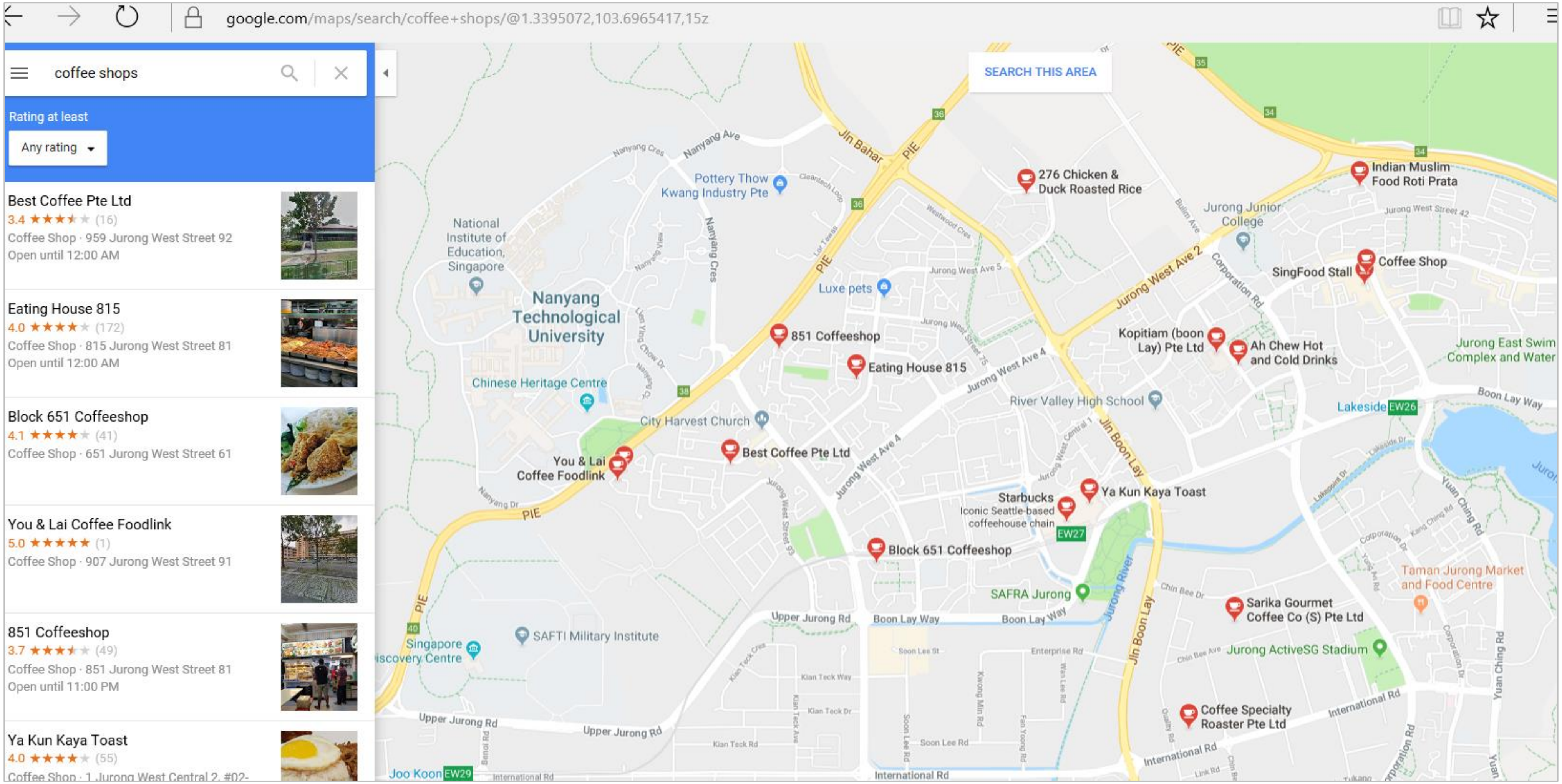
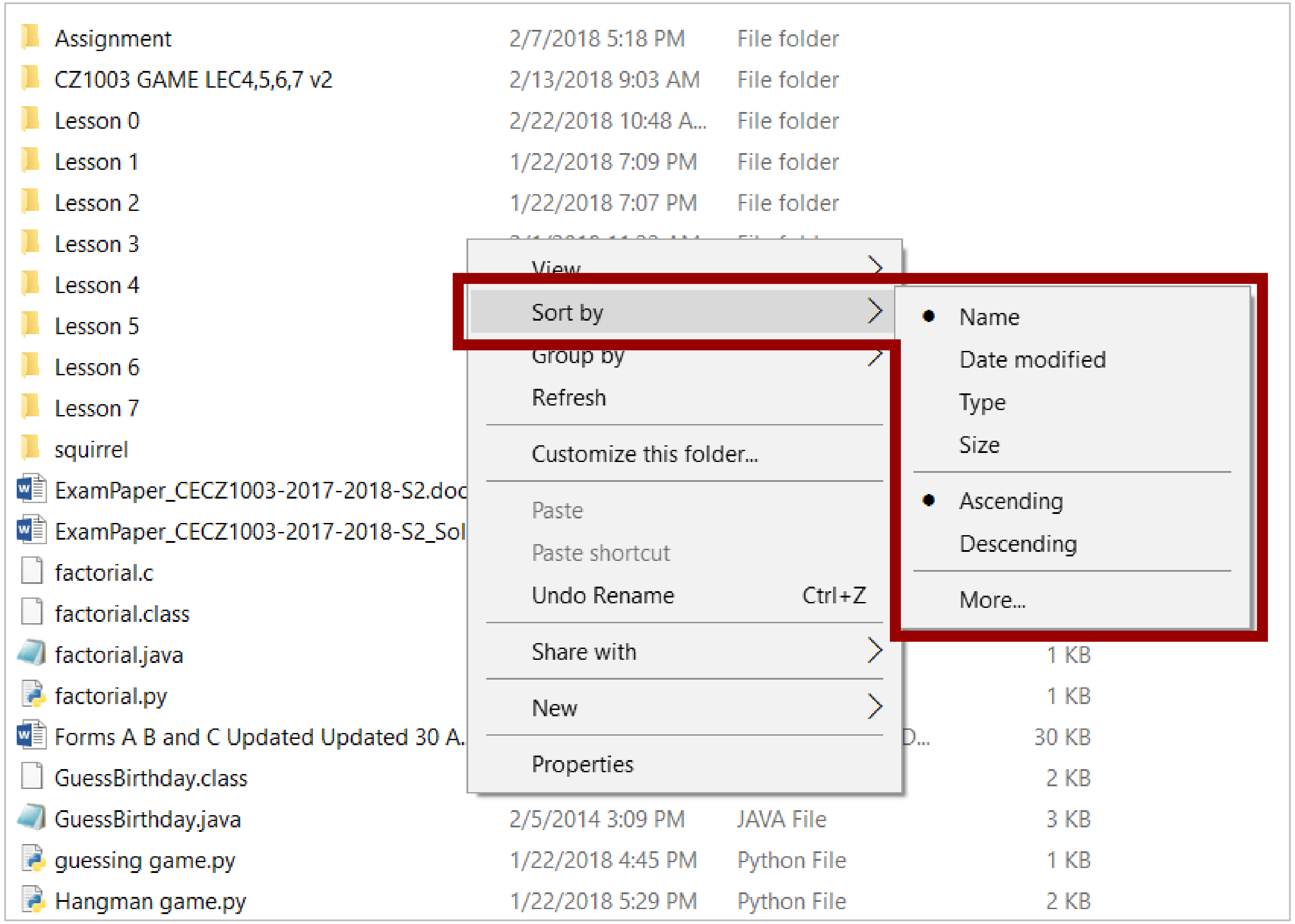
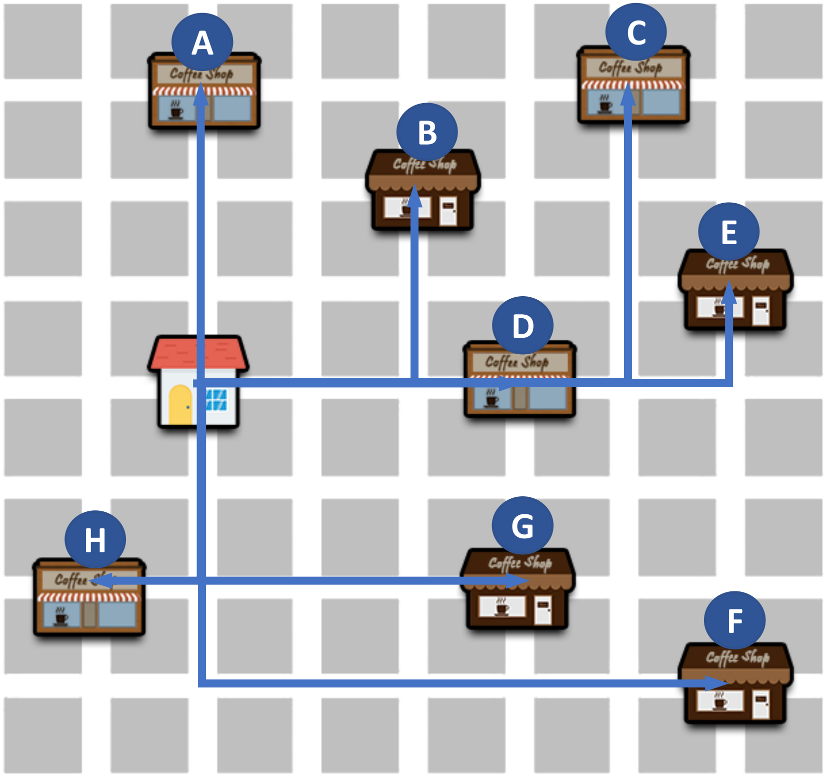
Algorithm Design: Sorting


google.com/maps/search/coffee+shops/@1.3395072,103.6965417,15z
coffee shops
Rating at least
Any rating
Best Coffee Pte Ltd
3.4 (16)
Coffee Shop · 959 Jurong West Street 92
Open until 12:00 AM
Eating House 815
4.0 (172)
Coffee Shop · 815 Jurong West Street 81
Open until 12:00 AM
Block 651 Coffeeshop
4.1 (41)
Coffee Shop · 651 Jurong West Street 61
You & Lai Coffee Foodlink
5.0 (1)
Coffee Shop · 907 Jurong West Street 91
851 Coffeeshop
3.7 (49)
Coffee Shop · 851 Jurong West Street 81
Open until 11:00 PM
Ya Kun Kaya Toast
4.0 (55)
SEARCH THIS AREA
276 Chicken & Duck Roasted Rice
Indian Muslim Food Roti Prata
Pottery Thow Kwang Industry Pte
National Institute of Education, Singapore
Nanyang Technological University
Jurong Junior College
SingFood Stall
Coffee Shop
Luxe pets
851 Coffeeshop
Eating House 815
Kopitiam (boon Lay) Pte Ltd
Ah Chew Hot and Cold Drinks
Jurong East Swim Complex and Water
Chinese Heritage Centre
City Harvest Church
River Valley High School
Lakeside EW26
You & Lai Coffee Foodlink
Best Coffee Pte Ltd
Ya Kun Kaya Toast
Starbucks
Iconic Seattle-based coffeehouse chain
EW27
Block 651 Coffeeshop
Taman Jurong Market and Food Centre
SAFRA Jurong
Sarika Gourmet Coffee Co (S) Pte Ltd
SAFTI Military Institute
Singapore Discovery Centre
Jurong ActiveSG Stadium
Coffee Specialty Roaster Pte Ltd
Joo Koon EW29
Jurong West Ave 2
Jurong West Ave 4
Jin Bahar
Jln Boon Lay
Boon Lay Way
Upper Jurong Rd
International Rd
Yuan Ching Rd
Corporation Rd
Nanyang Ave
PIE


Assignment
2/7/2018 5:18 PM
File folder
CZ1003 GAME LEC4,5,6,7 v2
2/13/2018 9:03 AM
File folder
Lesson 0
2/22/2018 10:48 A...
File folder
Lesson 1
1/22/2018 7:09 PM
File folder
Lesson 2
1/22/2018 7:07 PM
File folder
Lesson 3
Lesson 4
Lesson 5
Lesson 6
Lesson 7
squirrel
ExamPaper_CECZ1003-2017-2018-S2.doc
ExamPaper_CECZ1003-2017-2018-S2_Sol
factorial.c
factorial.class
factorial.java
factorial.py
Forms A B and C Updated Updated 30 A...
GuessBirthday.class
GuessBirthday.java
2/5/2014 3:09 PM
JAVA File
3 KB
guessing game.py
1/22/2018 4:45 PM
Python File
1 KB
Hangman game.py
1/22/2018 5:29 PM
Python File
2 KB
1 KB
1 KB
30 KB
2 KB
View
Sort by
Group by
Refresh
Customize this folder...
Paste
Paste shortcut
Undo Rename
Ctrl+Z
Share with
New
Properties
Name
Date modified
Type
Size
Ascending
Descending
More...

Recall: Application of Looping

Find the Distance to N Locations



Coffeeshop	Distance
Coffeeshop A	3
Coffeeshop B	4
Coffeeshop C	7
Coffeeshop D	3
Coffeeshop E	6
Coffeeshop F	8
Coffeeshop G	5
Coffeeshop H	3

Sort by distance

Coffeeshop	Distance
Coffeeshop A	3
Coffeeshop D	3
Coffeeshop H	3
Coffeeshop B	4
Coffeeshop G	5
Coffeeshop E	6
Coffeeshop C	7
Coffeeshop F	8

Lesson Objectives

At the end of this lesson, you should be able to:

- Describe the process of sorting
- Explain the importance of different types of sorting algorithms
- Perform sorting algorithms particularly sorting alphabetically or numerically
- Sort an array using bubble sort and merge sort
- Apply your knowledge and understanding of sorting algorithms to your problem solving
- Recognize that “no single” best sorting applies to all scenarios

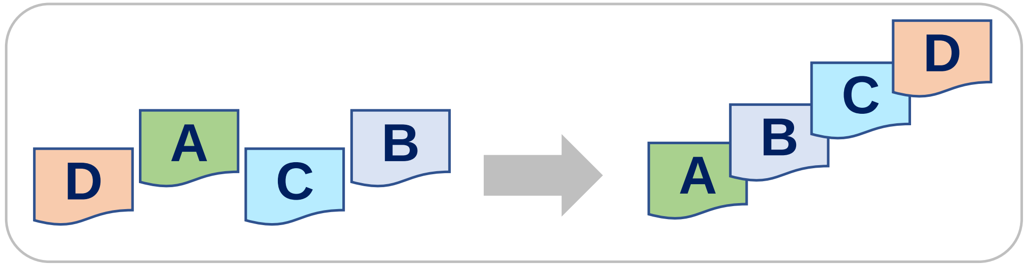
Topic Outline

- Importance of Sorting
- Bubble Sort
- Merge Sort
- Comparison of Sorting Algorithms

Sorting Algorithms

Sorting Algorithm

- In computer science, it is an algorithm that puts elements in a list of a certain order.
- The most frequently used orders are **numerical** and **alphabetical orders**.
- Efficient sorting is important for optimizing the efficiency of other algorithms (such as search and merge algorithms).



Sorting Algorithms: Review of Complexity

Name	Best	Average	Worst	Memory	Stable	Method	Other Noted
Timesort	-	n log n	n log n	n	Yes	Insertion & Merging	n comparisons when the data is already sorted.
Bubble sort	n	n^2	n^2	1	Yes	Exchanging	Tiny code
Cocktail sort	-	-	n^2	1	Yes	Exchanging	
Comb sort	-	-	-	1	No	Exchanging	Small code size
Gnome sort	-	-	n^2	1	Yes	Exchanging	Tiny code size
Selection sort	n^2	n^2	n^2	1	No	Selection	Its stability depends on the implementation. Used to sort this table in safari or other Webkit wed browser [2]
Insertion sort	n	n^2	n^2	1	Yes	Insertion	Average case is also $o\ (n + d)$, where d is the number of inversions
Cycle Sort	-	n^2	n^2	1	No	Insertion	In-place with theoretically optimal number of writes
Shell Sort	-	-	n $\log^2$ n	1	No	Insertion	
Binary tree sort	-	n log n	n log n	n	Yes	Insertion	When using a self-balancing binary search tree
Library sort	-	n log n	n^2	n	Yes	Insertion	
Merge sort	n log n	n log n	n log n	Depends	Yes	Merging	Used to sort this table in Firefox [3]
In-place merge sort	-	n log n	n log n	1	Depends	Merging	Example implementation here: [4] ; can be implemented as a stable sort based on stable in-place merging: [5]
Heapsort	n log n	n log n	n log n	1	No	Selection	
Smoothsort	-	-	n log n	1	No	Selection	An adaptive sort – n comparisons when the data is already sorted, and $o\ (0)$ swaps.
Quicksort	n log n	n log n	n^2	log n	Depends	Partitioning	Can be implemented as a stable sort depending on how the pivot is handled. Naïve variants use $o\ (n)$ space
Introsort	-	n log n	n log n	log n	No	Hybrid	Used in SGI STL Implementations
Patience sorting	-	-	n log n	n	No	Insertion & Selection	Finds all the longest increasing subsequences within O (n log n)
Strand sort	-	n log n	n^2	n	Yes	Selection	
Tournament sort	-	n log n	n log n			Selection	

- Most of the primary sorting algorithms run on different space and time complexity.
- Time Complexity is defined to be the time the computer takes to run a program (or algorithm in our case).
- Space complexity is defined to be the amount of memory the computer needs to run a program.

More on this later..

Bubble Sort

- Sometimes referred to as “sinking sort”.
- One of the simplest sorting algorithm.
- Repeatedly steps through the list to be sorted, compares each pair of adjacent items, and swaps them if they are in the wrong order.
- The pass through the list is repeated until no swaps are needed, which indicates that the list is sorted.
- The algorithm, which is a comparison sort, is named for the way smaller or larger elements "bubble" to the top of the list.

Bubble Sort: Step by Step

NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

The bubble sort makes multiple passes through a list.

For each pass, the bubble sort is operated as follows:

1. Compare the first two number, and if the second number is smaller than the first, then the numbers are swapped.

54	26	93	17	77	31	44	55	20

26	54	93	17	77	31	44	55	20

26 < 54
Swap

2. Then move down one number, compare the number and the number that follows it, and swap the two numbers, if necessary.

26	54	93	17	77	31	44	55	20

93 is not less than 54: NO Swapping

3. Repeat this process.

26	54	93	17	77	31	44	55	20

26	54	17	93	77	31	44	55	20

17 < 93
Swap

Bubble Sort: First Pass

First Pass

until the last two numbers of the array have been compared

- Largest number has now moved to the bottom of the list.
- Each sequence of comparison is called a pass.

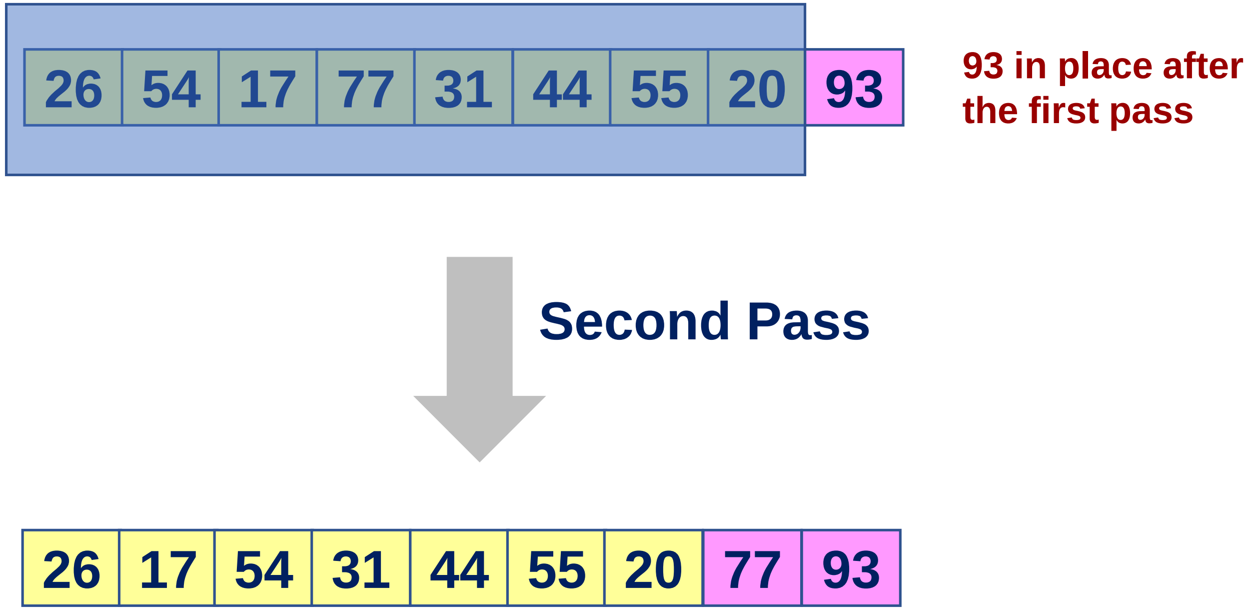
54	26	93	17	77	31	44	55	20	Swap
26	54	93	17	77	31	44	55	20	No Swap
26	54	93	17	77	31	44	55	20	Swap
26	54	17	93	77	31	44	55	20	Swap
26	54	17	77	93	31	44	55	20	Swap
26	54	17	77	31	93	44	55	20	Swap
26	54	17	77	31	44	93	55	20	Swap
26	54	17	77	31	44	55	93	20	Swap
26	54	17	77	31	44	55	20	93	93 in place after the first pass

First Pass

Bubble Sort: Second Pass

At the **start of the second pass**,

- the largest value is now in place
- there are n – 1 items left to sort
- meaning, there will be n – 2 pairs



Bubble Sort: Repeat Process (n – 1 passes) to End

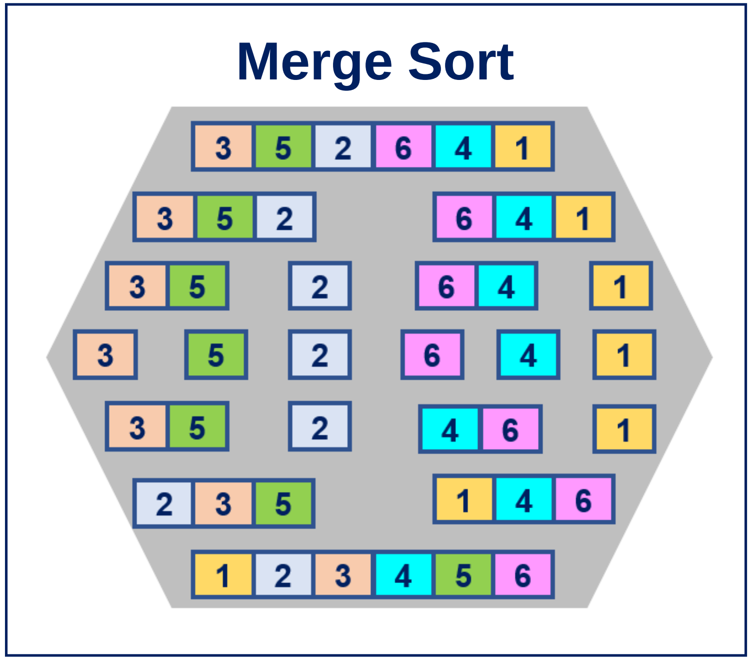
- Since each pass places the next largest value in place, the total number of passes necessary will be n − 1.

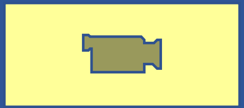
- After completing the n − 1 passes, the smallest item must be in the correct position with no further processing required.

17	20	26	31	44	54	55	77	93

Merge Sort

- Merge sort is an example of a divide-and-conquer style of algorithm.
- A problem is repeatedly broken up into sub-problems, often using recursion, until they are small enough to be solved.
- The solutions are combined to solve the larger problem.
- The idea behind merge sort is to break the data into parts that can be sorted trivially, then combine those parts knowing that they are sorted.





Click the video icon to watch the Merge Sort Visualization

Merge Adjacent List

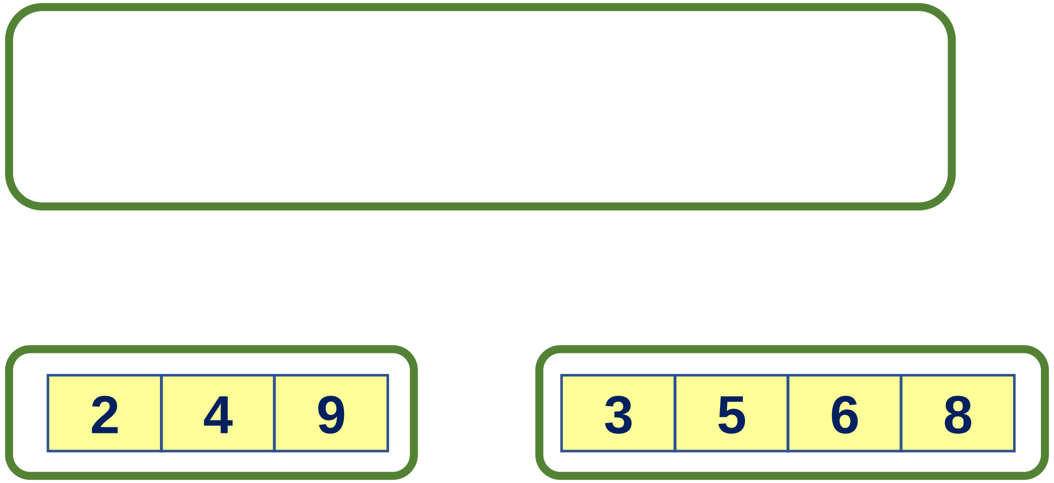
This means we have a list on the left and a list on the right.

Step 1 Compare the first elements of both lists one by one.

Step 2 Move the smaller element out of the list that it was found in. Add this value to the list of “sorted items”.

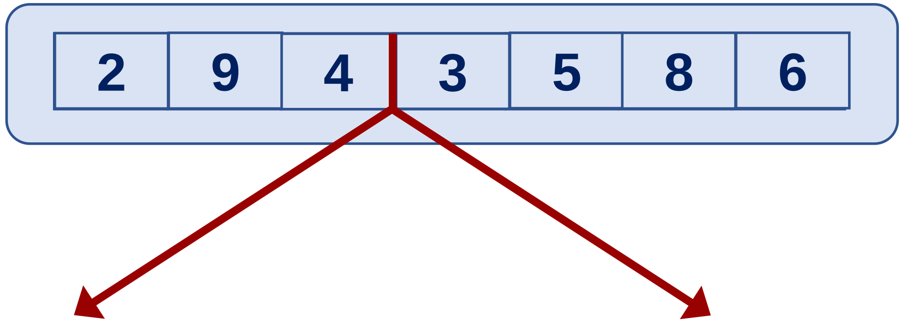
Step 3 Repeat the process until only a single list remains.

Step 4 One list should still contain elements. This list is sorted. Move its contents into the result list.



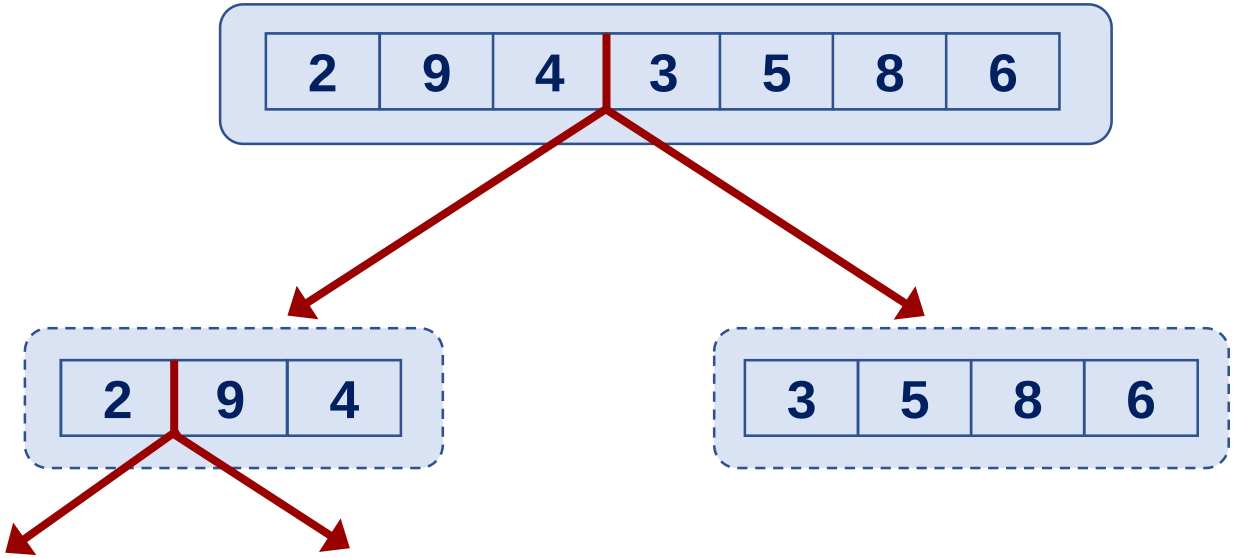
Merge Sort: Execution Example

Partition



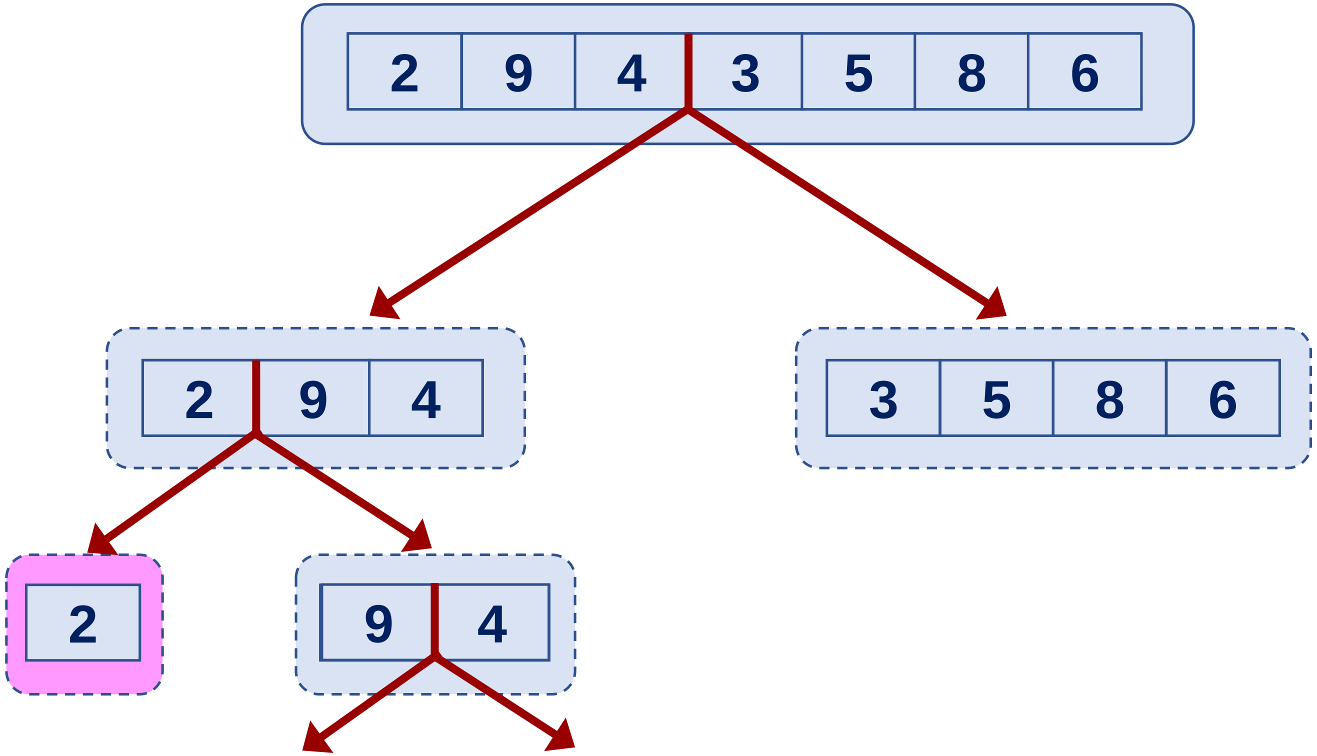
Merge Sort: Execution Example (Cont’d)

Partition



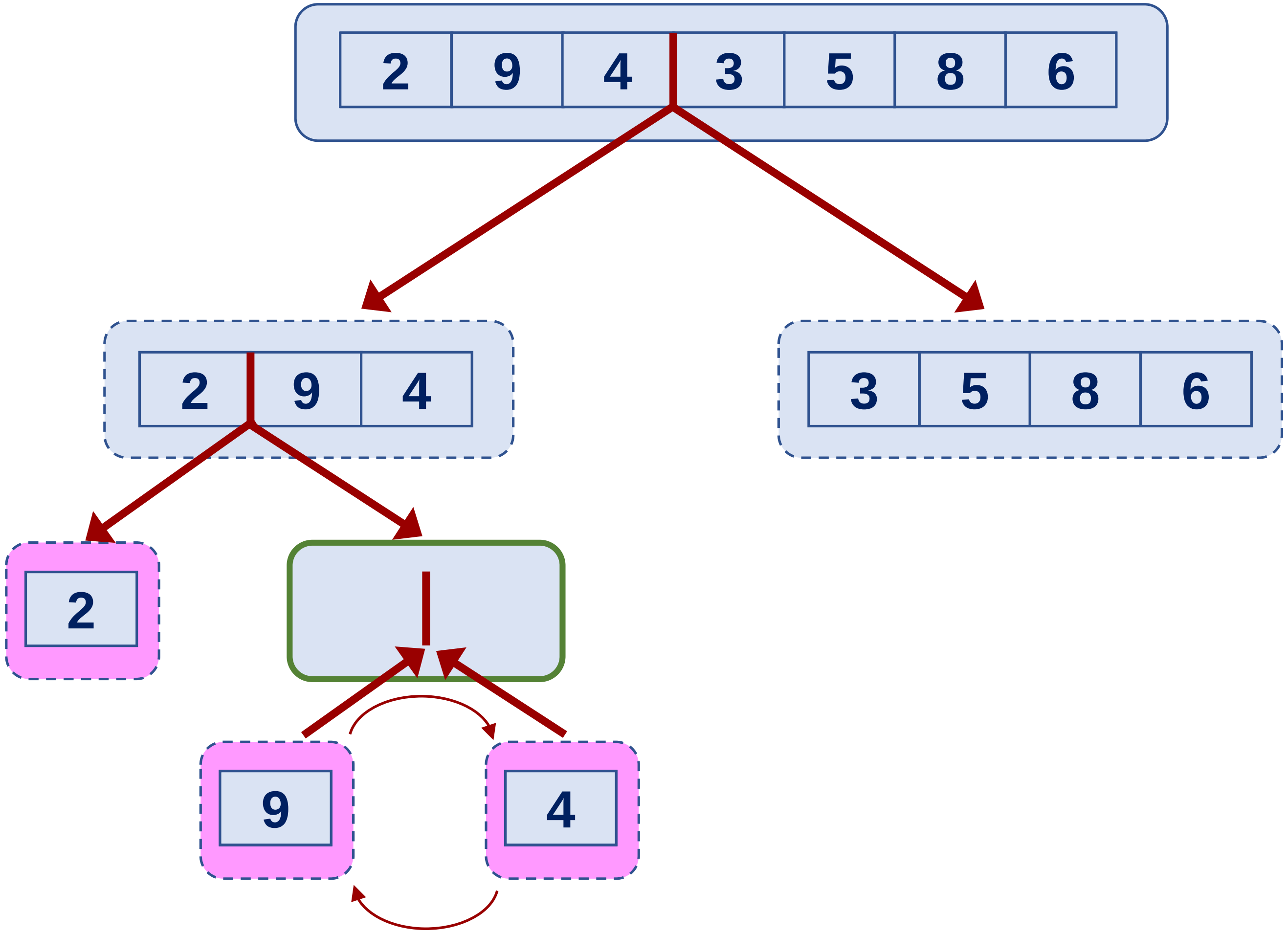
Merge Sort: Execution Example (Cont'd)

Partition

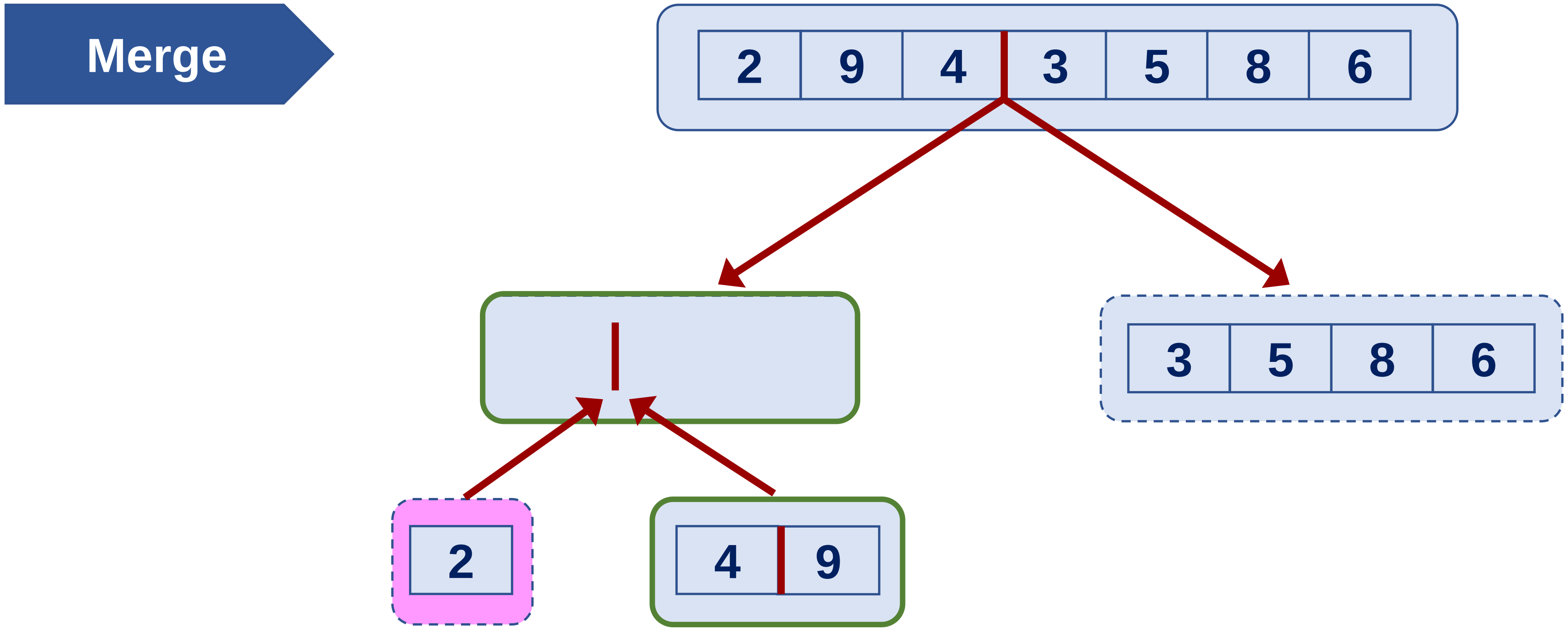


Merge Sort: Execution Example (Cont'd)

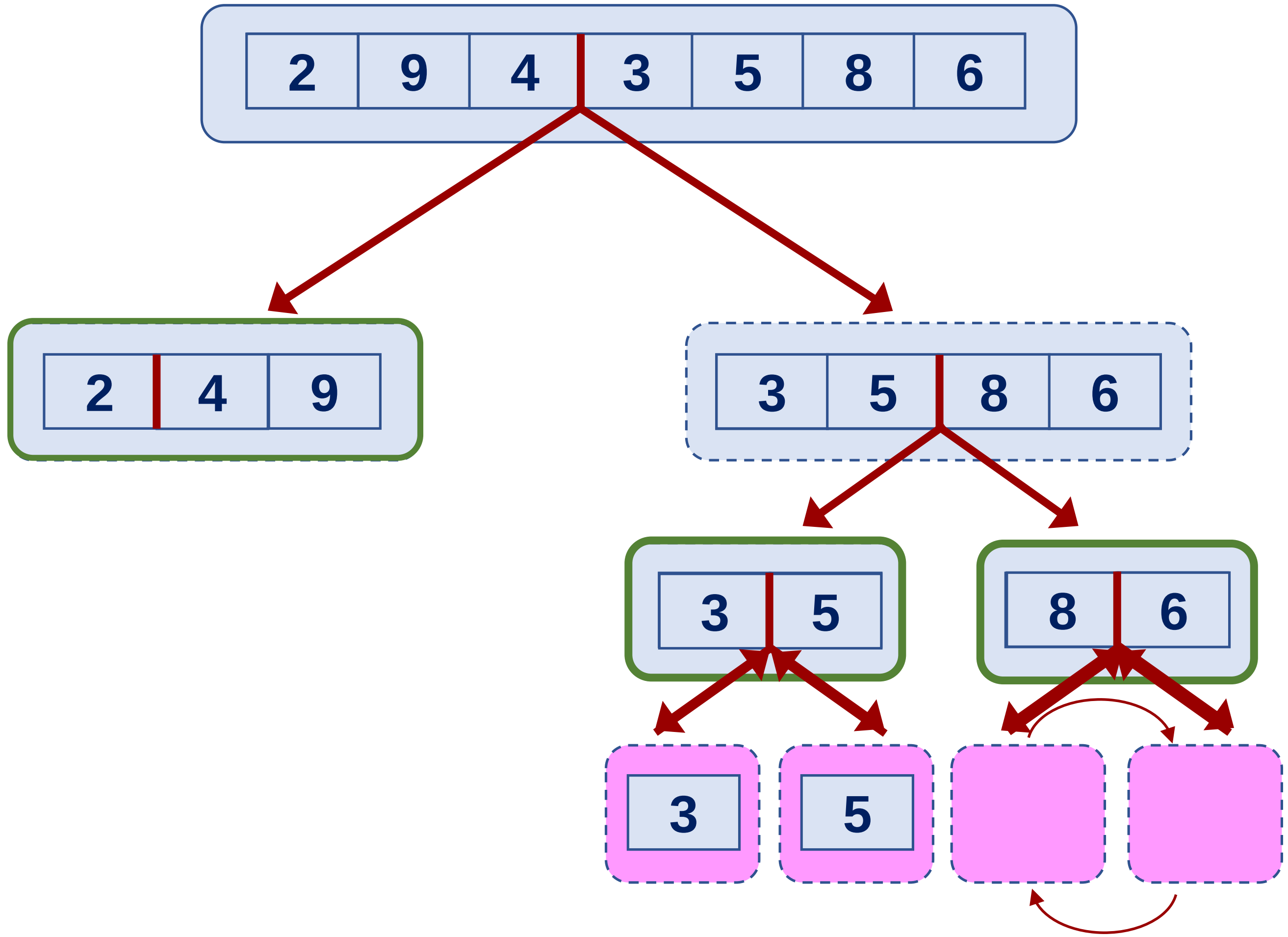
Merge



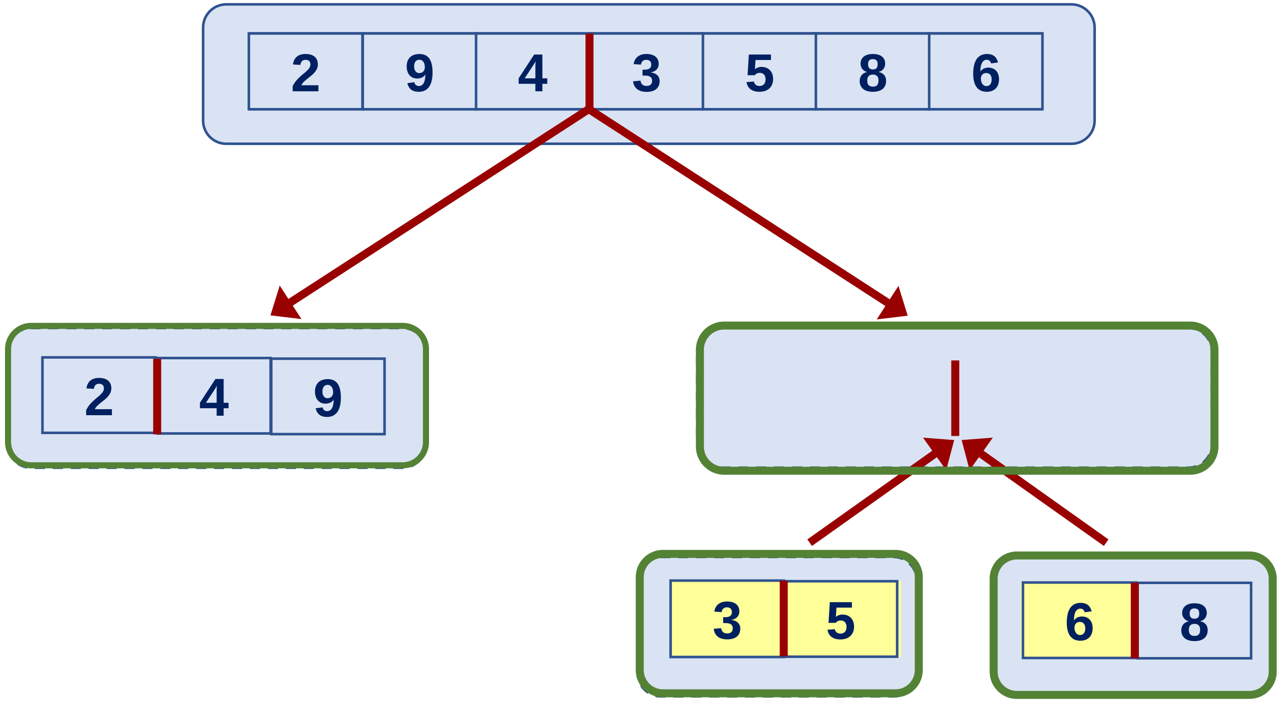
Merge Sort: Execution Example (Cont'd)



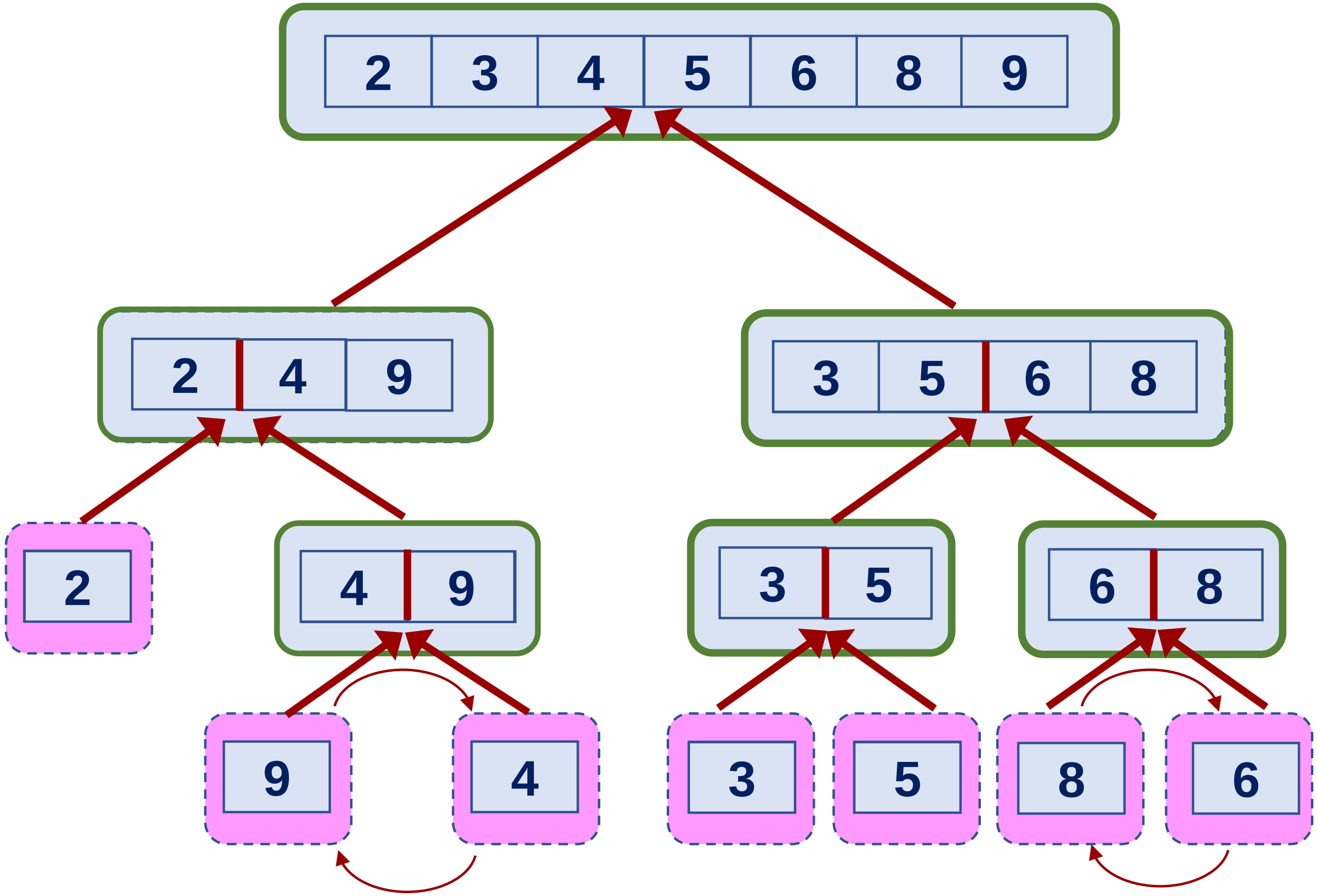
Merge Sort: Execution Example (Cont'd)



Merge Sort: Execution Example (Cont'd)



Merge Sort: Execution Example (Cont'd)



Summary

SORTING

Importance

- **Practical Applications**: People by last name, countries by population, search engine relevance
- **Fundamental to other Algorithms**

Different algorithms have different asymptotic and constant-factor trade-offs

- No single 'best' sort for all scenarios
- Knowing just one way to sort is not enough

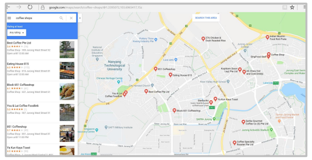
Bubble Sort

- Orders a list of values by repetitively comparing neighboring elements and swapping their positions, if necessary
- Easier to implement but slower than other sorts

Merge Sort

- An important divide-and-conquer sorting algorithm
- It is a recursive algorithm
  1. Divides the list into halves
  2. Sorts each half separately
  3. Then merges the sorted halves into one sorted array
- Extremely efficient algorithm with respect to time

References for Images

No.	Slide No.	Image	Reference
1	3		Google Maps
2	9		By User:Bobarino - Made by following Information.png, CC BY-SA 3.0, retrieved April 18, 2018 from https://en.wikipedia.org/w/index.php?curid=9180601.
3	10		Bubble Soap [Online Image]. Retrieved July 3, 2018 from https://www.maxpixel.net/Colorful-Fly-Soap-Bubbles-Make-Soap-Bubbles-2405969.