Mathematical Logics
Introduction*

Fausto Giunchiglia and Mattia Fumagallli

University of Trento

*Originally by Luciano Serafini and Chiara Ghidini
Modified by Fausto Giunchiglia and Mattia Fumagalli

Outline

1. Mental, computational and logical models
2. Language
3. Logical modeling
4. Why Logic? Formal and informal languages/ models

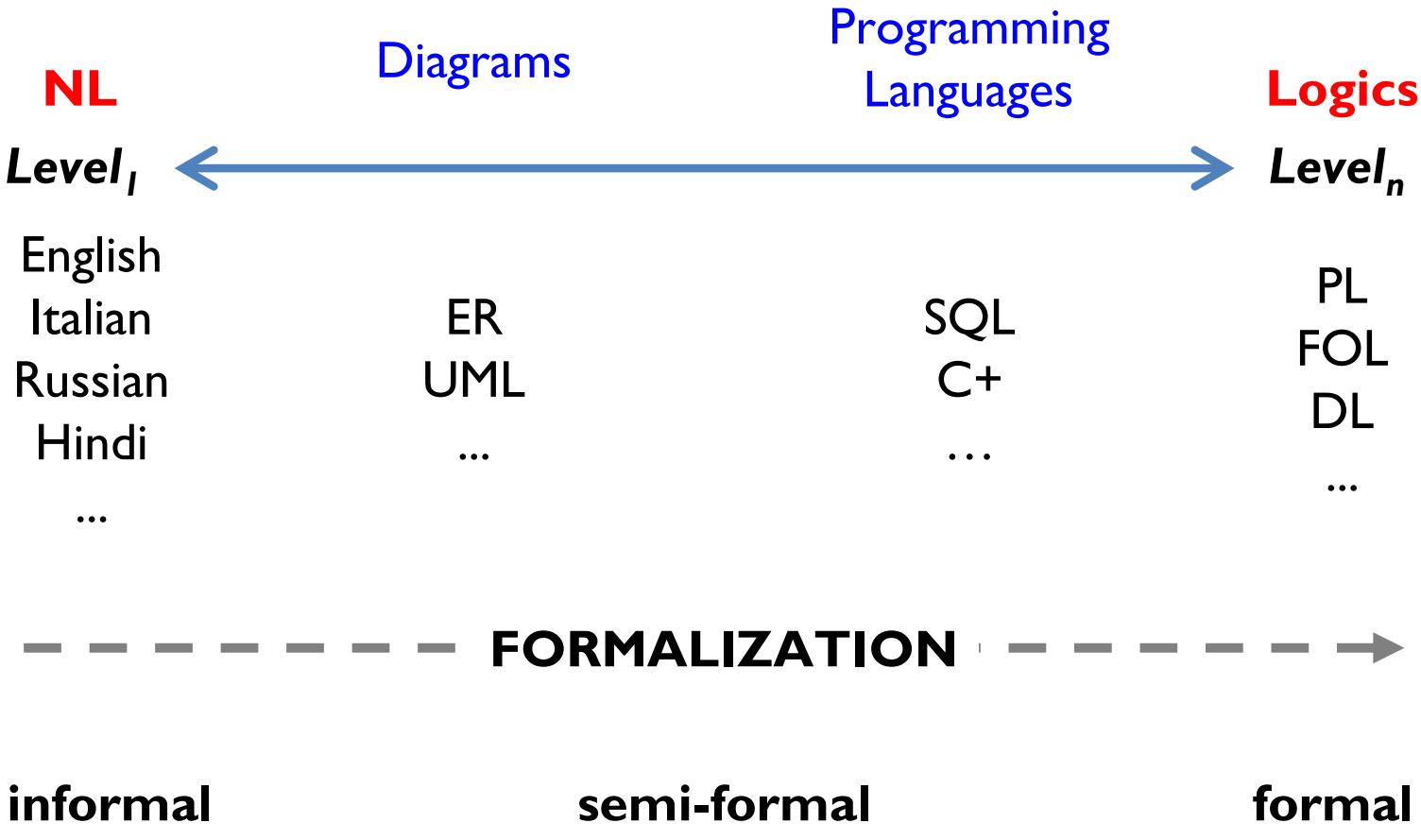
(Conceptual) Modeling

There are various types of specification models depending on the language they use:

- Informal models (use natural language)
- Semi-formal models (use structured semi-formal languages with (semi-)formal syntax and informal semantics, e.g., ER, UML)
- Logical models (use Logical languages, namely a specific type of formal models)

Levels of Formalization

Syntax and Semantics can be formal or informal.



Informal Languages: Natural Language

Let us try to recognize relevant entities, relations and properties in the NL text below

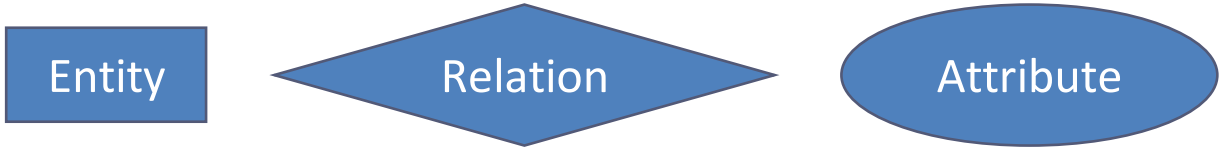
The Monkey-Bananas (MB) problem by McCarthy, 1969 *"There is a monkey in a laboratory with some bananas hanging out of reach from the ceiling. A box is available that will enable the monkey to reach the bananas if he climbs on it. The monkey and box have height Low, but if the monkey climbs onto the box he will have height High, the same as the bananas. [...]"*

Question: How shall the monkey reach the bananas?

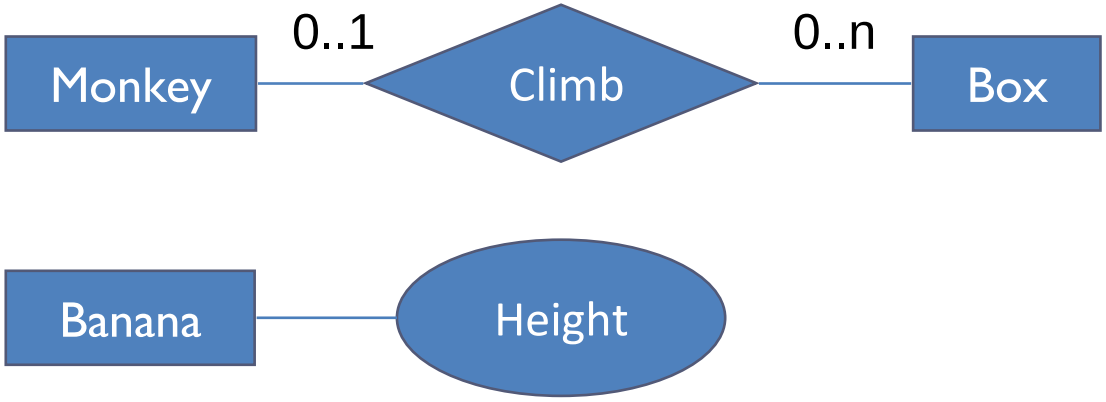
NOTE: Natural languages (e.g., English, Italian, …) have informal syntax and informal semantics.

Languages with Formal Syntax

In the Entity-Relationship (ER) Model [Chen 1976] the alphabet is a set of graphical objects, that are used to construct schemas (the sentences).



Examples of ER sentences:



NOTE: Diagrams (e.g., UML, ER, EER, …) have semi-formal syntax and semi-formal semantics.

Why Natural Languages?

Used for	Advantages	Disadvantages
Informal specification	Cheaper to use (Often used at the very beginning of problem solving, when we need a direct, "flexible", well-understood language and the problem is still largely unclear) Useful to interact with users	Semantics is informal, (largely ambiguous, possible misunderstandings) Pragmatically inefficient for automation

Why Diagrams?

Used for	Advantages	Disadvantages
Semi-formal specification (to provide more structured and organized specification than natural languages)	Cheap to use (Largely structured and organized; usually used in representation with unified languages when things are non-trivial or when more precision is required w.r.t. Natural Language) Useful to interact with users	Semantics is informal (largely ambiguous, possible misunderstandings) Pragmatically inefficient for automation

Why Logic?

Used for	Advantages	Disadvantages
Formal specification	Well-understood with formal syntax and formal semantics: we can better specify and prove correctness/completeness …	Hardly usable to interact with users Costly
Automation	Pragmatically efficient for automation exploiting the explicitly codified semantics: reasoning services (building AI)	Effectiveness to be compared with Machine learning

Mathematical Logics
Introduction*

Fausto Giunchiglia and Mattia Fumagallli

University of Trento

*Originally by Luciano Serafini and Chiara Ghidini
Modified by Fausto Giunchiglia and Mattia Fumagalli