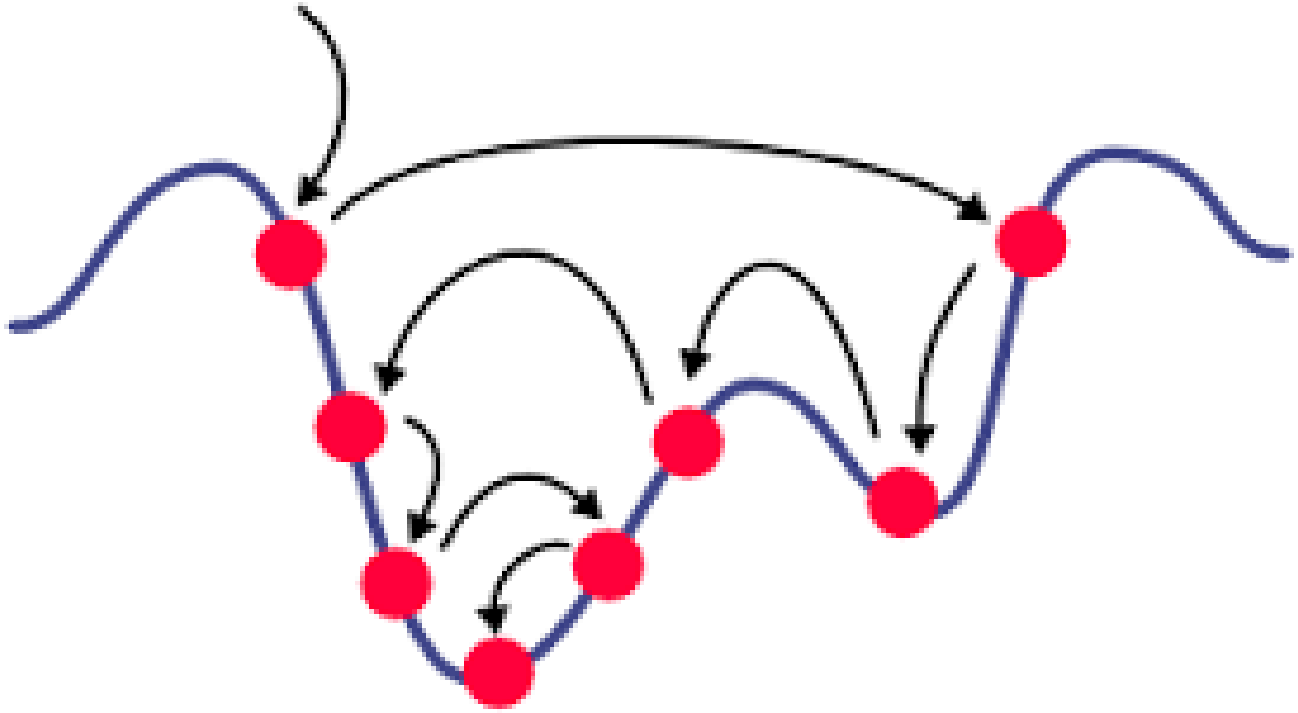
METAHEURISTICS



Objectives

This course provides a complete background that enables readers to design and implement powerful metaheuristics to solve complex optimization problems in a diverse range of application domains.

Designing efficient metaheuristics for optimization problems.

How metaheuristics are applied to solve the real-world examples of problems?

Recommended Text Books and References

- Talbi, E.-G. (2009). ***Metaheuristics: from design to implementation*** (Vol. 74): John Wiley & Sons.

- Zäpfel, G., Braune, R., & Bögl, M. (2010). ***Metaheuristic search concepts: A tutorial with applications to production and logistics***: Springer Science & Business Media.

Lecture Schedule:

Week 1	**Common Concepts for Metaheuristics:** Optimization Models Optimization Methods
Week 2	**Common Concepts for Metaheuristics:** Solution Representation — Objective Function Constraint Handling — Parameter Tuning
Week 3	**Single-Solution Based Metaheuristics** Common Concepts
Week 4	**Single-Solution Based Metaheuristics** (Methods)
Week 5	**Population-Based Metaheuristics** Common Concepts

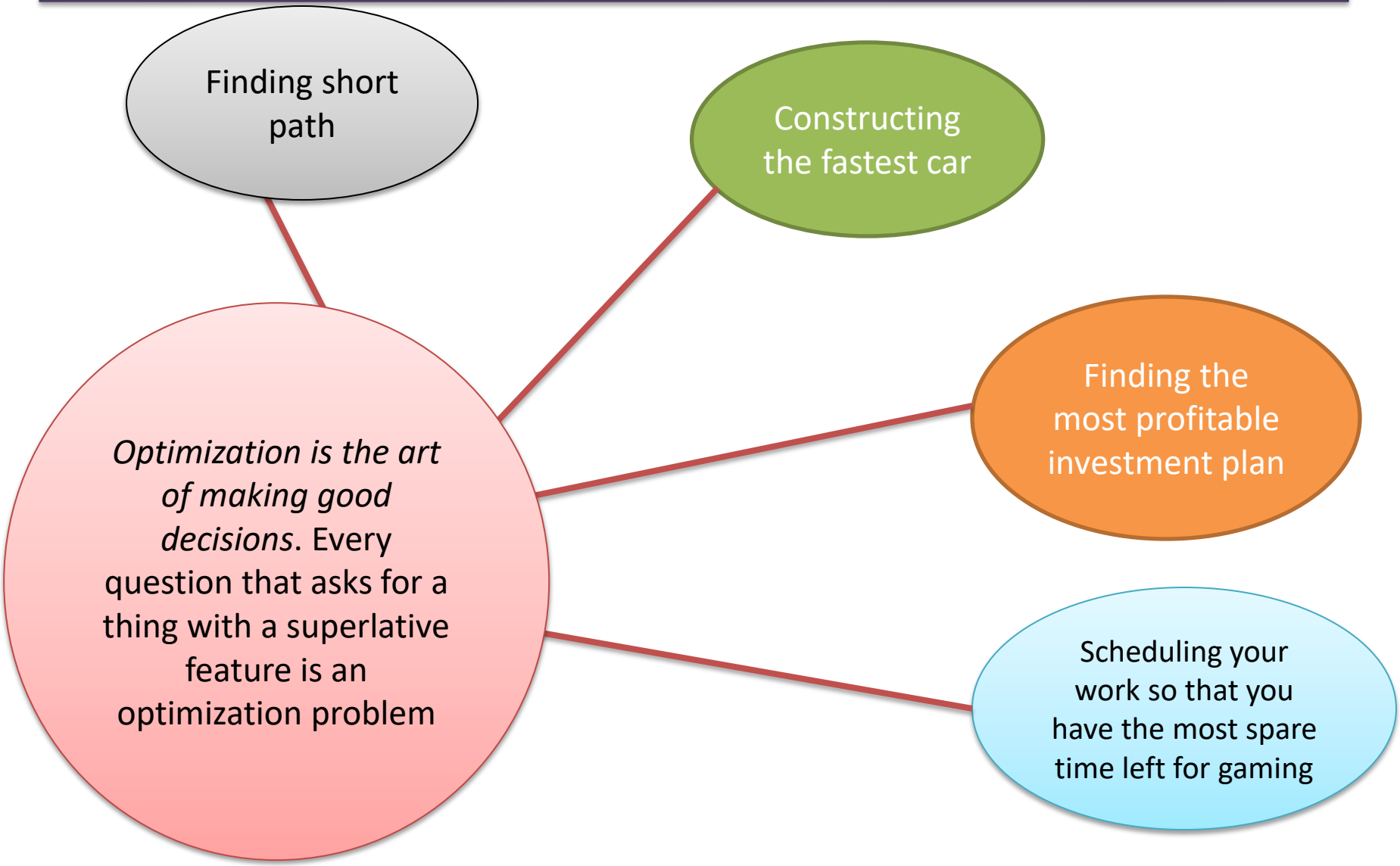
Lecture Schedule:

Week 6	**Population-Based Metaheuristics** (Methods)
Week 7	**Mid-term Exam 2**
Week 8	**Metaheuristics for Multiobjective**
Week 9	**Hybrid Metaheuristics**
Week 10	**Hyper Heuristic**

Lecture Schedule:

Week 11	**Performance Analysis of Metaheuristics**
Week 12	**Mid-term Exam 2**
Week 13	Projects presentation
Week 14	Projects presentation
Week 15	-----

What is optimization?



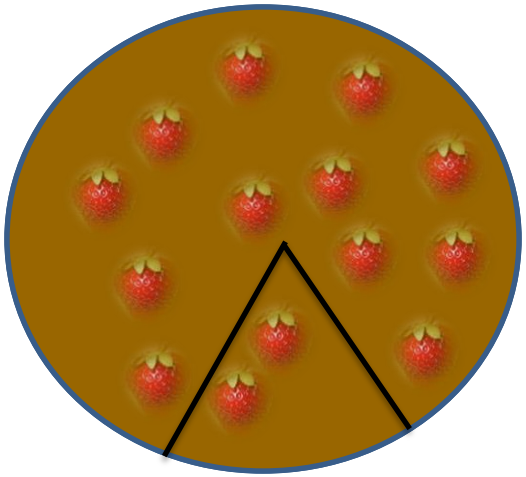
What is optimization?

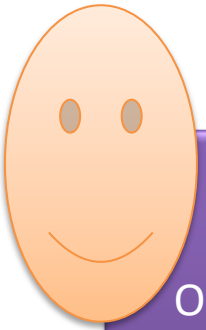
The Optimization Problem is: Find values of the variables that minimize or maximize the objective function while satisfying the constraints.

How can we solve such problems?

finding one solution to a problem is almost always very easy and can be done extremely fast.

finding the best possible solution (satisfying constraints) is what takes very long





Optimization algorithms bridge this gap: They trade in solution quality for runtime, by finding very good (but not necessarily optimal) solutions within feasible time.

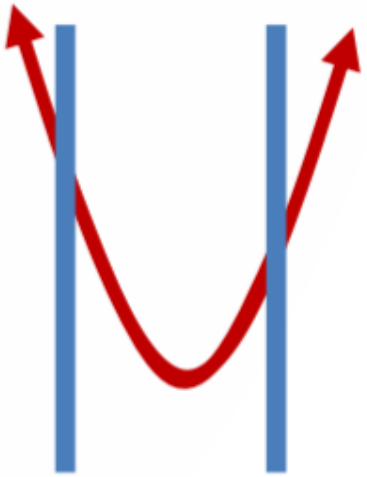
Optimization problems:

Unconstrained Optimization Problem

- an objective function that depends on real variables with no restrictions on their values.
- either had no boundaries, or the boundaries were soft.

Constrained Optimization Problem

The process of optimizing an objective function with respect to some variables in the presence of constraints on those variables. A constraint is a hard limit placed on the value of a variable.



Optimization problems:

Discrete Optimization Problem

- An optimization problem with discrete variables.
- looking for an object such as an integer, from a countable set.

finite number of feasible solutions

Integer programming

The discrete set is a subset of integers

Combinatorial Optimization

The discrete set is a set of objects, or combinatorial structures, such as routes

Continuous Optimization Problem

- the variables are allowed to take on any value within a range of values.

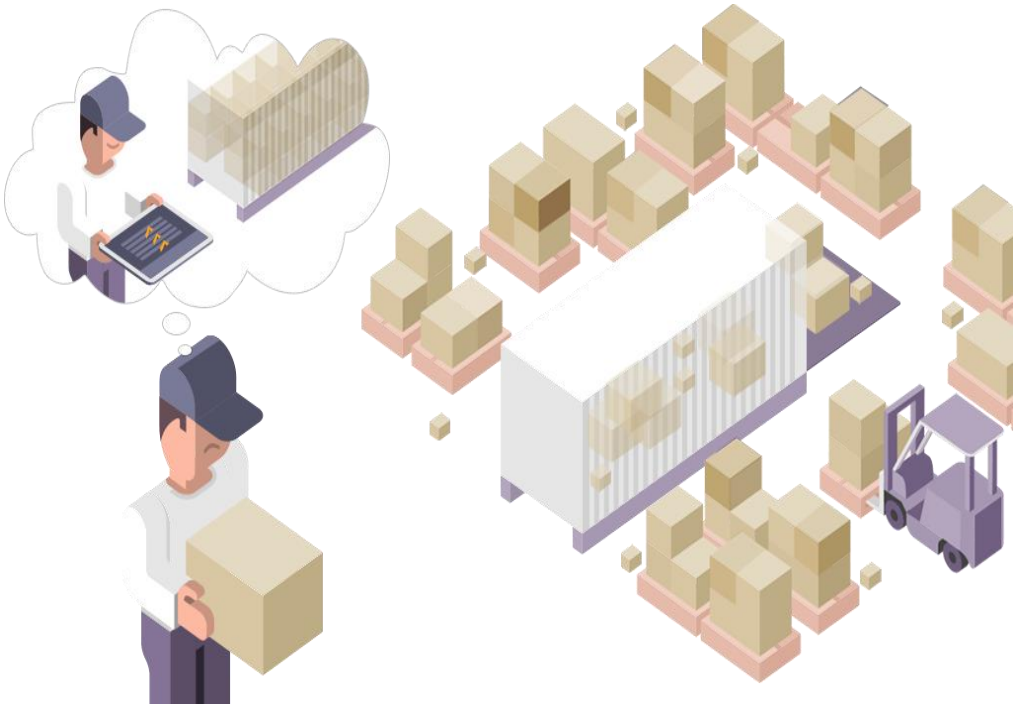
Simple to solve

Real numbers

Infinite number of feasible solutions

Optimization problems-Examples:

Bin Packing Problem

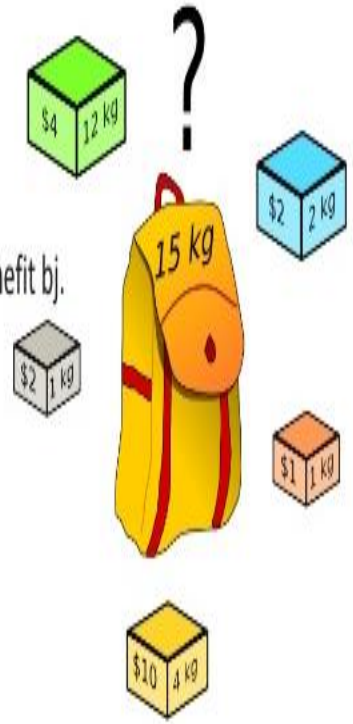


asking for the minimum number of containers (each of the same volume) needed to package a certain set of (differently-sized) items

Optimization problems-Examples:

Knapsack Problem

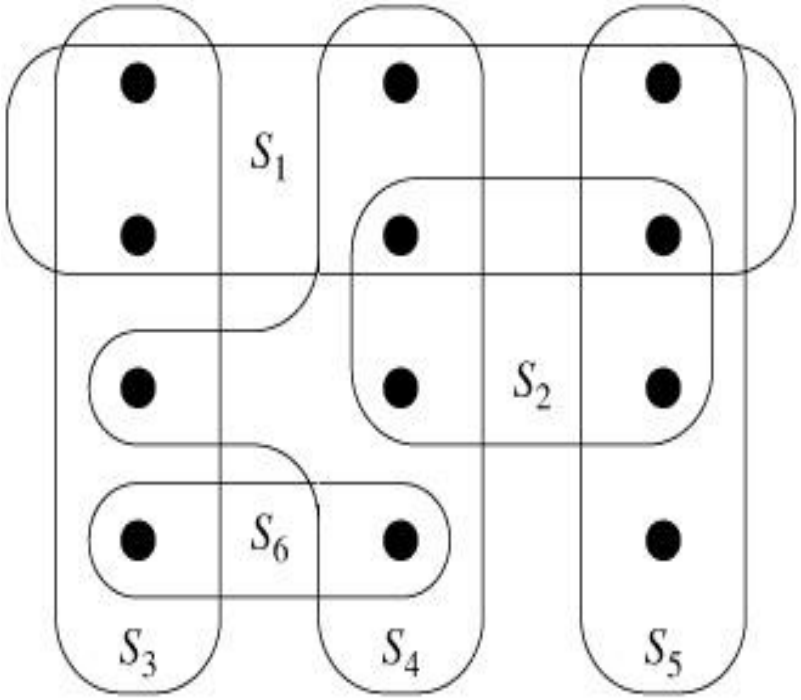
- You have a knapsack that has capacity (weight) W.
- You have several items I1,…,In.
- Each item Ij has a weight wj and a benefit bj.
- You want to place a certain number of copies of each item Ij in the knapsack so that:
  - The knapsack weight capacity is not exceeded and
  - The total benefit is maximal.



asking for the maximum sum value of items (selected from a specific set of items with different values and sizes) we can pack into a given volume

Optimization problems-Examples:

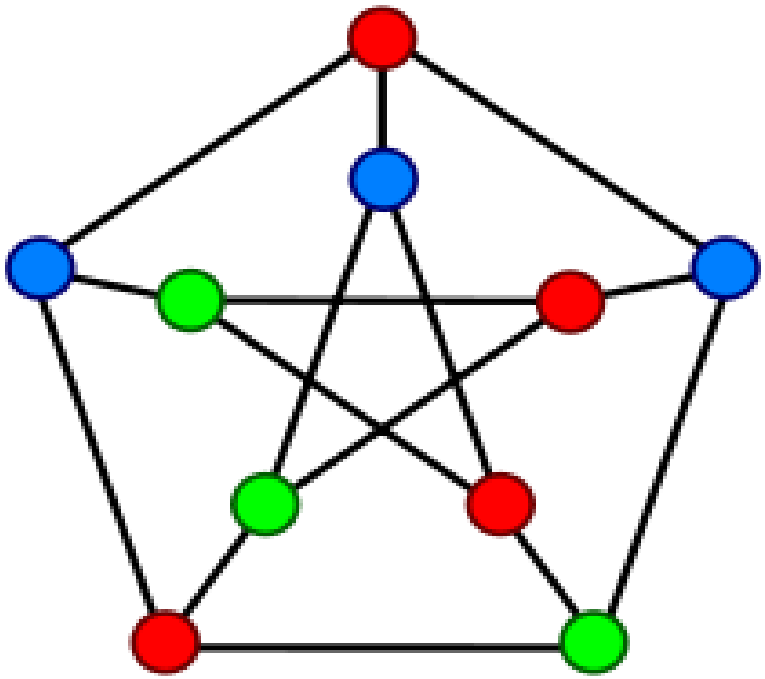
Set Covering Problem



where a set of subsets is given and we want to find the minimum number of subsets whose union still covers all the elements in all subsets.

Optimization problems-Examples:

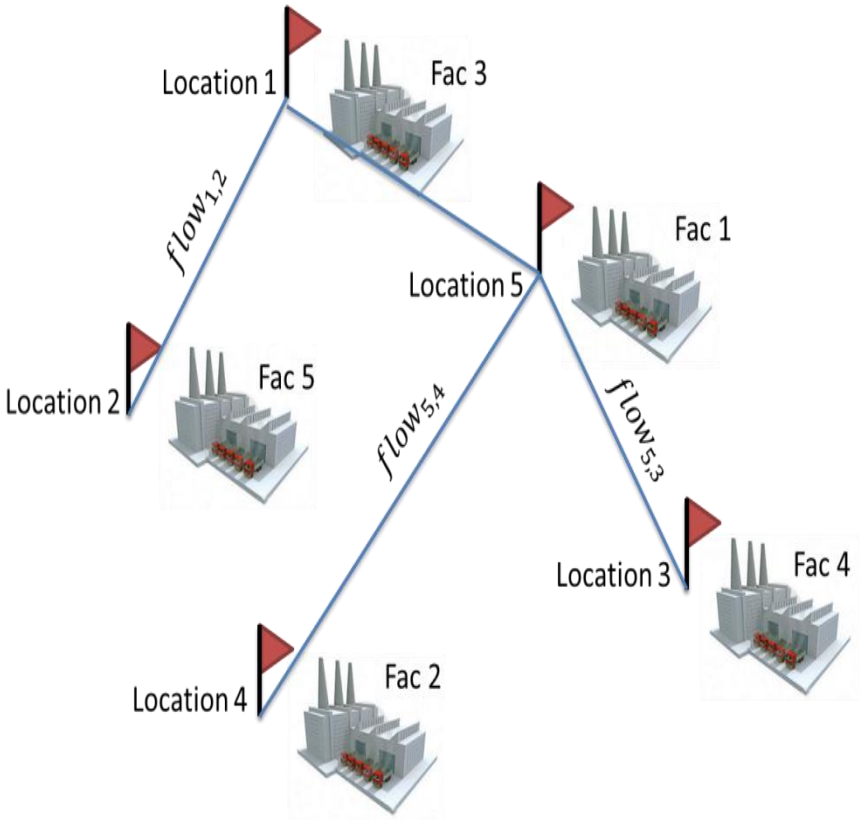
Graph Coloring



we ask for the minimum number of colors to be assigned to the nodes of a given graph so that no two nodes connected by an edge have the same color

Optimization problems-Examples:

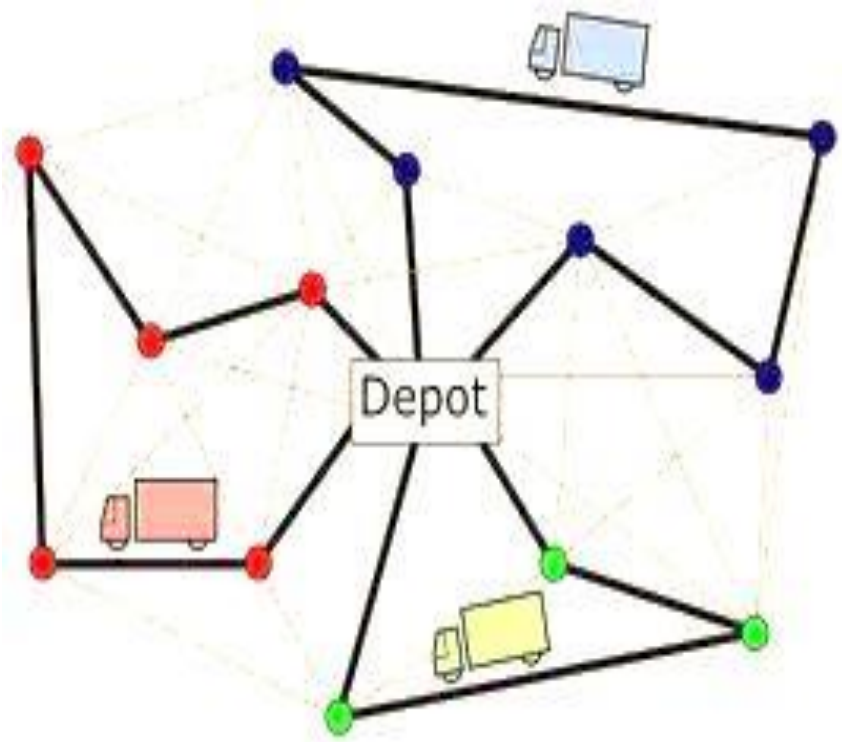
Quadratic Assignment Problem



find an assignment with minimal total sum product of ***flow*distance***.

Optimization problems-Examples:

Capacitated VRP



The objective is to minimize the vehicle fleet **OR** the sum of travel time.
not exceed the capacity of the vehicle which serves that route.