OULUN YLIOPISTO
UNIVERSITY of OULU

A Software approach to

Mathematical Programming

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4 March 2015

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Introduction

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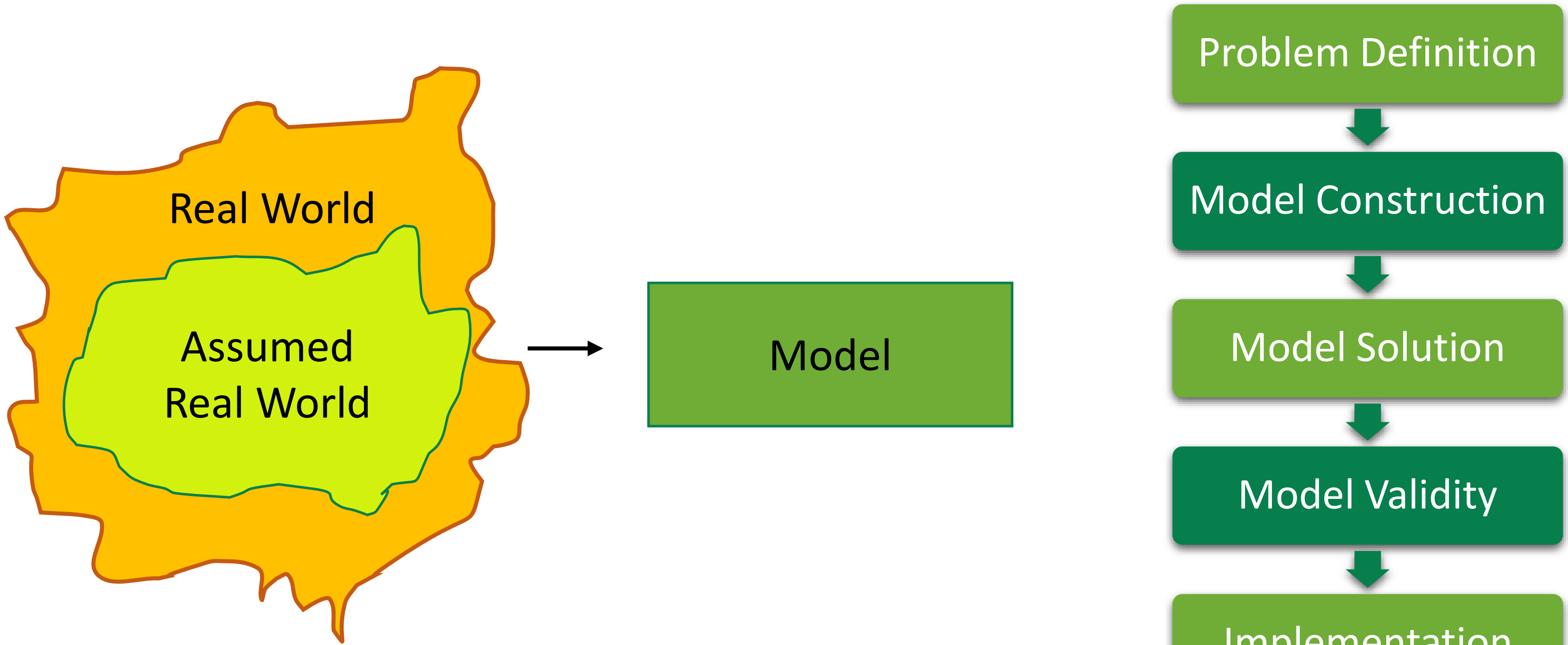
Mathematical Programming



Mathematical Programming techniques

1. Linear Programming
2. Integer Programming
3. Mixed Integer Programming
4. Dynamic Programming
5. Network Programming
6. Nonlinear programming

Solving a Mathematical Programming

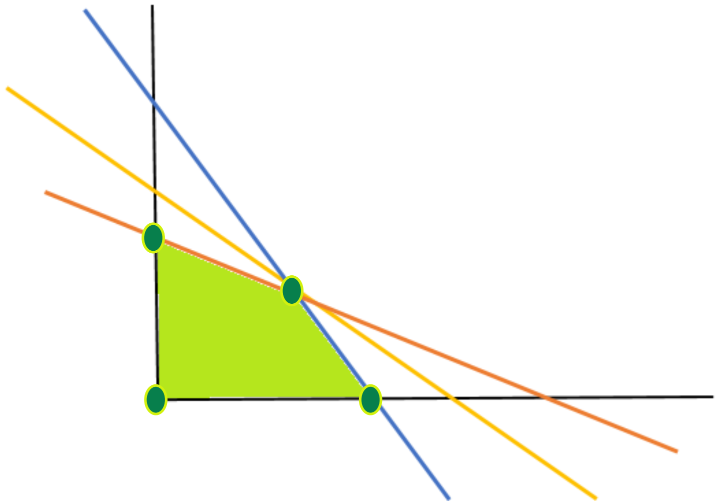
- Goal :

  “ To find an Optimum solution ”

- Algorithms:
  - provides fixed computational rules
  - are applied repeatedly to the problem
  - each repetition (iteration) moving the solution closer to the optimum.

Solving a Mathematical Programming

- Simplex Method
  - solves LP problems
  - tests adjacent vertices of the feasible sets
  - at each iteration Simplex chooses the variable that will produce the largest change towards optimum solution



- Software
  - GAMS
  - AMPL
  - Lingo
  - …

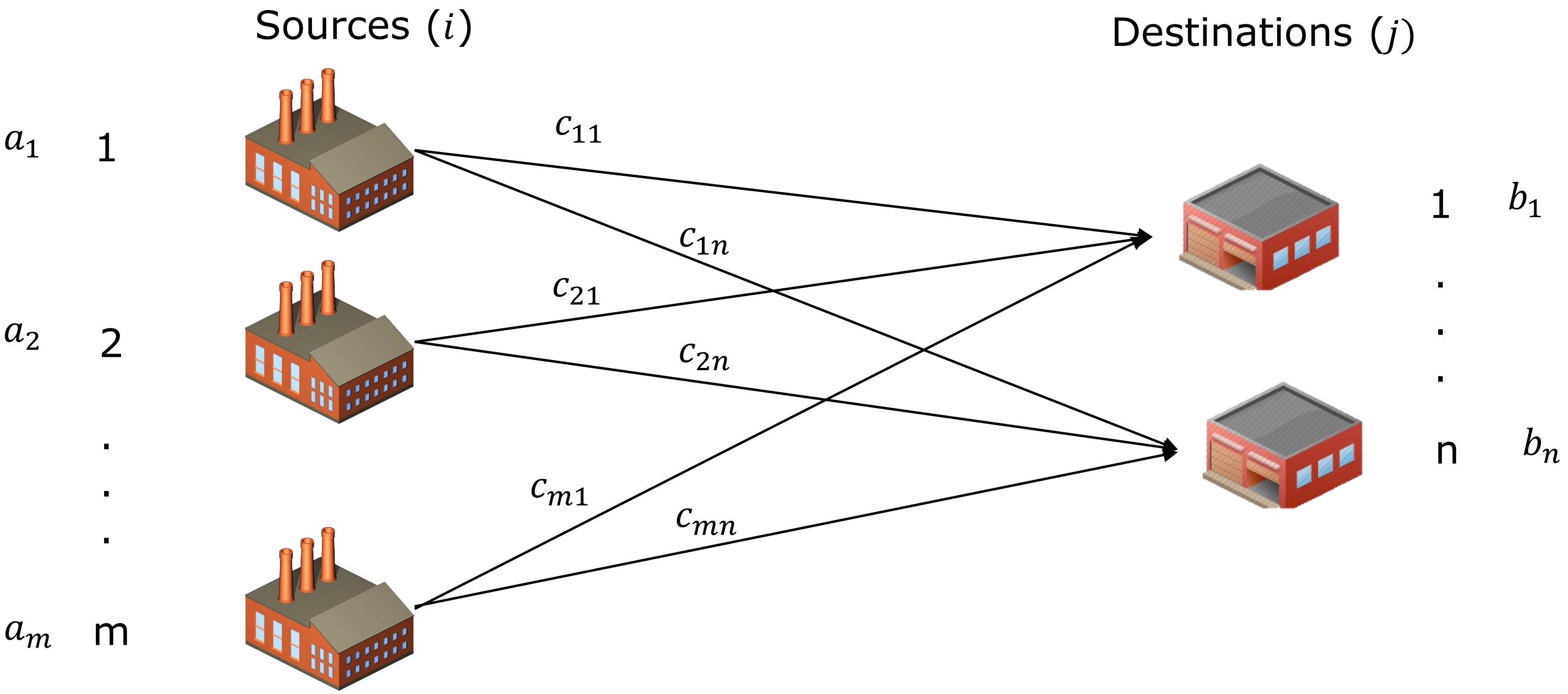
GAMS Software

What is GAMS?

- General Algebraic Modeling System
- High-level modeling system for mathematical optimization
- GAMS solves
  - Linear optimizations
  - Non-linear optimizations
  - Mixed-integer optimizations
- Tailored for large scales optimization problems

GAMS Software

Transportation Problem



GAMS Software

Decision Variable

x_{ij} The amount shipped from *i* to *j*

Parameters

c_{ij} Shipping Cost from *i* to *j*

a_i Supply Capacity of source i

b_j Demand of Destination *j*

Mathematical Formulation

$$\min z = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} x_{ij}$$

$Subject\ to$:

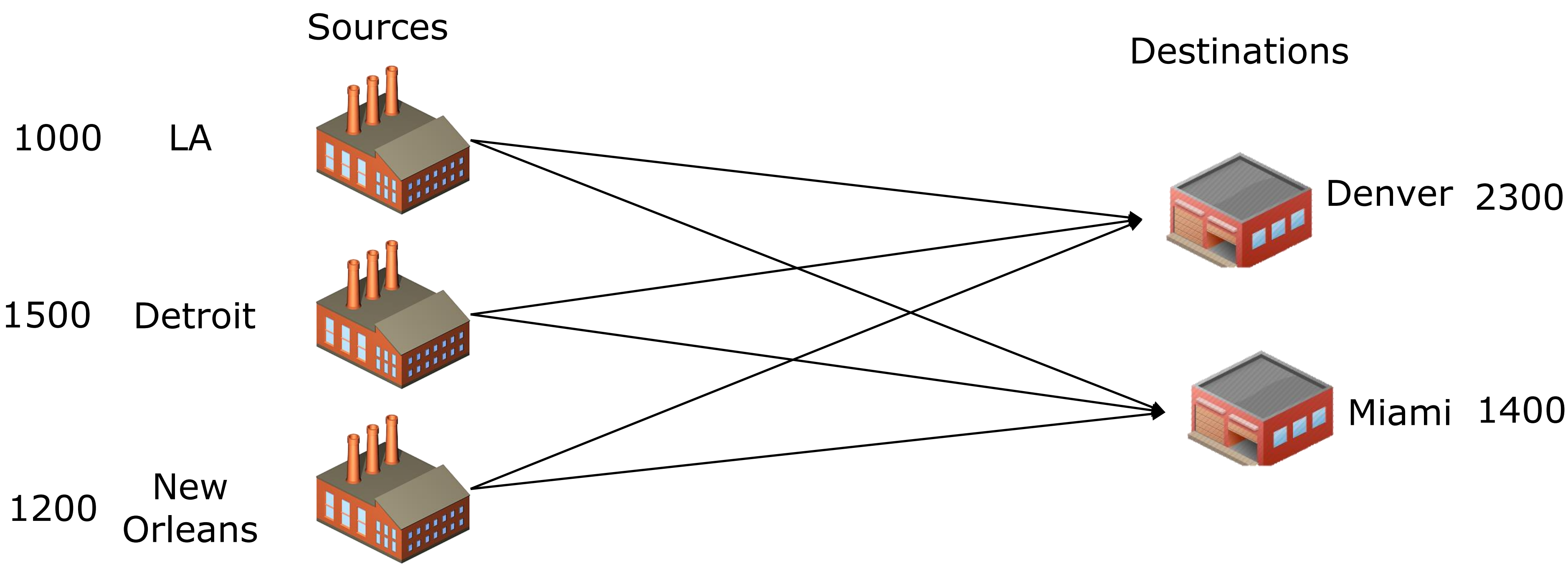
$$\sum_{j=1}^{n} x_{ij} \le a_i \quad for\ i = 1,,,,,m$$

$$\sum_{i=1}^{m} x_{ij} \ge b_j \quad forj = 1,,,,,n$$

$$x_{ij} \ge 0\ for\ all\ i\ and\ j$$

GAMS Software

Example (Hamdy Taha, 2011)



GAMS Software

Example-Parameters

Table (1). Transportation Cost per Car		
	Denver	Miami
Los Angeles	$80	$215
Detroit	$100	$108
New Orleans	$102	$68

GAMS Software

Mathematical Formulation

$$\min z = 80x_{11} + 215x_{12} + 100x_{21} + 108x_{22} + 102x_{31} + 68x_{32}$$

$x_{11} + x_{12} = 1000$ Los Angeles

$x_{21} + x_{22} = 1500$ Detroit

$x_{31} + x_{32} = 1200$ New Orleans

$x_{11} + x_{21} + x_{31} = 2300$ Denver

$x_{12} + x_{22} + x_{32} = 1400$ Miami

$x_{ij} \geq 0 \; for \; i = 1,2,3 \; and \; j = 1,2$

Heuristics and Metaheuristics

- Both find “good and satisfactory” solutions in shorter time

- The quality of algorithms is usually based on a tradeoff between:
  - Optimality
  - Completeness
  - Accuracy
  - Execution Time

Assignment

- Formulate the following transportation problem and solve it in GAMS.

Shipping Costs						
		Warehouses				Supply
		1	2	3	4	
Factories	1	470	520	654	890	75
	2	350	416	690	750	100
	3	995	670	350	685	125
Demand		85	70	65	80	

- Download GAMS here

References

1. Taha, H., *Operations Research an Introduction*, Pearson, New Jersey, 2011
2. INFORMS: What is Operations Research?
3. GAMS Website
4. Richard E. Rosenthal's GAMS Tutorial
5. Wikipedia: General Algebraic Modeling System
6. Education.com: Algorithms and Heuristics

Thank You for Your Attention

Question and Answer

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