

Data Modeling

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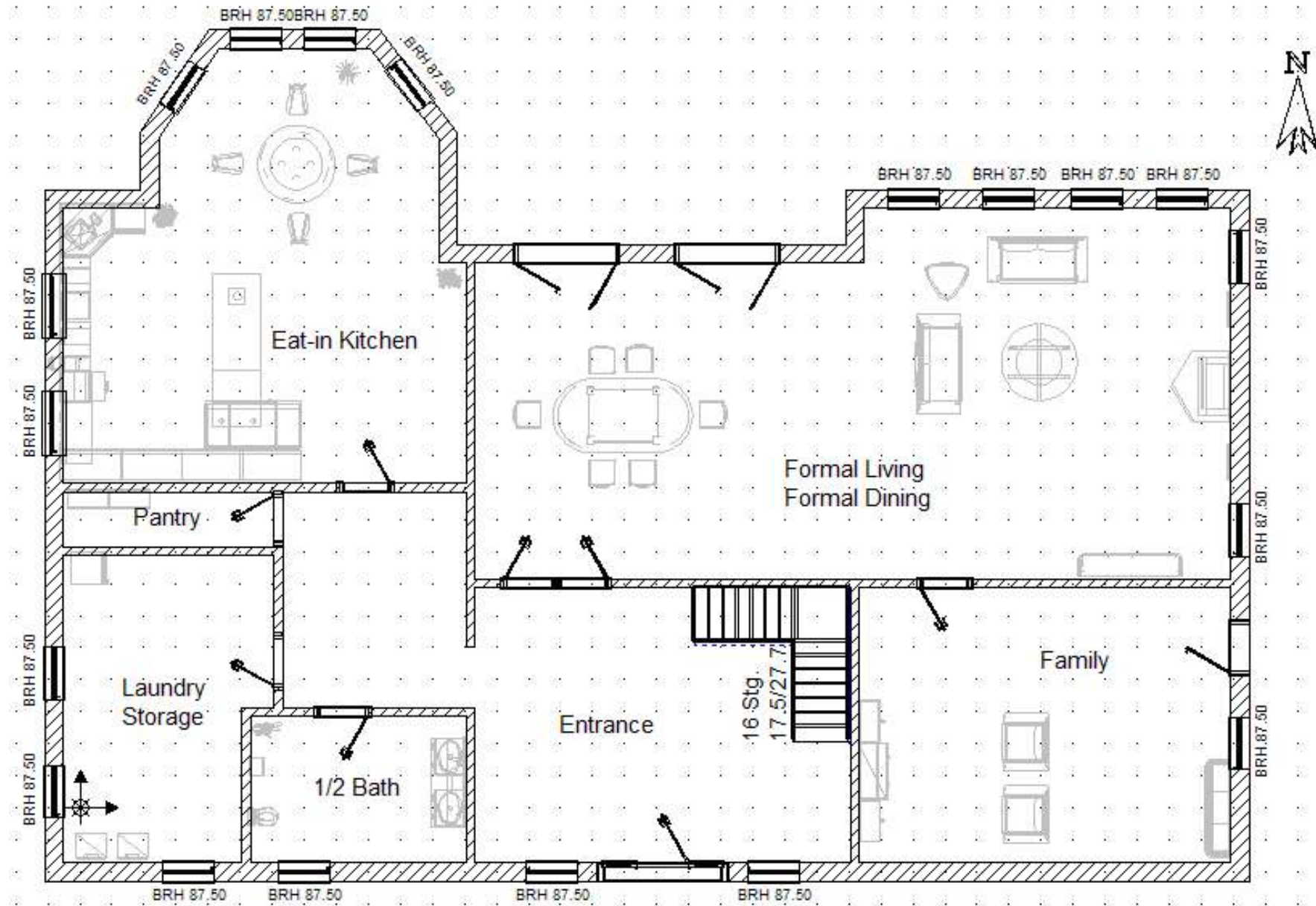




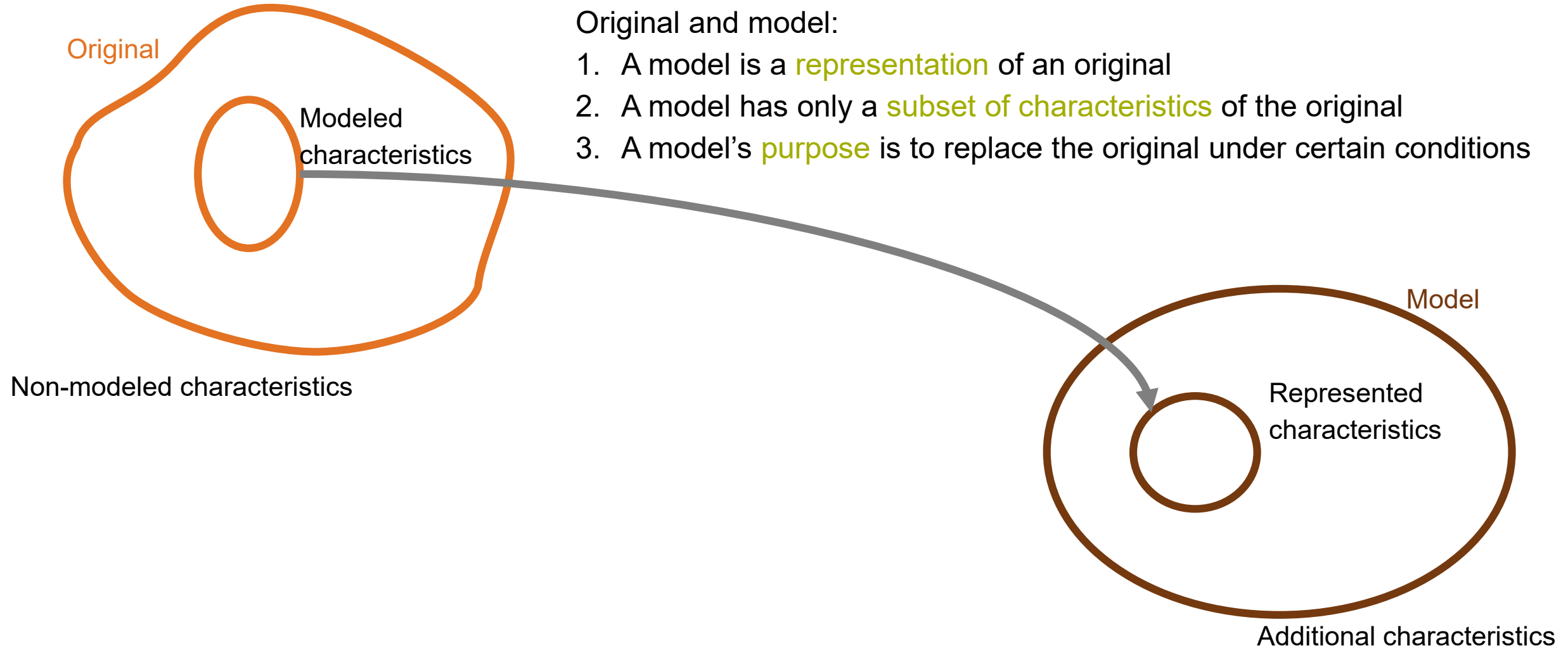




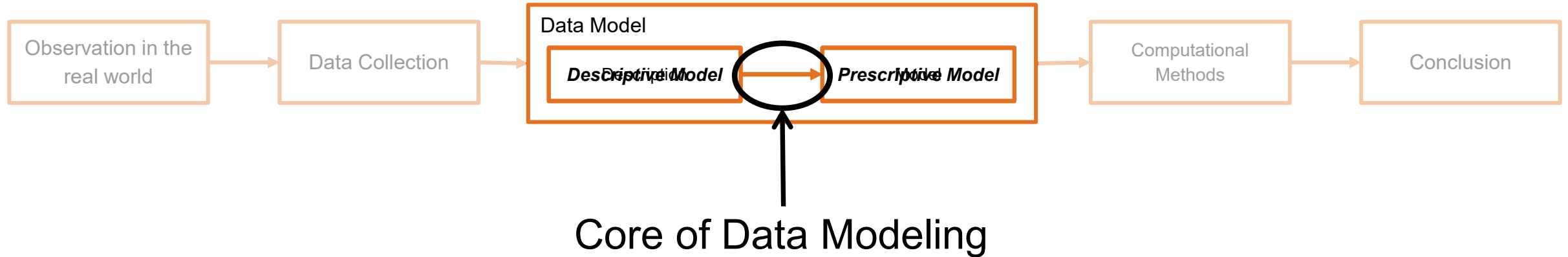




Models in General



Turning Descriptions Into Models



Descriptive Model

$O \blacktriangleright M$ – “O is modeled by M”

- Original is *prior* to the model
- Model describes original

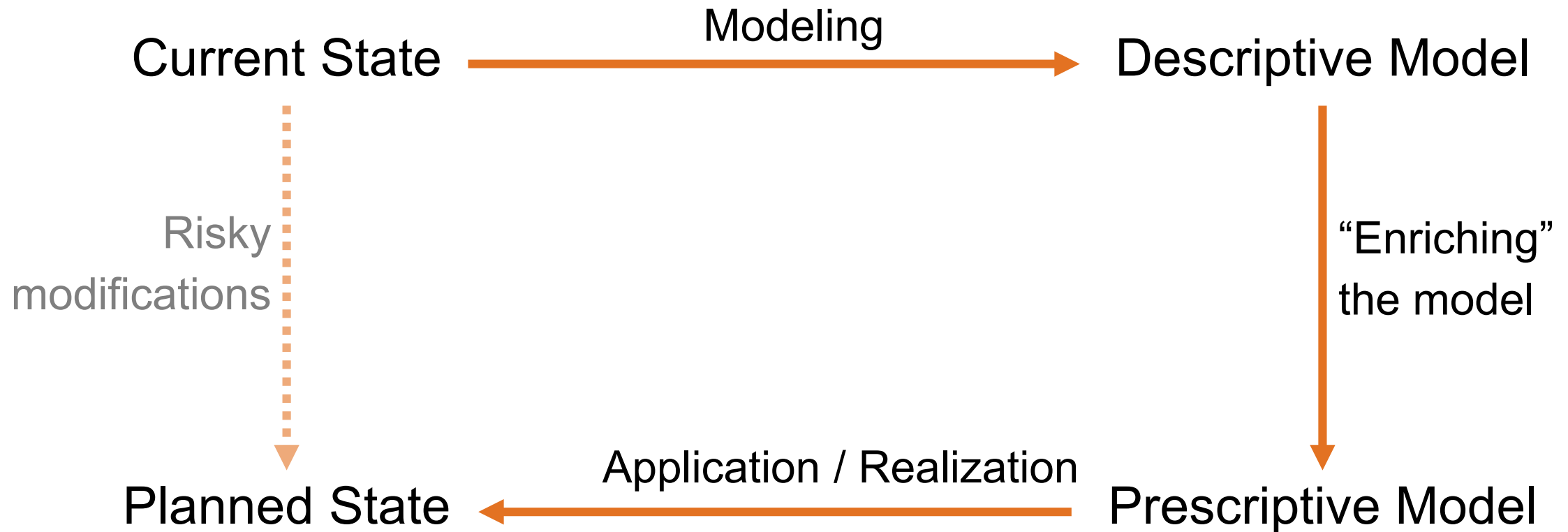


Prescriptive Model

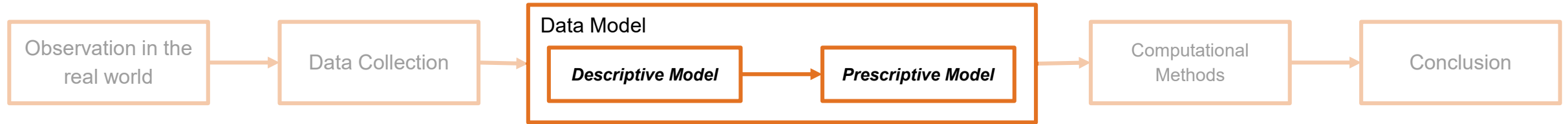
$M \blacktriangleleft O$ – “M is concretised to O”

- “Original” exists *after* the model
- Model prescribes an original

Descriptive vs. Prescriptive Models



Turning Descriptions Into Models



A proper data model presents an understandable **meaning for data** and offers a **common vocabulary** to talk about it.

Formal Modeling



Models for Modeling?

A model by itself is not processable by machines by itself

In order to be processable, models

- must be represented in an unambiguous and explicit language and
- must be represented in a language that represents the salient features of the model



We Need a Set of Rules

Formal models use a specific set of rules

- that explicitly and exhaustively define the model's syntax and semantics, and
- that allows the data to be processed automatically

Formal models

- are the building block for communication about data
- ensure a higher data-quality because they impose certain requirements on input data
- allow for a seamless exchange or merging of data
(if they follow certain standards)

Different Formal Models

Process Modeling

Modeling of events in time:
the amount of water passing
through a river bed in a given time,
the change of employment resulting
from specific events, or the spread
of a new scientific concept in
scientific texts

Also includes simulation, i.e.
modeling of more complex
processes

System Modeling

Design of software systems, usually
an abstract view of the design
of a piece of software

Data Modeling

Modeling of entities:
documents, events, information
systems, agents, data sets

Different Formal Models

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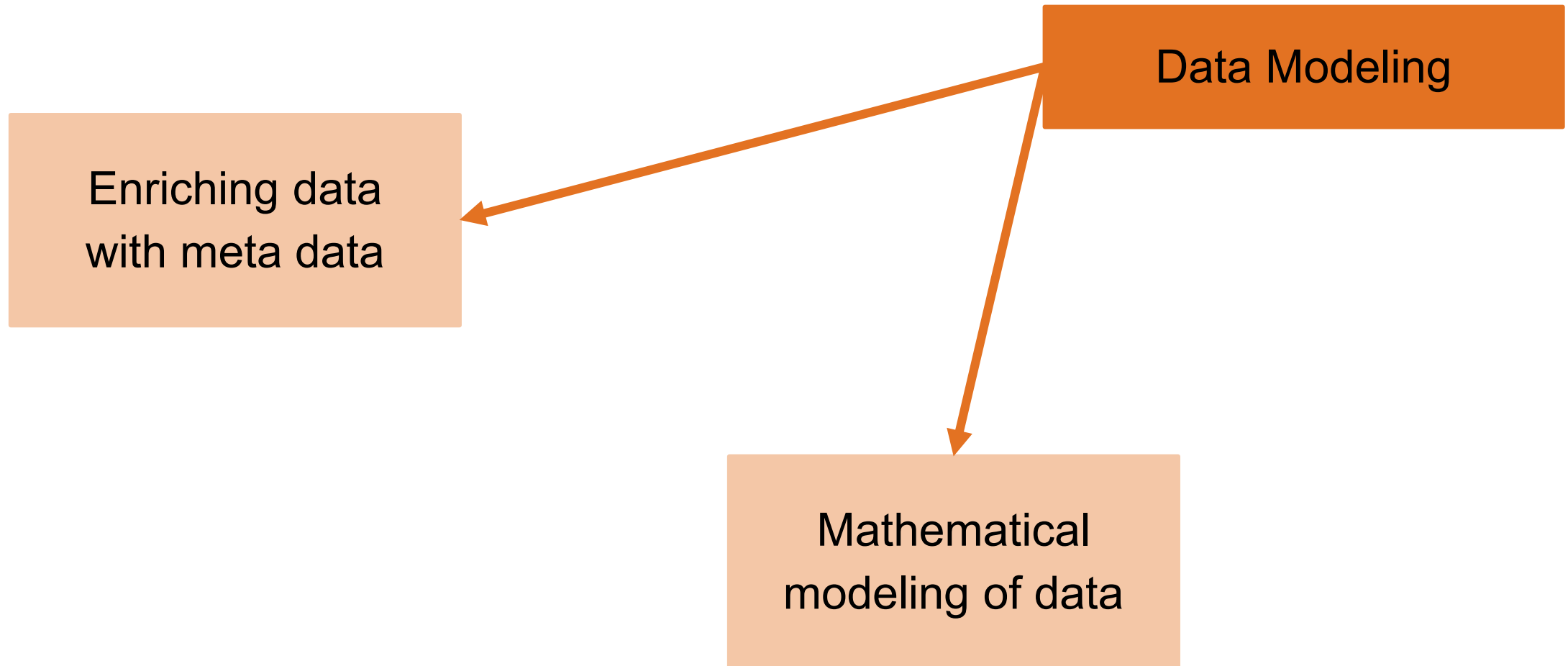
System Modeling

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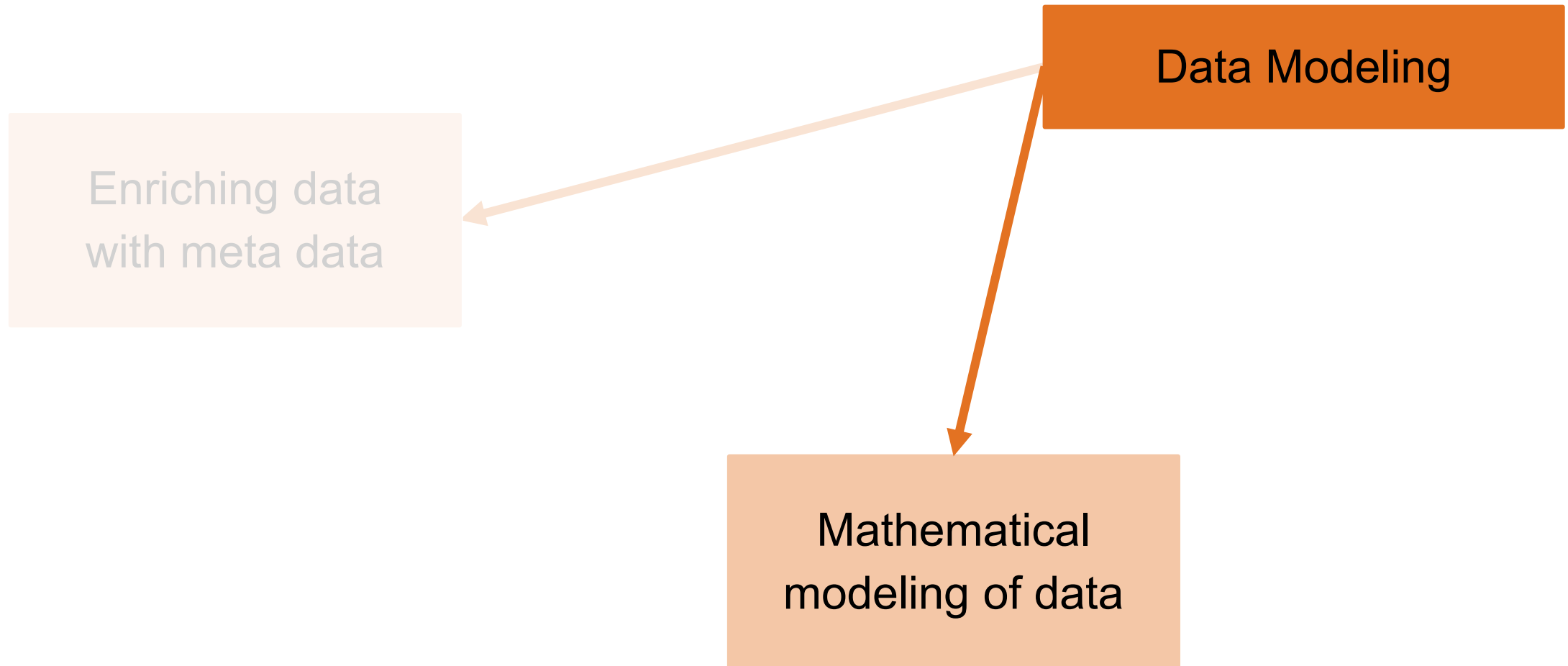
Data Modeling

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Modeling Data Formally



Modeling Data Formally



Mathematical Modeling



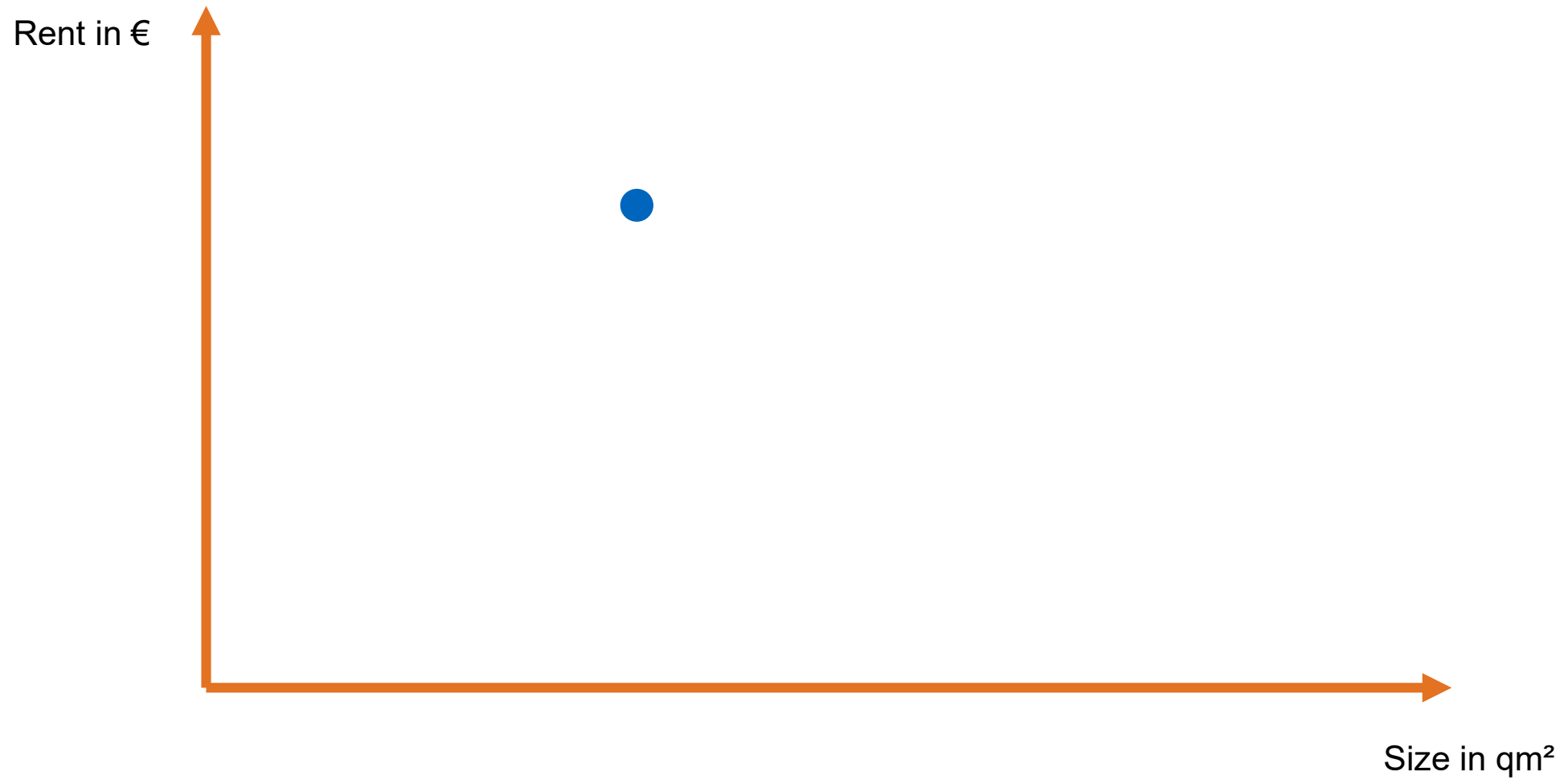
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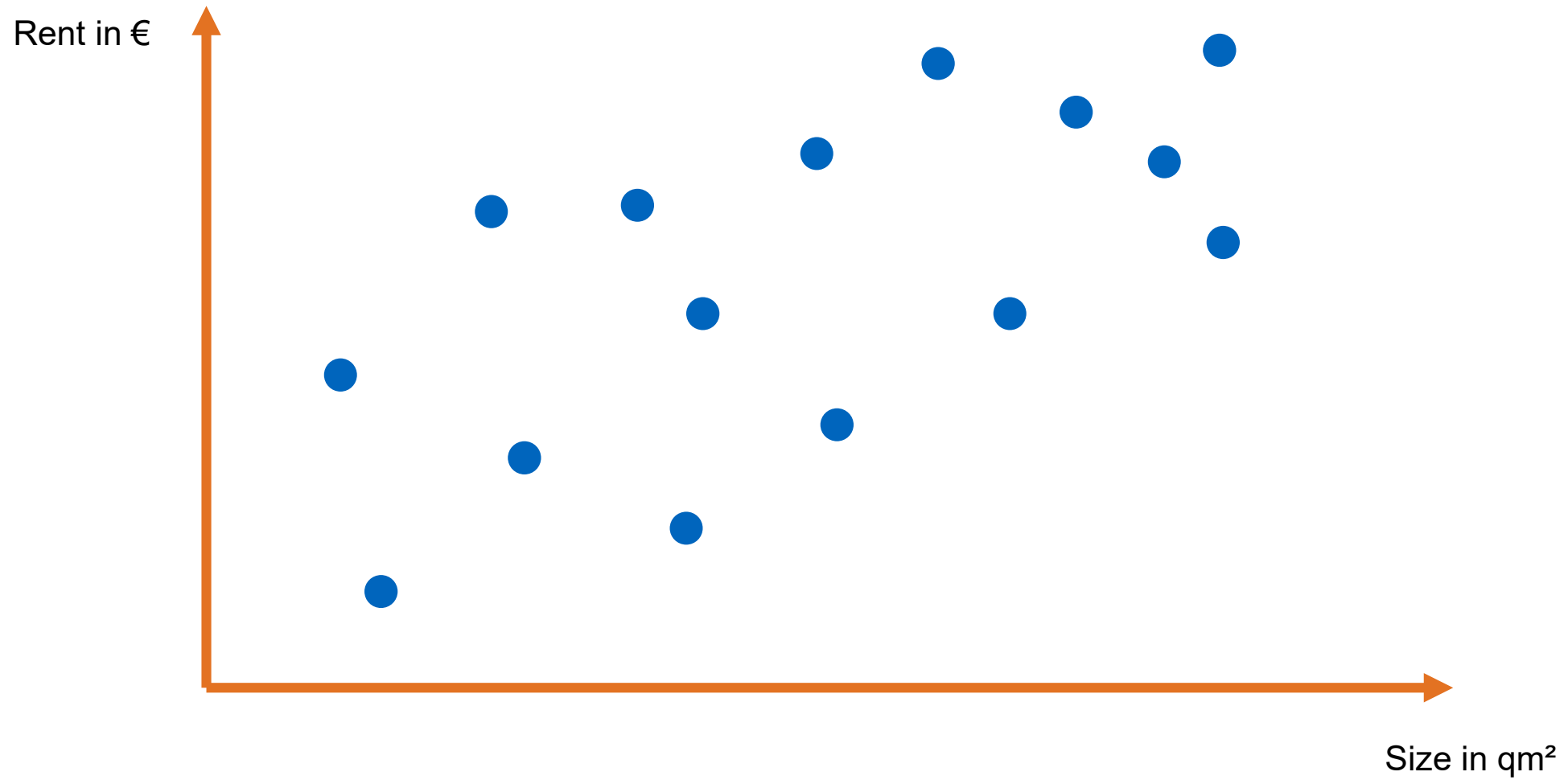
Mathematical Modeling



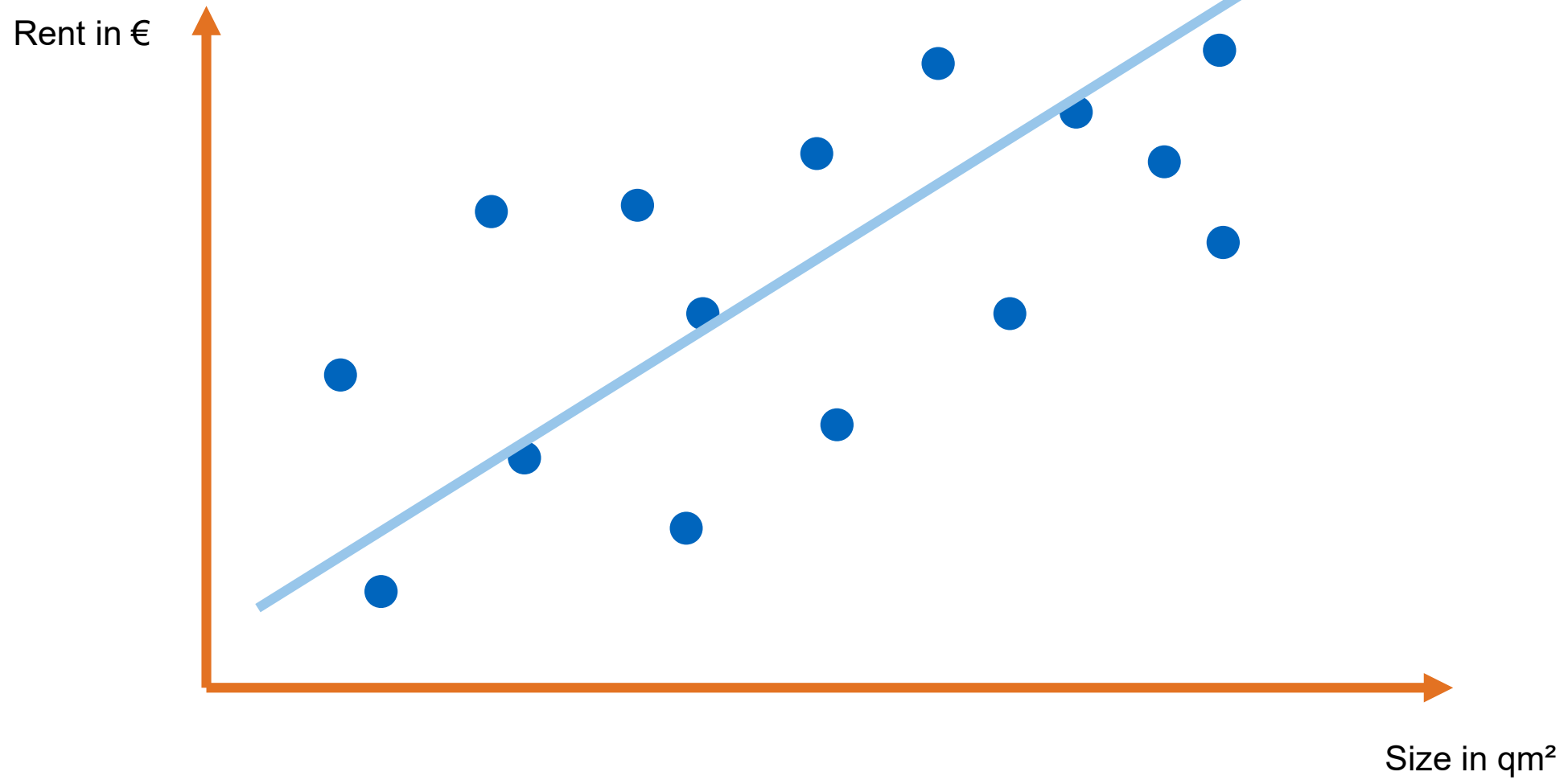
Mathematical Modeling



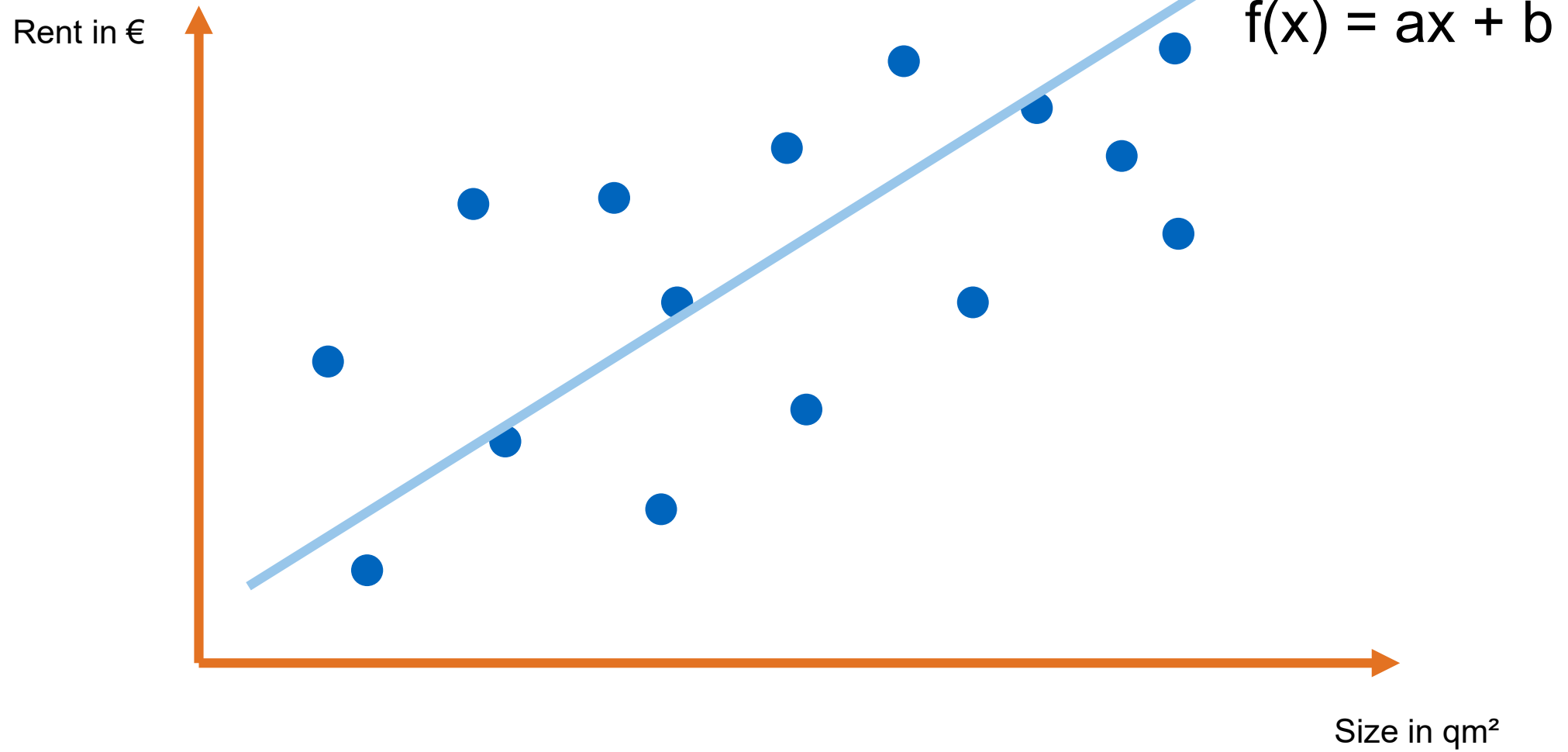
Mathematical Modeling



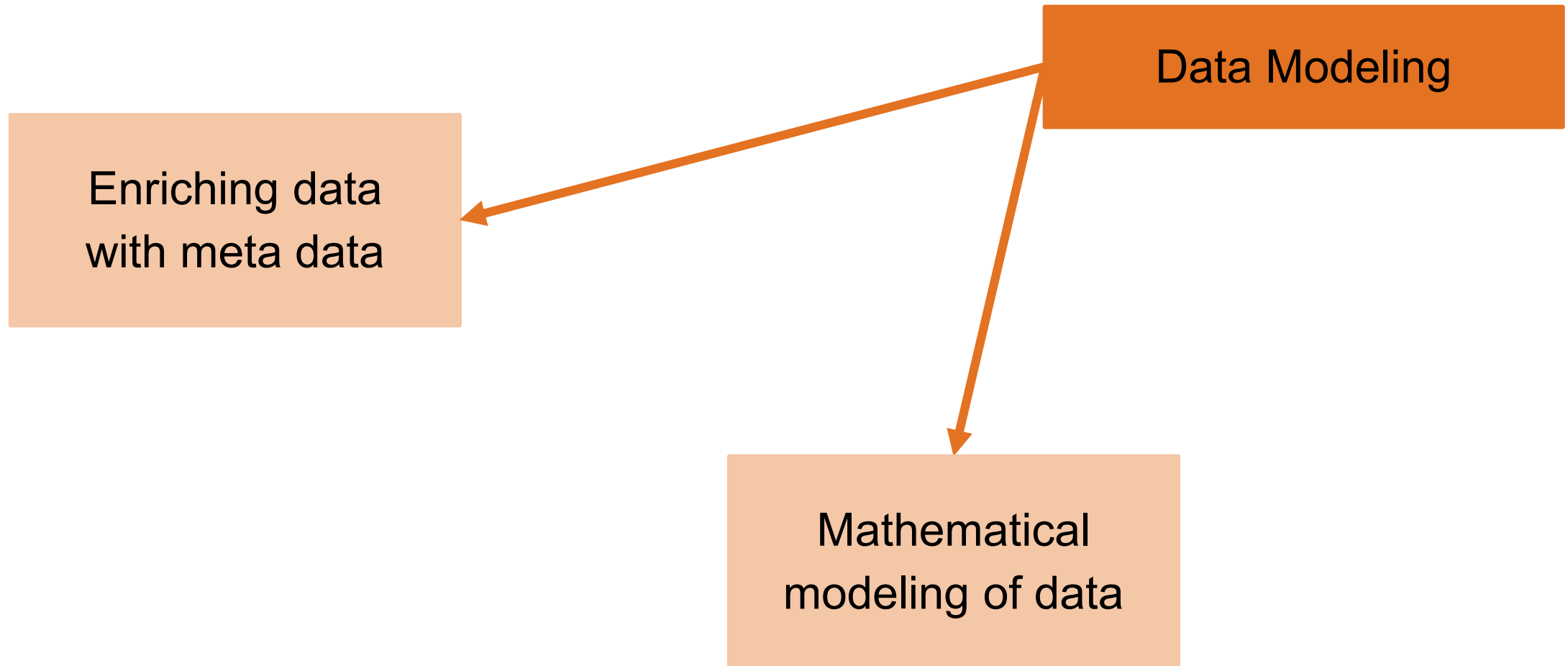
Mathematical Modeling



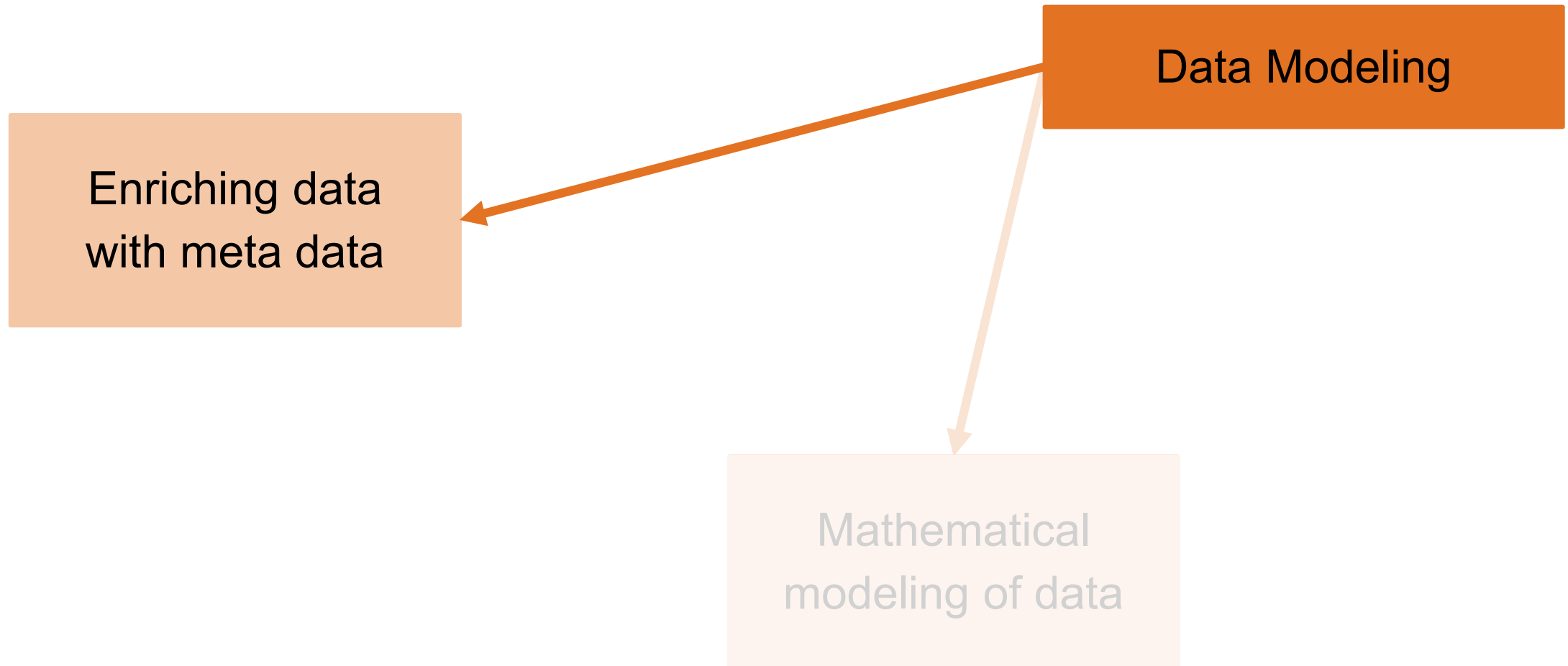
Mathematical Modeling



Modeling Data Formally



Modeling Data Formally



Data About Data

Meta data is data about modeled instances.

Meta data is used for discovery, query, and management of data

Meta data is highly structured information

More about meta data later!

Meta data is kept

- in separate databases, or
- bundled together with the data but clearly distinguishable from it

Modeling Data...for what?

Research-driven Models

Modes are created for
specific research questions

Operationalizing research questions
and making it “tangible”

Tailored to specific question. Often
useless for others.

Curation-Driven Models

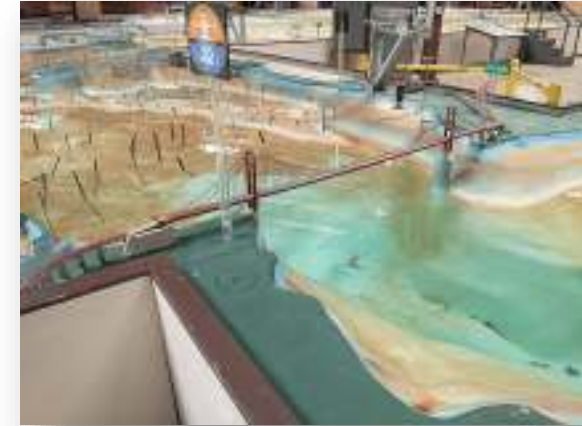
Modeling is meant to make digital
resources sustainable and lasting.

Used by libraries and archives or
cooperations among researchers

Summary

Characteristics of models:

1. A model is a **representation** of an original
2. A model has only a **subset of characteristics** of the original
3. A model's **purpose** is to replace the original under certain conditions



Descriptive Model

- Original is *prior* to the model
- Model describes original

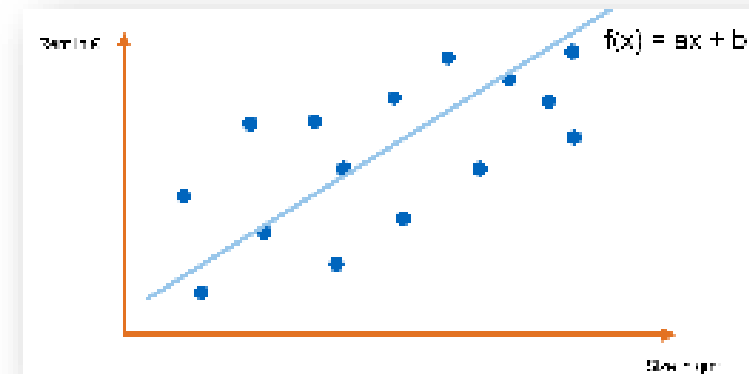
VS

Prescriptive Model

- “Original” exists *after* the model
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Conceptual Modeling



Why again?

By data modeling we try to find a translation of real-world situations to data & databases

Data models enable a user to define the data using high-level constructs without worrying about many low-level details of how data will be stored on disk

Data modeling can be viewed as series of steps with the ultimate goal of meeting a set of requirements specified by future users of the data, or people who act on their behalf.

Aim of Data Modeling

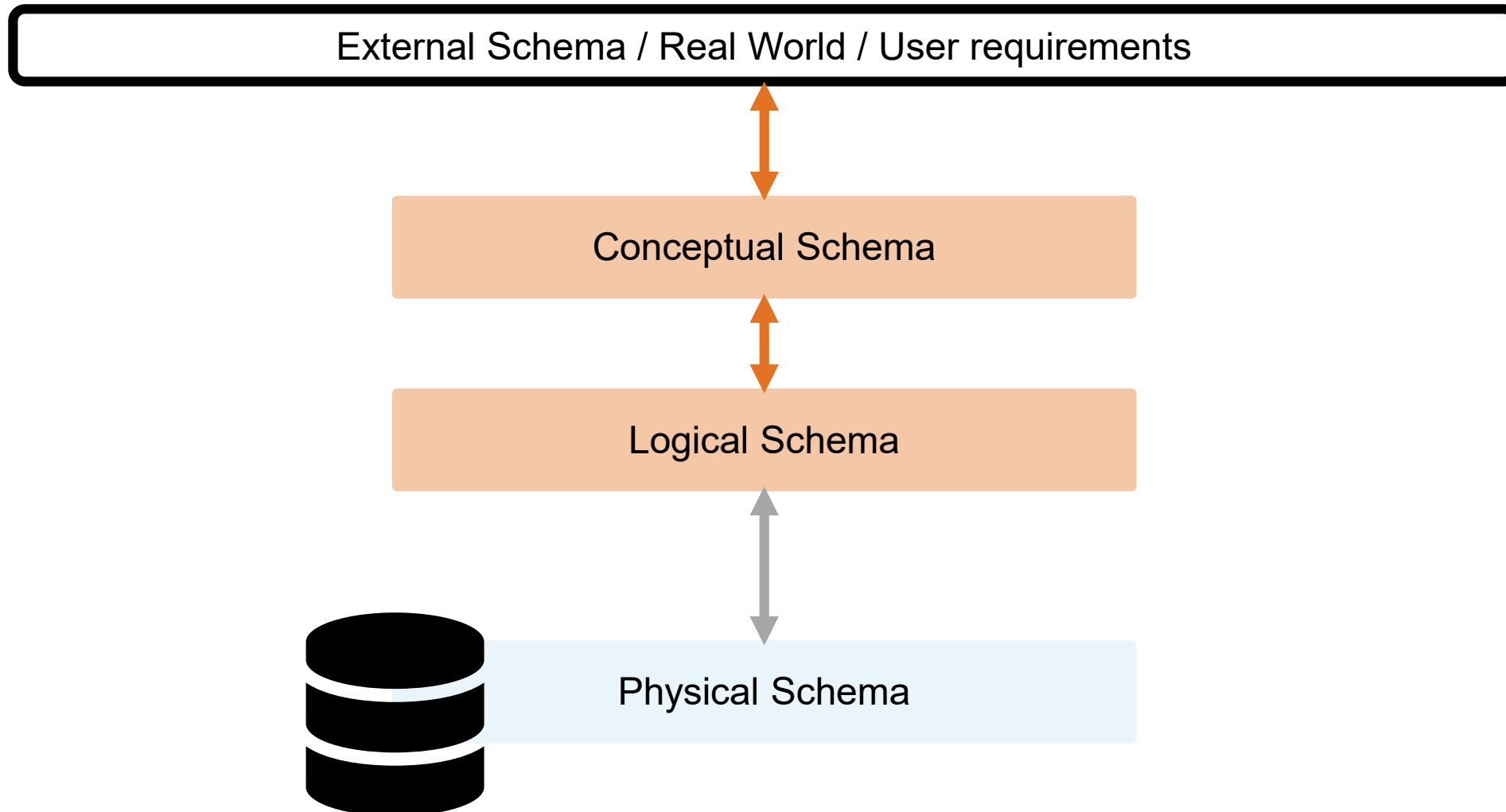
Fulfil user requirements!

Intended usage of a digital entity is the single most important factor determining

- the selection,
- the amount and depth of the annotations
- the complexity and
- richness of the data model.

Clear analysis of the requirements of the digital entities in question is an important step in data modeling.

Levels of Abstraction



Levels of Abstraction

External Schema / Real World / User requirements

First step of modeling:
Identify relevant entities,
attributes and relations

Conceptual Schema

Purposeful mapping of
real-world information
to a finite set of
modeled elements.

Logical Schema

Physical Schema



The Conceptual Data Model

- **Classification**
Fix object types (entities)
- **Abstraction**
Identify relevant characteristics (attributes)
- **Relations**
Describe relations between objects
- **Identification**
Chose unique identifiers (keys)

Modeling a scenario



Modeling a scenario

Object types:

- Lectures
- Students
- Research assistants
- Professors



Attributes:

- Lectures: Lecture number
- Lectures: Titel & ECTS
- Students: Student ID
- Students: Semester
- Employees: Staff number
- Employees: Room

Relations:

- Students LISTEN to lectures
- Professors GIVE lectures
- Professors TEST students
- Assistants WORK FOR profs
- Lectures REQUIRE other lectures

Identifiers:

- Students: student ID
- Employees: Staff number



Conceptual Entities and Relations

An **entity-relationship model** (or **ER model**) describes interrelated things of interest in a specific domain of knowledge.

Source: wikipedia

ER models contain

- **Entities**

An entity may be defined as a thing capable of an independent existence that can be uniquely identified.

Exists either physically or logically.

Can be thought of as nouns.

- **Relations**

A relationship captures how entities are related to one another.

- **Attributes**

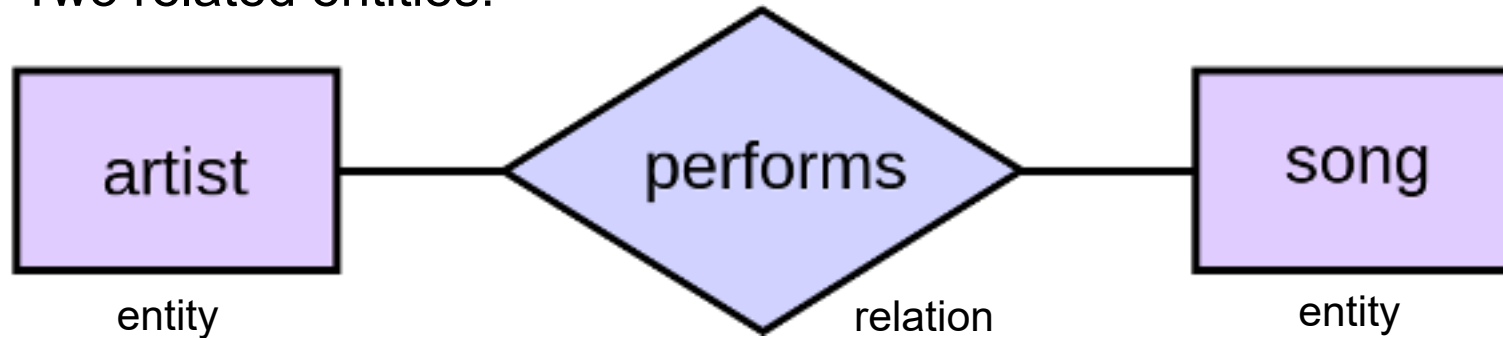
Both entities and relations can have attributes.

Data item or property.

- **Cardinality**

Entities, Relations & Attributes

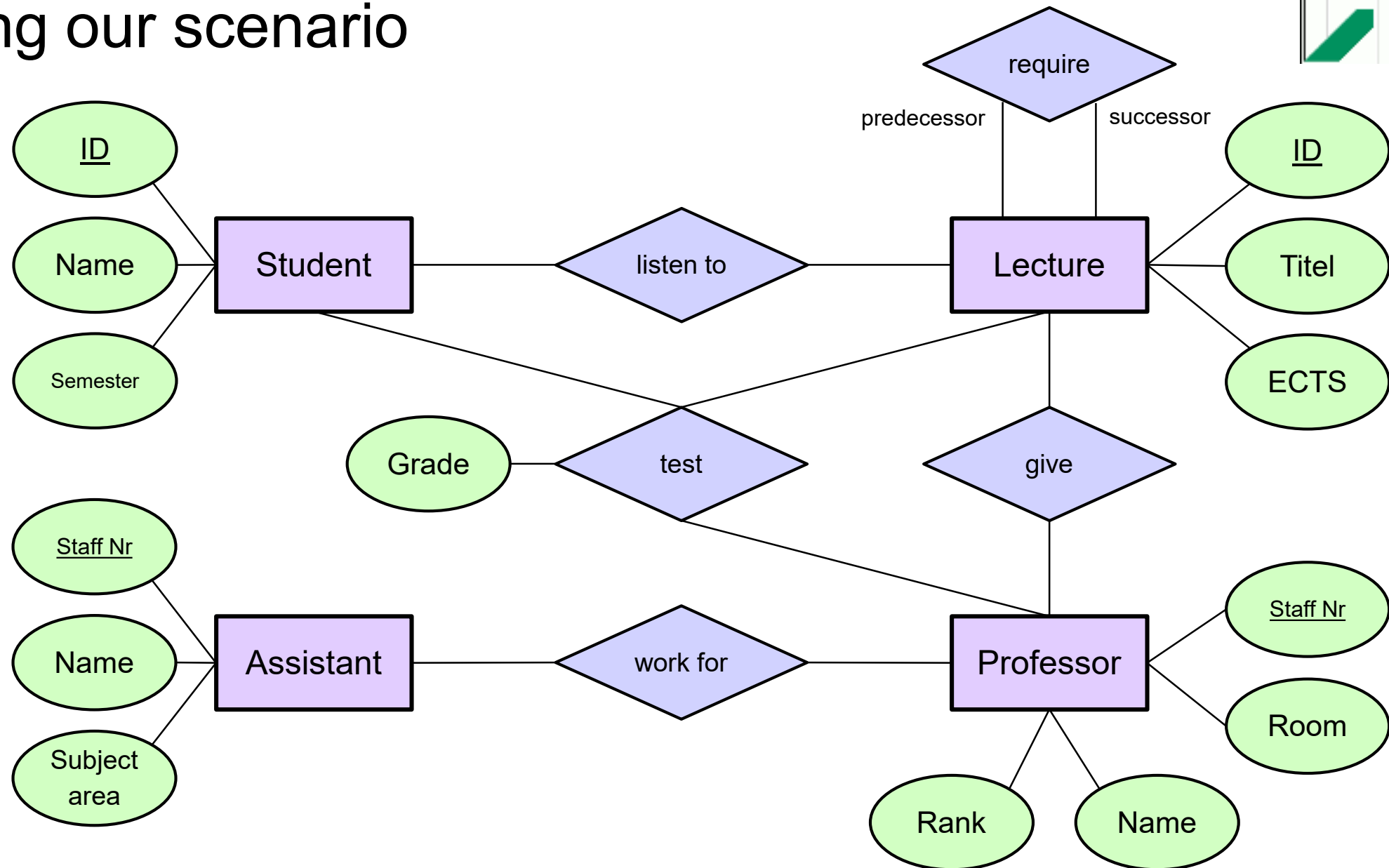
Two related entities:



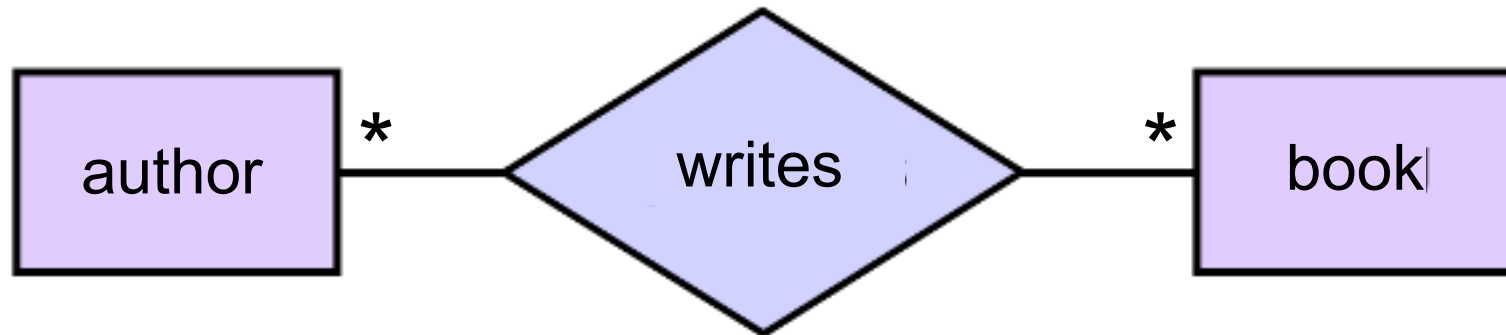
Entities and relations with attributes:



Modeling our scenario



Cardinality



1:1

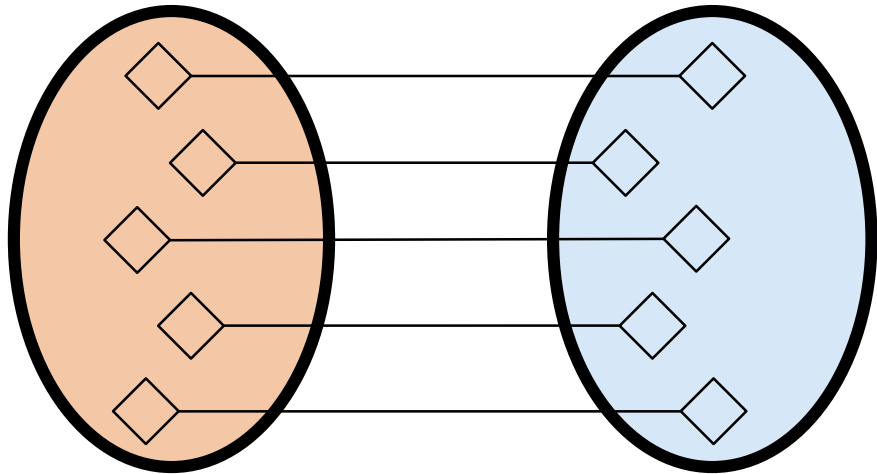
1:n

n:1

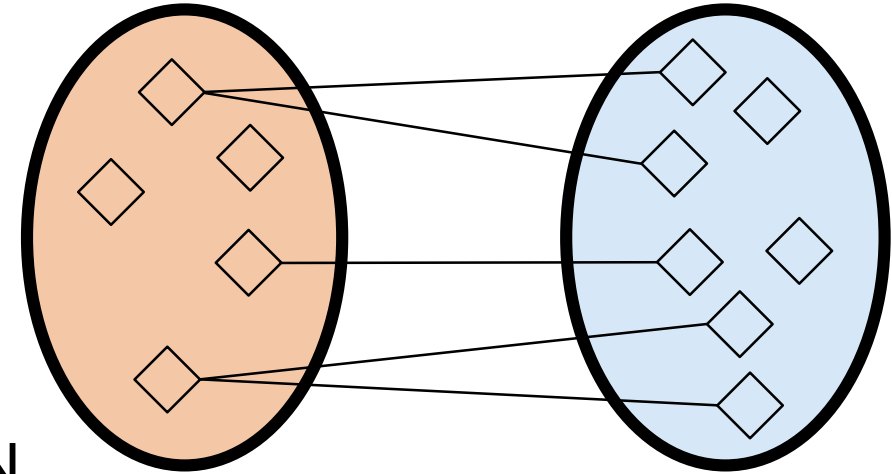
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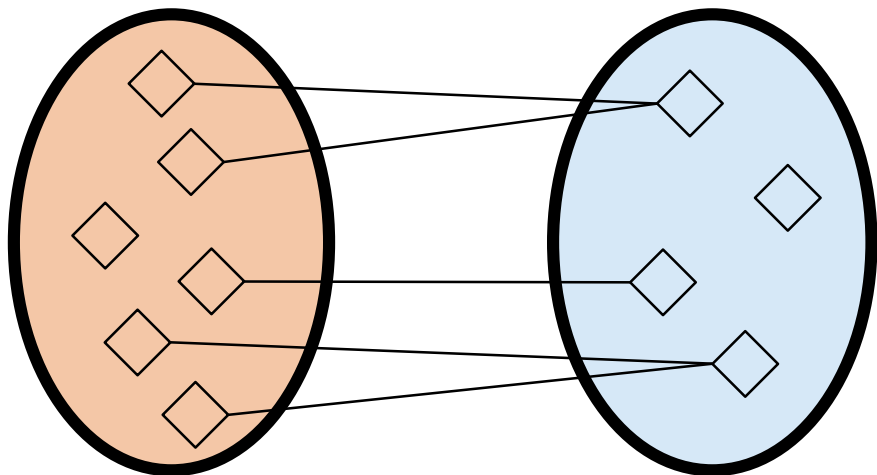
Cardinality



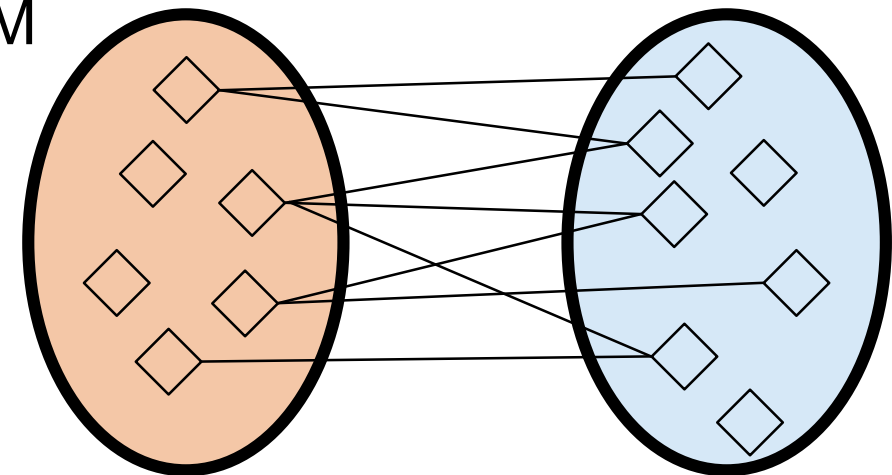
1:1



1:N

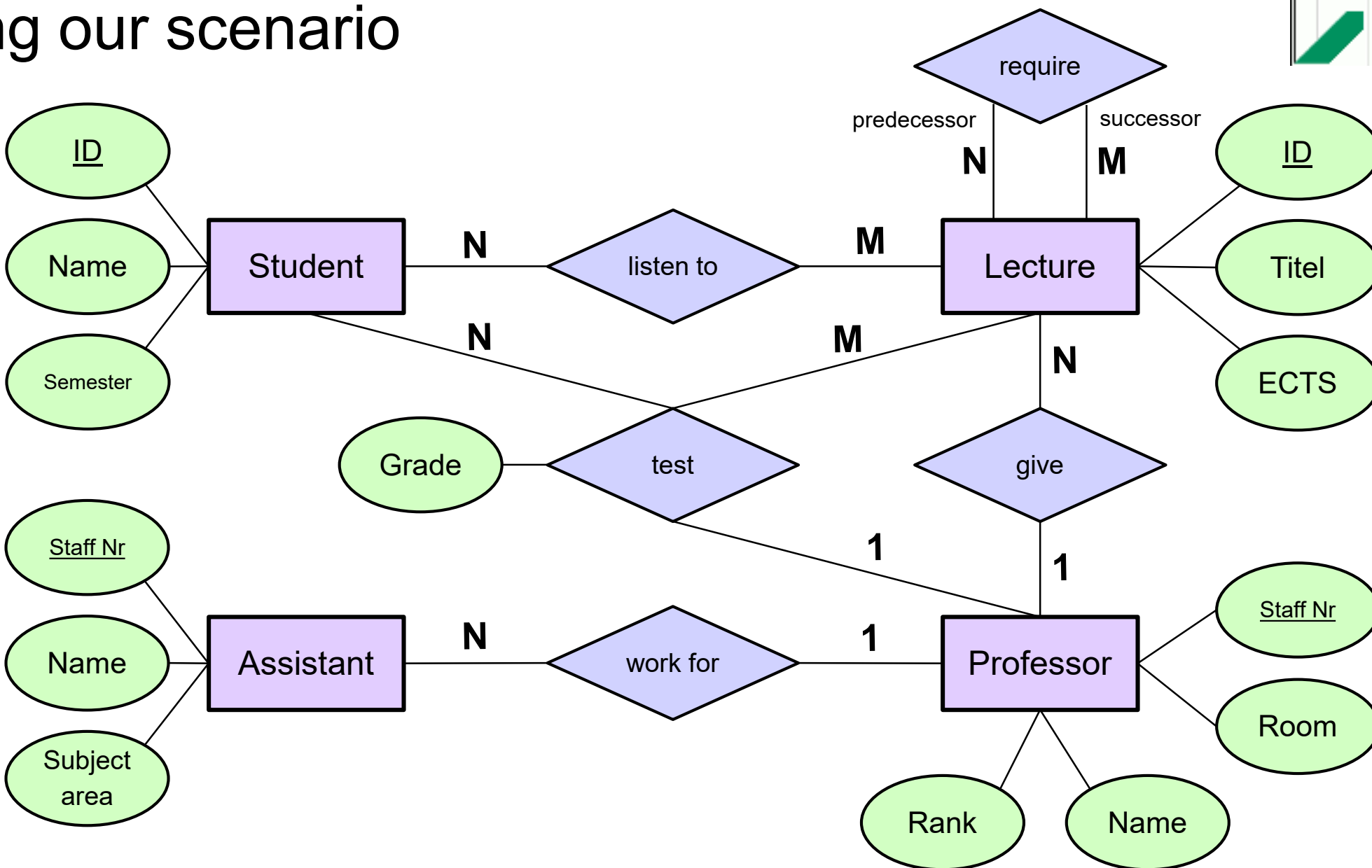


N:1



N:M

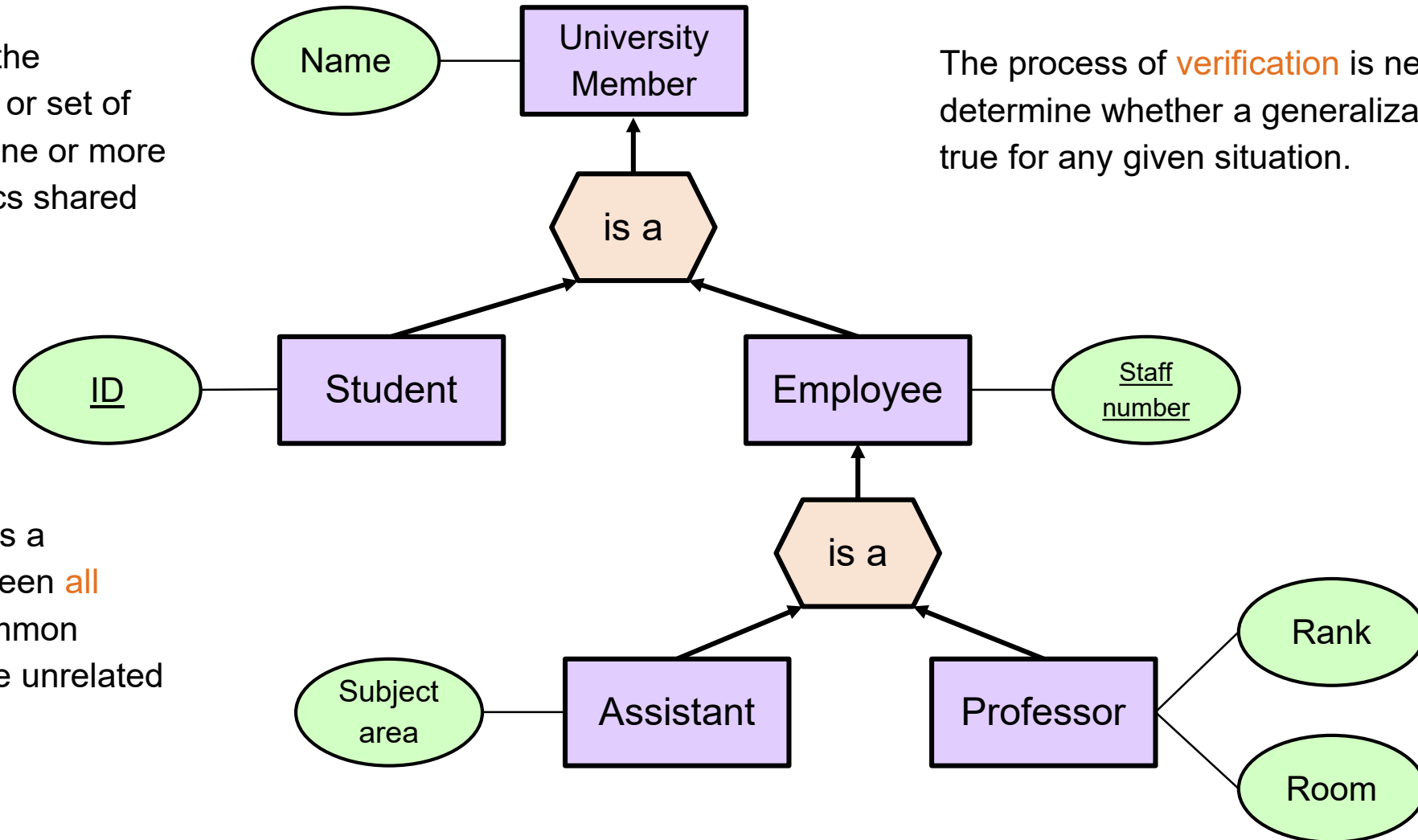
Modeling our scenario



Generalization

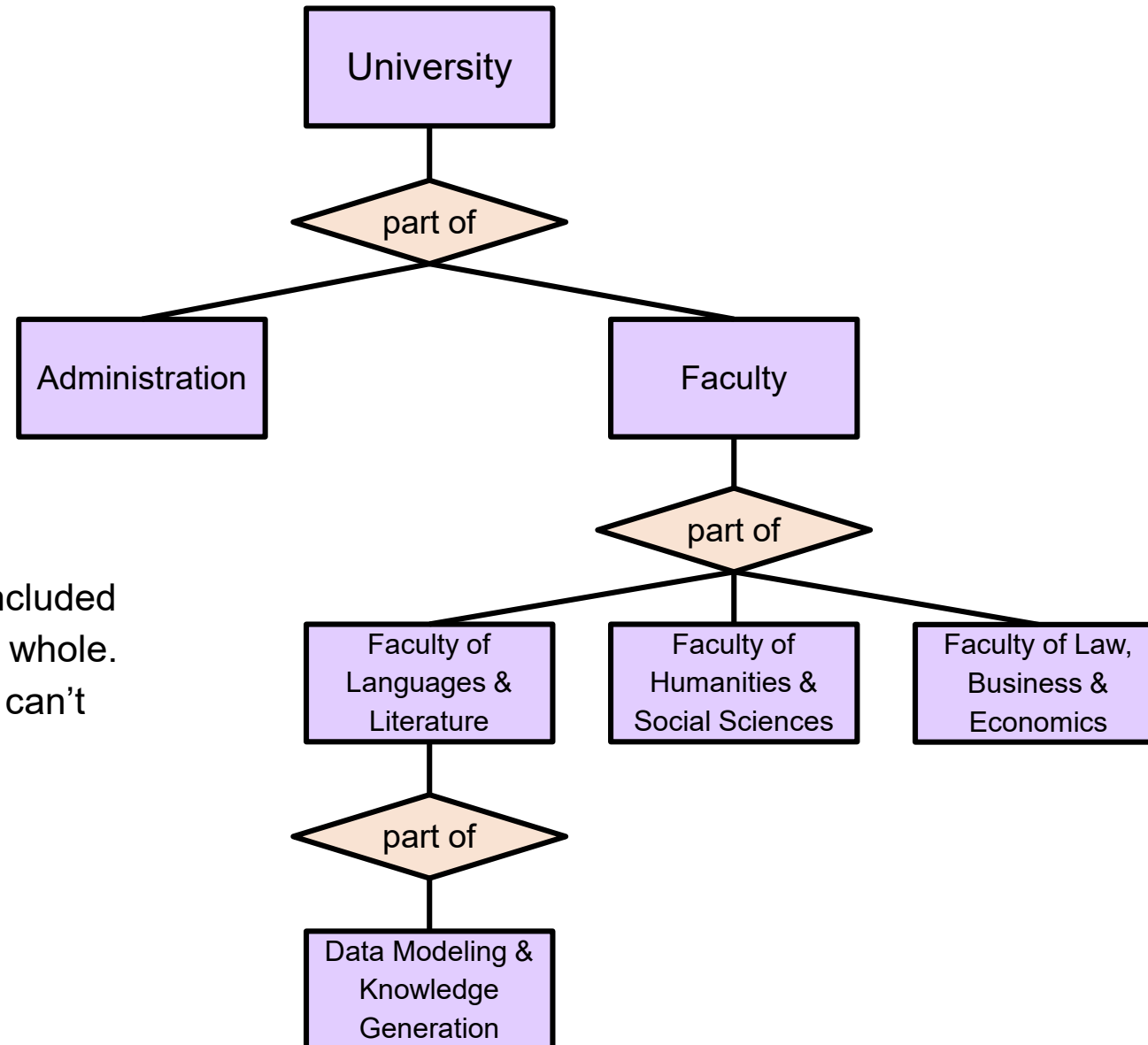
Generalizations posit the existence of a domain or set of elements, as well as one or more common characteristics shared by those elements

The process of **verification** is necessary to determine whether a generalization holds true for any given situation.



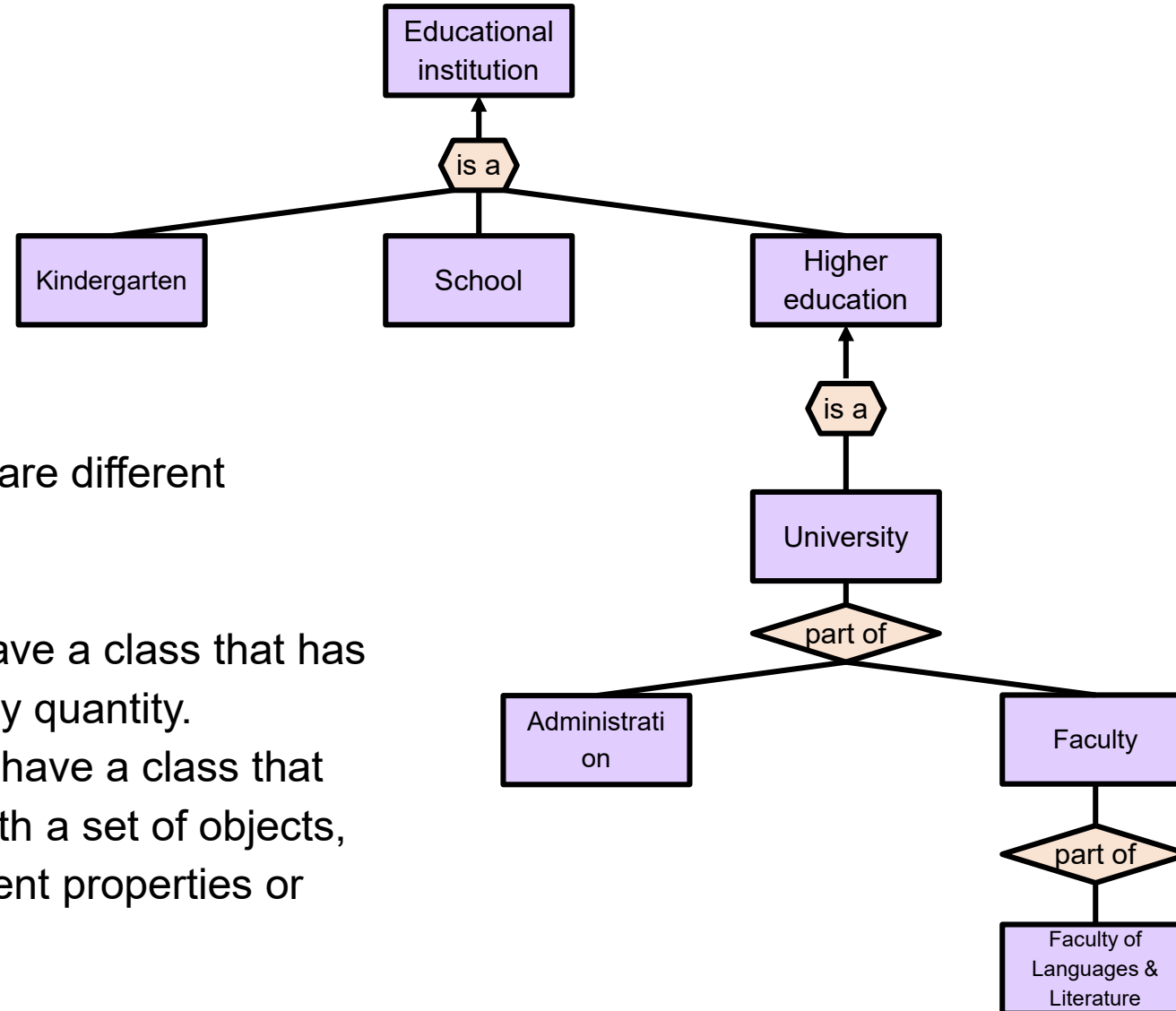
Generalization requires a common relation between **all** parts. Without this common relation, parts might be unrelated

Composition a.k.a. Composed Aggregation



In a **composition**, parts are physically included in the whole. Parts live and die with the whole. A part can only belong to a whole but it can't exist on its own.

Generalization & Composition



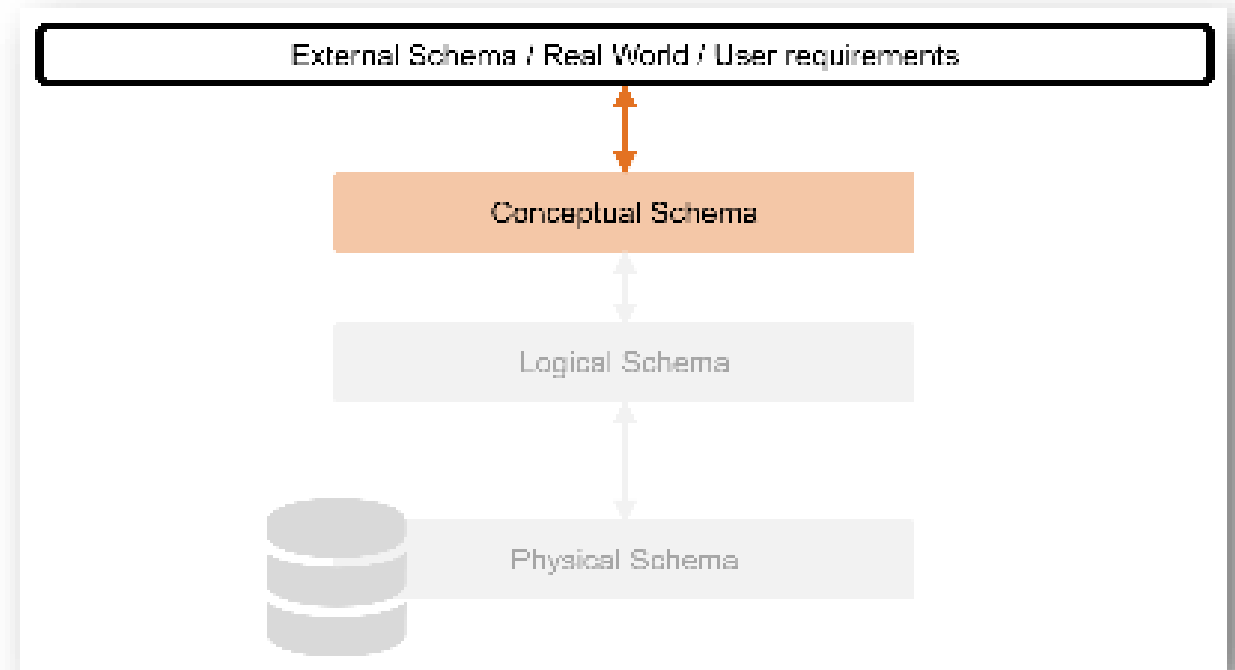
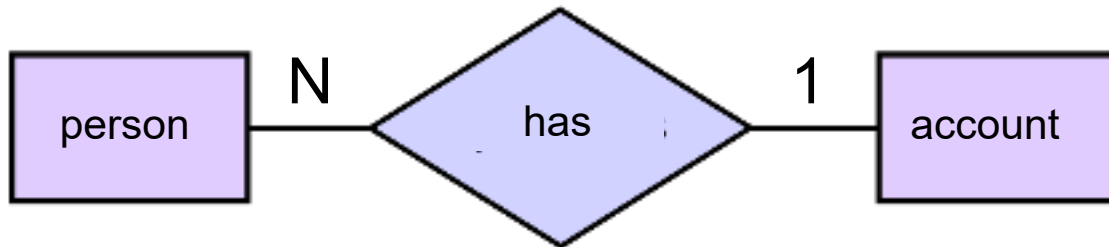
Generalization and composition are different concepts:

- Use **composition** when you have a class that has a set of another objects, in any quantity.
- Use **generalization** when you have a class that shares common properties with a set of objects, but can also have other different properties or behavior.

Summary

By data modeling we try to find a translation of real-world situations to data & databases

Clear analysis of the requirements is an important step in data modeling.



An **entity-relationship model** describes interrelated things of interest in a specific domain of knowledge.

Thanks.

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