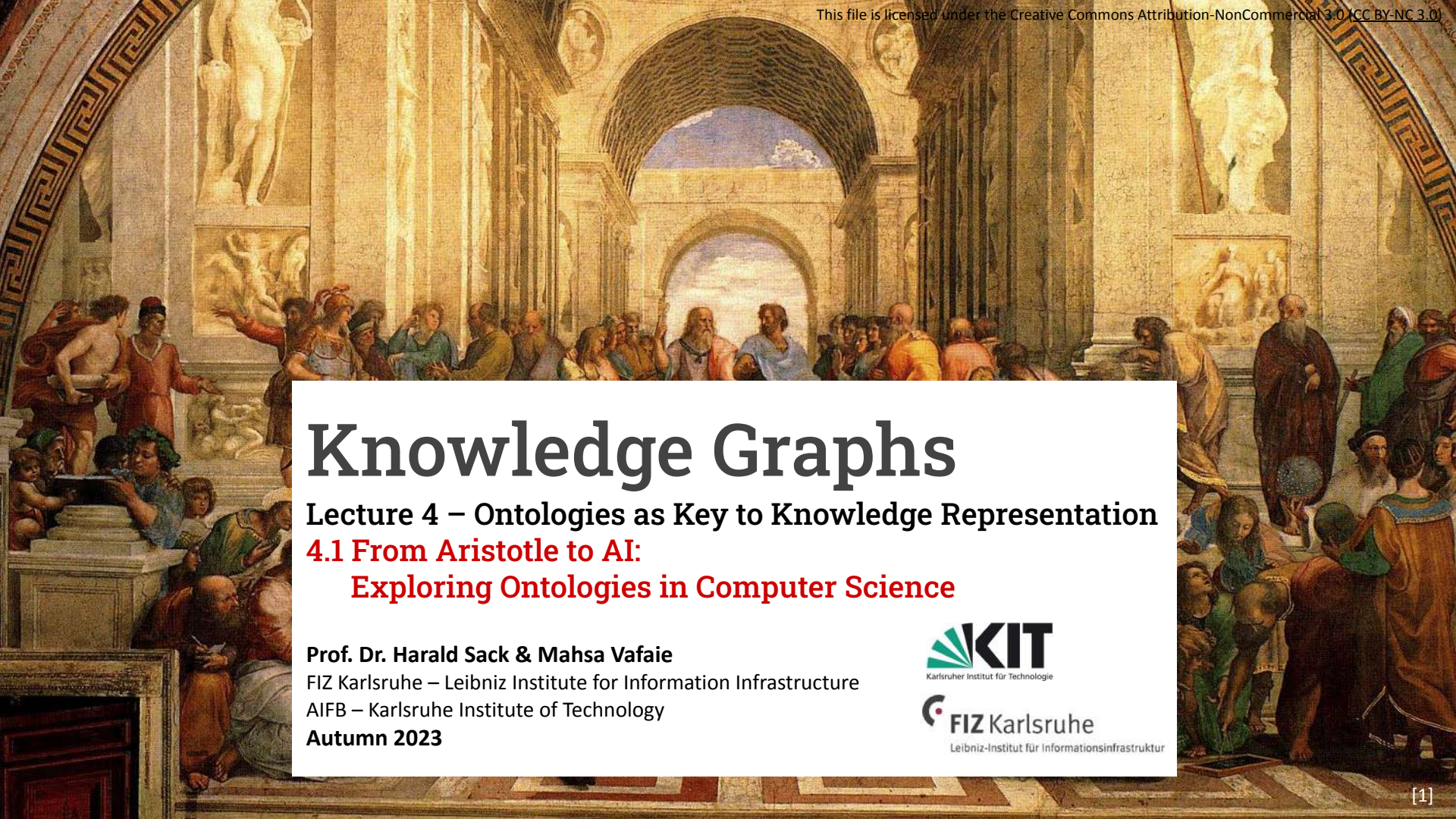


Knowledge Graphs

Lecture 4 – Ontologies as Key to Knowledge Representation

4.1 From Aristotle to AI: Exploring Ontologies in Computer Science

Prof. Dr. Harald Sack & Mahsa Vafaie
FIZ Karlsruhe – Leibniz Institute for Information Infrastructure
AIFB – Karlsruhe Institute of Technology
Autumn 2023

Knowledge Graphs

Lecture 4: Ontologies as Key to Knowledge Representation

Karlsruher Institut für Technologie

FIZ Karlsruhe
Leibniz Institute for Information Infrastructure

ONTOLOGY is the philosophical study of the nature of being, existence, or reality, as well as the basic categories of being and their relations...

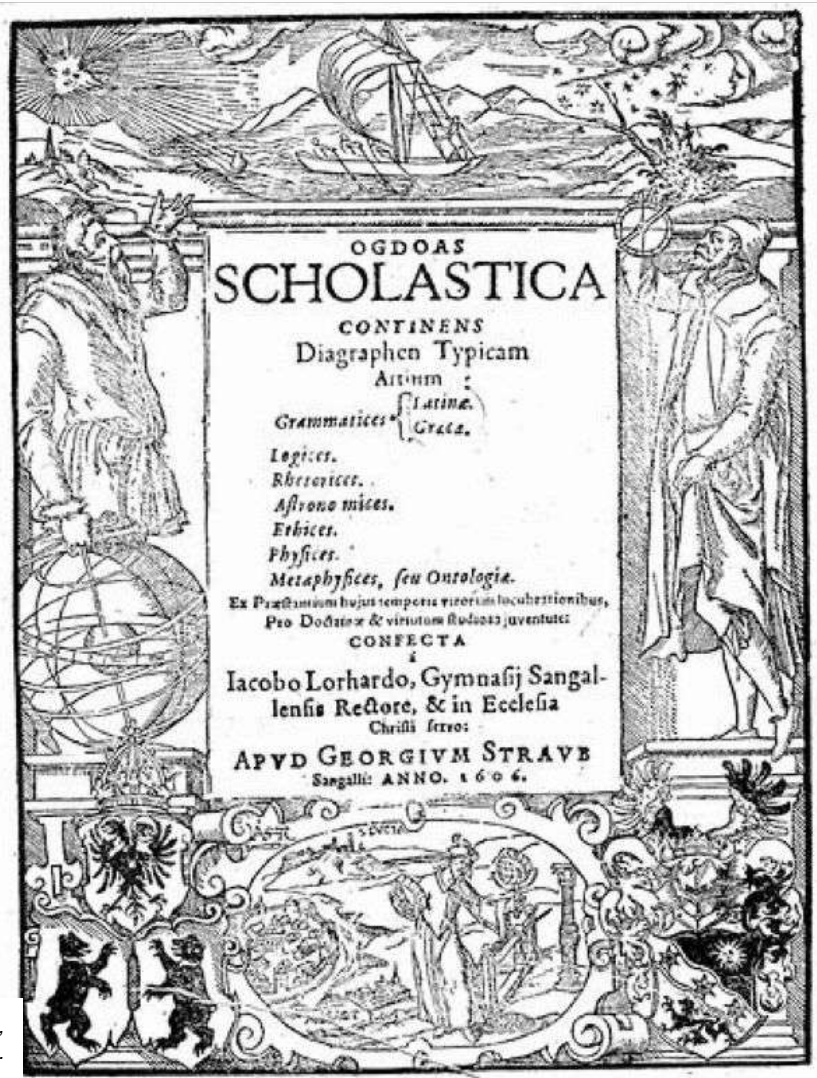
[1]

What is Ontology?

- **Etymology:**
  - ον [greek] participle of “to be”
  - λογια [greek] science
- **(simplified) Definition:**

  “philosophical study of the nature of being, existence, or reality, as well as the basic categories of being and their relations....” (Wikipedia)
- **General Question:**

  “what does exist or can be said to exist?”
- The term ***ontology*** first turned up in 1606 in Jacob Lorhard’s *Ogdoas Scholastica*



Jacob Lorhard: Ogdoas Scholastica, continens Diagraphen Typicam artium: Grammatices (Latinae, Graecae), Logices, Rhetorices, Astronomices, Ethices, Physices, Metaphysices, seu Ontologiae. Sangalli: Straub, 1606.

Fundamental Questions of Ontology

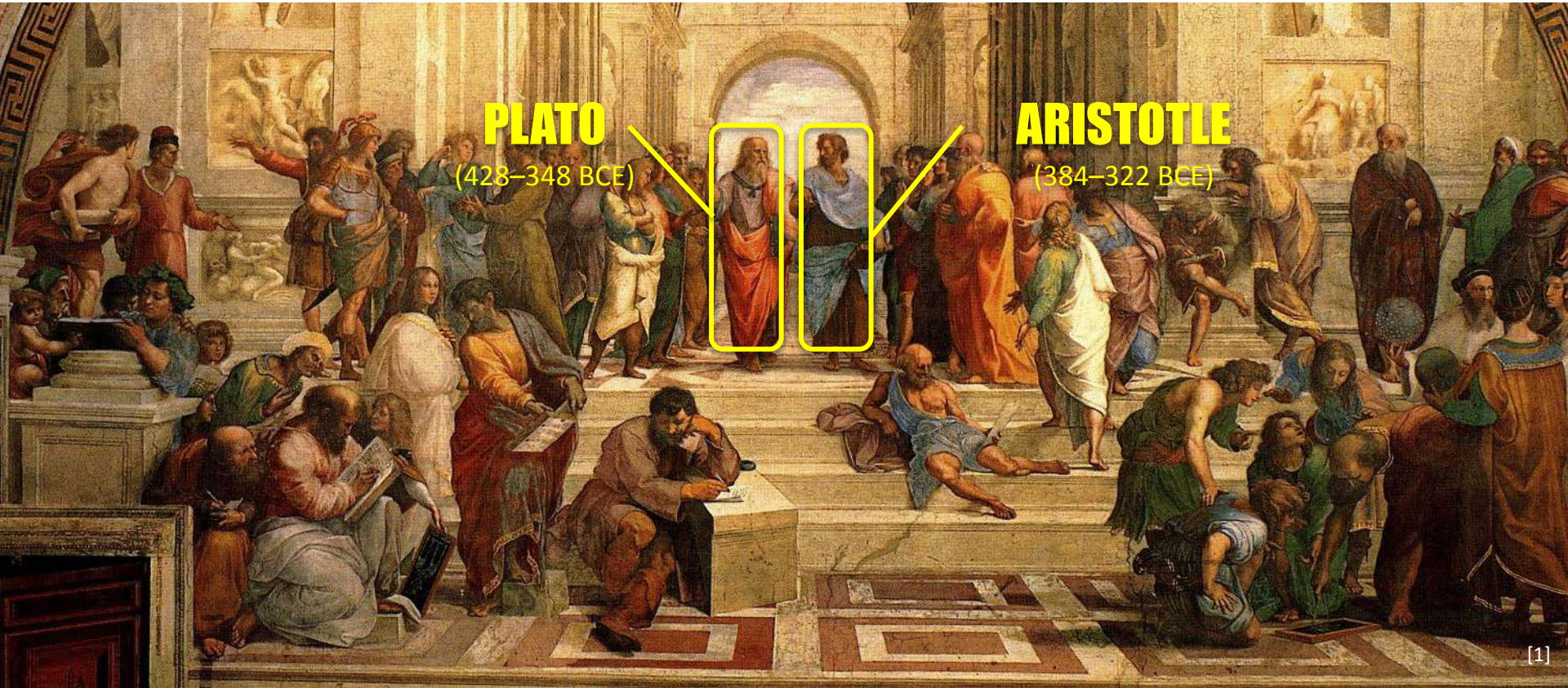
1. **What does it mean for a being to be?**
   - When are two things identical?
   - Is everything that exists also real?
   - Does something exist, if it is only possible?
   - Are there non-existing things?

2. **What categories of objects do exist?**
   - Do things exist that are only unique or only multiple (Universalia)?
   - Do things exist that are unilaterally dependent on others (Substances)?
   - Of which sort is this dependency (Causality)?
   - Do necessary properties exist (Essences)?
   - How do composed things relate to their components?


LEXICON
PHILOSOPHICVM,
QVO TANQVAM CLAVE
PHILOSOPHIÆ FORES
APERIVNTVR,
Informatum opera & ſtudio
RODOLPHI GOCLENII
SENIORIS, IN ACADEMIA MAVRITIANA,
quæ eſt MARCHIOBVRGI, Philoſophiæ Profeſſoris primarij.
QVÆ SECVLO ALTERI PROSVNT,
ſere arbores.
FRANCOFVRTI,
Typis viduæ Matthiæ Beckeri, impenſis Petri Muſculi
& Ruperti Piſtorij.
M. DC. XIII.

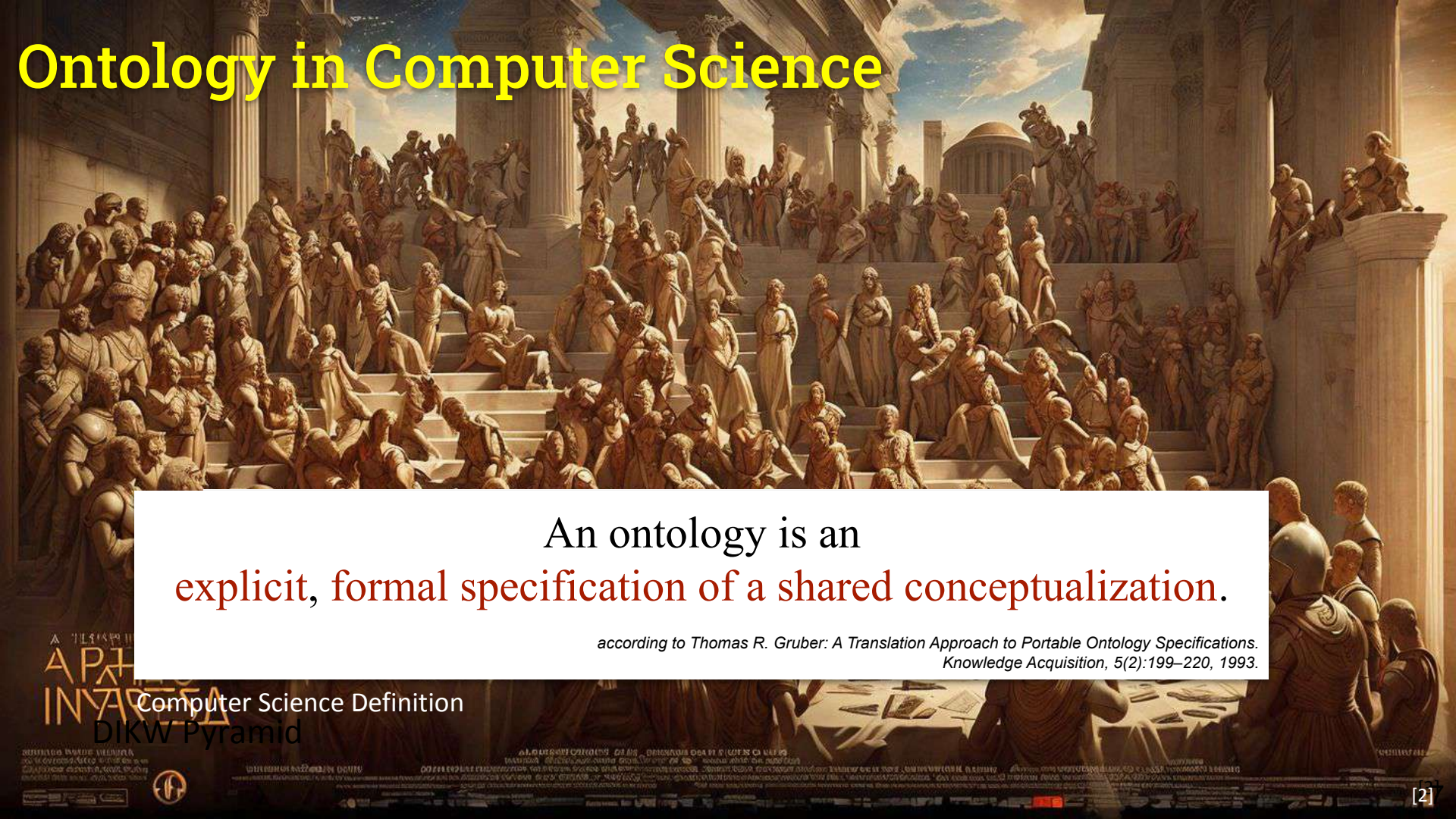
Rudolph Goclenius: Lexicon philosophicum, quo tantam clave philosophiae fores aperiuntur, 1613

ONTOLOGY is the philosophical study of the nature of being, existence, or reality, as well as the basic categories of being and their relations...



[1]

Ontology in Computer Science



An ontology is an
explicit, formal specification of a shared conceptualization.

according to Thomas R. Gruber: A Translation Approach to Portable Ontology Specifications. Knowledge Acquisition, 5(2):199–220, 1993.

Computer Science Definition
DIKW Pyramid

Ontology in Computer Science

An ontology is an
explicit, formal specification of a shared conceptualization.

according to Thomas R. Gruber: A Translation Approach to Portable Ontology Specifications. Knowledge Acquisition, 5(2):199–220, 1993.

conceptualization:	abstract model (domain, identified relevant concepts, relations)
explicit:	meaning of all concepts must be defined
formal:	machine understandable
shared:	consensus about ontology

How to represent Ontologies

- Ontologies can be represented via **Classes, Relations** and **Instances**
- **Classes** are abstract groups, sets, or collections of individuals or objects and represent **ontology concepts**
- Classes are characterised via **attributes**
- **Attributes** are name-value pairs

*„A **philosopher** is a person who practices or investigates philosophy. The term philosopher comes from the Ancient Greek meaning 'lover of wisdom'. The coining of the term has been attributed to the Greek thinker Pythagoras (6th century BCE)“.*

informal description

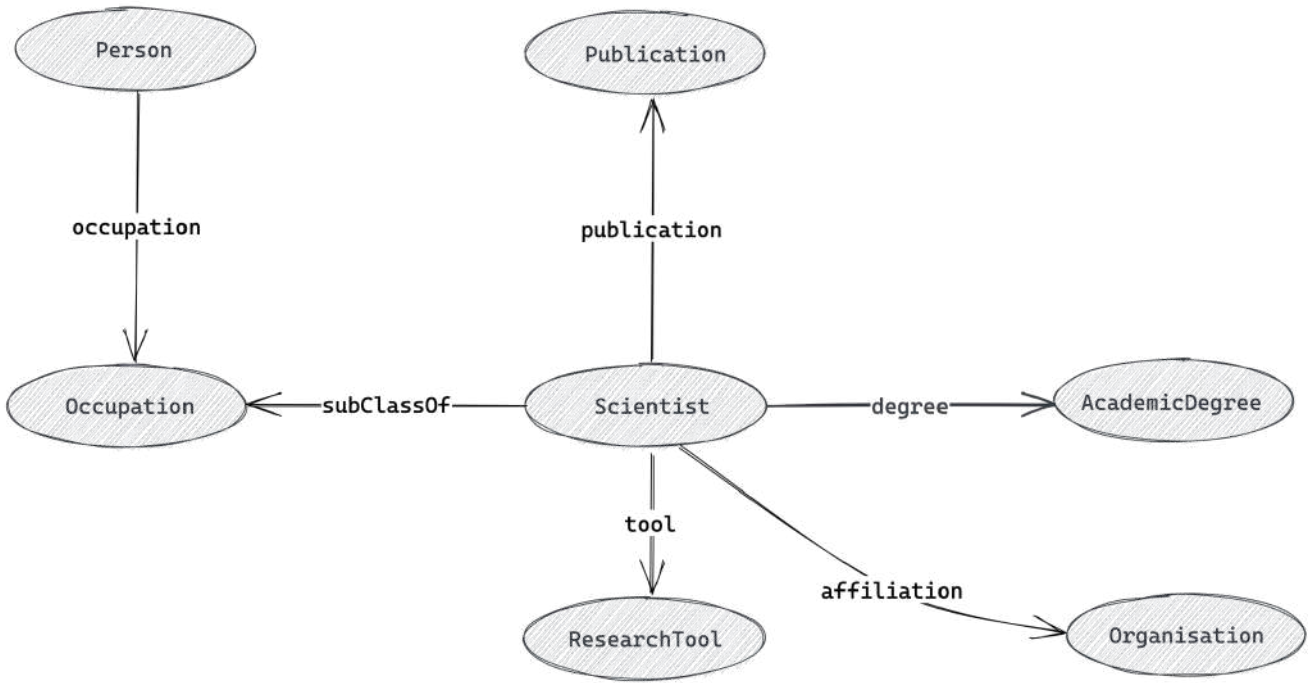
Philosopher

- *first name <string>*
- *surname <string>*
- *address <string>*
- *number of publications <string>*
- *impact factor <float>*
- *…*

semi-formal description

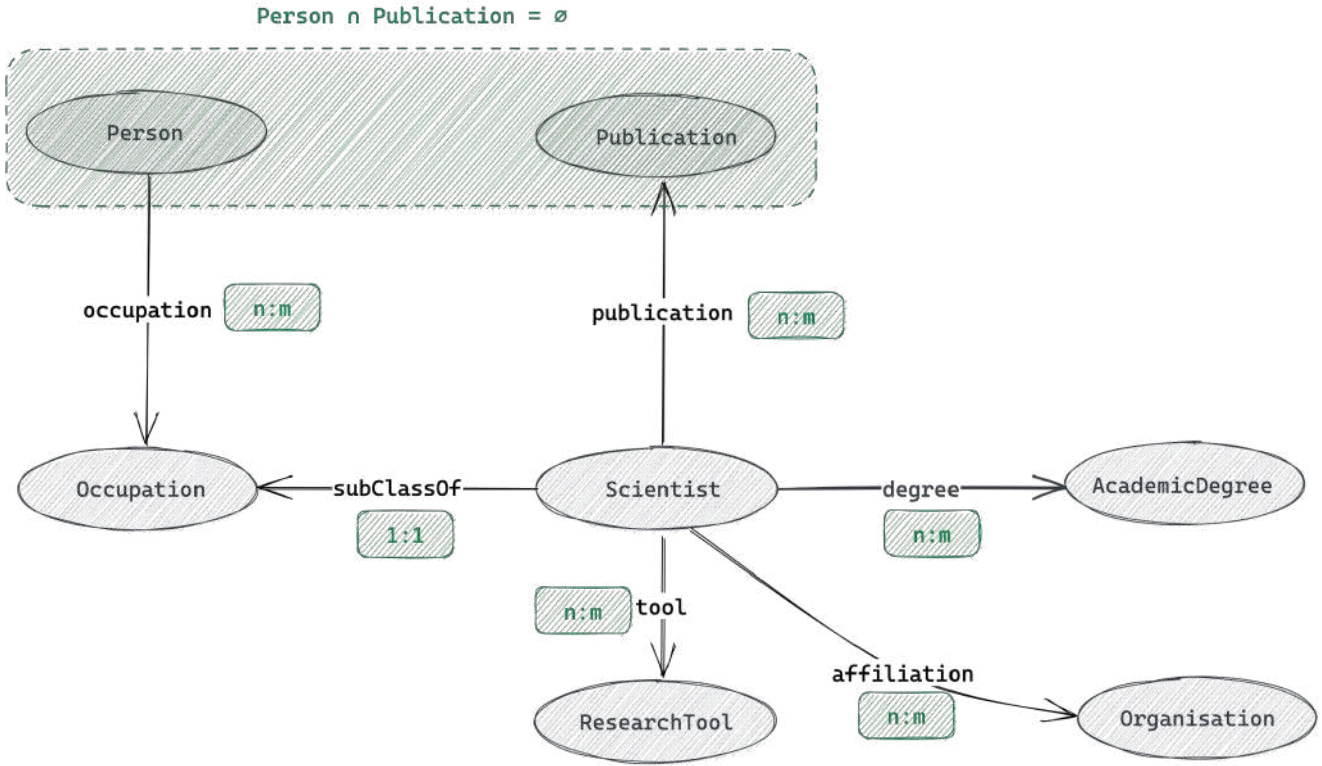
How to represent Ontologies

- Classes can be **related** to other classes
- **Relations** are special attributes, whose values are objects of (other) classes



How to represent Ontologies

For Relations and Attributes, **Rules** (**Constraints**) can be defined that determine allowed/valid values.



How to represent Ontologies

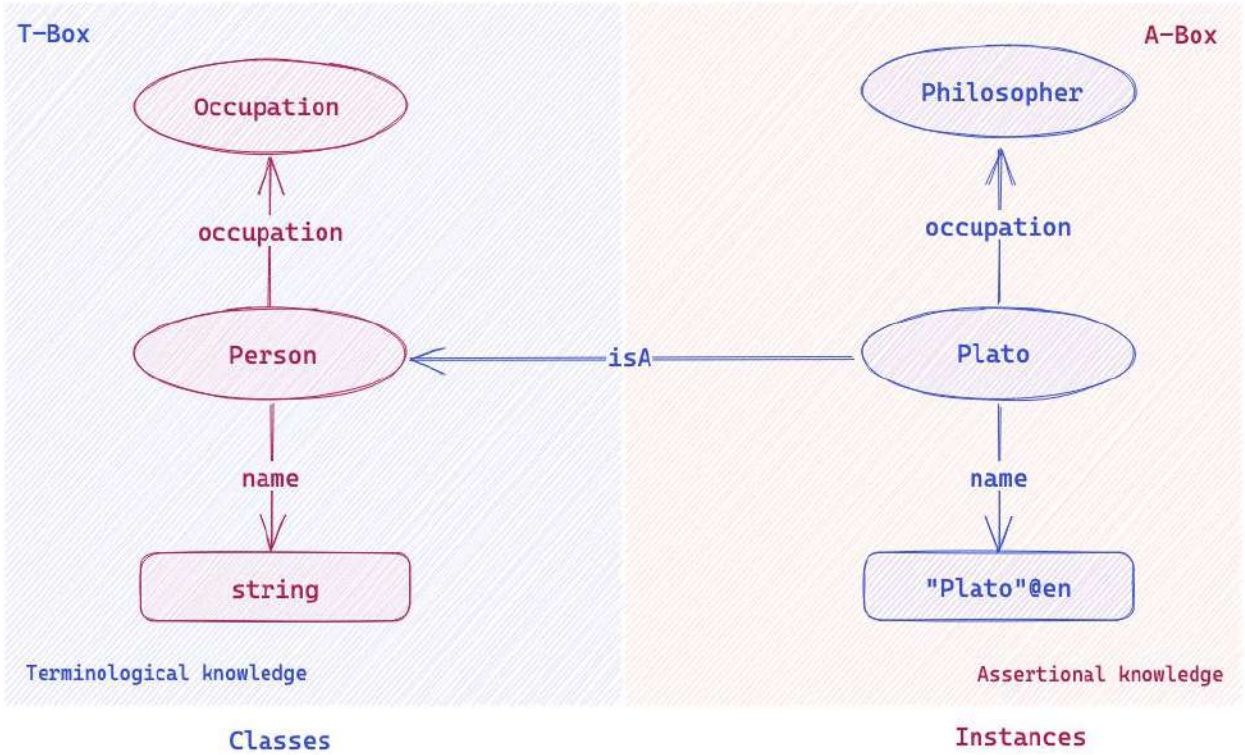
- Classes, relations, and constraints can be combined to form (complex) **Statements / Assertions.**
- Special Case: **formal Axioms**

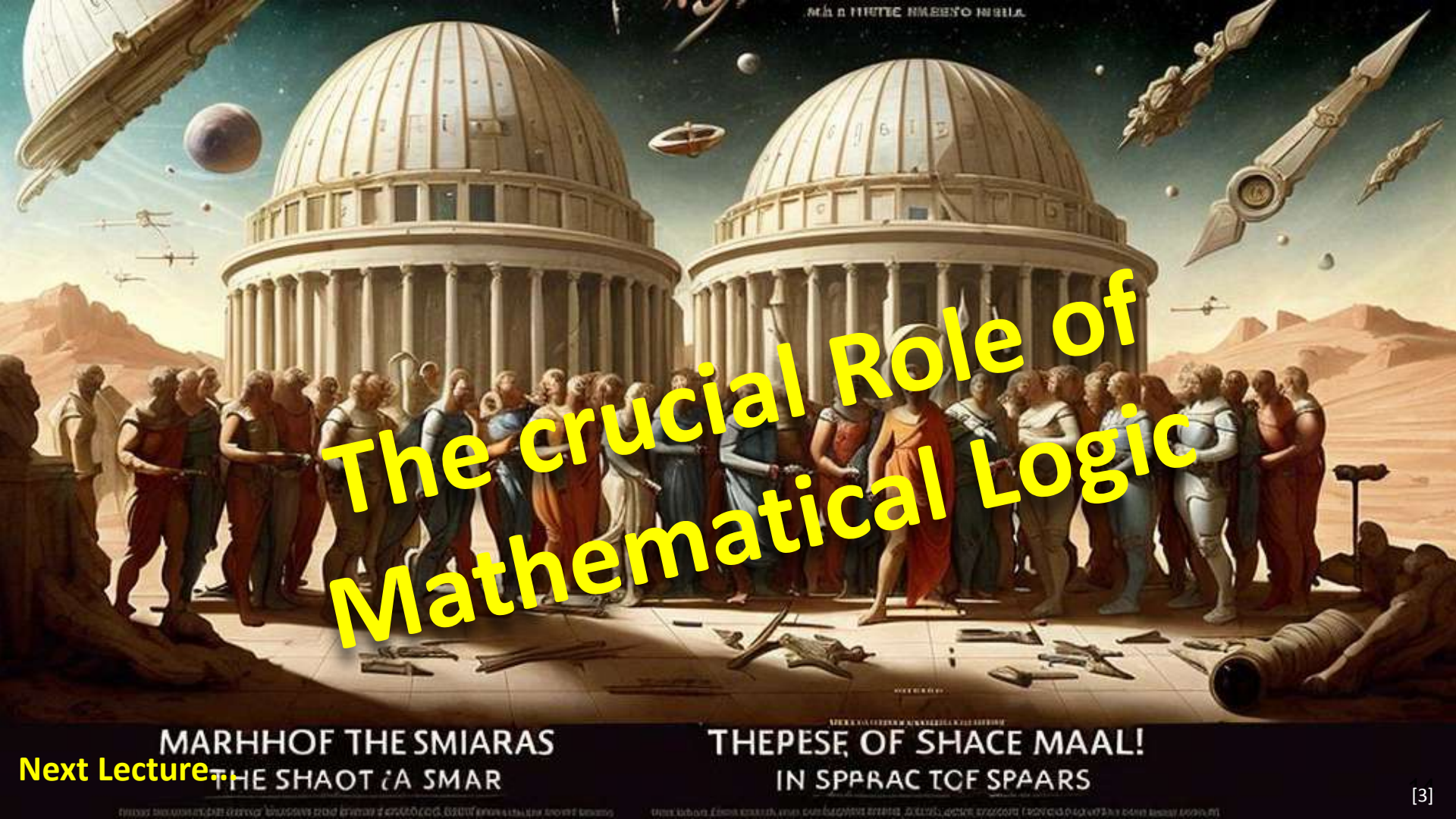
Example:
„A philosopher is somebody who knows himself.“

- **Axioms** describe knowledge that cannot be expressed simply with the help of other existing components.

How to represent Ontologies

Instances describe individuals of an ontology.





Next Lecture...

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  Chap. 7.1 Shape Constraint Language - SHACL, pp. 453–500.

Picture References:

[1] Raphael, School of Athens, 1511, [Public Domain], https://commons.wikimedia.org/wiki/File:%22The_School_of_Athens%22_by_Raffaello_Sanzio_da_Urbino.jpg

[2] "A Scifi movie poster depicting Raphael's "School of Athens" with all the important classical Philosophers including their significant tools set into a retro futuristic urban environment of planet Mars with spaceships in the sky.", created via ArtBot, Deliberate, 2023, [CC-BY-4.0], https://tinybots.net/artbot

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