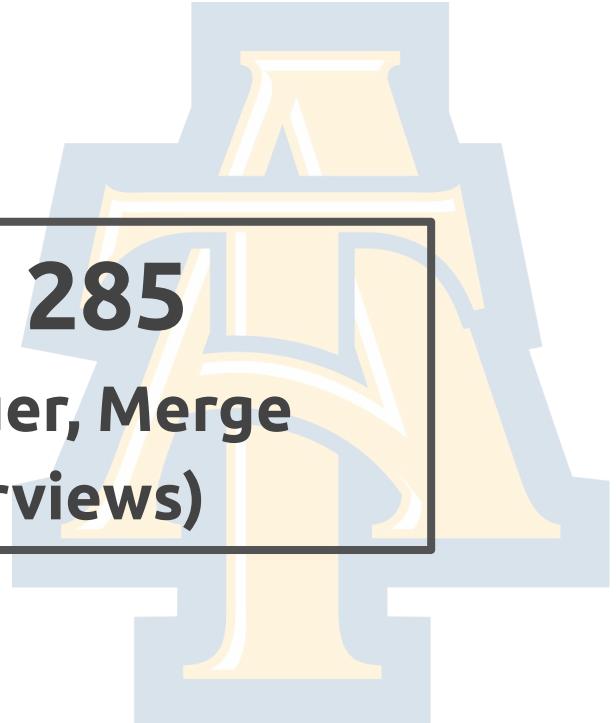


COMP - 285
Advanced Algorithms

Welcome to COMP 285

Lecture 7: Divide and Conquer, Merge Sort + CS Job Hunting (Interviews)

Lecturer: Chris Lucas (cflucas@ncat.edu)



HW2 was released!

Due 09/15 @ 11:59PM ET

HW2 was released!

With video walkthrough! (pilot)

HW1 grades by EoW!

Solutions will be released as well.

Career Opportunities!

CAREERS

- Blizzard Entertainment [SWE internship](#)
- Nintendo IT Software [Internship](#)
- DoD Counterintelligence [internship](#) *not necessarily technical*
- Siemens cybersecurity [internship](#)

www.comp285-fall22.ml

CAREERS

- Grant Thornton (Cybersecurity, specifically mentions ethical hacking!) [link](#)
- MLB Cybersecurity internship [link](#)
- IBM hardware engineering internship [link](#)

piazza

Quiz!

www.comp285-fall22.ml



**Recall where we
ended last lecture...**

Sorting

When comparing different sorting algorithms, these are some of the properties we care about:

- **Best-case/worst-case/average-case time complexity**
- **In-place: can we use only $O(1)$ additional space?**
- **Adaptive: does it run faster if the array is partially sorted?**
- **Stable: will elements of the same value stay ordered relative to each other?**

Selection Sort!!

Selection Sort Pseudocode

```
algorithm selectionSort
```

Input: `vector<int> vec` of size N

Output: `vector<int>` with sorted elements

```
for index i = 0, 1, 2, ..., N-2
```

```
    min_index = i
```

```
    for j = i+1, i+2, ..., N-1
```

```
        if vec[j] < vec[min_index]
```

```
            min_index = j
```

```
temp = vec[i]
```

```
vec[i] = vec[min_index]
```

```
vec[min_index] = temp
```

What's the tight upper-bound on the:

- Best-case runtime? $O(n^2)$
- Worst-case runtime? $O(n^2)$
- Average-case runtime? $O(n^2)$
- Worst-case space complexity? $O(1)$

Is this adaptive? No

Insertion Sort!!

Insertion Sort In-Place Pseudocode

```
algorithm insertionSort
```

```
  Input: vector<int> vec of size N
```

```
  Output: vector<int> with sorted elements
```

```
  for index i = 1, 2, ..., N-1
    next = vec[i]
    j = i-1
    while j >= 0 and vec[j] > next
      vec[j+1] = vec[j]
      j = j-1
    vec[j+1] = next
```

What's the tight upper-bound on the:

- Best-case runtime? $O(n)$
- Worst-case runtime? $O(n^2)$
- Average-case runtime? $O(n^2)$
- Worst-case space complexity? $O(1)$

Is this adaptive? Yes

QuickSort!!

QuickSort: Pseudocode

```
algorithm quickSort
  Input: vector<int> vec of size N
  Output: vector<int> with sorted elements
```

```
if N < 2
  return vec
pivot = vec[N-1]
left = new empty vec
right = new empty vec
for index i = 0, 1, 2, ... N-2
  if vec[i] <= pivot
    left.push_back(vec[i])
  else
    right.push_back(vec[i])
return quickSort(left) + [pivot] + quickSort(right)
```

- Pick the last element in the list.
(Pivot)
- Put the rest of the elements into two partitions (lists)
 - "all elements \leq pivot"
 - "all elements $>$ pivot"
- Then do the same steps on the two partitions until the lists are small enough to not need sorting. (recursion!)
- Once we've sorted the smaller lists, glue them back together at each level, along with the pivot.

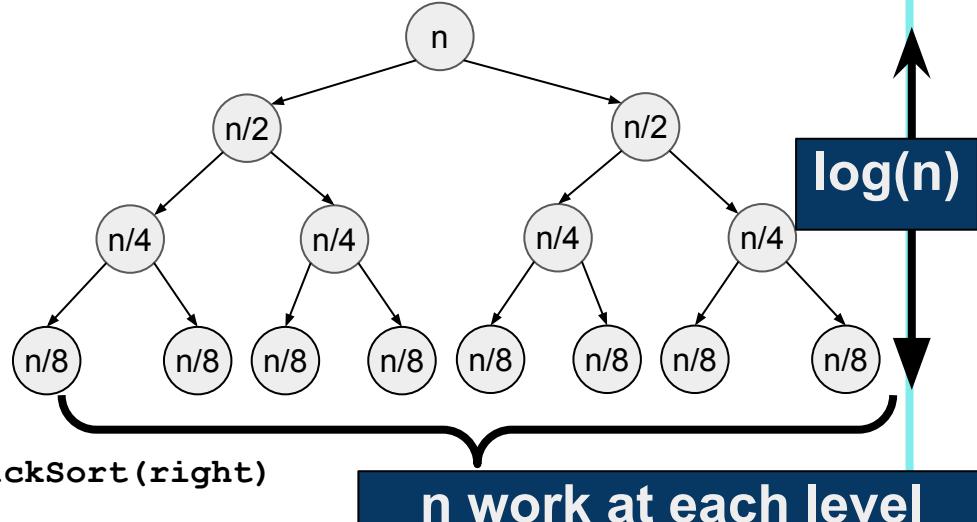
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```

What's the tight upper-bound on the:

- Best-case runtime? $O(n \log n)$



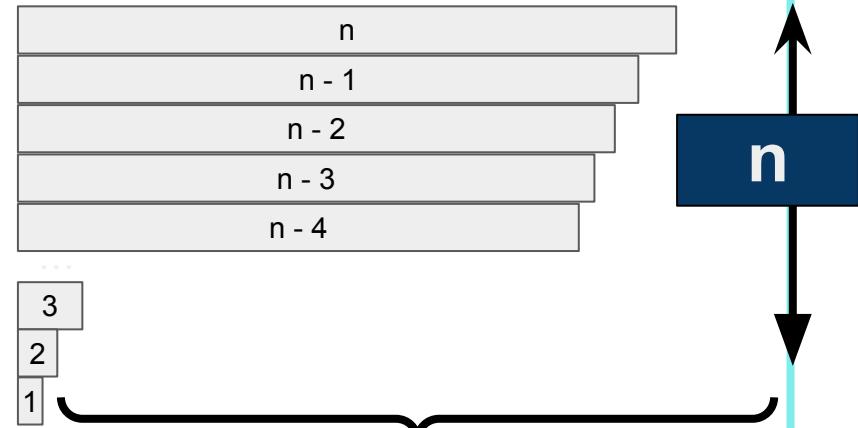
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```

What's the tight upper-bound on the:

- Best-case runtime? $O(n \log n)$
- Worst-case runtime? $O(n^2)$



$n/2$ work on average

QuickSort: Pseudocode

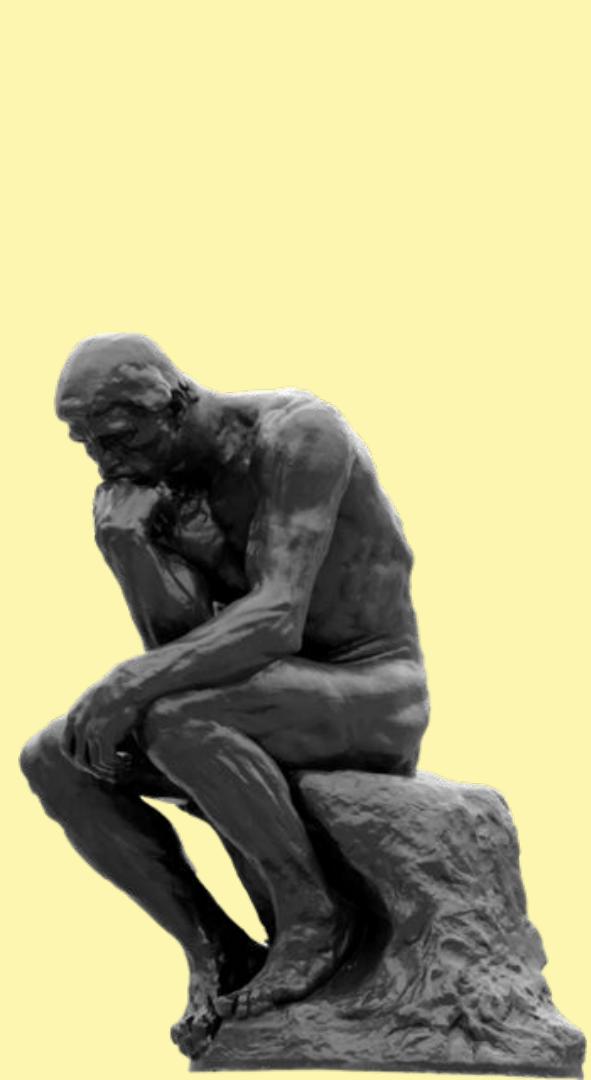
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What's the tight upper-bound on the:

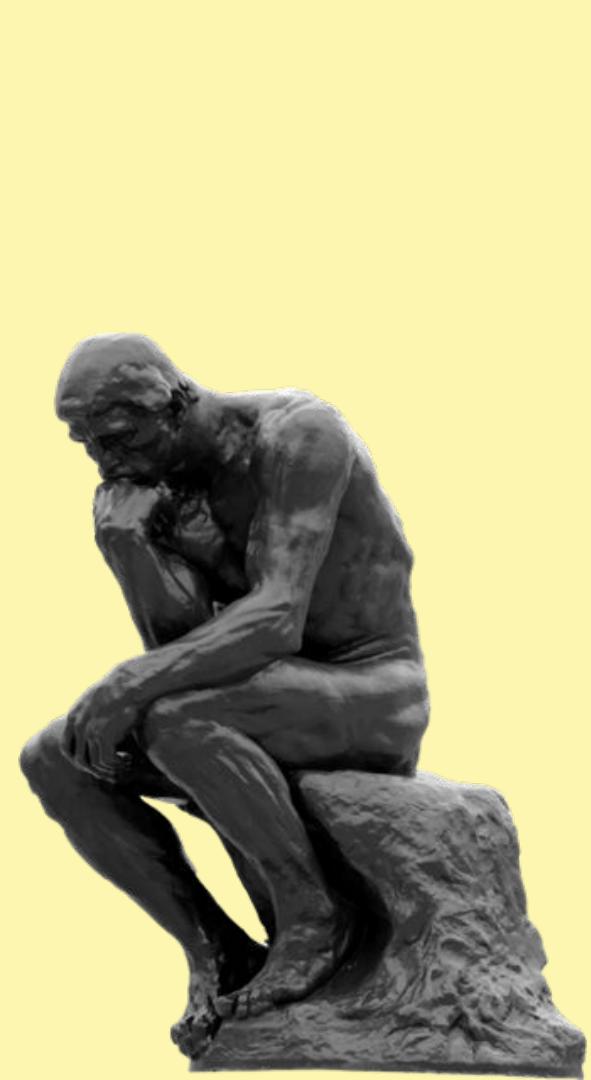
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- Worst-case runtime? $O(n^2)$
- Average-case runtime? $O(n \log n)$
- Worst-case space complexity? $O(n^2)$

Is it adaptive? NO

A black and white photograph of Auguste Rodin's bronze sculpture "The Thinker". The figure is a man with a beard, sitting on a large, irregular rock. He is in a contemplative pose, with his right arm resting on his chin and his head tilted down. The background is a plain, light-colored wall.

Big Questions!

- What is divide and conquer (technically)?
- What about MergeSort?
- How to pass behavioral interviews?

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Divide & Conquer

Divide & Conquer is a pattern in recursive algorithms that has two defining characteristics:

1. At each step, there are 2 or more recursive calls
2. The problem is being reduced by some multiplicative factor at each call

If there is only 1 recursive call (even if reduced by some constant amount instead of a multiplicative factor), then it's called **decrease and conquer**.

What is this function?

```
algorithm doSomePrinting
    input: positive integer n
    output: prints n, floor(n/2), floor(n/4), floor(n/8), ..., 1

    print n
    if n > 0
        doSomePrinting(floor(n/2))
```

Poll Options

1. Decrease & Conquer
2. Divide & Conquer
3. Neither

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What is this function?

```
algorithm createTwoHalves
    input: positive integer n
    output: ??
    if n == 1
        return 1
    return createTwoHalves(n/2)
        + createTwoHalves(n/2)
```

Poll Options

1. Decrease & Conquer
2. Divide & Conquer
3. Neither

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Kahoot!

www.kahoot.it, Code: 107 406

Enter your @aggies.ncat email

What is this function?

```
algorithm fib
    input: integer n >= 0
    output: nth fibonacci number
    if n = 0 || n == 1:
        return n
    else
        return fib(n-1) + fib(n-2)
```

Poll Options

1. Decrease & Conquer
2. Divide & Conquer
3. Neither

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What is this function?

```
algorithm quickSort
    Input: vector<int> vec of size N
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    if N < 2
        return vec
    pivot = vec[N-1]
    left = new empty vec
    right = new empty vec
    for index i = 0, 1, 2, ... N-2
        if vec[i] <= pivot
            left.push_back(vec[i])
        else
            right.push_back(vec[i])
    return quickSort(left) + [pivot] + quickSort(right)
```

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Poll Options

1. Decrease & Conquer
2. Divide & Conquer
3. Neither

What is this function?

```
algorithm binarySearchHelper
```

Input: sorted vector<int> vec, integer target x, left index a, and right index b

Output: index of x in vec if it exists, -1 otherwise

```
if a > b
    return -1
midpoint = floor((b + a)/ 2)
if vec[midpoint] == x
    return midpoint
else if vec[midpoint] < x
    return binarySearchHelper(vec, x, midpoint+1, b)
else
    return binarySearchHelper(vec, x, a, midpoint-1)
```

Divide & Conquer is a pattern in recursive algorithms that has two defining characteristics:

1. At each step, there are 2 or more recursive calls
 2. The problem is being reduced by some multiplicative factor at each call
- If there is only 1 recursive call (even if reduced by some constant amount instead of a multiplicative factor), then it's called decrease and conquer.

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Big Questions!

- What is divide and conquer (technically)?
- What about MergeSort?
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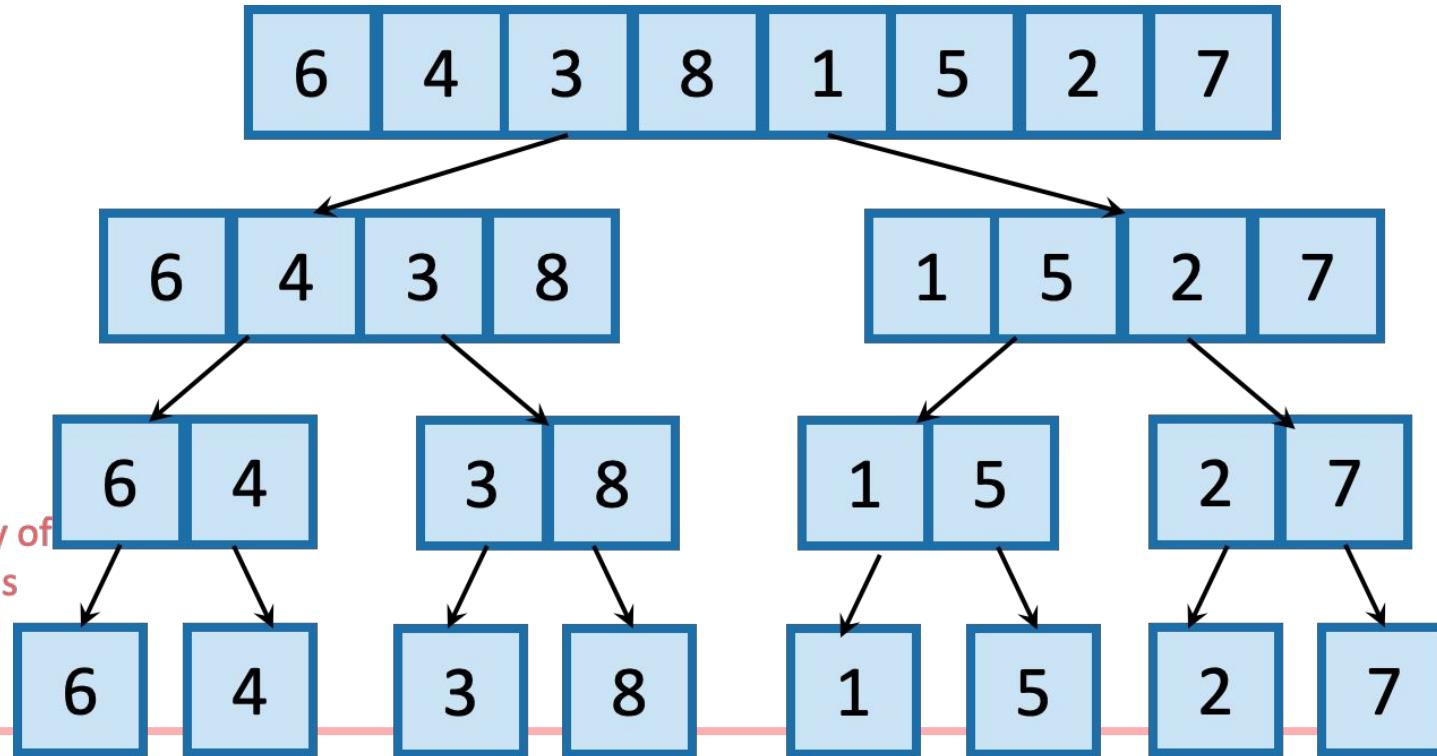
MergeSort!!

MergeSort Intuition

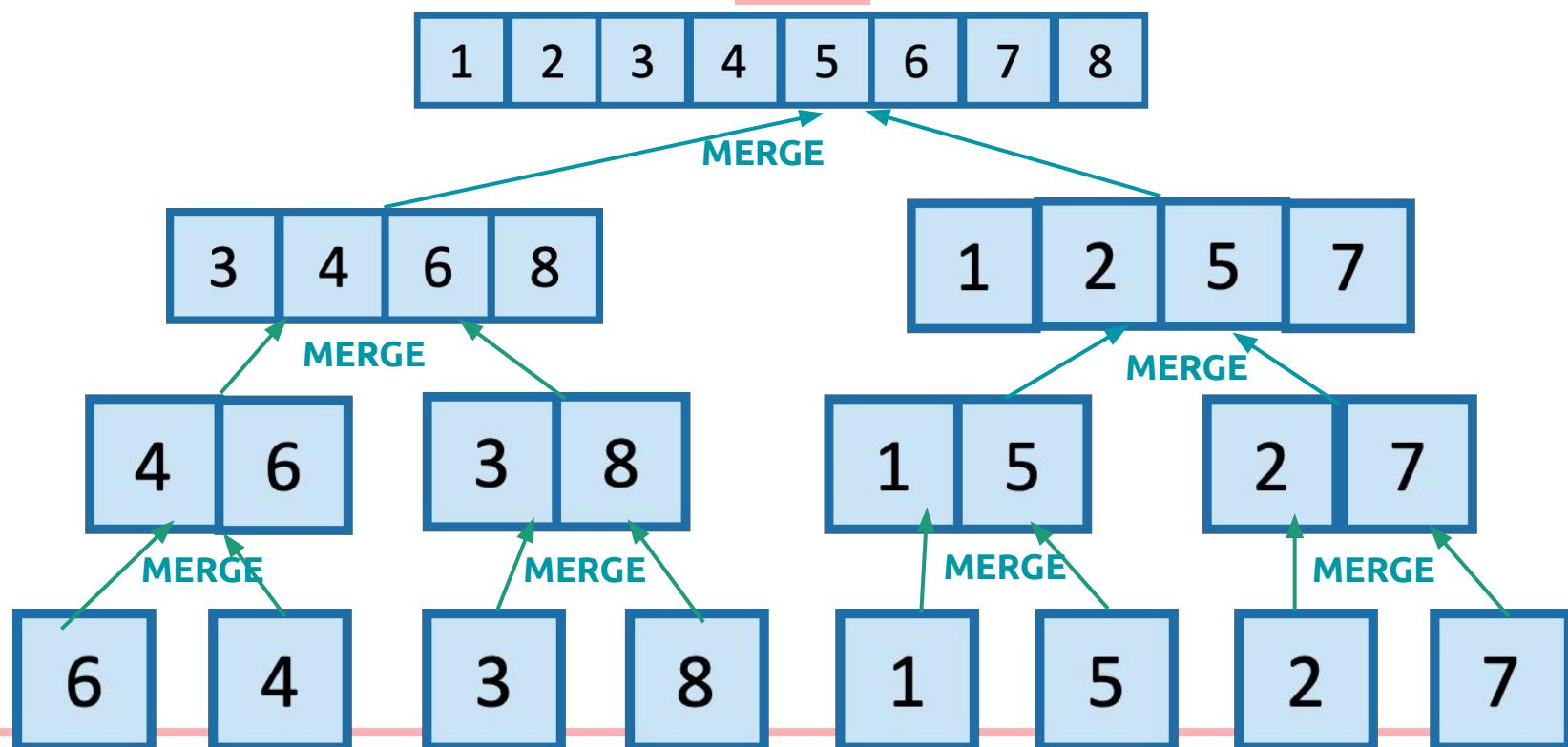
- **Base case:** If the length of the vec is size 1 or smaller, then the vec is already sorted.
- **Recursive calls:** Divide the vec into left and right halves and recursively sort the left and right half.
- **Solution building:** Once you have the sorted left and sorted right, merge them together into one big sorted vec.

What actually happens?

First, we recurse all the way down to base cases.



Then we merge on our way back up!



A bunch of sorted lists of length 1 (in the order of the original sequence).

Merge Sort Pseudocode

```
algorithm mergeSort
    Input: vector of ints vec of size N
    Output: vec with its elements in sorted order

    if N <= 1
        return vec
    midpoint = floor(N/2)
    left = mergeSort(vec[0 to midpoint])
    right = mergeSort(vec[midpoint to N])
    return merge(left, right)
```

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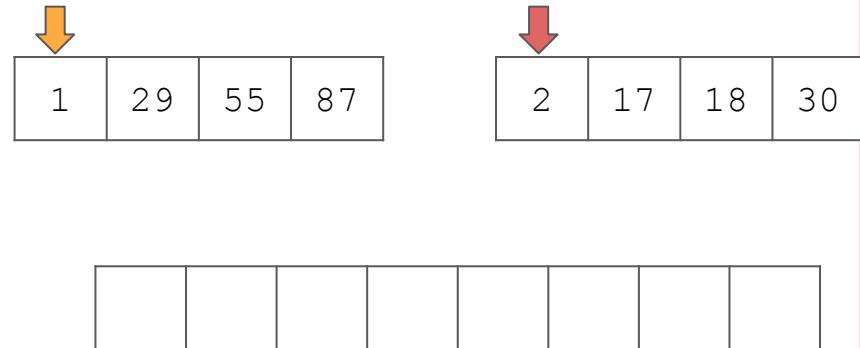
Merge Sort Pseudocode

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algorithm merge
  Input: two sortedvecs vec1 and vec2
  Output: vec3 that contains the elements of vec1 and vec2 in sorted order

  i = 0; j = 0; vec3 = empty vec
  while i < vec1.size() and j < vec2.size()
    if vec1[i] <= vec2[j]
      vec3.push_back(vec1[i])
      i++
    else
      vec3.push_back(vec2[j])
      j++

  // Add remainder of other vector
  while i < vec1.size()
    vec3.push_back(vec1[i])
    i++
  while j < vec2.size()
    vec3.push_back(vec2[j])
    j++

  return vec3
```



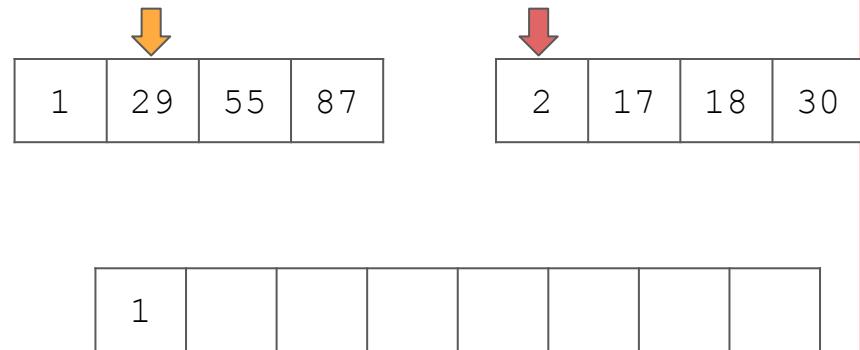
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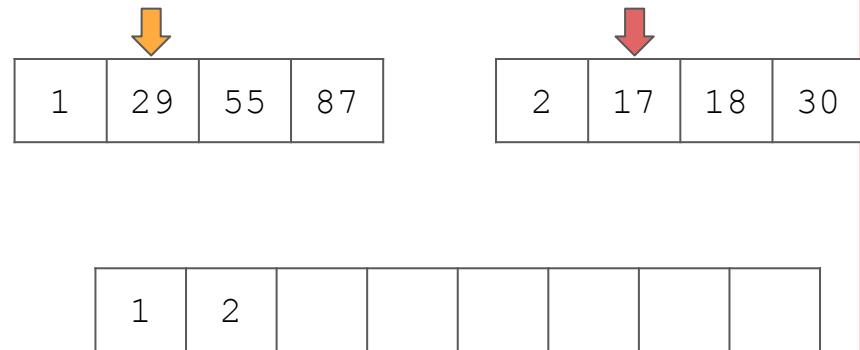
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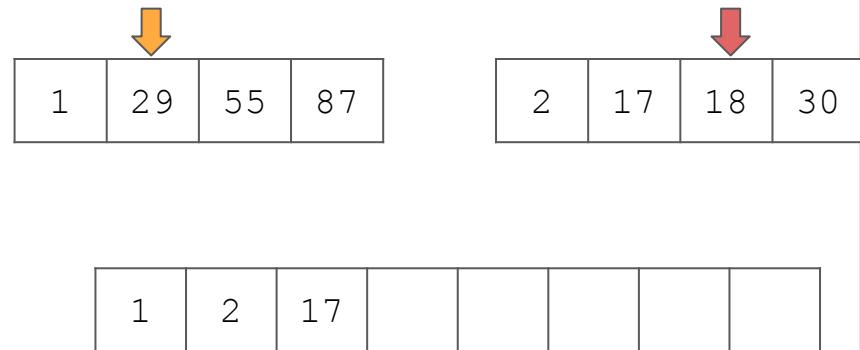
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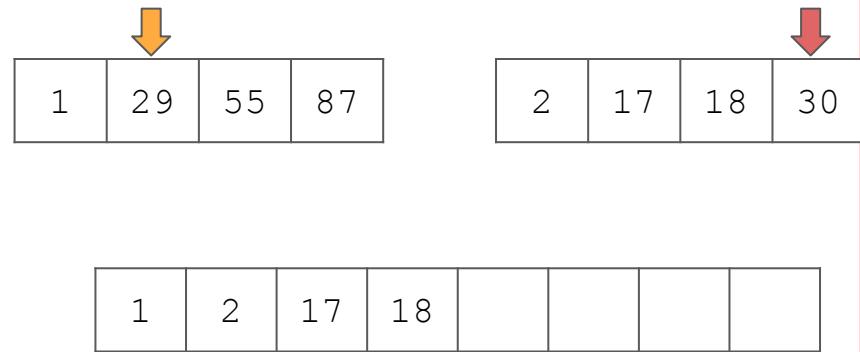
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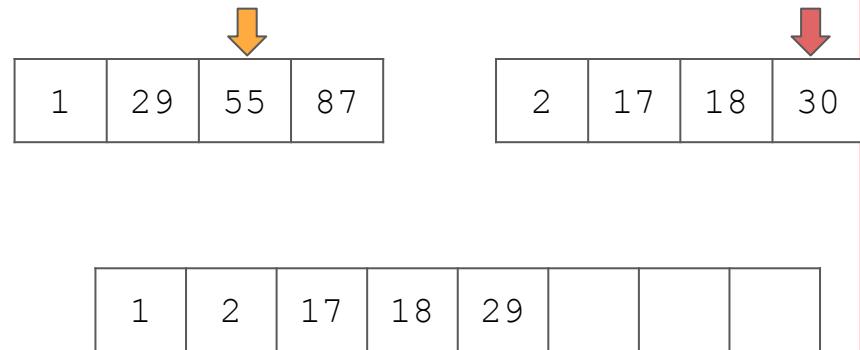
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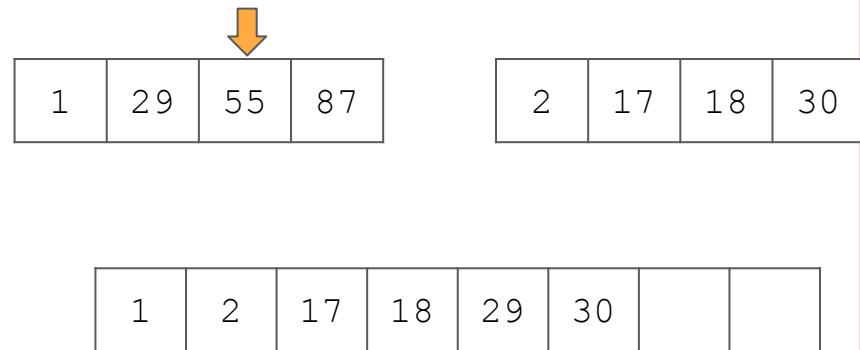
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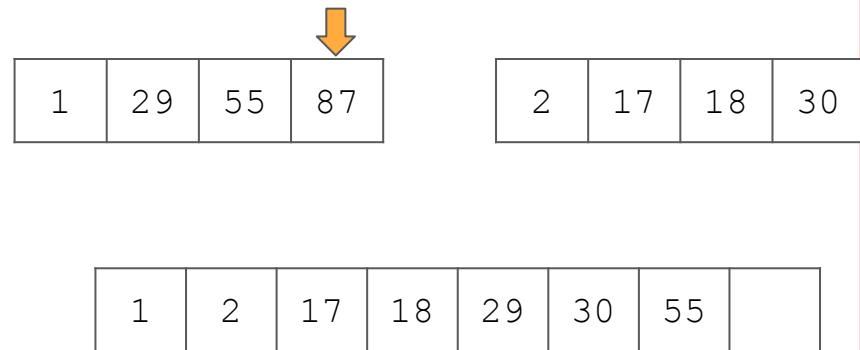
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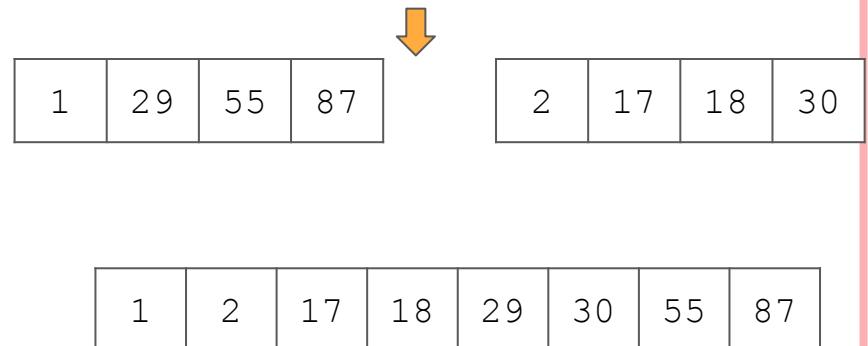
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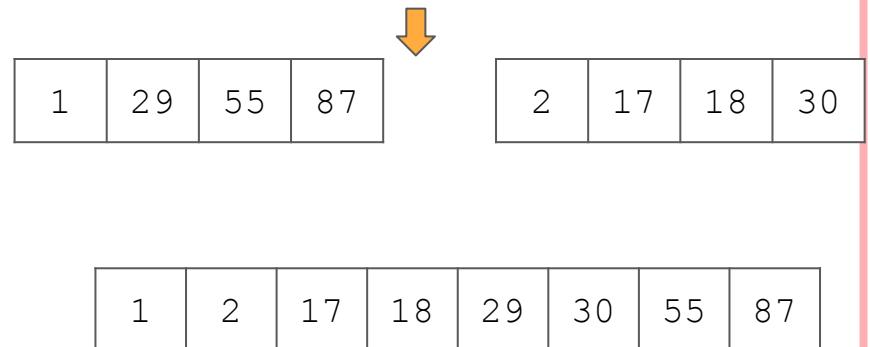
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```

```
return vec3
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- Runtime:
- Space complexity:

Merge Sort Pseudocode

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  return vec3
```

- Runtime: $O(n)$
- Space complexity: $O(n)$

Merge Sort Pseudocode

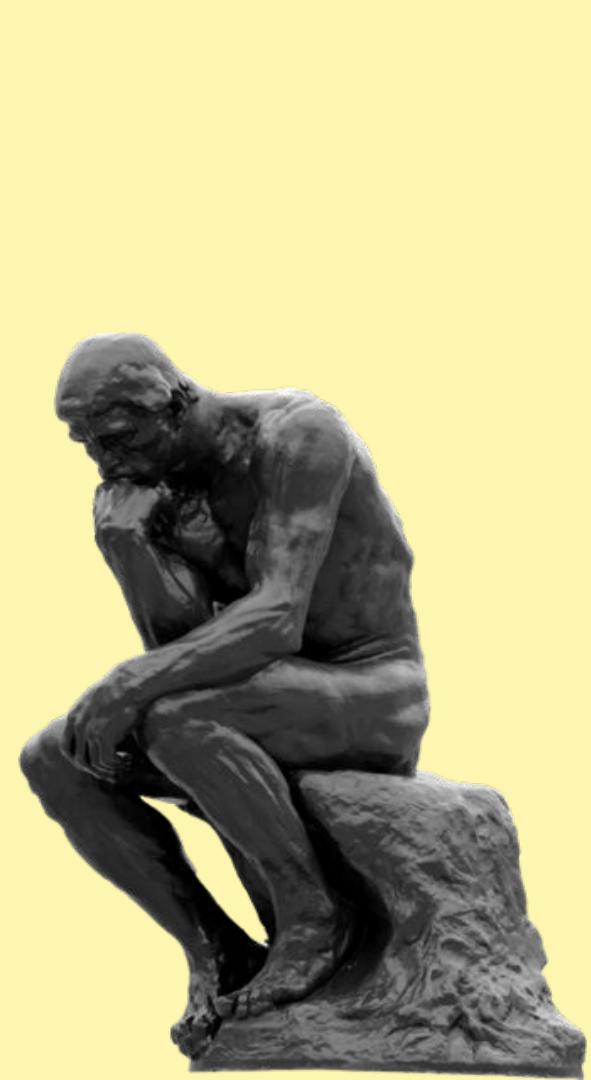
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```

Base case: If the length of the vec is size 1 or smaller, then the vec is already sorted.

Recursive calls: Divide the vec into left and right halves and recursively sort the left and right half.

Solution building: Once you have the sorted left and sorted right, merge them together into one big sorted vec.

A black and white photograph of Auguste Rodin's bronze sculpture "The Thinker". The figure is a man in a crouched, contemplative pose, resting his chin on his hand. He is positioned on the left side of the slide, against a solid yellow background.

Big Questions!

- What is divide and conquer (technically)?
- What about MergeSort?
- How to pass behavioral interviews?



Behavioral Mock Interviews

Interviewer Training

Let's Quickly Check In:



Please scan the QR Code & fill out the survey to come





Hello 😊

I'm Denzel Palm and I am a University recruiter here at Meta on our Early Talent Diversity (University) Recruitment Team— here are a few things about me so we can get acquainted:

- Based in Detroit, MI 
- Been @ Meta for <1 year 
- Western Michigan Alum
- Comms Mkt Major 

What are Behavioral Mock Interviews?

- A behavioral mock interview is anytime somebody asks you to talk about yourself in order to learn whether you have the required soft skills for a role and will be a good fit for the company.
- **Soft Skills vs Hard Skills:** Hard skills refer to the job-related knowledge and abilities that employees need to perform their job duties effectively. Soft skills, on the other hand, are the personal qualities that help employees really thrive in the workplace.
- **Mock Interview do not count** towards or against a candidate's application process



What should a interviewee expect?

- Interviewee's taking part in a Behavioral Mock Interview should expect the following:
- **Introduction:** The interviewer will introduce themselves and set expectations.
- **Questions:** Interviewer will ask a series of targeted questions geared towards Soft Skills.
- **Q&A:** Time will be allowed for Q&A. At this time ask any prepared questions you might have for the interviewer.



Interview Samples Questions

• Time Management

- Tell me about the last time you handled a long-term project. How did you keep the project on track?

• Overcoming Challenges

- Tell me about a time when you made a mistake. What did you do to correct it?

• Communication

- Give me an example of a time when you persuaded someone. How'd you do it and why?

• Teamwork

- Share an example of how you were able to motivate a coworker, your peers or your team.

• Adaptability

- Tell me about a time when you had to be creative to solve a problem.



How To Best Answer Questions

- The **STAR** method is a structured manner of responding to a behavioral-based interview question by discussing the specific **situation, task, action, and result** of the situation you are describing.

How to use the S-T-A-R Method

- **Situation:** Set the scene and give the necessary details for your example
- **Task:** Describe what your responsibility was in the situation.
- **Action:** Explain exactly what steps you took to address it
- **Result:** Share what outcomes your actions achieved and provide any data driven results.



Interview is Over, What Questions Should I Ask

- It's a great best practice to come to your interview with prepared questions. Please remember to keep questions, professional and on topic.
- **Examples:**
 - How would you describe your organization's culture?
 - What do you find most challenging about working for this organization?
 - What have you enjoyed the most so far about working here?
 - Can you tell me more about professional development opportunities your company offers?
 - How do you evaluate success in this role?



QUESTIONS ?





How was the pace today?

COMP - 285
Advanced Algorithms

Welcome to COMP 285

Lecture 7: Divide and Conquer, Merge Sort + CS Job Hunting (Interviews)

Lecturer: Chris Lucas (cflucas@ncat.edu)

