

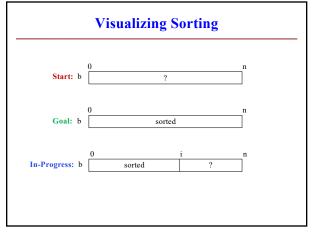
**Binary Search** def binary\_search(v,b): # Loop variable(s) i = 0, j = len(b)while i < j and b[i] != v: Requires that the mid = (i+j)//2if b[mid] < v: data is sorted! j = mid elif b[mid] > v: i = midBut few checks! return mid return -1 # not found

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The Sorting Challenge

- Given: A list of numbers
- Goal: Sort those numbers using only
  - Iteration (while-loops or for-loops)
  - Comparisons (< or >)
  - Assignment statements
- Why? For proper analysis.
  - Methods/functions come with hidden costs
  - Everything above has no hidden costs
  - Each comparison or assignment is "1 step"

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**Insertion Sort** sorted i = 0while i < n: # Push b[i] down into its # sorted position in b[0..i] 2 4 4 5 6 6 7 i = i+1Remember the restrictions!

5 6

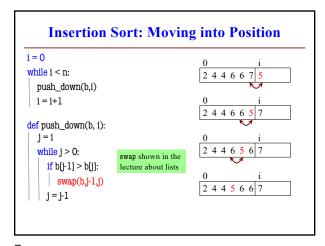
## **Horizontal Notation**

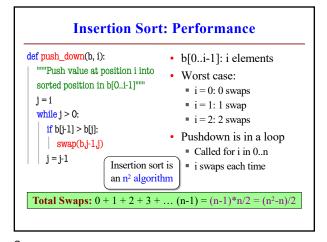
- Want a pictoral way to visualize this sorting
  - Represent the list as long rectangle
  - We saw this idea in divide-and-conquer

h h+1

(h+1) - h = 1

- Do **not** show individual boxes
  - Just dividing lines between regions
  - Label dividing lines with indices
  - But index is either left or right of dividing line





1

## Algorithm "Complexity"

- Given: a list of length n and a problem to solve
- Complexity: rough number of steps to solve worst case
- Suppose we can compute 1000 operations a second:

Complexity	n=10	n=100	n=1000
log n	0.003 s	0.006 s	0.01 s
n	0.01 s	0.1 s	1 s
n log n	0.016 s	0.32 s	4.79 s
n <sup>2</sup>	0.1 s	10 s	16.7 m
n <sup>3</sup>	1 s	16.7 m	11.6 d
2 <sup>n</sup>	1 s	4x10 <sup>19</sup> y	3x10 <sup>290</sup> y

A New Algorthm

Start: b

0

7

Goal: b

0

sorted

In-Progress: b

o

sorted, ≤ b[i..]

First segment always
contains smaller values

9

## **Selection Sort**

i = 0 while i < n:# Find minimum in b[i..] i = 0  $2 \ 4 \ 4 \ 6 \ 6 \ 8 \ 9 \ 9 \ 7 \ 8 \ 9$   $2 \ 4 \ 4 \ 6 \ 6 \ 7 \ 9 \ 9 \ 8 \ 8 \ 9$   $2 \ 4 \ 4 \ 6 \ 6 \ 7 \ 9 \ 9 \ 8 \ 8 \ 9$  i = i + 1

Remember the restrictions!

What is the Problem?

- Both insertion, selection sort are **nested loops** 
  - Outer loop over each element to sort
  - Inner loop to put next element in place
  - Each loop is n steps.  $n \times n = n^2$
- To do better we must eliminate a loop
  - But how do we do that?

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- What is like a loop? **Recursion!**
- Will see how to do this next lecture

11 12

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