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Model and modeling

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Model

- Definition
  - Esquema teórico, generalmente en forma matemática, de un sistema o de una realidad compleja (por ejemplo, la evolución económica de un país), que se elabora para facilitar su comprensión y el estudio de su comportamiento. (Diccionario de la lengua española. Real Academia Española)
  - Simplified description, especially a mathematical one, of a system or process to assist calculations and predictions. (Oxford Dictionary)
- Accurate representation of a reality
- Decision support tool
- May involve a multidisciplinary team
- Balance between a detailed representation and the skill to obtain a solution
- *Modeler*: specifies and develops the model
- *Expert*: knows the real problem

Two main risks

- Exhaustive model, quasi-real. It may be impossible to find an algorithm for solving the problem
- Simple model to use an available algorithm. It may obtain solutions for a non-existent problem
- Model must be a compromise between those pathological extremes

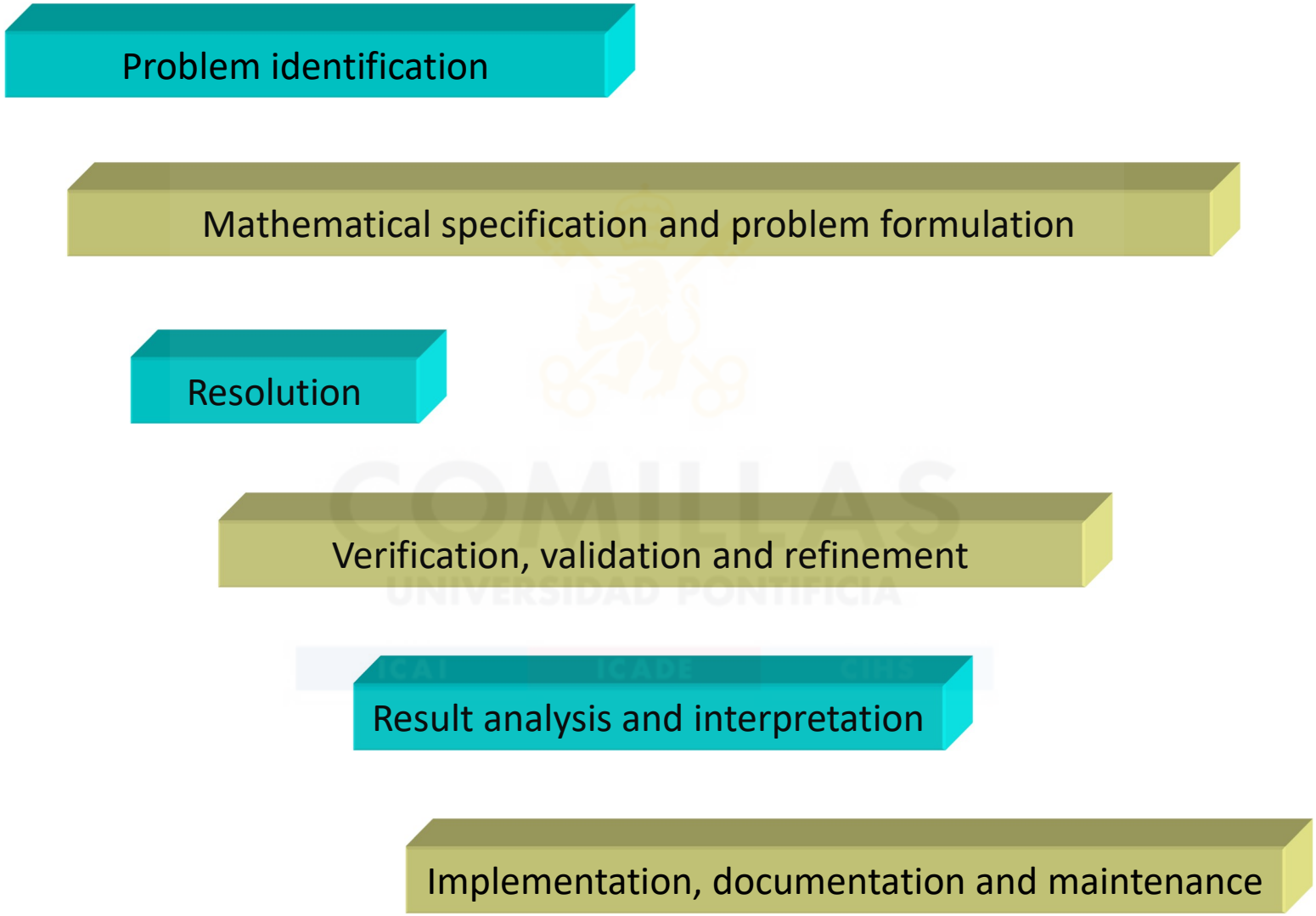
Modeling

- Science
  - Analysis and detection of relations among data
  - Hypotheses and approximations
  - Specific solution algorithms
  - Model solution
- Art
  - Vision and interpretation of the reality
  - Style in modeling and documentation
  - Elegance and simplicity in development
  - Creative use of tools

Modeling benefits

- Dialog between modeler and expert
- Organization of available information
- Structures the understanding of the problem
- Internalizes the organizational structure of the company
- Allows sharing of hypotheses between the modeler and the expert
- Gives an analysis tool
- Shows the improvement path by taking these decisions

Stages in model development



Problem identification

- Collection of relevant information
- Problem definition in vague terms
- Interpretation and translation to accurate terms
- Data are crucial. Use to be the bottleneck
- Essential stage for the decisions to be useful

It is imperative to be sure that the model adequately represents the reality to be modeled.

Input data

- GIGOLO
- Garbage In, Garbage Out, Look Out !

The best model is useless if input data aren't adequately refined.

Mathematical specification and formulation

- Definition of variables, equations, objective function, parameters
- Identification of problem type (LP, MIP, NLP)
- Emphasis on formulation accuracy and beauty
- Analysis of problem size and structure
- Categories of LP problems as a function of their size

	CONSTRAINTS	VARIABLES
SAMPLE CASE	100	100
MEDIUM SIZE	10000	10000
BIG SIZE	500000	500000
LARGE SCALE	>500000	>500000

Conceptual design

- To a hammer, every problem is a nail.

The modeling techniques and level of detail must be according to the problem structure and the expectations and needs of the client.

Conceptual modeling

- A month devoted to programming may “save” a couple of library hours.

The time not dedicated to conceptual modeling delays the model implementation exponentially.

Resolution

- Algorithm for obtaining the optimal or quasi-optimal or, at least, satisfactory solution
- Find attractive quasi-optimal solutions
- Different solution methods
- Different implementations of the chosen algorithm

Verification, validation, and refinement

- Debug the code
- Test the validity of the simplifications adopted
- Test the suitability to reality
- Extend the model to include new capabilities

Model: validation

- The past is not stochastic

Testing the model results with actual system data is imperative.

Result analysis and interpretation

- Sensitivity analysis of the input parameters
- Robustness of the optimal solution

Implementation, documentation, and maintenance

- Crucial stage for model success
- Clear, accurate, and complete documentation
- User manual with technical, mathematical, and computer specification
- Training of possible users

Linear Programming (LP)

- **Diet problem:**
  - The daily minimum needs of a calf are 700 g of proteins, 28 g of calcium, and 150 mg of vitamins.
  - The available types of food are feed and forage with a unitary cost of 0.30 and 0.35 €/kg. The nutritional composition per kg of each type of food is shown in the table below.
  - Determine the optimal daily amount of each food to minimize the total feeding cost.

	Proteins (g)	Calcium (g)	Vitamins (mg)
Feed	30	2	10
Forage	45	1	5