CS 200: Algorithm Analysis

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TAs: Brandon Charles
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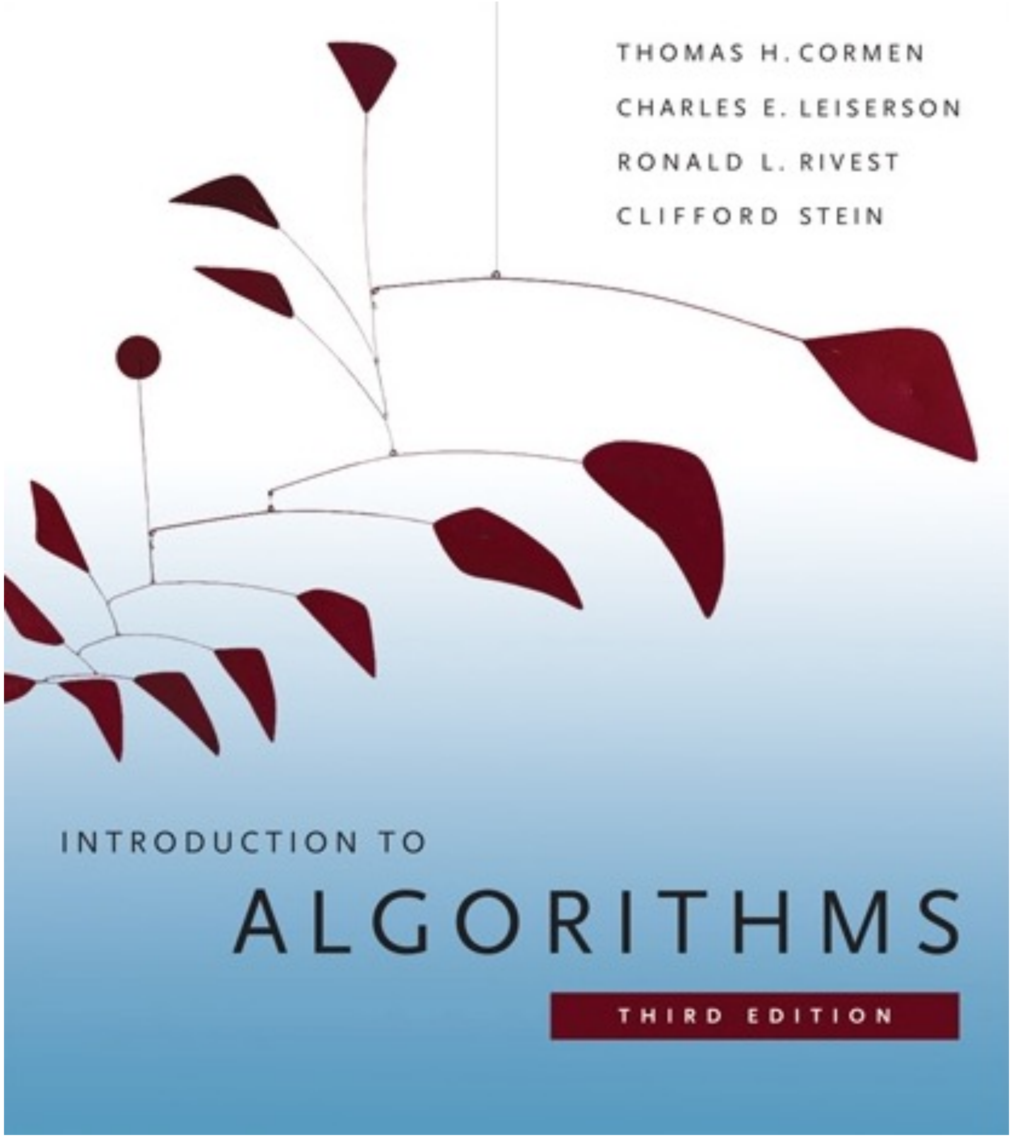
Administrative info:

- Course website
- Book
- Syllabus
- Moodle

This course serves two purposes, which are served in each half of the semester:

- Design and analyze algorithms
- Prepare for Senior IS



Introduction

CLRS 1.1 & 1.2

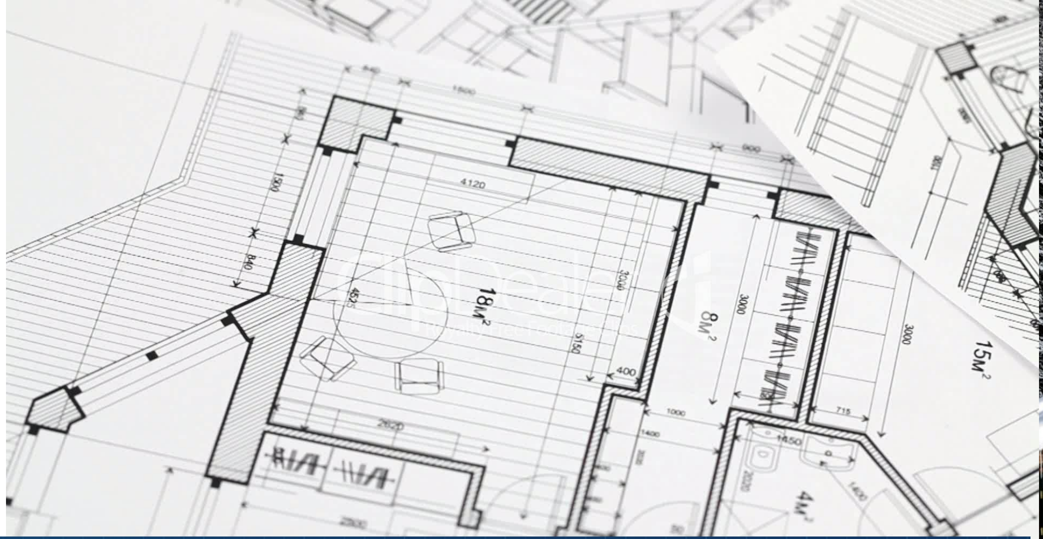
Example: Boss assigns a task

- Given today's prices of pork, grain, sawdust, etc…
- Given constraints on what constitutes a hotdog.
- Make the cheapest hotdog.

Every industry asks these questions.

- Mundane programmer: "Um? Tell me what to code."
- Better: "I learned an algorithm that will work."
- Best: "I can develop an algorithm for you."

How to do this?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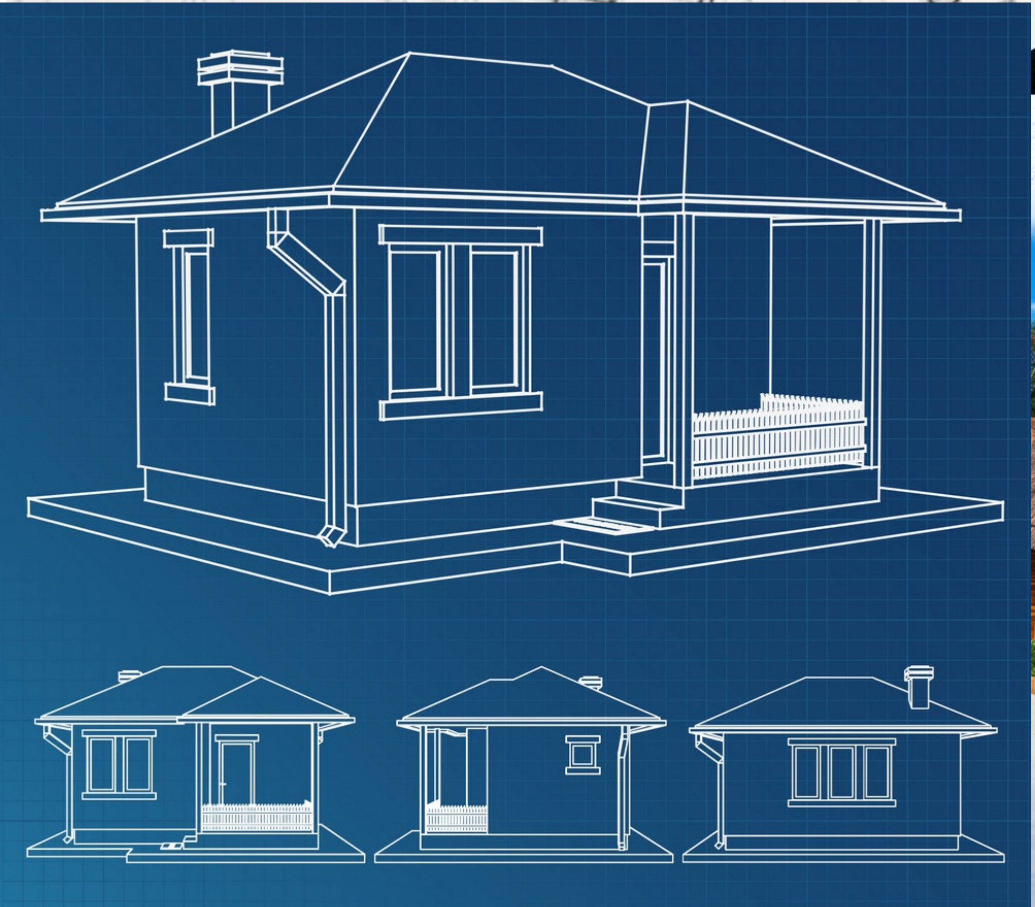
715

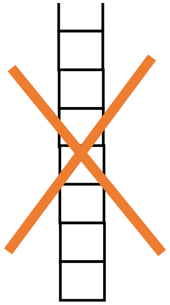


PETER RUPRECHT

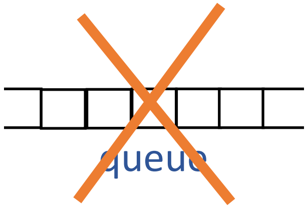
Tools you need

Example: Design an inventory system which can quickly find an item.

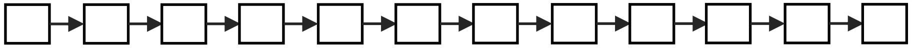
- What data structure to use?



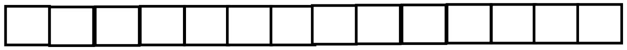
stack



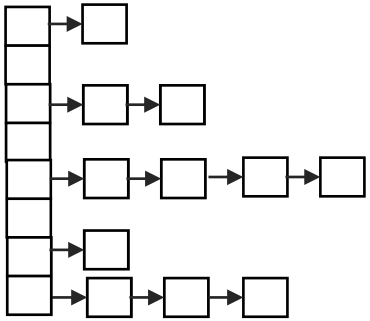
queue



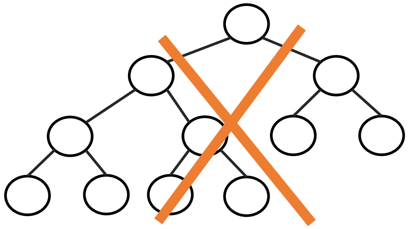
linked list



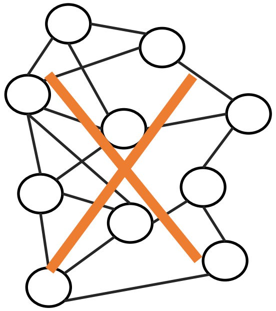
array



hash table



tree



graph

Tools you need

Example: Design an inventory system which can quickly find an item.

- What approach to take?

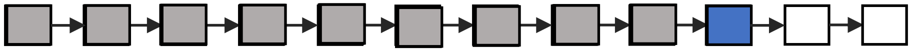
  Brute force

  Dynamic programming

  Divide and conquer

  Greedy method

  Prune and search



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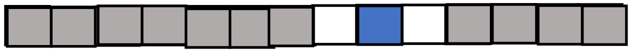

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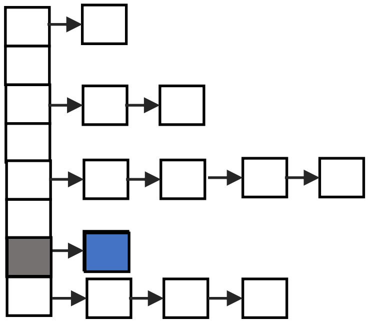


hash table

- Are there any existing algorithms that could be used/modified?

Tools you need

Example: Design an inventory system which can quickly find an item.

- How to determine which solution is best?

- Does it work as required?

  Rationalization

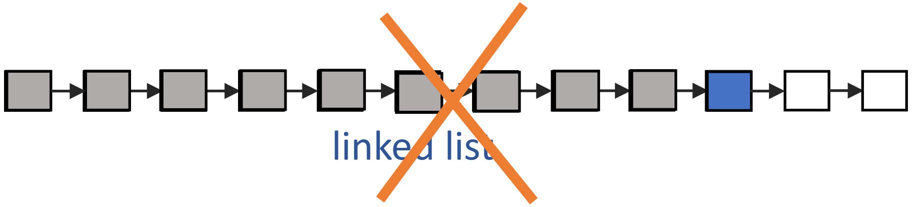
  Proof of correctness

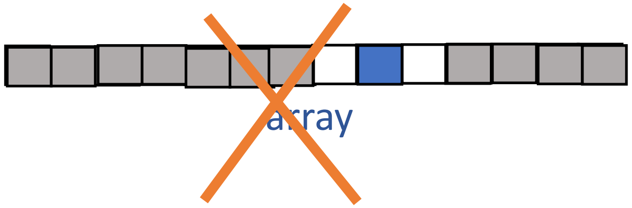
- How much memory is required? How long does it take?

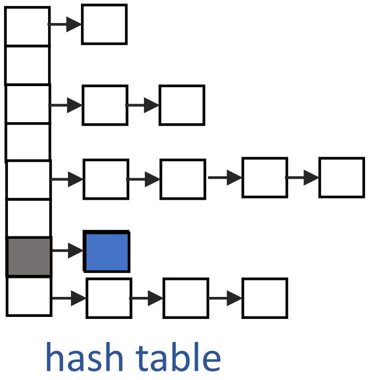
  Big-oh notation

  Amortization

  Complexity analysis







Algorithm Analysis

- How to evaluate algorithms (correctness, complexity)
  - Notations and abstractions for describing algorithms
- Advanced data structures and their analysis
- Fundamental techniques to solve the vast array of unfamiliar problems that arise in a rapidly changing field
  - Up to date grasp of fundamental problems and solutions
  - Approaches to solve
- To think algorithmically like a ‘real’ computer scientist

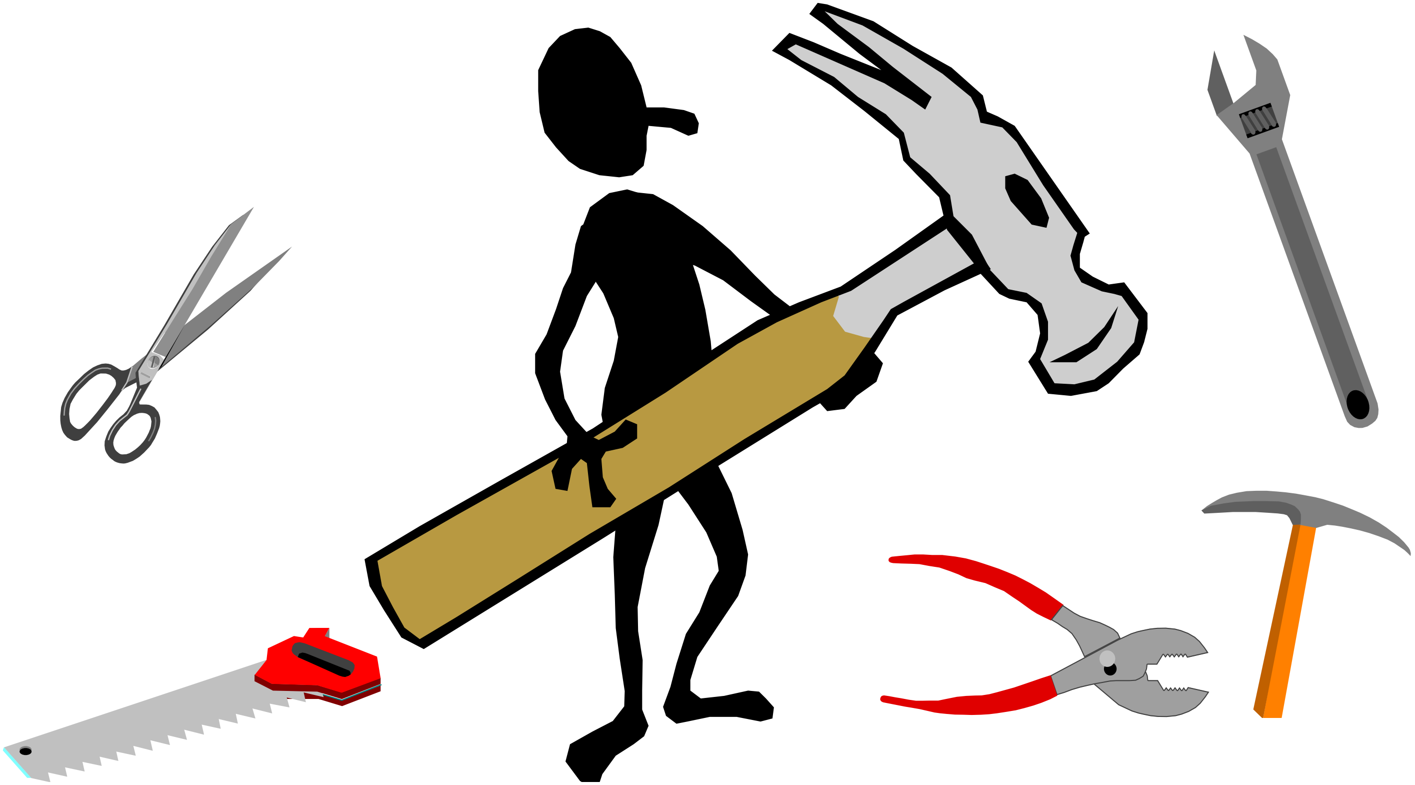
Course Content

- A list of algorithms
  - Learn the code
  - Trace them until you are convinced that they work
  - Implement them.

```
class InsertionSortAlgorithm extends SortAlgorithm {
 void sort(int a[]) throws Exception {
           for (int i = 1; i < a.length; i++) {
             int j = i;
             int B = a[i];
             while ((j > 0) && (a[j-1] > B)) {
              a[j] = a[j-1];
              j--;  }
             a[j] = B;
         }
}
```

Course Content

- A survey of algorithmic design techniques
- Abstract thinking
- How to develop new algorithms for any problem that may arise



Start with some math

Time complexity as a function

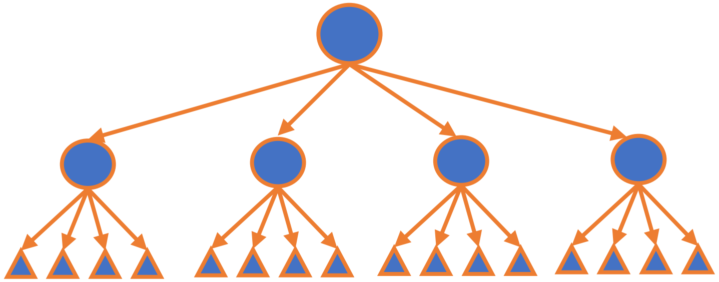
$t(n) = \Theta(n^2)$

Counting primitive operations

- Sequences and summations
- Linear functions
- Logarithmic and exponential functions

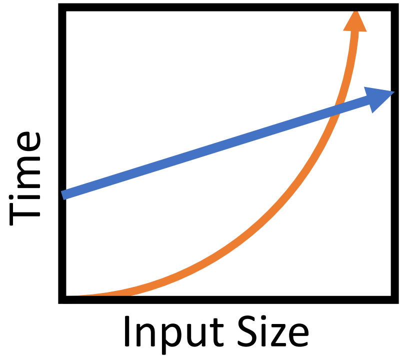
$$a + ar + ar^2 + ar^3 + \cdots + ar^{n-1} = \sum_{k=0}^{n-1} ar^k = a\left(\frac{1-r^n}{1-r}\right)$$

Recurrence Relations

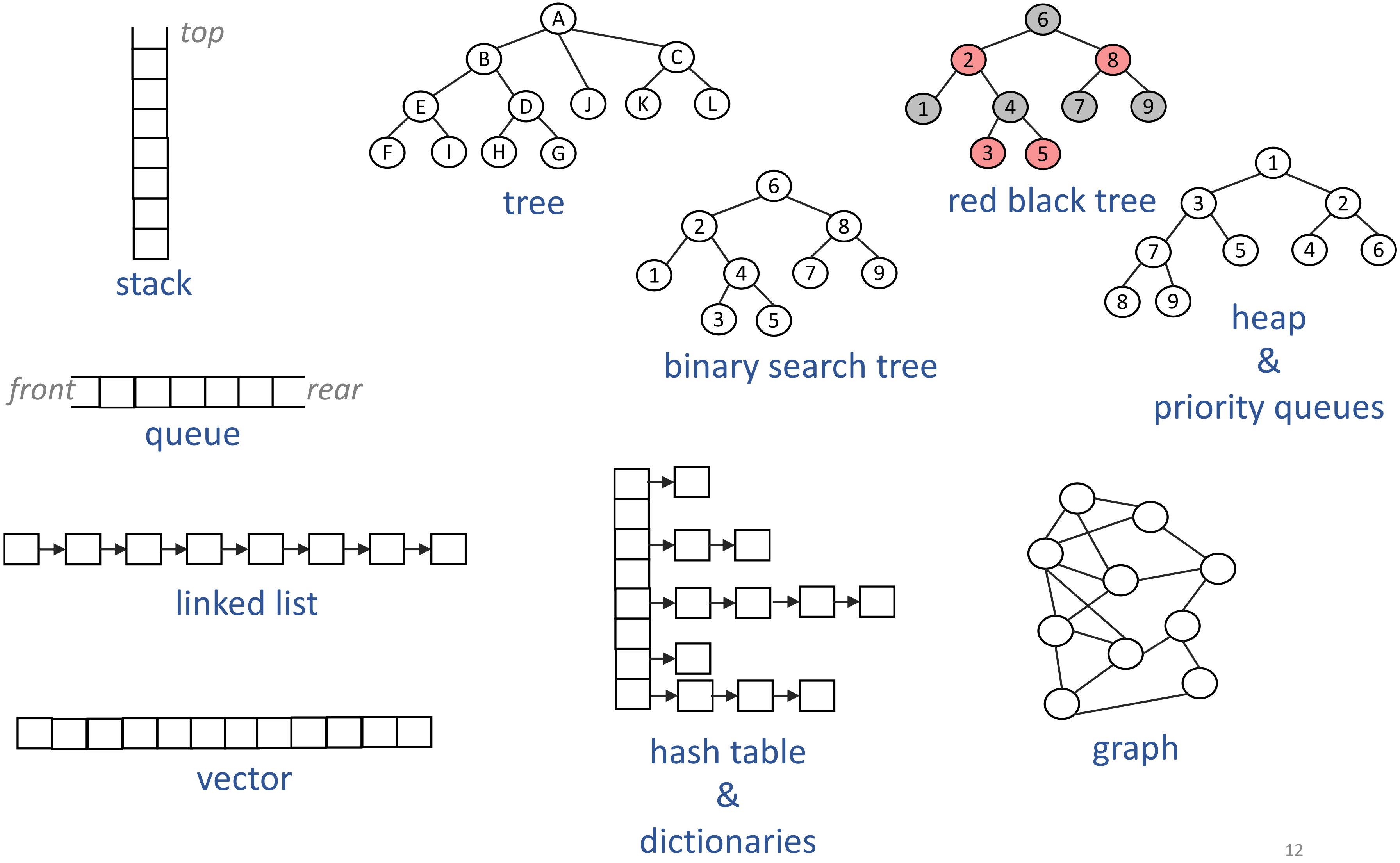


$T(n) = a\, T(n/b) + f(n)$

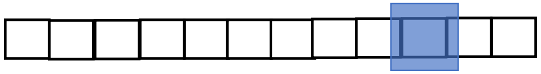
Classifying functions

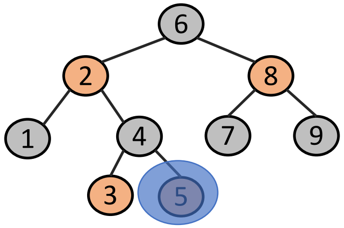


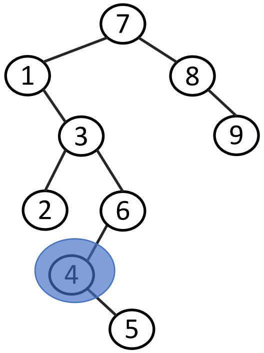
Data Structures

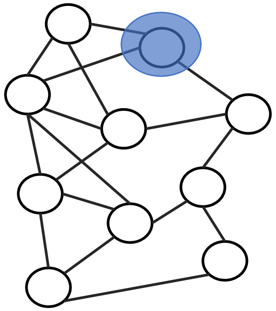


Searching & Sorting









insertion sort

selection sort

heap sort

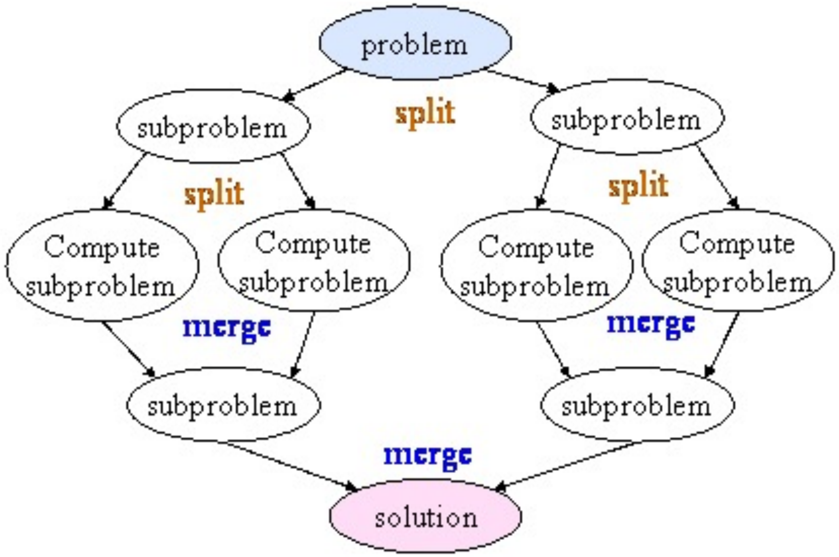
merge sort

quick sort

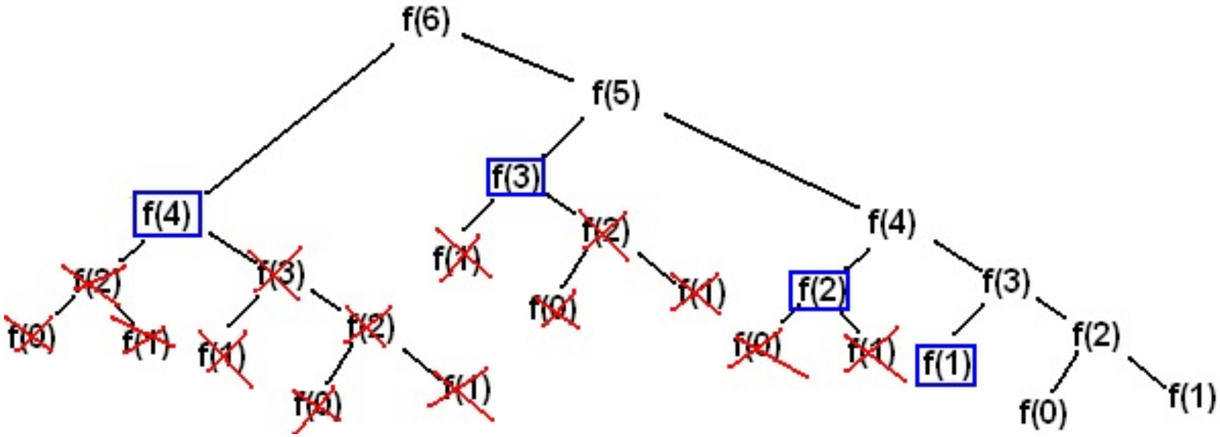
Fundamental Techniques

Greedy Algorithms

Divide and Conquer



Dynamic Programming

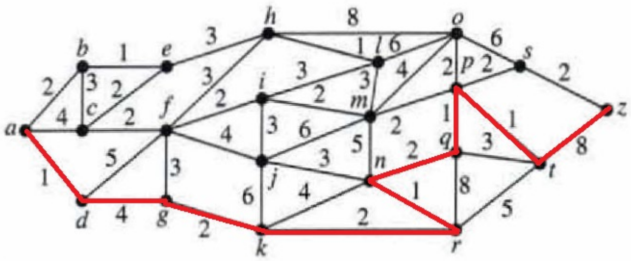


Applications in a wide variety of areas: Junior IS

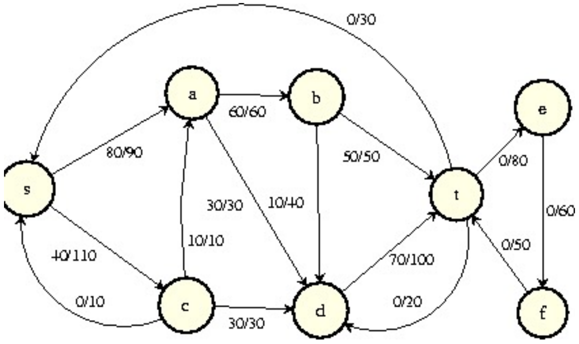
Over the last 6 weeks of the course, each student will undertake a major individual computer science project in the context of a particular application of interest to the student.

- Written component & software component
- Should include algorithm analysis
- Cover methods/topics not covered in the first 8 weeks

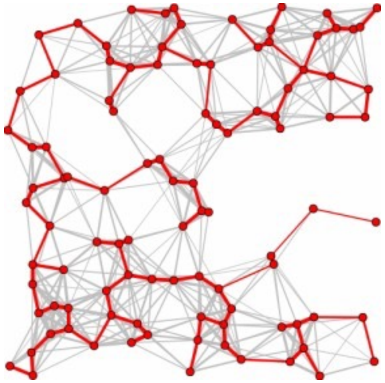
Shortest path



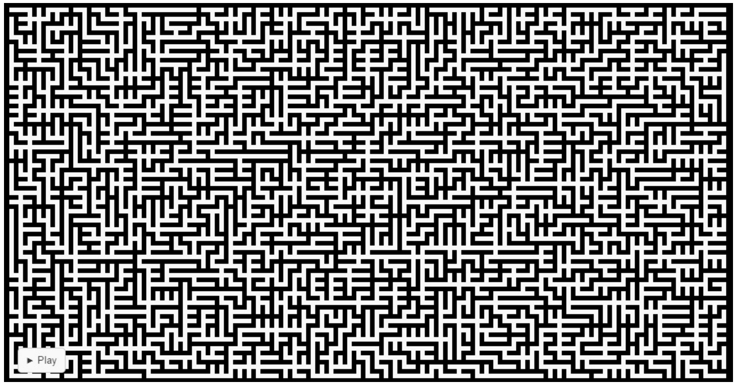
Network flow



Minimum Spanning Tree



Graph search



Useful Learning Techniques

- You are expected to read ahead (before class)
  - This will facilitate more productive discussion during class
  - Plicker questions will be based on assigned reading

- Guess at potential algorithms for solving a problem
  - Look for input instances where your algorithm is wrong

- Practice explaining
  - You’ll be tested on your ability to explain material

- Ask questions
  - Why is it done this way and not that way?