Nature Inspired Computing and Applications

Topics: Algorithm, Optimization, Optimization Applications, Optimization Problems and Feasibility Problems

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Algorithm

- A step-by-step procedure of **providing calculations and instructions** is called **algorithm**.
  But it is tough to find out,
  What is the **best algorithm** for a specific problem?
  What **kind of problem** can be solved by a given algorithm?

- This can only be identified by validating **optimization** of an algorithm.

Optimization

- A **process** of making something (as a design of a system, or decision) as fully **perfect, functional, or effective as possible**

- Optimization means **provide an algorithm** in such a manner that it is said to be best in terms of
  - **Minimum energy consumption/ Cost consumption**
  - **Maximum profit/output**
  - **Maximum performance/ efficiency**

- Hence, Objectives is to **save time, money, energy, resources, and to maximize efficiency, performance, quality.**

Some Examples of Optimization Applications

- Travel Salesman Problem
- Optimal Tariff design
- Time Tabling
- Waste water treatment Plant design
- Designing of optimal electrical wiring in a building
- Determine he trajectory for physical objects.
- Determine the trajectory for Space / Air vehicles.
- Determine a civil engineering structure for minimum cost
- Map Colouring Problem

Optimization Problem-1 JOB SCHEDULING PROBLEM

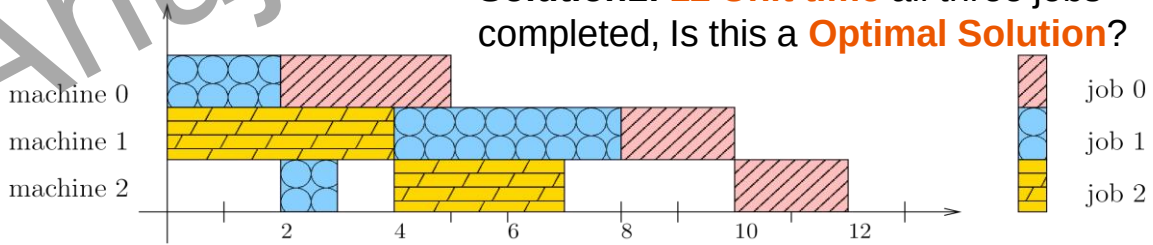
- **Problem:** Multiple jobs are processed on several machines. Each job consists of a sequence of tasks, which must be performed in a given order, and each task must be processed on a specific machine. **Complete all jobs in minimum time on machines**

  Constraints:
  - No task for a job can be started until the previous task for that job is completed.
  - A machine can only work on one task at a time.
  - A task, once started, must run to completion.

job 0 = [(0, 3), (1, 2), (2, 2)]
job 1 = [(0, 2), (2, 1), (1, 4)]
job 2 = [(1, 4), (2, 3)]

Explanation: Job 0 has three tasks.
Ist Task: (0, 3),machine 0 in 3 units time.
IInd Task: (1, 2), machine 1 in 2 units time and so on.

Solution1: 12 Unit time all three jobs completed, Is this a **Optimal Solution**?



Solution 2:

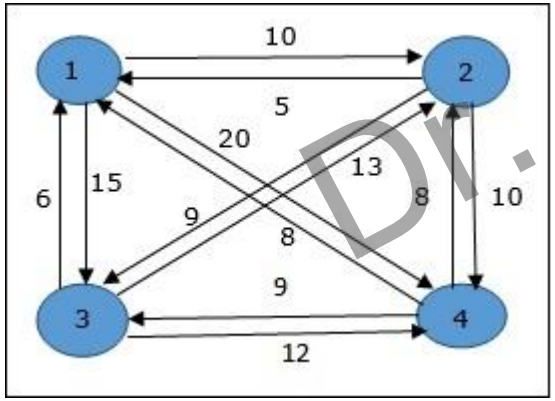
Machine 0: job_0_0 job_1_0
Machine 1: job_2_0 job_0_1 job_1_2
Machine 2: job_1_1 job_0_2 job_2_1

11 Unit Time. Better Solution

Optimization Problem-2 **Travel Salesman Problem**

- The challenge of **finding the shortest yet most efficient route** for a person to take. **Given a list of destinations** and **distance** between destinations. **Identify order to visit destination to minimize their travel time?**

  Constraints:
  - Person can visit each destination exactly once.
  - Person will end the journey in city of origin?



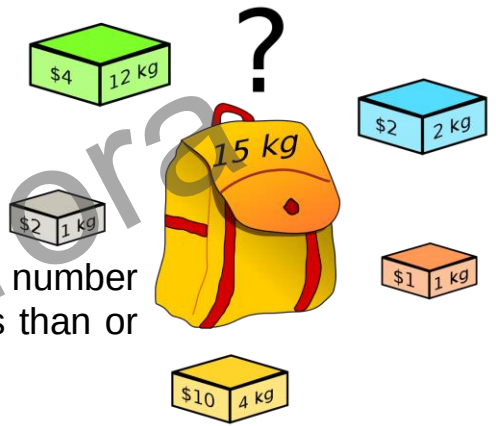
Solution 1:

Cost (2→3→4→1→2) = 9+12+8+10 = 39

Cost (4→2→3→1→4) = 8+9+6+20 = 43

Cost (3→1→2→4→3) = 6+10+10+9 = 35

Optimization Problem



Knapsack Problem

- Given a set of items, each with a **weight and a value**, determine the number of each item to include in a collection so that the total weight is less than or equal to a given limit and the total value is as large as possible.

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Job Scheduling Problem → Minimization Problem

Travel Salesman Problem → Minimization Problem

Knapsack Problem → Maximization Problem

Optimization Problem: Map Colouring/ Graph Colouring

- Four sets of colour: Red, Yellow, Blue, Green are used to colour six countries
- No pair of neighbouring countries can have same colour.

Map Colouring Problem

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Feasibility Problem

Graph Coloring Problem

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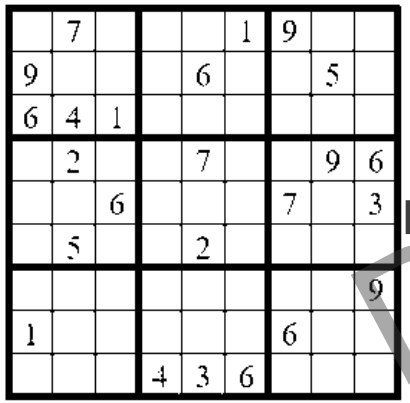
Feasibility Problem

Feasibility Problems are subset of optimization Problem

Feasibility Problems: Sudoku

- In a 9*9 partially filled matrix puzzle. Fill 9*9 matrix with integer from 1 to 9 such as each integer appear only once across columns and rows and 3*3 major region.



Sudoku Problem

Solution 1

Solution 2

Solution 3