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Definition 1

An **Integer Linear Program** or **Integer Program** is a Linear Program in which all variables are required to be integral.

Definition 2

A **Mixed Integer Program** is a Linear Program in which a subset of the variables are required to be integral.

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Set Cover

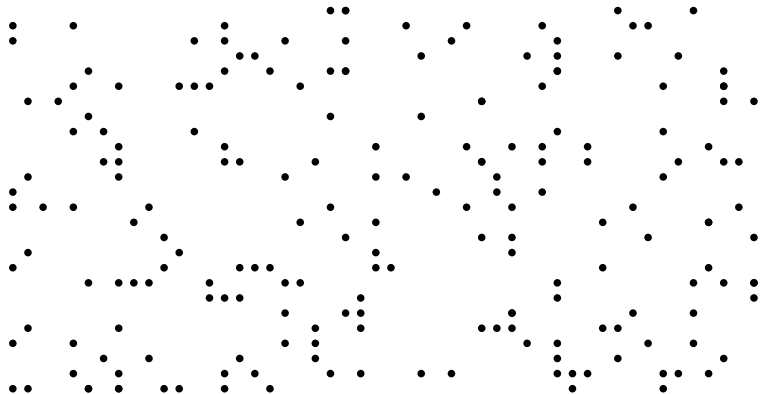
Given a ground set U , a collection of subsets $S_1, \dots, S_k \subseteq U$, where the i -th subset S_i has weight/cost w_i . Find a collection $I \subseteq \{1, \dots, k\}$ such that

$$\forall u \in U \exists i \in I: u \in S_i \text{ (every element is covered)}$$

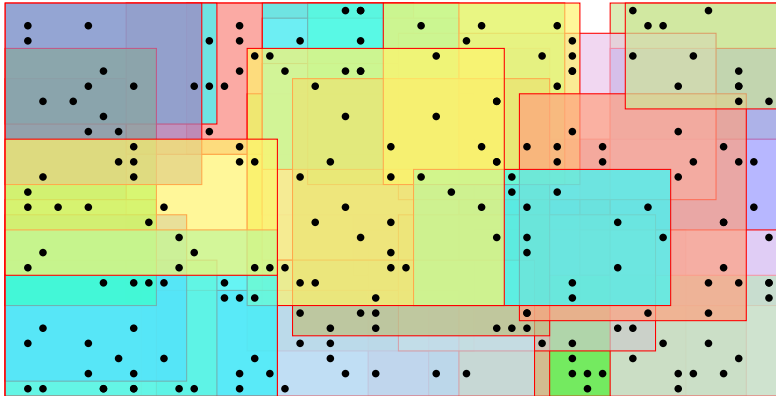
and

$$\sum_{i \in I} w_i \text{ is minimized.}$$

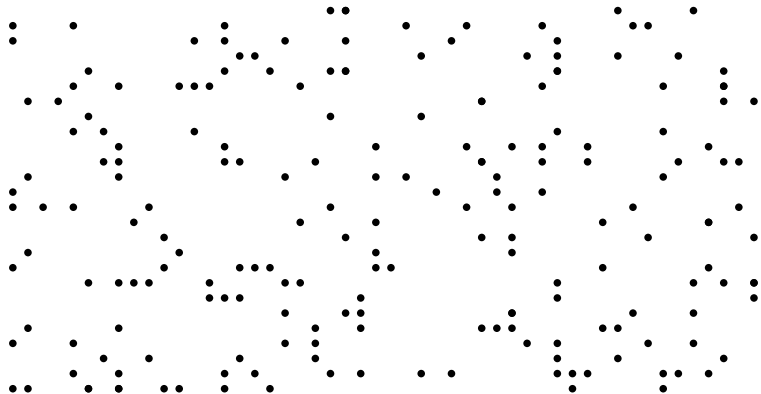
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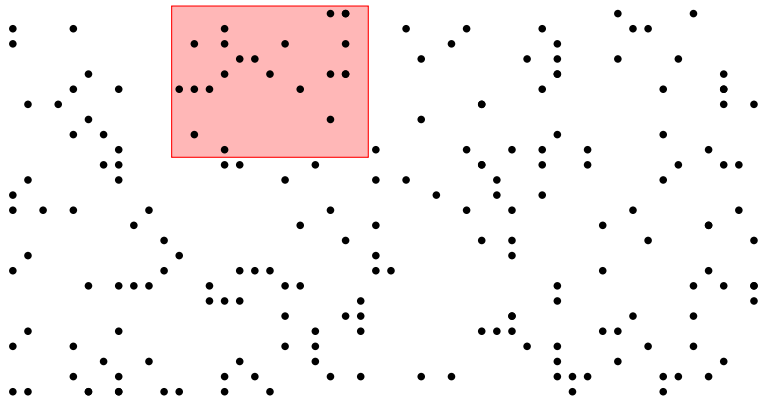
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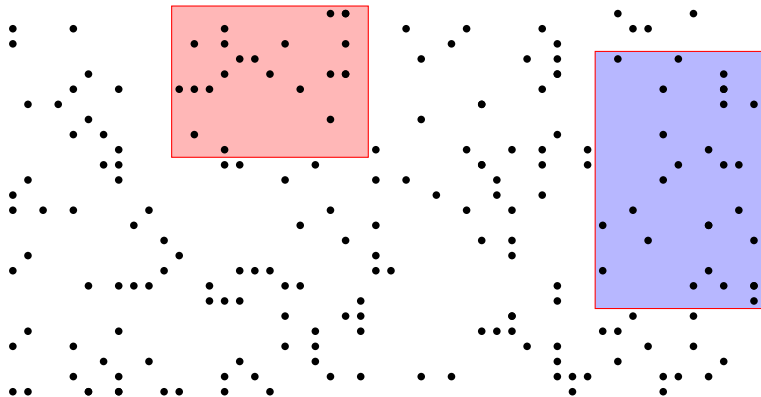
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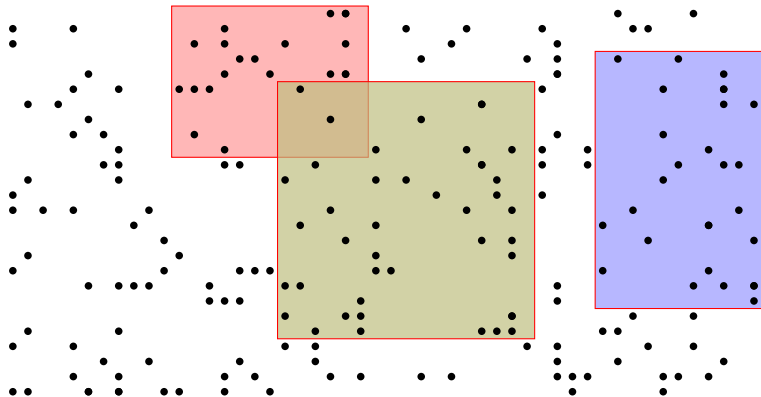
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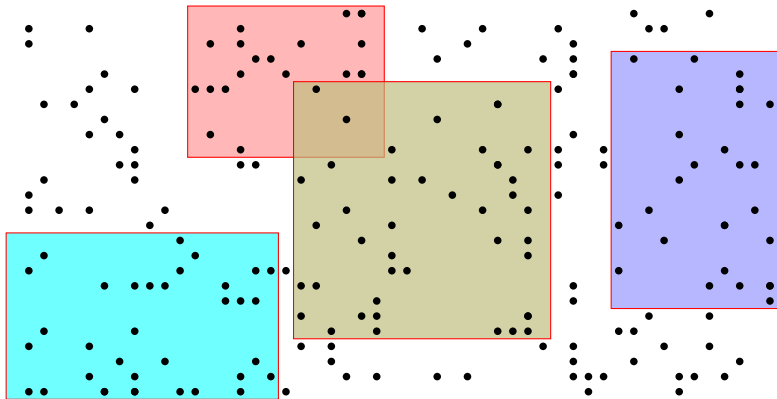
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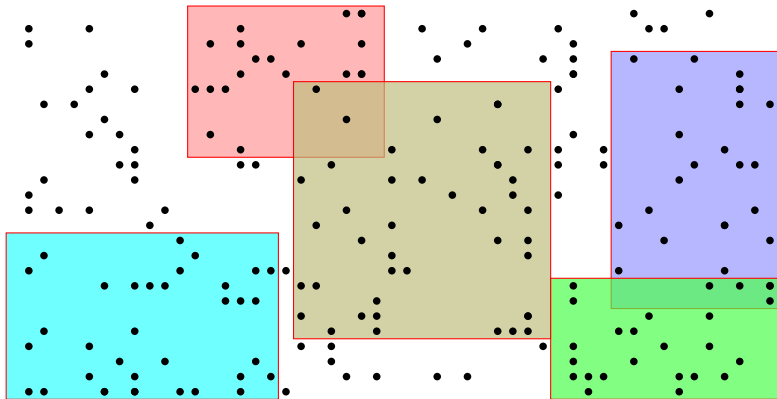
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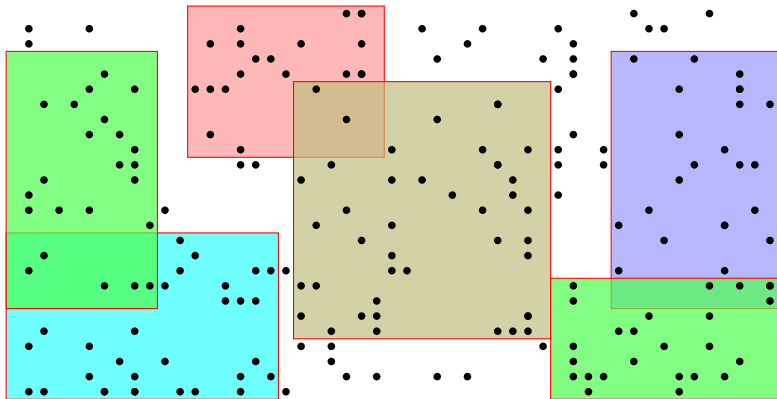
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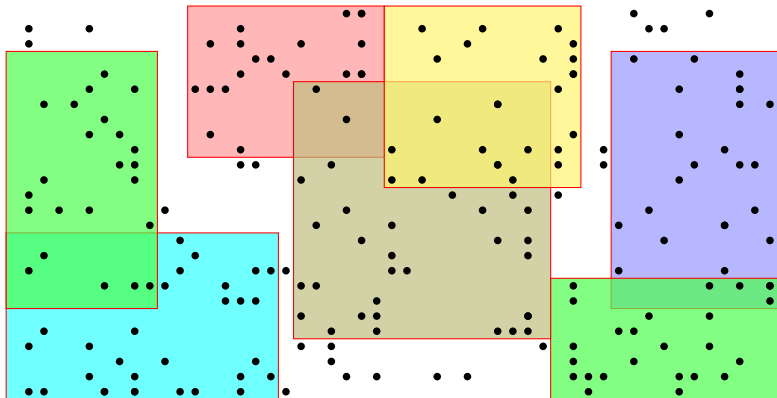
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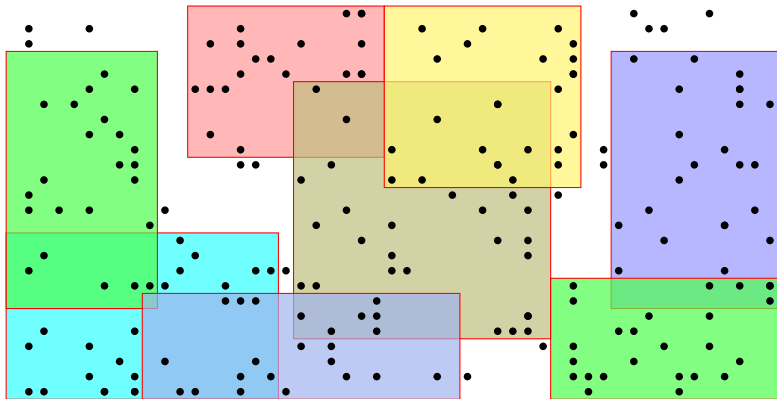
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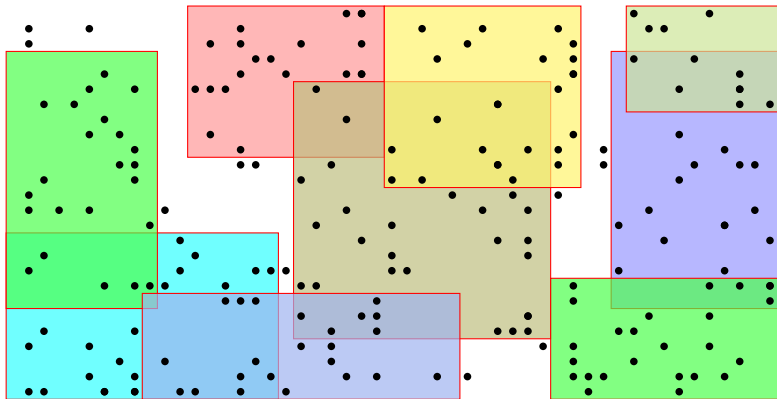
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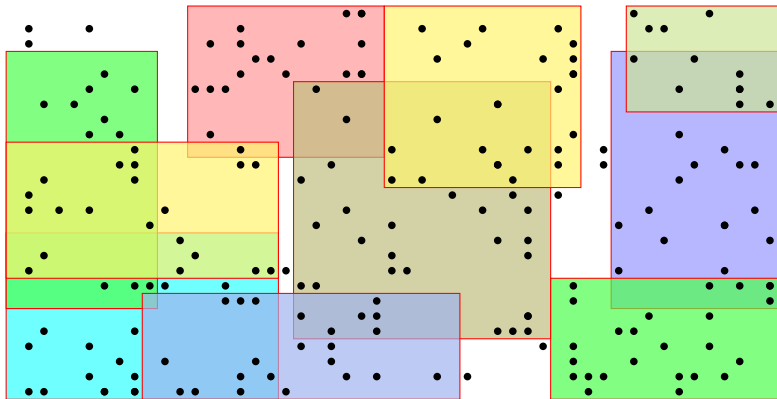
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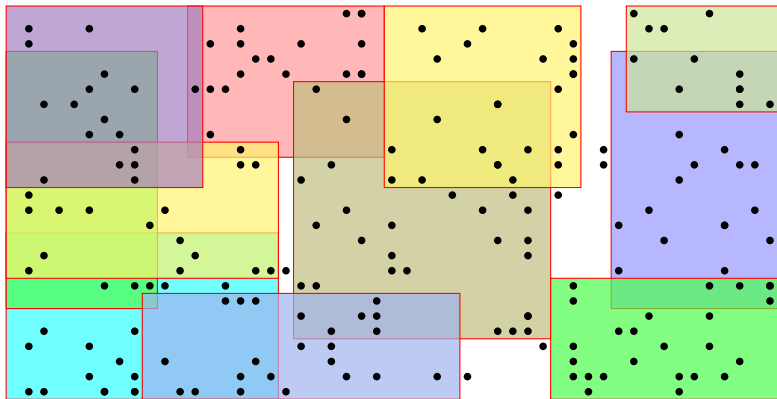
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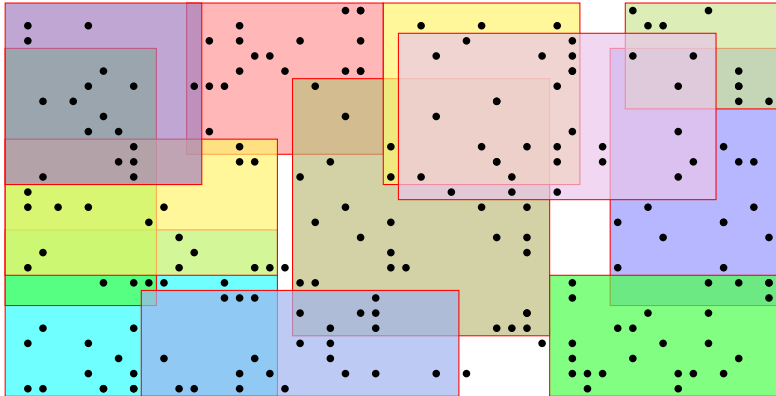
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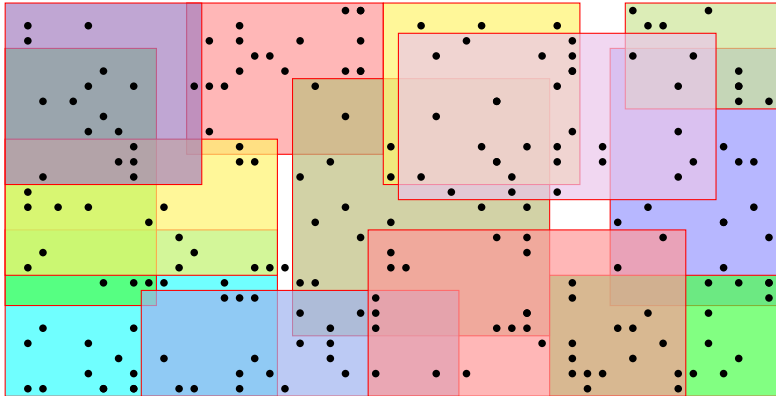
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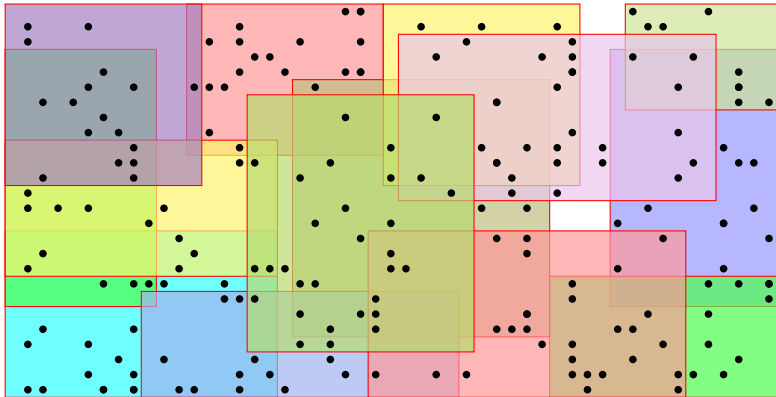
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IP-Formulation of Set Cover

$$\begin{array}{llll} \min & & \sum_i w_i x_i & \\ \text{s.t.} & \forall u \in U & \sum_{i:u \in S_i} x_i & \geq 1 \\ & \forall i \in \{1, \dots, k\} & x_i & \geq 0 \\ & \forall i \in \{1, \dots, k\} & x_i & \text{integral} \end{array}$$

Vertex Cover

Given a graph $G = (V, E)$ and a weight w_v for every node. Find a vertex subset $S \subseteq V$ of minimum weight such that every edge is incident to at least one vertex in S .

IP-Formulation of Vertex Cover

$$\begin{array}{ll} \min & \sum_{v \in V} w_v x_v \\ \text{s.t.} & \forall e = (i, j) \in E \quad x_i + x_j \geq 1 \\ & \forall v \in V \quad x_v \in \{0, 1\} \end{array}$$

Maximum Weighted Matching

Given a graph $G = (V, E)$, and a weight w_e for every edge $e \in E$.
Find a subset of edges of maximum weight such that no vertex is incident to more than one edge.

$$\begin{array}{ll} \max & \sum_{e \in E} w_e x_e \\ \text{s.t.} & \forall v \in V \quad \sum_{e: v \in e} x_e \leq 1 \\ & \forall e \in E \quad x_e \in \{0, 1\} \end{array}$$

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Maximum Independent Set

Given a graph $G = (V, E)$, and a weight w_v for every node $v \in V$. Find a subset $S \subseteq V$ of nodes of maximum weight such that no two vertices in S are adjacent.

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Knapsack

Given a set of items $\{1, \dots, n\}$, where the i -th item has weight w_i and profit p_i , and given a threshold K . Find a subset $I \subseteq \{1, \dots, n\}$ of items of total weight at most K such that the profit is maximized.

$$\begin{array}{ll} \max & \sum_{i=1}^n p_i x_i \\ \text{s.t.} & \sum_{i=1}^n w_i x_i \leq K \\ & \forall i \in \{1, \dots, n\} \quad x_i \in \{0, 1\} \end{array}$$

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Definition 3

A linear program LP is a **relaxation** of an integer program IP if any feasible solution for IP is also feasible for LP and if the objective values of these solutions are identical in both programs.

We obtain a relaxation for all examples by writing $x_i \in [0, 1]$ instead of $x_i \in \{0, 1\}$.

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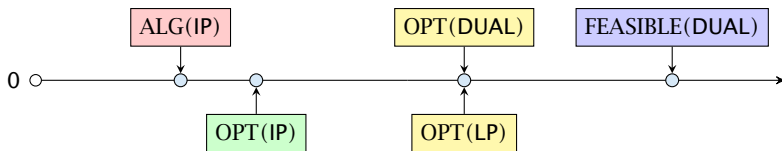
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By solving a relaxation we obtain an upper bound for a maximization problem and a lower bound for a minimization problem.

Relations

Maximization Problems:



Minimization Problems:

