Algorithms

How do you Shuffle Cards?

- What items do you need?
- What tools do you need?
- What skills do you need?
- What prior knowledge do you need?

al - khwarithmi

- Abu Abdallah Muhammad ibn Musa al-Khwarizmi
  - Latin nickname Algorithmi
- Wrote many books for solutions to linear and quadratic equations
- These transformed over the years into algorithms

Video link

Algorithm

A finite list of specific instructions for carrying out a procedure or solving a problem

Euclid

- Greek mathematician from 300 BC
- Discovered a simple way to calculate the greatest common divisor
  - Used to reduce fractions

Euclid's Algorithm (GCD)

1. Start with 2 numbers, A and B
2. If either one is zero, the answer is the other number
3. Subtract the smaller number from the larger number
4. Repeat steps 2-4 until answer is found

Example: GCD of 1071 & 462

- 1071, 462
- 609, 462
- 147, 462
- 147, 315
- 147, 168
- 147, 21
- 126, 21
- 105, 21
- 84, 21
- 63, 21
- 42, 21
- 21, 21
- 21, 0
- ***21***

Sorting

Sorting Algorithms

- Insertion Sort
- Bubble Sort
- Merge Sort
- Quicksort

Insertion Sort

6 5 3 1 8 7 2 4

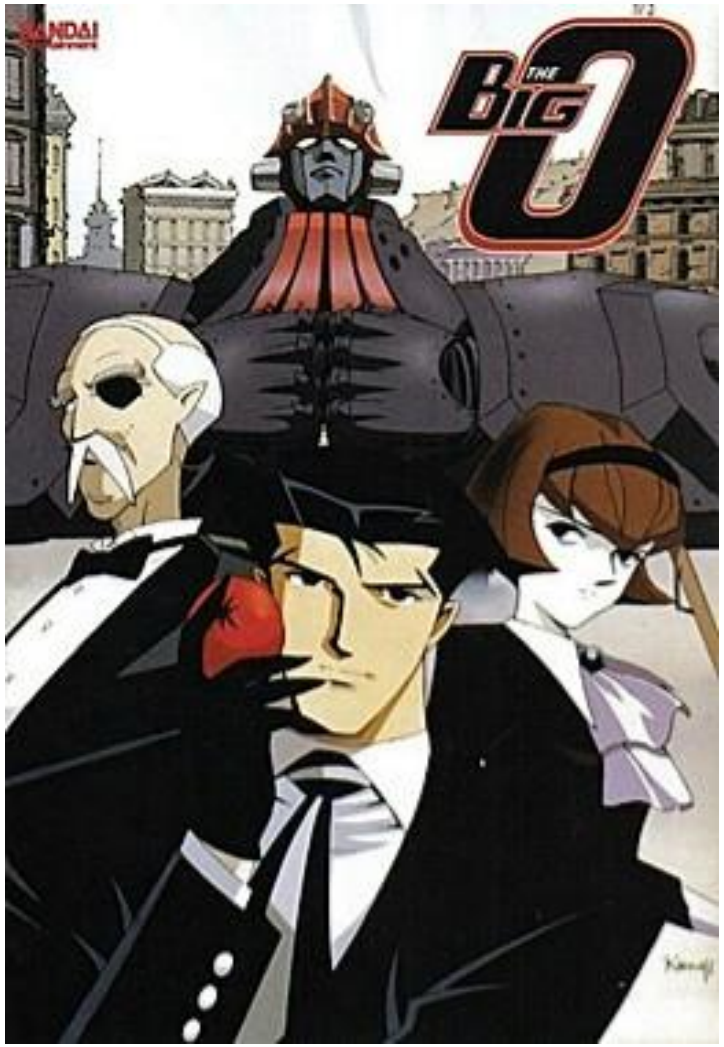
1. Choose an element from the source
2. Place it in the correct place in destination
3. Repeat until source is empty

Bubble Sort

1. Compare the first two elements
2. If they are out of order, swap them
3. Move one element over and repeat
4. When the end is reached, start over
5. Continue until no more swaps are made

Big O Notation

- Expresses the complexity of an algorithm
- Approximates the number of steps needed based on the size of the input
- Worst-case scenario

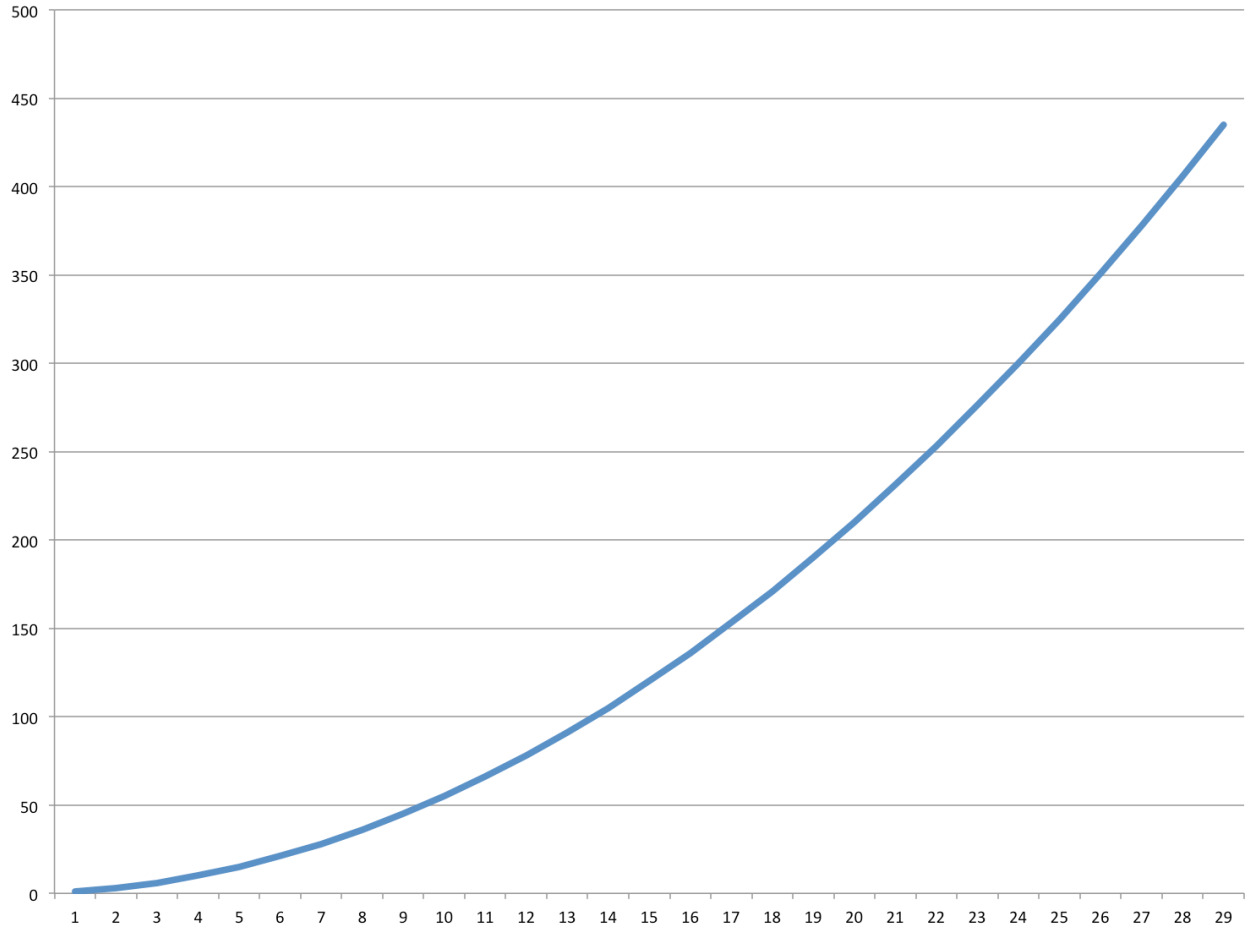


Bubble Sort – Worst Case

- 3, 2, 5, 4, 7, 6, 9, 8, J, 10, K, Q, A
- A, 2, K, 3, Q, 4, J, 5, 10, 6, 9, 7, 8
- A, Q, K, 10, J, 8, 9, 6, 7, 4, 5, 3, 2
- A, K, Q, J, 10, 9, 8, 7, 6, 5, 4, 3, 2
- 2, 4, 6, 8, 10, Q, A, 3, 5, 7, 9, J, K

- 6
- 42
- 73
- 78
- 21

Bubble Sort – Worst Case



Sorting Algorithms

- Insertion Sort - $O(n^2)$
- Bubble Sort - $O(n^2)$
- Merge Sort
- Quicksort

Merge Sort

1. Split the items into two halves
2. Repeat step 1 until each has 1 item
3. Choose 2 parts and merge them together by choosing the smallest item repeatedly from the front of each part
4. Continue merging parts together until no more remain

Image Source: Wikipedia

Quicksort

1. Choose an item from the list as a "pivot"
2. Put all items less than that item to its left, and put all items greater to its right
3. Repeat these steps for the items on each side of the pivot.

6 5 3 1 8 7 2 4

Image Source: Wikipedia

Sorting Algorithms

- Insertion Sort - $O(n^2)$
- Bubble Sort - $O(n^2)$
- Merge Sort - $O(n \log n)$
- Quicksort - $O(n^2)$ - avg. $O(n \log n)$

What is a Heuristic?

Using experience based technique to find a satisfactory solution to a problem (which may or may not be the absolute best solution

Everyday Heuristics

- Rule of Thumb
- Educated Guess
- Common Sense
- Try something and work backwards
- Do a simpler problem first

Tradeoffs

mage Source: Wikipedia

Traveling Salesman Problem

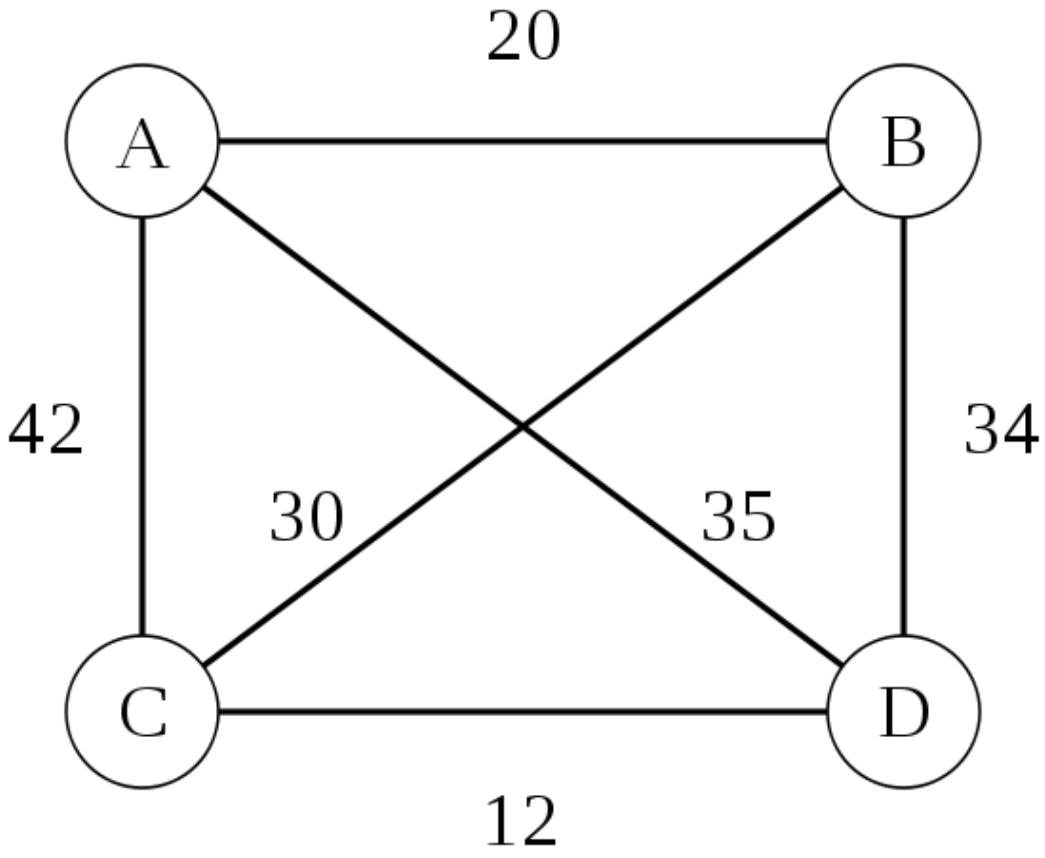


Image Source: Wikipedia

Traveling Salesman Problem - Algorithms

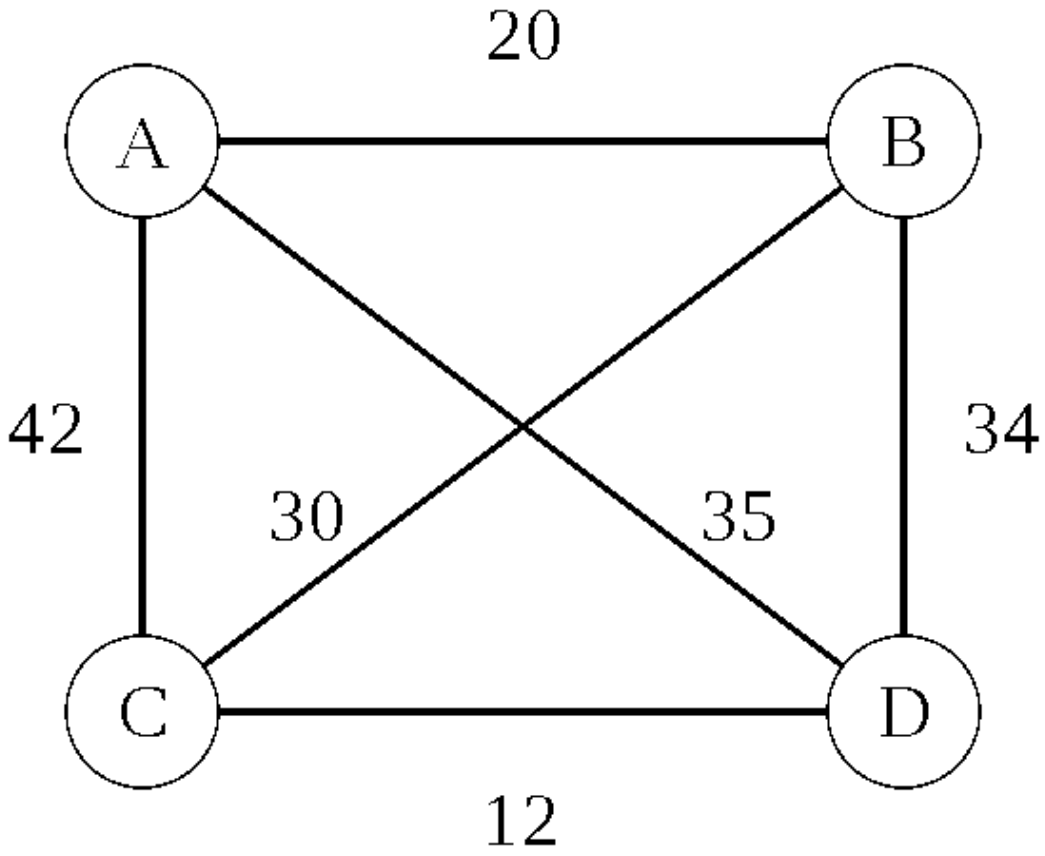
- Brute Force - O(n!)
  - Easy & Cheap, but not fast
  - 8 cities = 40320 steps
- Dynamic Programming - $O(2^n)$
  - Faster, but not easy or cheap
  - 8 cities = 256 steps

Traveling Salesman Problem: Heuristic

Nearest Neighbor (Greedy Algorithm)

- Pick any city (we'll use B)
- Go to the closest city you haven't been to yet
- From that city, repeat this process until all cities have been visited

Greedy Solution: 67 miles



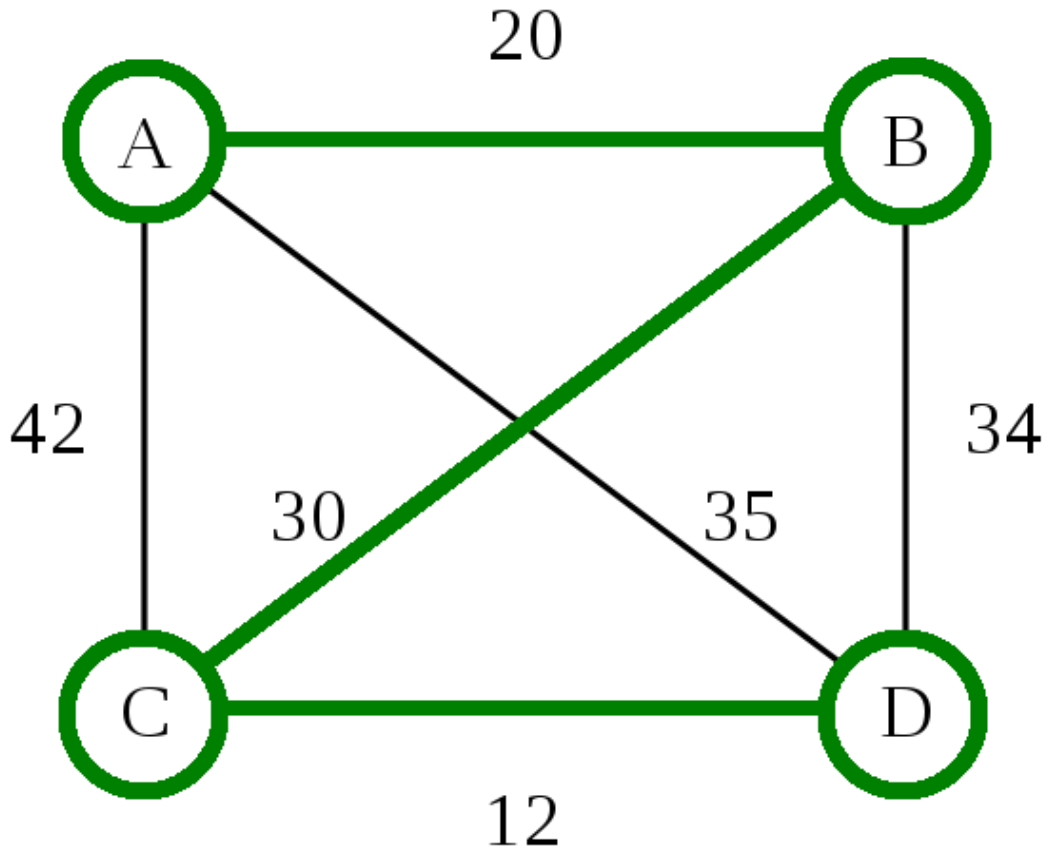
Traveling Salesman Problem: Heuristic

Nearest Neighbor (Greedy Algorithm) - O(d n)

- d is the number of dimensions
- n is the number of cities
- 8 cities = 16 steps (assuming 2D maps)

Time can vary widely based on how the data is presented and sorted

Optimal Solution: 62 miles



Tradeoffs

mage Source: Wikipedia