University at Buffalo
The State University of New York

CPLEX SEMINAR

Hernan Caceres

Ph.D. Student ISE
President ISE-GSA
Assistant Professor UCN-Chile

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What is CPLEX?

IBM ILOG CPLEX Optimization Studio

1. The Optimization Programming Language (**OPL**), used to write mathematical models.
2. An integrated development environment (**IDE**) that enables you to develop and test the models.
3. The **CPLEX** Optimizer engine, to find solutions to models that require mathematical programming techniques.
4. The **CP** Optimizer engine, to find solutions to models that require constraint programming techniques.

What is CPLEX?

Model Development Tools

CPLEX Studio (IDE) **OPL Modeling Language**

Excel, Access, others

Your own program

ILOG Concert Technology (C++, .NET, Java)

Optimization Engines

Math Programming
CPLEX Optimizer
(Simple, Barrier, Mixed Integer)

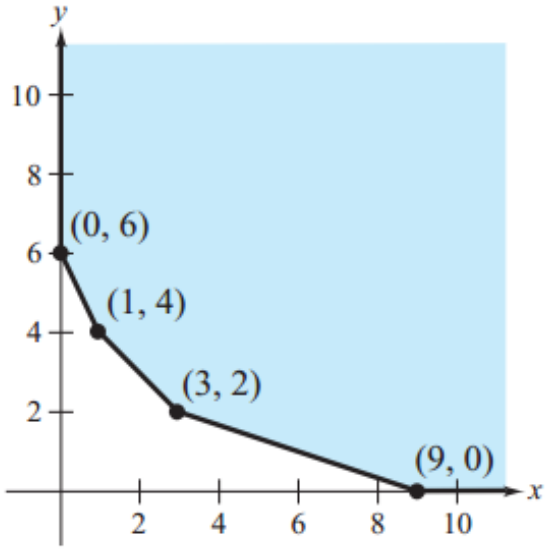
Constraint Programming
CP Optimizer

MATLAB others

CPLEX Optimization Studio

Basic LP example

$$
\begin{aligned}
\min \quad & 0.12x + 0.15y \\
\text{s.t.} \quad & 60x + 60y \geq 300 \\
& 12x + 6y \geq 36 \\
& 10x + 30y \geq 90 \\
& x \geq 0, y \geq 0
\end{aligned}
$$



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Advanced LP example

A cargo plane has three compartments for storing cargo: front, center and rear. These compartments have the following limits on both weight and space:

Compartment	Weight capacity (tons)	Space capacity (cubic meters)
Front	10	6800
Center	16	8700
Rear	8	5300

Furthermore, the weight of the cargo in the respective compartments must be the same proportion of that compartment's weight capacity to maintain the balance of the plane.

The following four cargoes are available for shipment on the next flight:

Cargo	Weight (tons)	Volume (cubic meters/ton)	Profit ($/ton)
C1	18	480	310
C2	15	650	380
C3	23	580	350
C4	12	390	285

Any proportion of these cargoes can be accepted. The objective is to determine how much (if any) of each cargo C1, C2, C3 and C4 should be accepted and how to distribute each among the compartments so that the total profit is maximized.

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https://goo.gl/05amA0

Advanced LP example

$$\max \quad \sum_{i \in A} \sum_{j \in B} p_i x_{ij}$$

Profit of cargo i

$$\text{s.t.} \quad \sum_{j \in B} x_{ij} \leq a_i \quad \forall i \in A$$

Available weight i

$$\sum_{i \in A} x_{ij} \leq c_j \quad \forall j \in B$$

Capacity of compartment j

$$\sum_{i \in A} v_i x_{ij} \leq V_j \quad \forall j \in B$$

Space capacity of compartment j

$$\frac{1}{c_j} \sum_{i \in A} x_{ij} = y \quad \forall j \in B$$

Volume of cargo i

$$x_{ij} \geq 0, y \geq 0$$

A is the set of cargos
A = {C1, C2, C3, C4}

B is the set of compartments
B = {front, center, rear}

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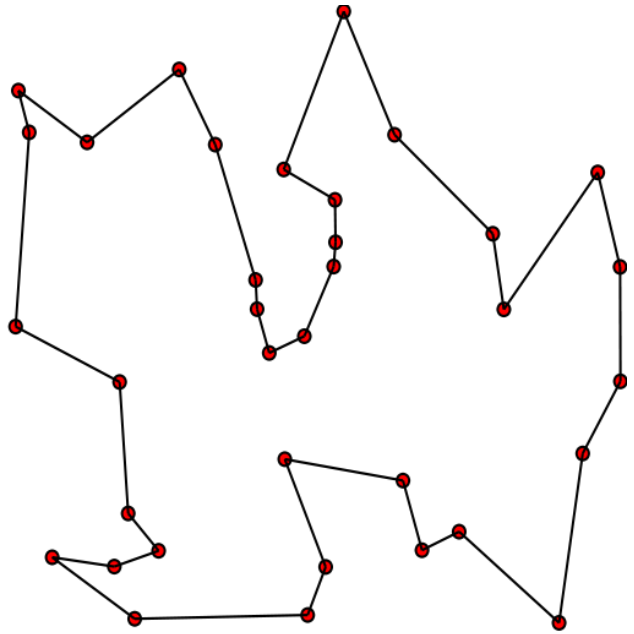
MIP example (traveling salesman problem)

$A = \{1, 2, 3, \ldots, n\}$ is the set of all cities

$$x_{ij} = \begin{cases} 1 & \text{the path goes from city } i \text{ to city } j \\ 0 & \text{otherwise} \end{cases}$$



$$\min \quad \sum_{i \in A} \sum_{j \neq i, j \in A} c_{ij} x_{ij}$$

$$\text{s.t.} \quad \sum_{i \in A, i \neq j} x_{ij} = 1 \quad j \in A$$

$$\sum_{j \in A, j \neq i} x_{ij} = 1 \quad i \in A$$

$$u_i - u_j + (n-1)x_{ij} \leq n - 2 \quad i \in A \setminus \{1\}, j \in A \setminus \{1\}, i \neq j$$