iteration: a[0..i-1] is sorted

   a. Insert a[i] into its correct position in a[0..i].

   b. Add 1 to i.

   Postcondition for each iteration: a[0..i-1] is sorted
3. Return the array a which will now be sorted.

Look Closer at Insertion Sort

Given an array a of length n, n > 0.

1. Set i = 1.
2. While i is not equal to n, do the following:

   Loop invariant: a[0..i-1] is sorted

   a. Insert a[i] into its correct position in a[0..i].

   b. Add 1 to i.
3. Return the array a which will now be sorted.

A <u>loop invariant</u> is a condition that is true at the start and end of each iteration of a loop.

Example (cont'd)

```
a = [26, 30, 53, 76, 14, 91, 68, 42]
i =                  4
```

Insert a[4] into its correct position in a[0..4]
and then add 1 to i:

76 moves to the right, then 53 moves to the right,

then 30 moves to the right, then 26 moves to the right,

now 14 is inserted back into the array

```
a = [14, 26, 30, 53, 76, 91, 68, 42]
i =                      5
```

Example

```
a = [14, 26, 30, 53, 76, 91, 68, 42]
i =                      5
```

Insert a[5] into its correct position in a[0..5]
and then add 1 to i:

91 is already in its correct position

```
a = [14, 26, 30, 53, 76, 91, 68, 42]
i =                          6
```

Example

```
a = [14, 26, 30, 53, 76, 91, 68, 42]
i =                          6
```

Insert a[6] into its correct position in a[0..6]
and then add 1 to i:

91 moves to the right,

76 moves to the right,

now 68 is inserted back into the array

```
a = [14, 26, 30, 53, 68, 76, 91, 42]
i =                           7
```

Example

```
a = [14, 26, 30, 53, 68, 76, 91, 42]
i =                              7
```

Insert a[7] into its correct position in a[0..7]
and then add 1 to i:

91 moves to the right, then 76 moves to the right,

then 68 moves to the right, then 53 moves to the right,

then 42 is inserted back into the array

```
a = [14, 26, 30, 42, 53, 68, 76, 91]
i =                                 8
```

Example

```
a = [14, 26, 30, 42, 53, 68, 76, 91]
i = 8
```

The array is sorted.

But how do we know that the algorithm always sorts correctly?

Reasoning with the Loop Invariant

The loop invariant is true at the end of each iteration, including the last iteration. After the last iteration, when we go to step 3:

a[0..i-1] is sorted AND i is equal to n

These 2 conditions imply that a[0..n-1] is sorted, but this range covers the entire array, so the array must always be sorted when we return our final answer!

Insertion Sort in Ruby

```
def isort(list)
      a = list.clone
      i = 1
      while i != a.length do
            move_left(a, i)
            i = i + 1
      end
      return a
end
```


insert a[i] into a[0..i] in its correct sorted position

Moving left

To move the element x at index i "left" to its correct position, start at position i-1, and search left until we find the first element that is less than x.

Then insert x back into the array to the right of the first element that is less than x when you searched from right to left in the sorted part of the array.

(The insert operation does not overwrite. Think of it as "squeezing into the array".)

Can you think of a special case for the step above?

Moving left: examples

Insert 68:

a = [14, 26, 30, 53, 76, 91, 68, 42]

Searching from right to left starting with 91, the first element less than 68 is 53.

Insert 68 to the right of 53.

Insert 76:

a = [26, 53, 76, 30, 14, 91, 68, 42]

Searching from right to left starting with 53, the first element less than 76 is 53.

Insert 76 to the right of 53 (where it was before).

Insert 14: SPECIAL CASE

a = [26, 30, 53, 76, 14, 91, 68, 42]

Searching from right to left starting with 76, all elements left of 14 are greater than 14. Insert 14 into the position 0.

The `move_left` algorithm

Given an array a of length n, n > 0 and a value at index i to be "moved left" in the array.

1. Remove a[i] from the array and store in x.
2. Set j = i-1.
3. While j >= 0 and a[j] > x, do the following:
   a. Subtract 1 from j.
4. Reinsert x into position a[j+1].

How is the special case handled here?

`move_left` in Ruby

```
def move_left(a, i)
    x = a.slice!(i)
    j = i-1
    while j >= 0 and a[j] > x do
        j = j - 1
    end
    a.insert(j+1, x)
end
```

remove the item at position i in array a and store it in x

logical operator AND: both conditions must be true for the loop to continue

insert x at position j+1 of array a, shifting all elements from j+1 and beyond over one position