Algorithm Design Approaches2

ESC108A Elements of Computer Science and Engineering

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Objectives

- At the end of this lecture, student will be able to
  - explain divide and conquer approach to algorithm design
  - explain reduce and conquer approach to solving problems

Contents

- Divide and Conquer Approach
- Reduce and Conquer

Divide and Conquer Approach

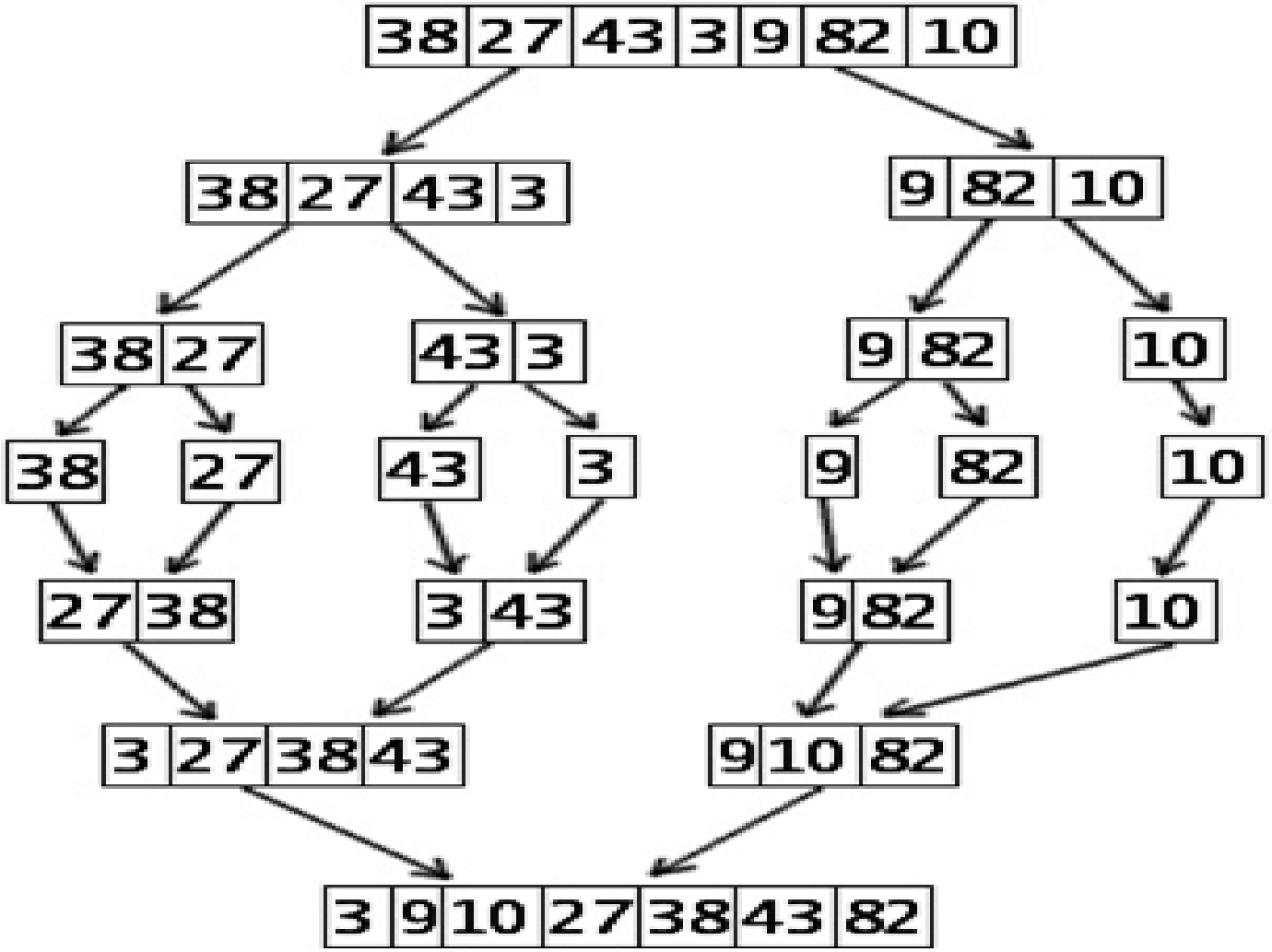
General Divide and Conquer Approach

- **Divide Phase**
  - Divide the problem into roughly equal sized sub-problems
  - Recursively, down to the smallest size
- **Conquer Phase**
  - Solve the sub-problems independently
  - Merge the solutions

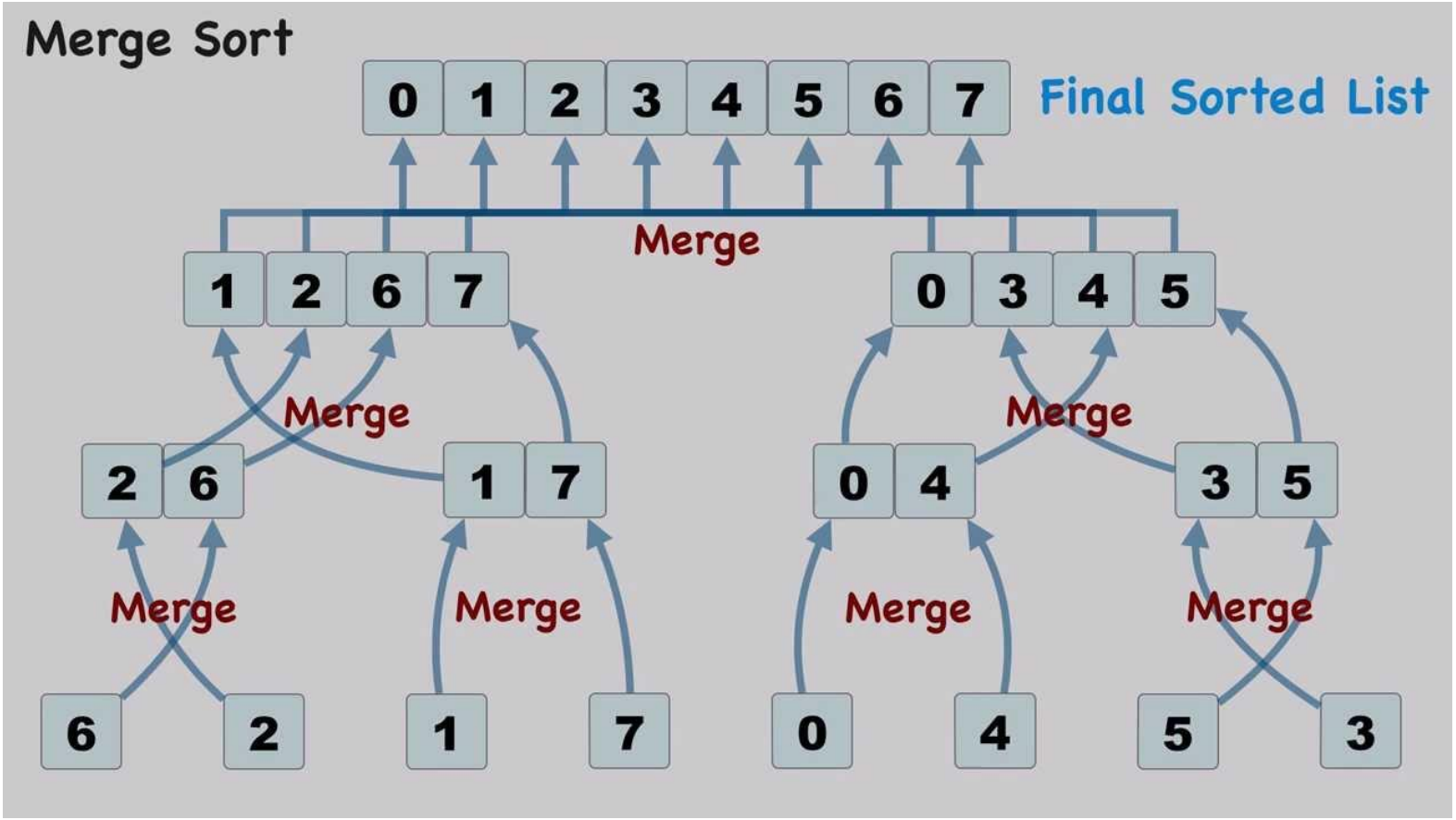
Important Characteristic: **Sub-problems are independent**

This approach can be applied any problem with this characteristic

Merge Sort



Merge Algorithm



Merge Sort Algorithm

The Algorithm

- Divide the array into two equal parts
- Recursively merge sort the left part of the array
- Recursively merge sort the right part of the array
- Merge the sorted left and the right part into a single sorted vector using **Merge Algorithm**

REDUCE AND CONQUER

Reduce and Conquer

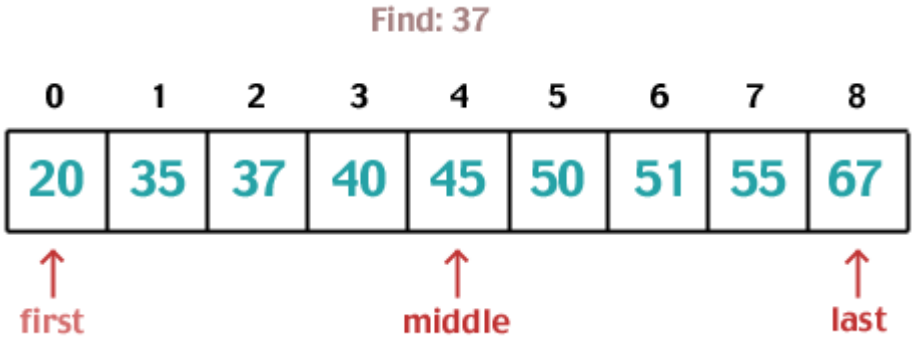
General approach

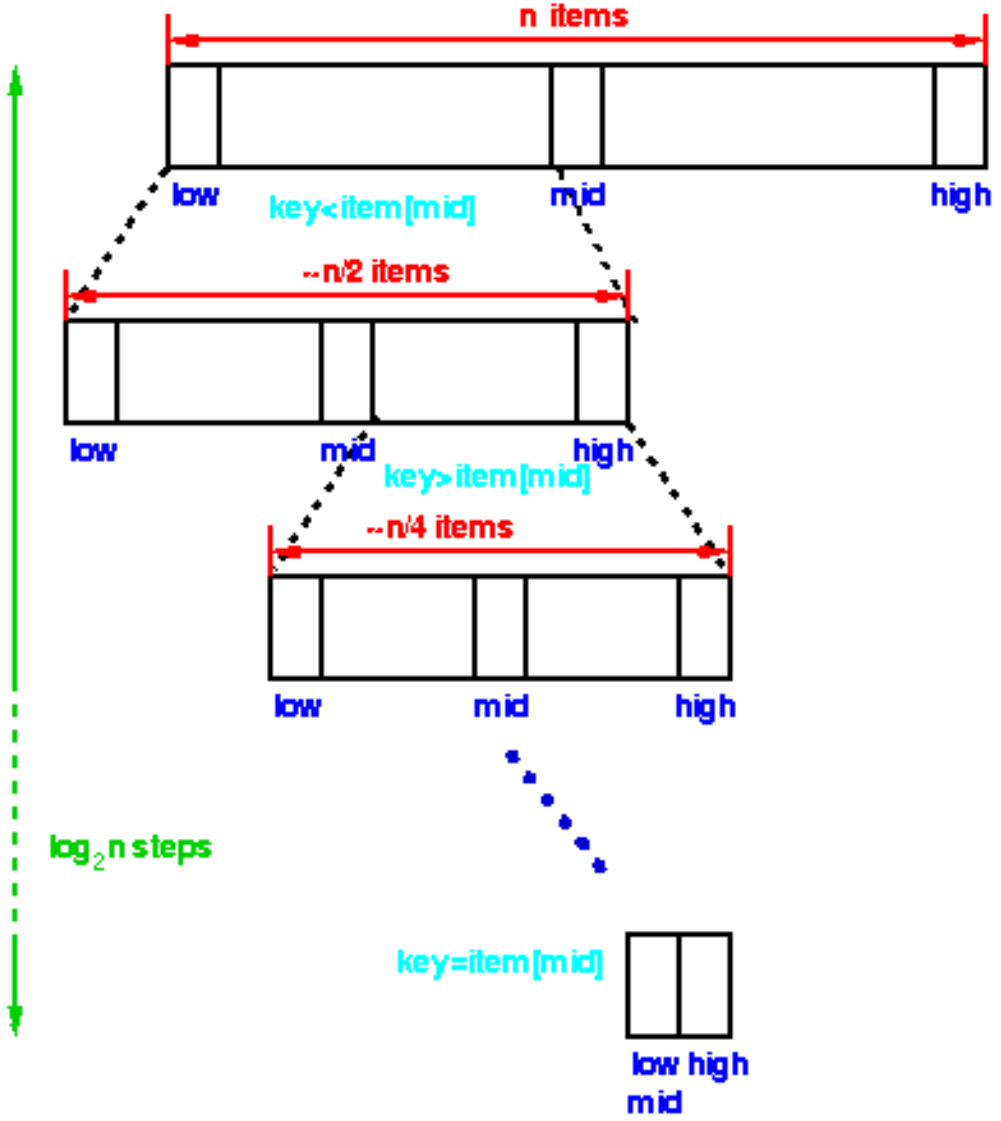
- **Divide** into sub-problems
- **Conquer**
  - Decision: Select the sub-problem to be solved
  - Solve the sub-problem

Example: Binary Search

- **Divide** the sorted array into (almost) equal parts
- **Conquer**
  - Have we found the item?
  - If no, choose left or right part of the array to search

Binary Search





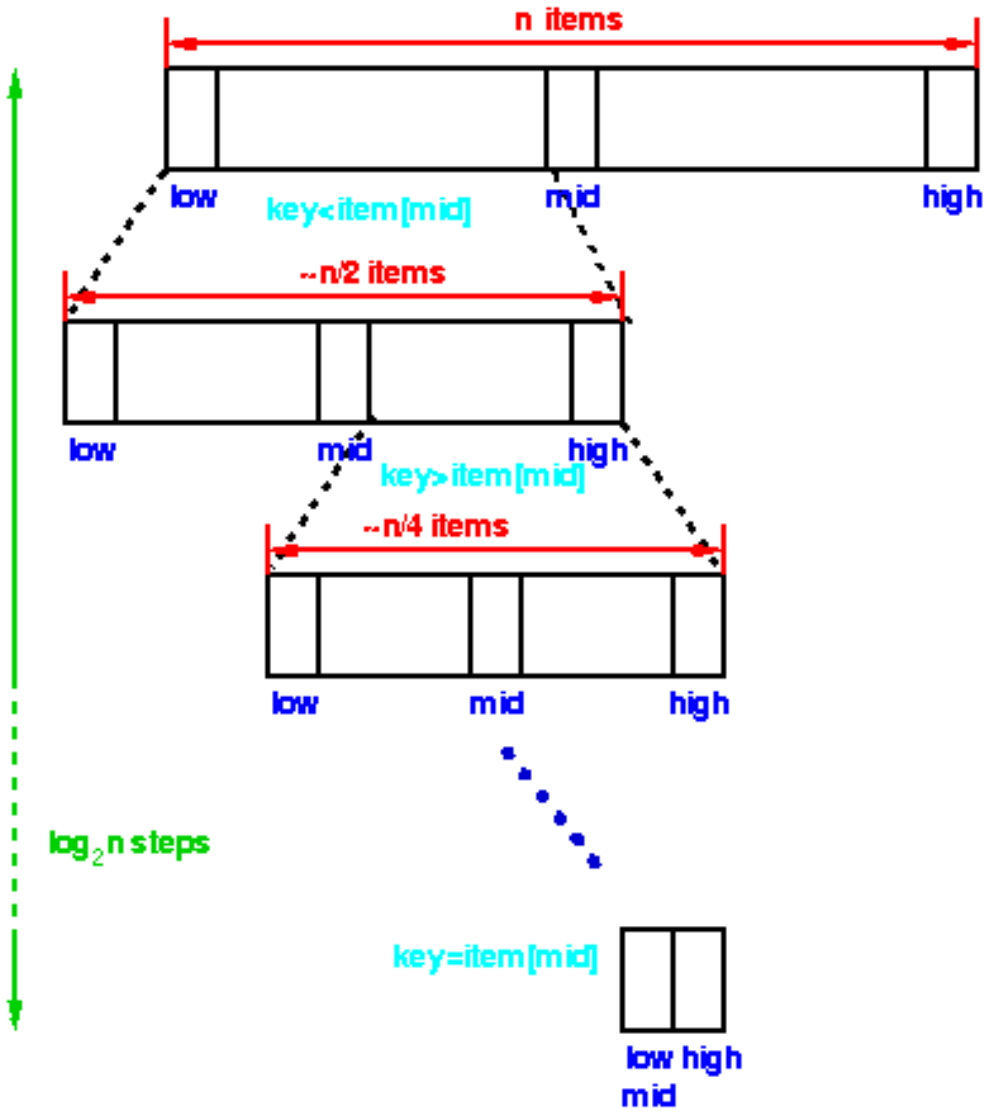
Binary Search Algorithm

Observation:

At each stage we are solving **only one of** the sub-problems!

So, we are conquering by **reducing** the problem!

Complexity?
= No of decisions/steps
= log n (How?)



Summary

- Divide and Conquer is a very general approach to solving problems and developing algorithms
- Divide and Conquer splits the problem into roughly equal sized sub-problems, solves the sub-problems and merges the solutions
- The important characteristic requirement of Divide and Conquer is that the sub-problems are independent
- Reduce and Conquer is an important variant of Divide and Conquer
- In Reduce and Conquer, at each stage, only one of the sub-problems needs to be solved

References

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Levitin, A. (2003) *Introduction to the Design and Analysis of Algorithms.* Addison-Wesley