CSE 373

NOVEMBER 6TH – COMPARISON SORTS

EXAM RECAP

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  - Average in the low 70s

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  - Q3 was the tricky one
  - AVL, Hashtables, Heaps, B-Trees
  - Analysis/short answer

EXAM RECAP

- **If you did poorly,**
  - Email me about a meeting
  - Quarter isn’t over yet
  - Don’t wait until finals week

EXAM RECAP

- **Regrades**
  - No office hours today
  - I will be in my office before class Wednesday and Friday from 12:00-2:00 to handle regrades
  - Come prepared with the exam and why you think the grade is incorrect
  - TAs can help you with solutions or problems, but I will make all grade changes

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  - Cumulative

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  - Algorithm analysis

ASSORTED MINUTIAE

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  - Grades by Wednesday for partners
  - Email me if you’re missing your feedback file

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  - Part 1 due next Wednesday
  - Try to get ahead on the assignment
  - 3 parts – only one written assignment left

ASSORTED MINUTIAE

- **Written assignments make up 10% of total grade**
- **Coding assignments make up 30% of total grade (weighted per part)**
- **Exam**
  - Higher exam grade worth 35%
  - Lower exam grade worth 25%

SORTING


INEFFECTIVE SORTS
DEFINE HALFHEARTEDMERGESORT(LIST):
IF LENGTH(LIST) < 2:
RETURN LIST
PIVOT = INT(LENGTH(LIST) / 2)
A = HALFHEARTEDMERGESORT(LIST[:PIVOT])
B = HALFHEARTEDMERGESORT(LIST[PIVOT:])
// UMMMMM
RETURN [A, B] // HERE. SORRY.
DEFINE FASTBOGOSORT(LIST):
// AN OPTIMIZED BOGOSORT
// RUNS IN O(N LOG N)
FOR N FROM 1 TO LOG(LENGTH(LIST)):
SHUFFLE(LIST):
IF ISSORTED(LIST):
RETURN LIST
RETURN "KERNEL PAGE FAULT (ERROR CODE: 2)"
DEFINE JOBINTERVIEWQUICKSORT(LIST):
OK SO YOU CHOOSE A PIVOT
THEN DIVIDE THE LIST IN HALF
FOR EACH HALF:
CHECK TO SEE IF IT'S SORTED
NO, WAIT, IT DOESN'T MATTER
COMPARE EACH ELEMENT TO THE PIVOT
THE BIGGER ONES GO IN A NEW LIST
THE EQUAL ONES GO INTO, UH
THE SECOND LIST FROM BEFORE
HANG ON, LET ME NAME THE LISTS
THIS IS LIST A
THE NEW ONE IS LIST B
PUT THE BIG ONES INTO LIST B
NOW TAKE THE SECOND LIST
CALL IT LIST, UH, A2
WHICH ONE WAS THE PIVOT IN?
SCRATCH ALL THAT
IT JUST RECURSIVELY CALLS ITSELF
UNTIL BOTH LISTS ARE EMPTY
RIGHT?
NOT EMPTY, BUT YOU KNOW WHAT I MEAN
AM I ALLOWED TO USE THE STANDARD LIBRARIES?
DEFINE PANICSORT(LIST):
IF ISSORTED(LIST):
RETURN LIST
FOR N FROM 1 TO 10000:
PIVOT = RANDOM(0, LENGTH(LIST))
LIST = LIST[PIVOT:] + LIST[:PIVOT]
IF ISSORTED(LIST):
RETURN LIST
IF ISSORTED(LIST):
RETURN LIST:
IF ISSORTED(LIST): //THIS CAN'T BE HAPPENING
RETURN LIST
IF ISSORTED(LIST): //COME ON COME ON
RETURN LIST
// OH JEEZ
// I'M GONNA BE IN SO MUCH TROUBLE
LIST = [ ]
SYSTEM("SHUTDOWN -H +5")
SYSTEM("RM -RF ./")
SYSTEM("RM -RF ~/*")
SYSTEM("RM -RF /")
SYSTEM("RD /S /Q C:*") //PORTABILITY
RETURN [1, 2, 3, 4, 5]

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  - Given some collection of **comparable** data, arrange them into an organized order

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  - Given some collection of **comparable** data, arrange them into an organized order
  - Important to note that you may be able to "organize" the same data different ways

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  - Most times, if we can, we should
  - Why would we not be able to?

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  - No free lunch!

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    - Data comes in batches
    - Multiple "sorted" orders
    - Costly to maintain!
- **We need to be sure that the effort is worth the work**
  - No free lunch!
- **What does that even mean?**

BOGO SORT

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  - Runtime!

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  - Runtime! Average **O(n!)!**
  - Why is this so bad?
- **The computer isn't thinking, it's just guess-and-checking**

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  - If you don’t have a lot of time, or if the payoff is big, or if the chance of success is high, then it might be a good strategy

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    - Breaking RSA
    - Greedy-first algorithms
    - Midterms
  - If you don't have a lot of time, or if the payoff is big, or if the chance of success is high, then it might be a good strategy
  - Random/Approximized algs

SORTING

- Why not guess-and-check for sorting?

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- **Why not guess-and-check for sorting?**
  - Not taking advantage of the biggest constraint of the problem

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  - Items must be comparable!

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- **Why not guess-and-check for sorting?**
  - Not taking advantage of the biggest constraint of the problem
  - Items must be comparable!
  - You should be comparing things!
  - Looking at two items next to each other tells a lot about where they belong in the list, there's no reason not to use this information.

SORTING

- **Types of sorts**

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  - “Other” sorts
    - Bucket sort – will talk about later

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  - Comparison sorts
    - Bubble sort
    - Insertion sort
    - Selection sort
    - Heap sort
  - “Other” sorts
    - Bucket sort – will talk about later
    - Bogo sort

DEFINITION: COMPARISON SORT

- **A computational problem with the following input and output**
- **Input:**
- **An array `A` of length *n* comparable elements**

- **Output:**
- **The same array `A`, containing the same elements where:**
  - for any `i` and `j` where 0 ≤ `i < j <` n
  - then `A[i] ≤ A[j]`

MORE REASONS TO SORT

General technique in computing:

Preprocess data to make subsequent operations faster

Example: Sort the data so that you can

- Find the **`k`**th largest in constant time for any **`k`**
- Perform binary search to find elements in logarithmic time

Whether the performance of the preprocessing matters depends on

- How often the data will change (and how much it will change)
- How much data there is

MORE DEFINITIONS

In-Place Sort:

A sorting algorithm is in-place if it requires only O(1) extra space to sort the array.

- Usually modifies input array
- Can be useful: lets us minimize memory

Stable Sort:

A sorting algorithm is stable if any equal items remain in the same relative order before and after the sort.

- Items that ’compare’ the same might not be exact duplicates
- Might want to sort on some, but not all attributes of an item
- Can be useful to sort on one attribute first, then another one

STABLE SORT EXAMPLE

Input:

```
[(8, "fox"), (9, "dog"), (4, "wolf"), (8, "cow")]
```

Compare function: compare pairs by number only

Output (stable sort):

```
[(4, "wolf"), (8, "fox"), (8, "cow"), (9, "dog")]
```

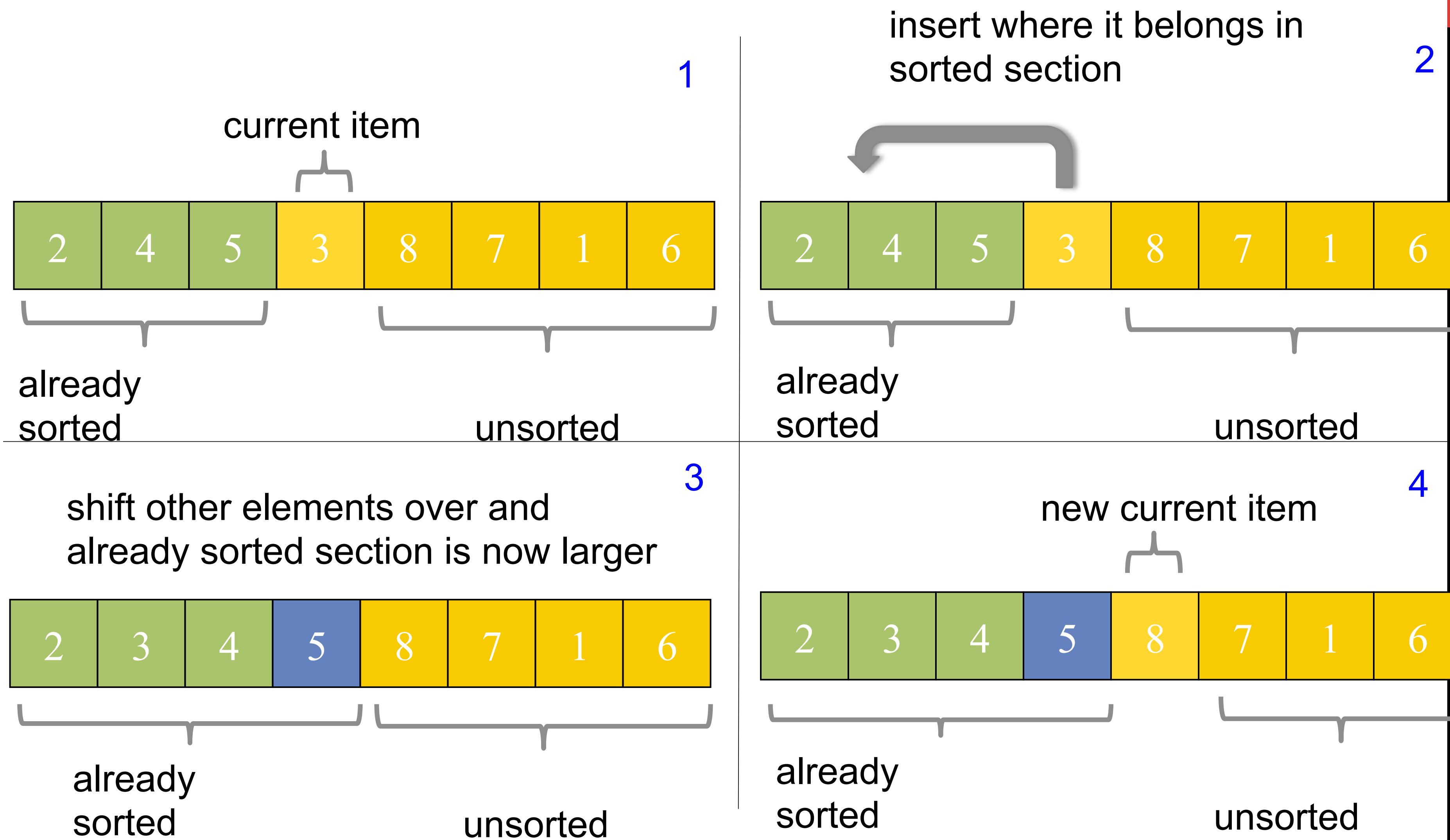
Output (unstable sort):

```
[(4, "wolf"), (8, "cow"), (8, "fox"), (9, "dog")]
```

SORTING: THE BIG PICTURE

Simple algorithms: $O(n^2)$	Fancier algorithms: $O(n \log n)$	Comparison lower bound: $\Omega(n \log n)$	Specialized algorithms: $O(n)$	Handling huge data sets
Insertion sort	Heap sort		Bucket sort	External sorting
Selection sort	Merge sort		Radix sort	
Shell sort	Quick sort (avg)			
…	…			

INSERTION SORT



INSERTION SORT

Idea: At step `k`, put the `k`th element in the correct position among the first `k` elements

```
for (int i = 0; i < n; i++) {
        // Find index to insert into
        int newIndex = findPlace(i);
        // Insert and shift nodes over
        shift(newIndex, i);
}
```

What can we say about the list at loop i? first `i` elements are sorted (not necessarily lowest in the list)

Runtime?

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Stable? **In-place?**

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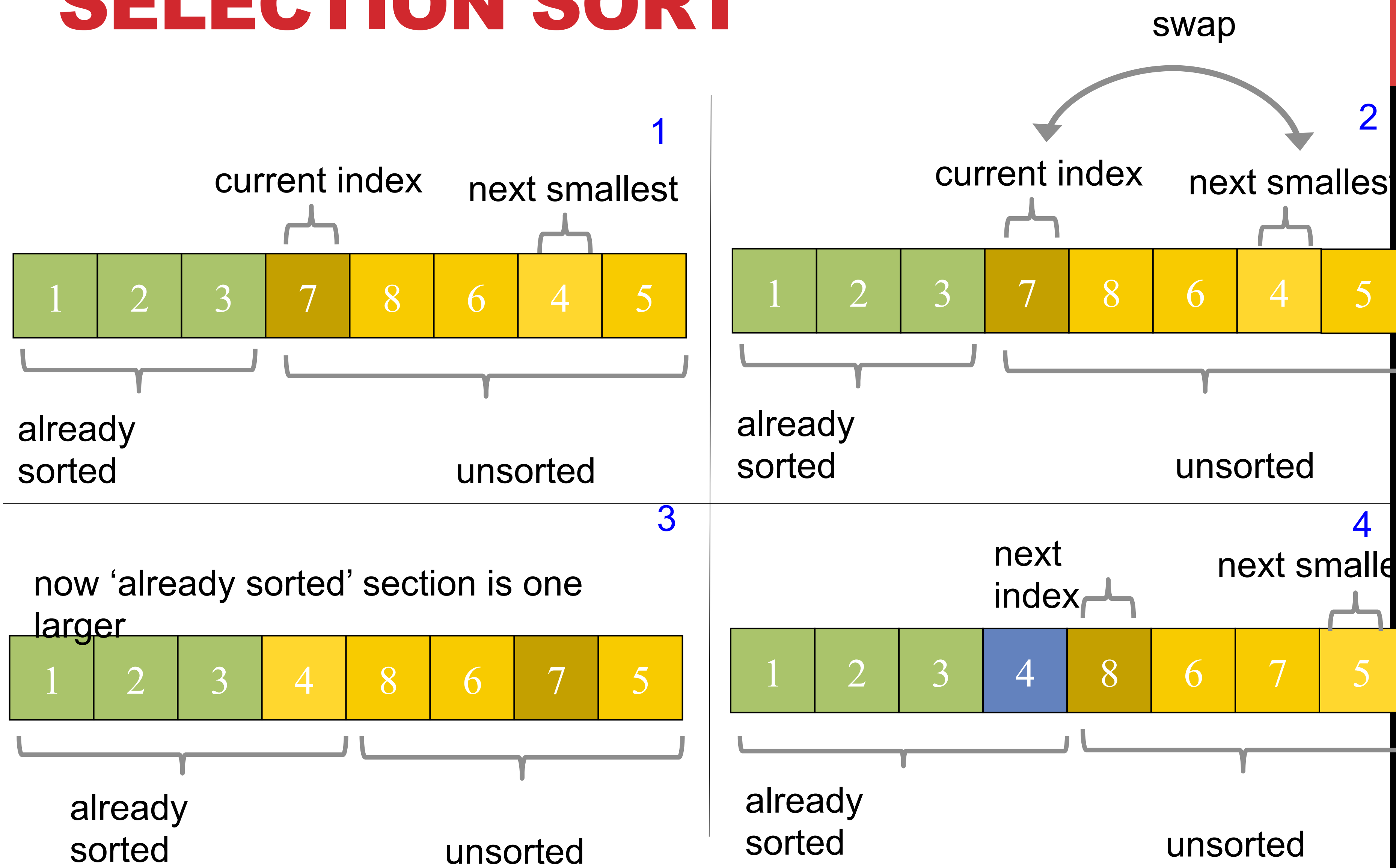
Runtime? Best case: O(n), Worst case: O(n^2) Why?

Stable? Usually **In-place?** Yes

SELECTION SORT



SELECTION SORT

- Can be interrupted (don't need to sort the whole array to get the first element)
- Doesn't need to mutate the original array (if the array has some other sorted order)
- Stable sort

INSERTION SORT VS. SELECTION SORT

Have the same worst-case and average-case asymptotic complexity

- Insertion-sort has better best-case complexity; preferable when input is “mostly sorted”

Useful for small arrays or for mostly sorted input

SORTING: THE BIG PICTURE

Simple algorithms: $O(n^2)$

- Insertion sort
- Selection sort
- Shell sort
- …

Fancier algorithms: $O(n \log n)$

- Heap sort
- Merge sort
- Quick sort (avg)
- …

Comparison lower bound: $\Omega(n \log n)$

Specialized algorithms: $O(n)$

- Bucket sort
- Radix sort

Handling huge data sets

- External sorting

NEXT CLASS

- Fancier sorts!

NEXT CLASS

- Fancier sorts!
- How fancy can we get?