UNIVERSITÀ
DEGLI STUDI
DI PADOVA

Introduction to Database Design

Basi di Dati

Bachelor's Degree in Computer Engineering
Academic Year 2024/2025

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DIPARTIMENTO
DI INGEGNERIA
DELL'INFORMAZIONE

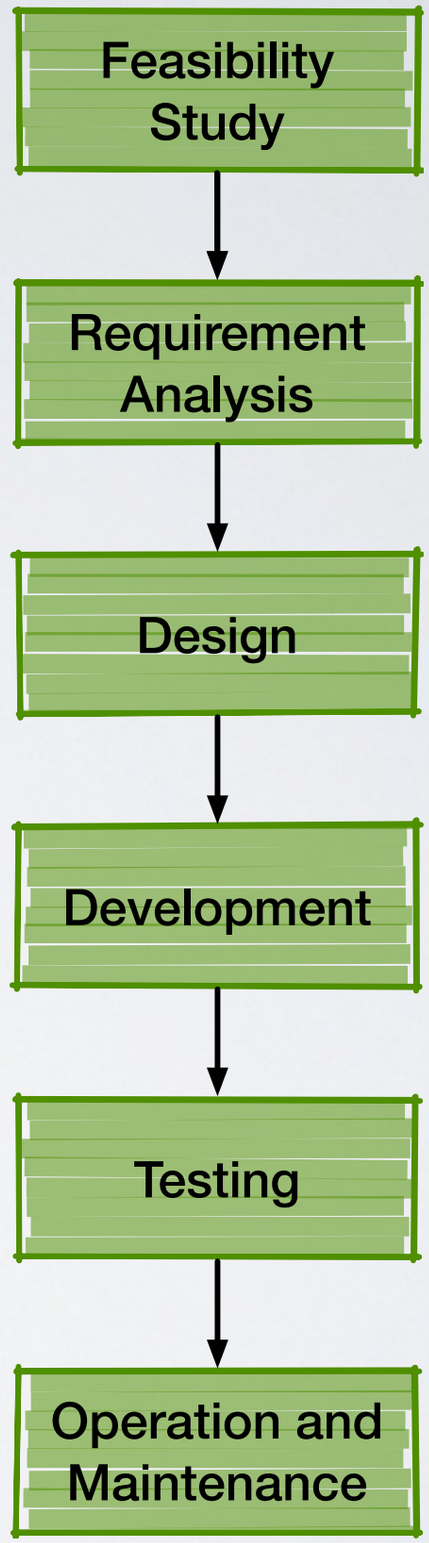
Outline

- Life cycle of an information system
- Requirement analysis
- Database design
- Conceptual, logical, and physical design

Software Lifecycle

Information System Life Cycle

- Feasibility Study
- Requirement Analysis
- Design
  - data design
  - application design
- Development
- Testing
- Operation and Maintenance



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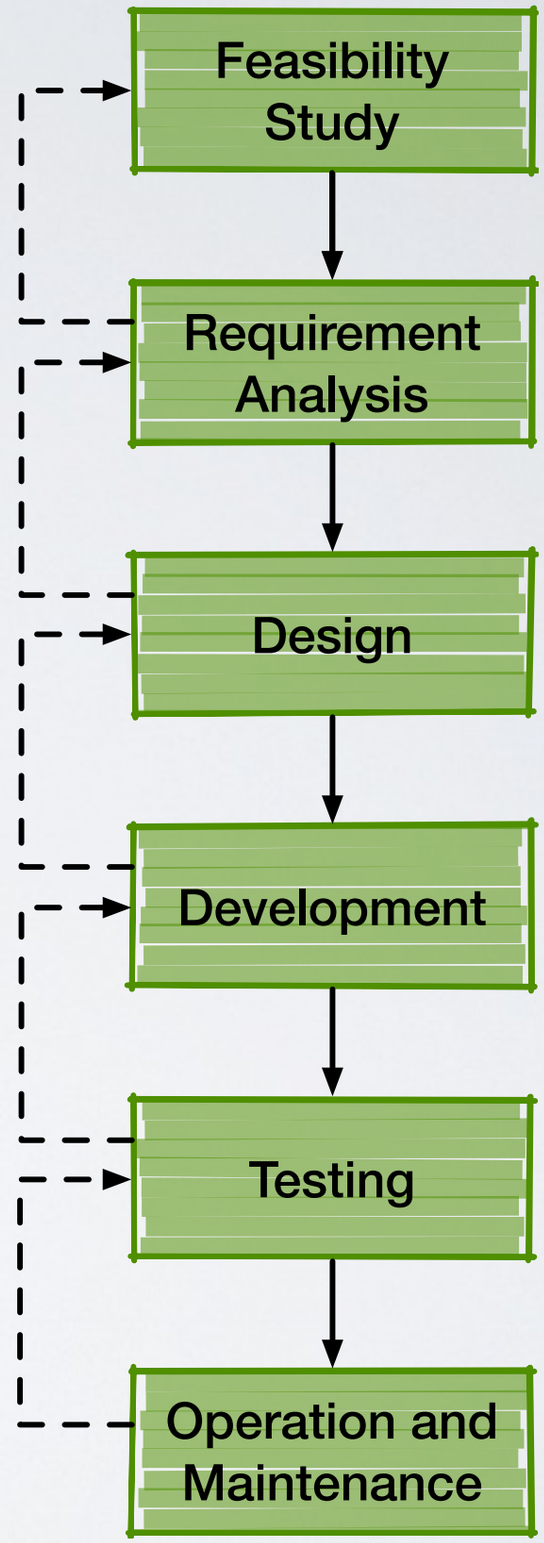

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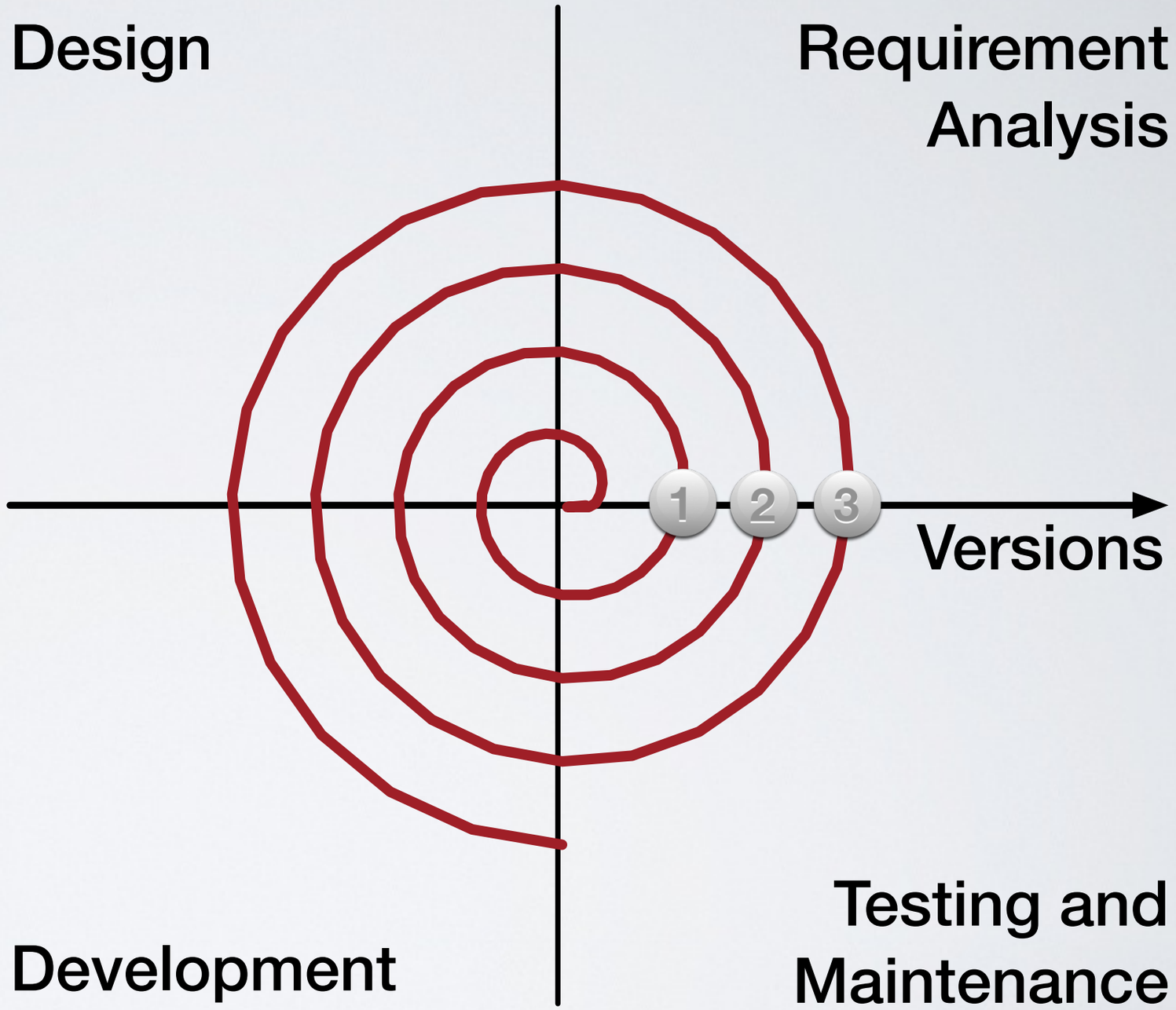


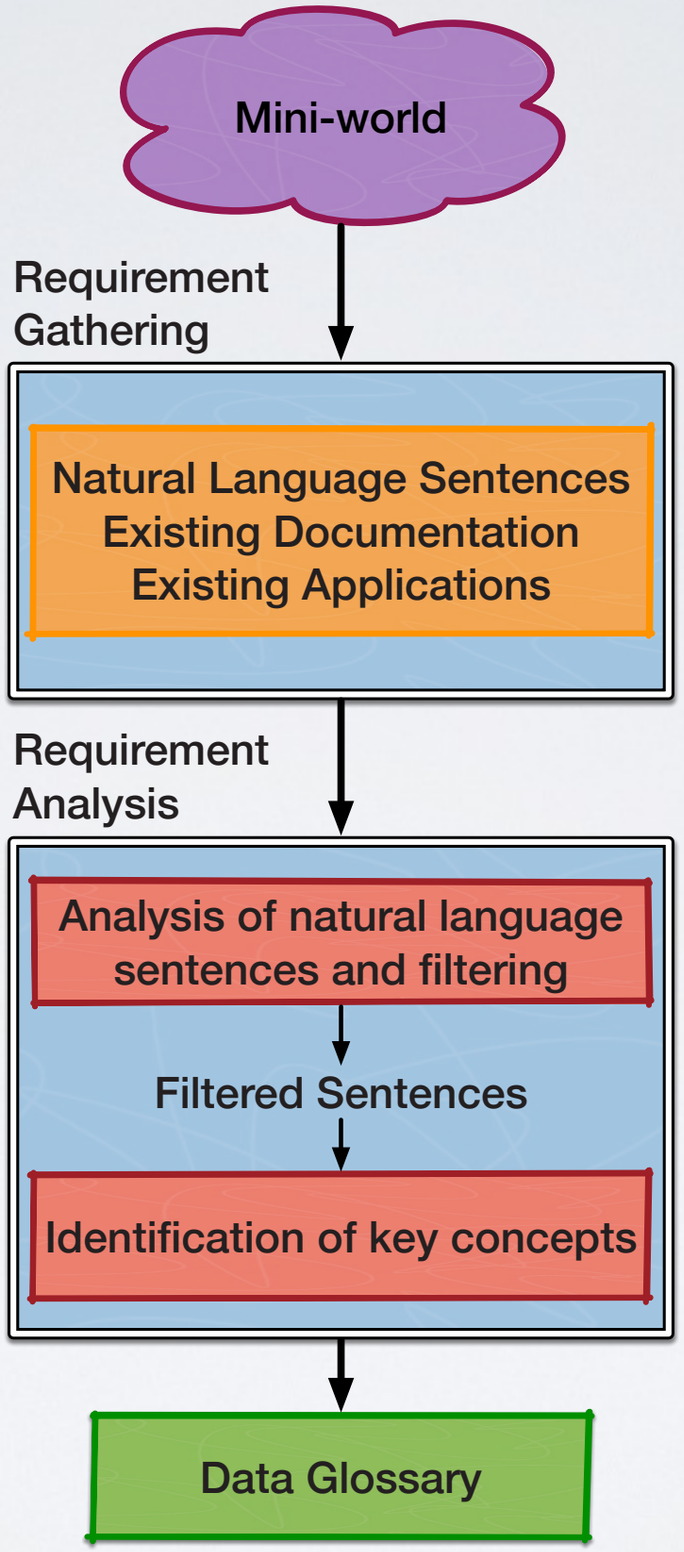
Requirement Analysis

Requirements

Requirements are the set of **features** that a **system** must **have** to **comply** with its **purpose**

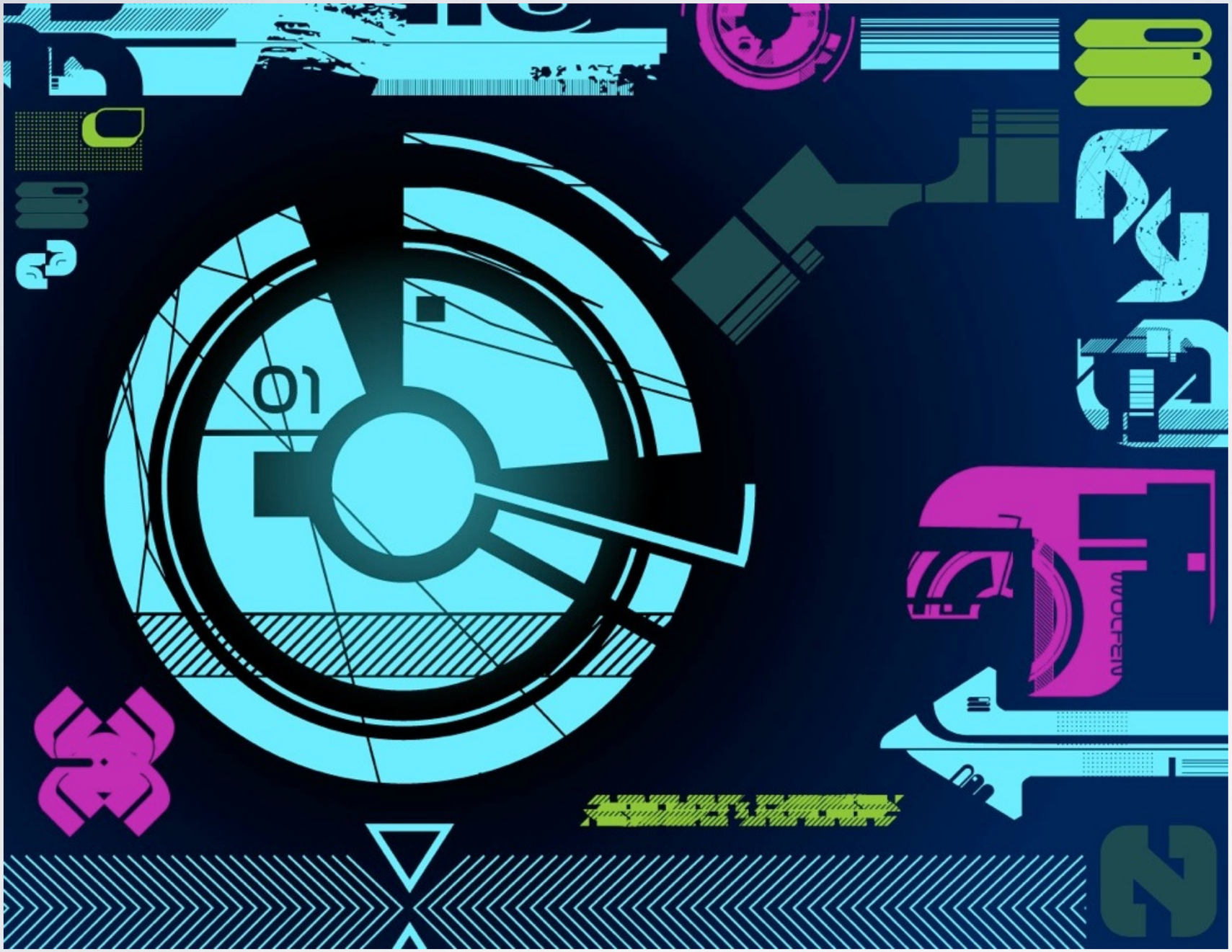
- Functional requirements
  - what the system must do, e.g. printing the invoice
- Non-functional requirements
  - the way in which a system must do something, e.g. printing in less than a minute
- Other constraints
  - general requirements set by stakeholder, often defined ahead, like using Linux

Requirements Gathering and Analysis



Users

Users



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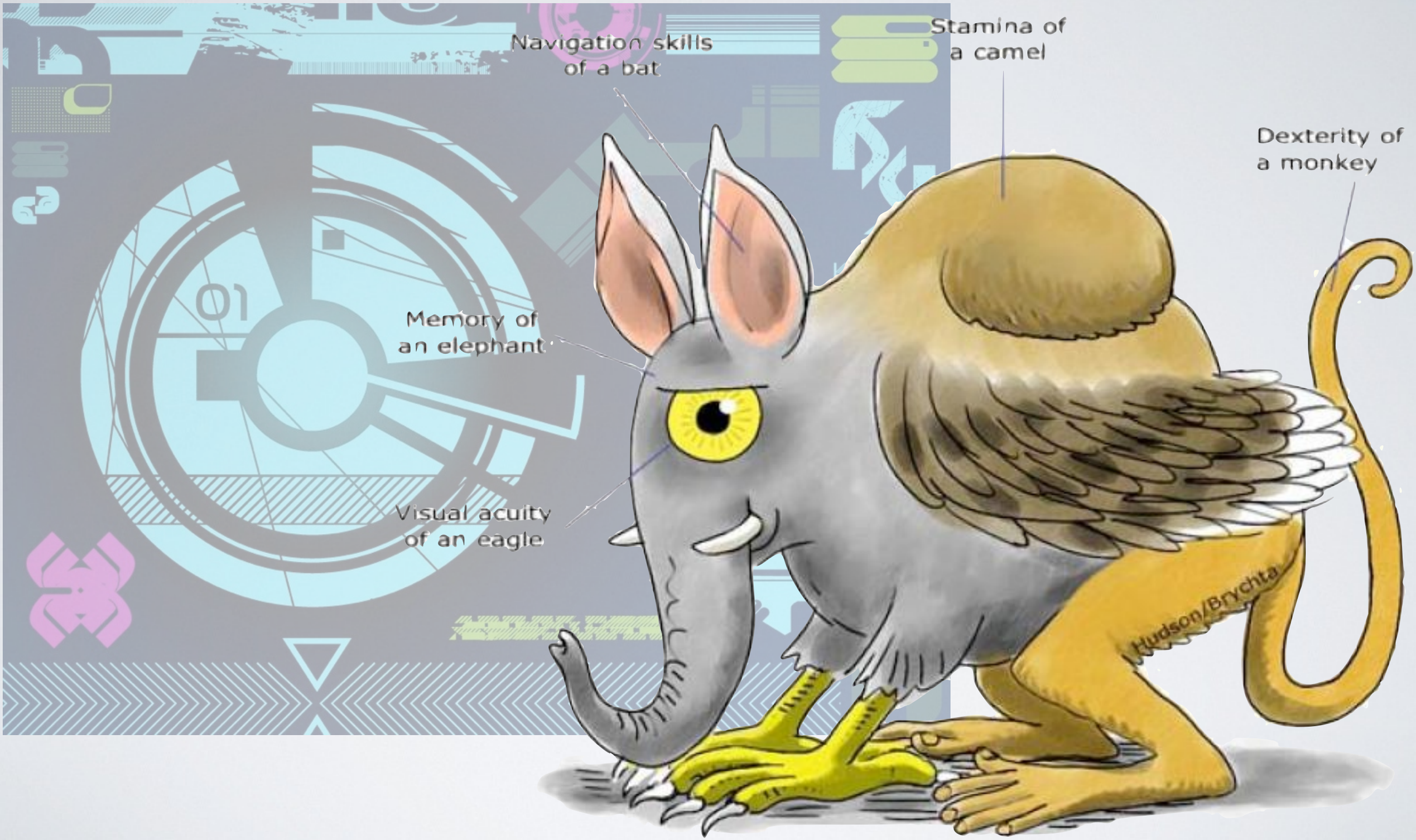
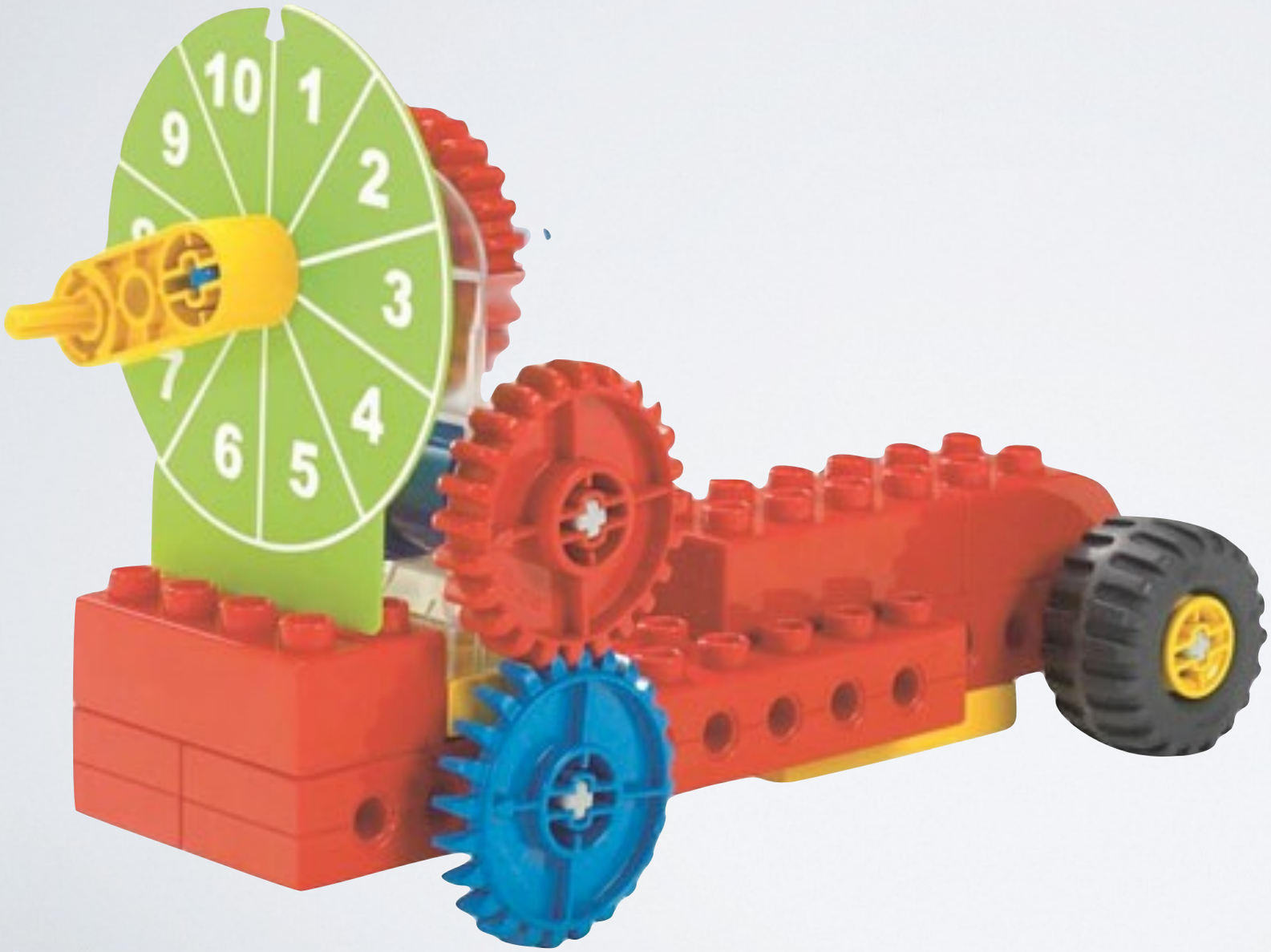

Navigation skills
of a bat
Stamina of
a camel
Dexterity of
a monkey
Memory of
an elephant
Visual acuity
of an eagle
Hudson/Brychta

Users



Users

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Errors, Errors, Errors

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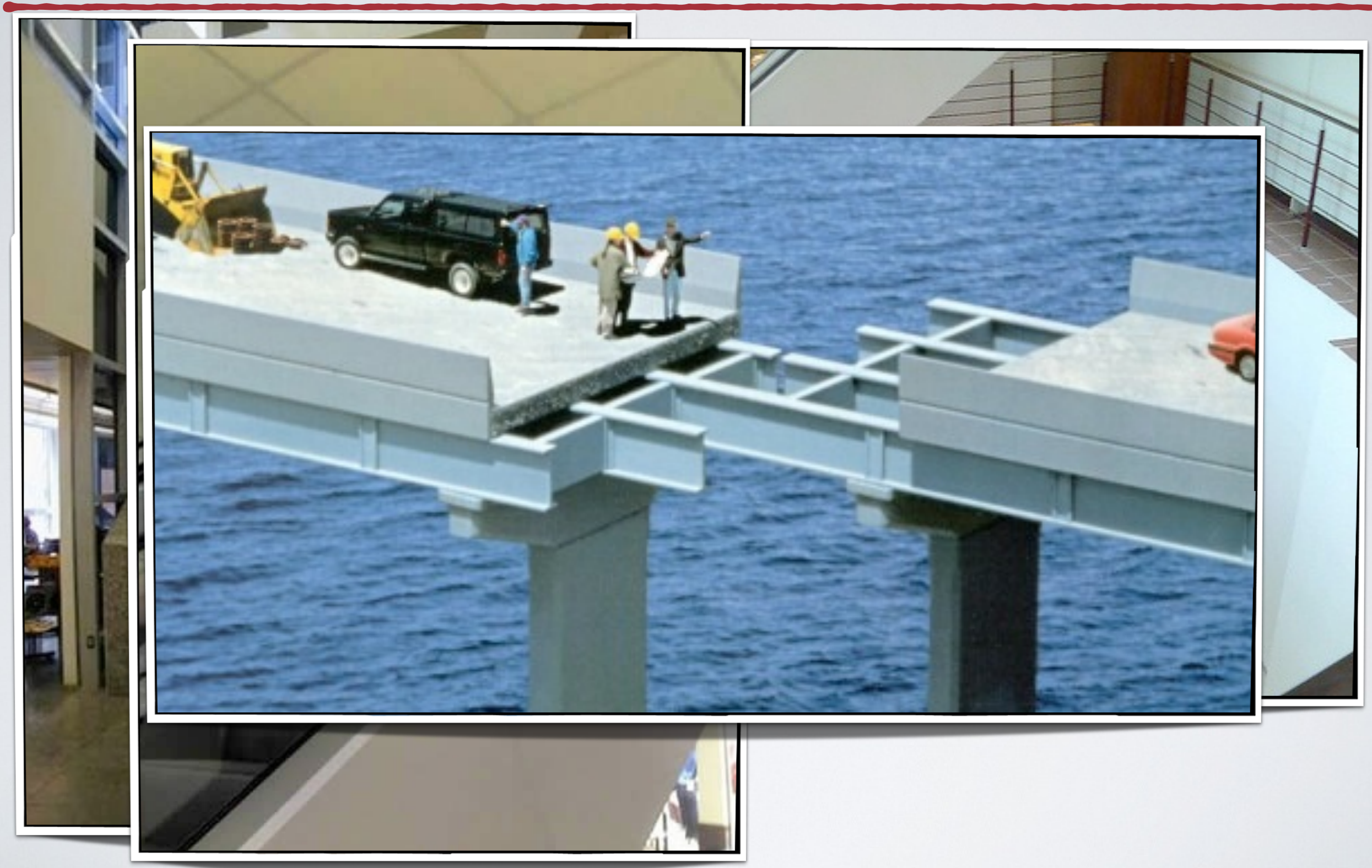
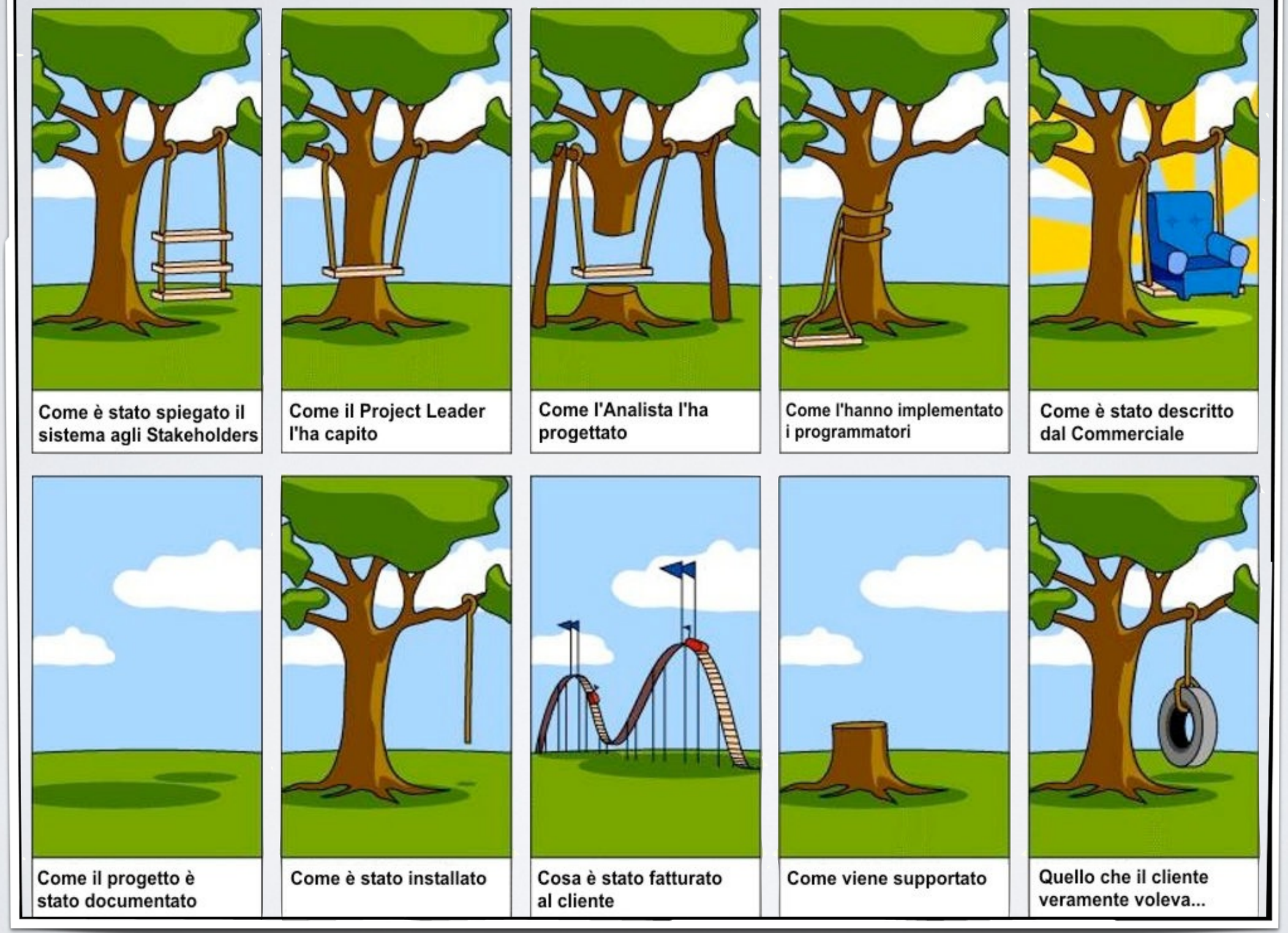


Bad Practices



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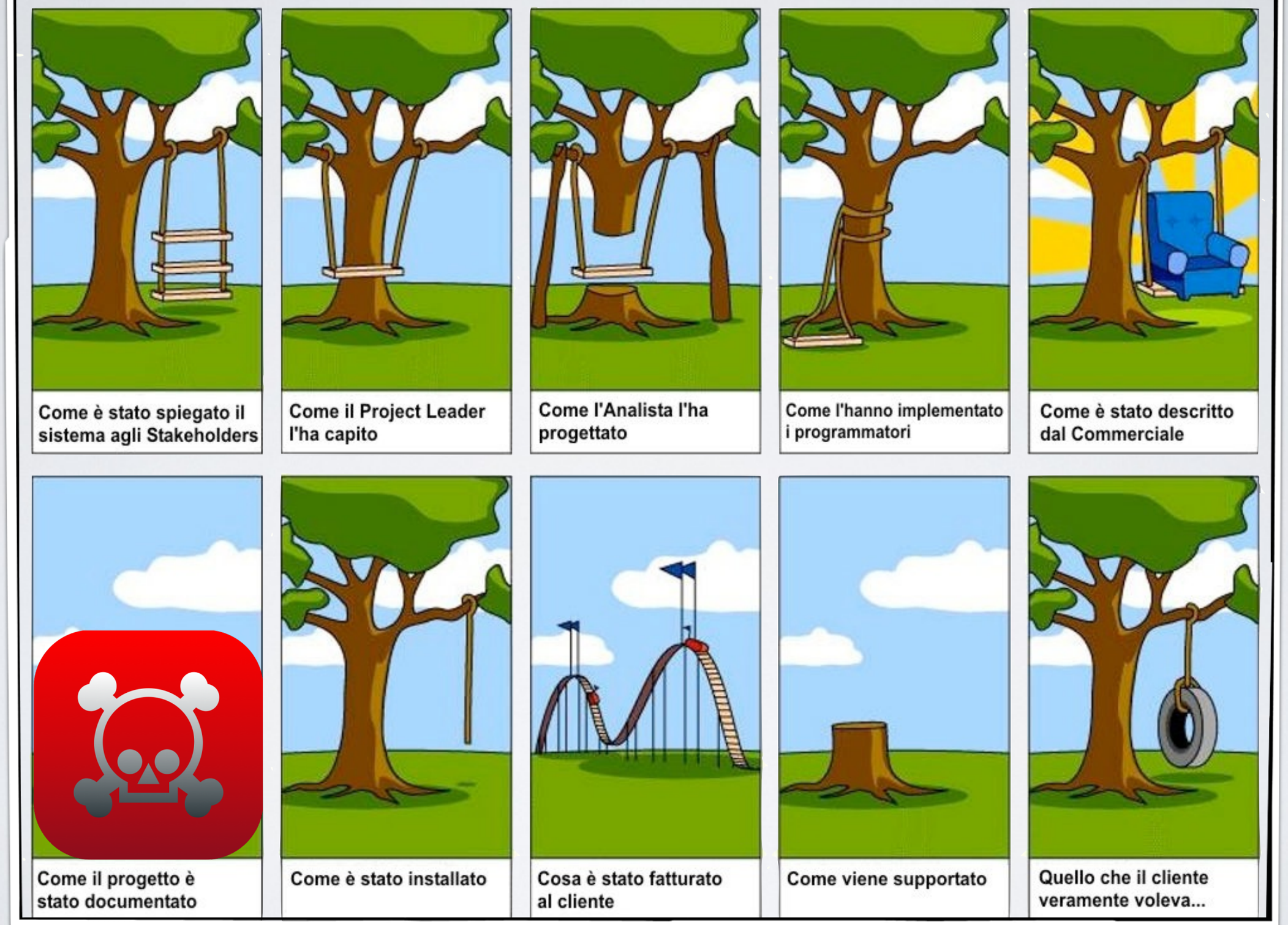


Database Design

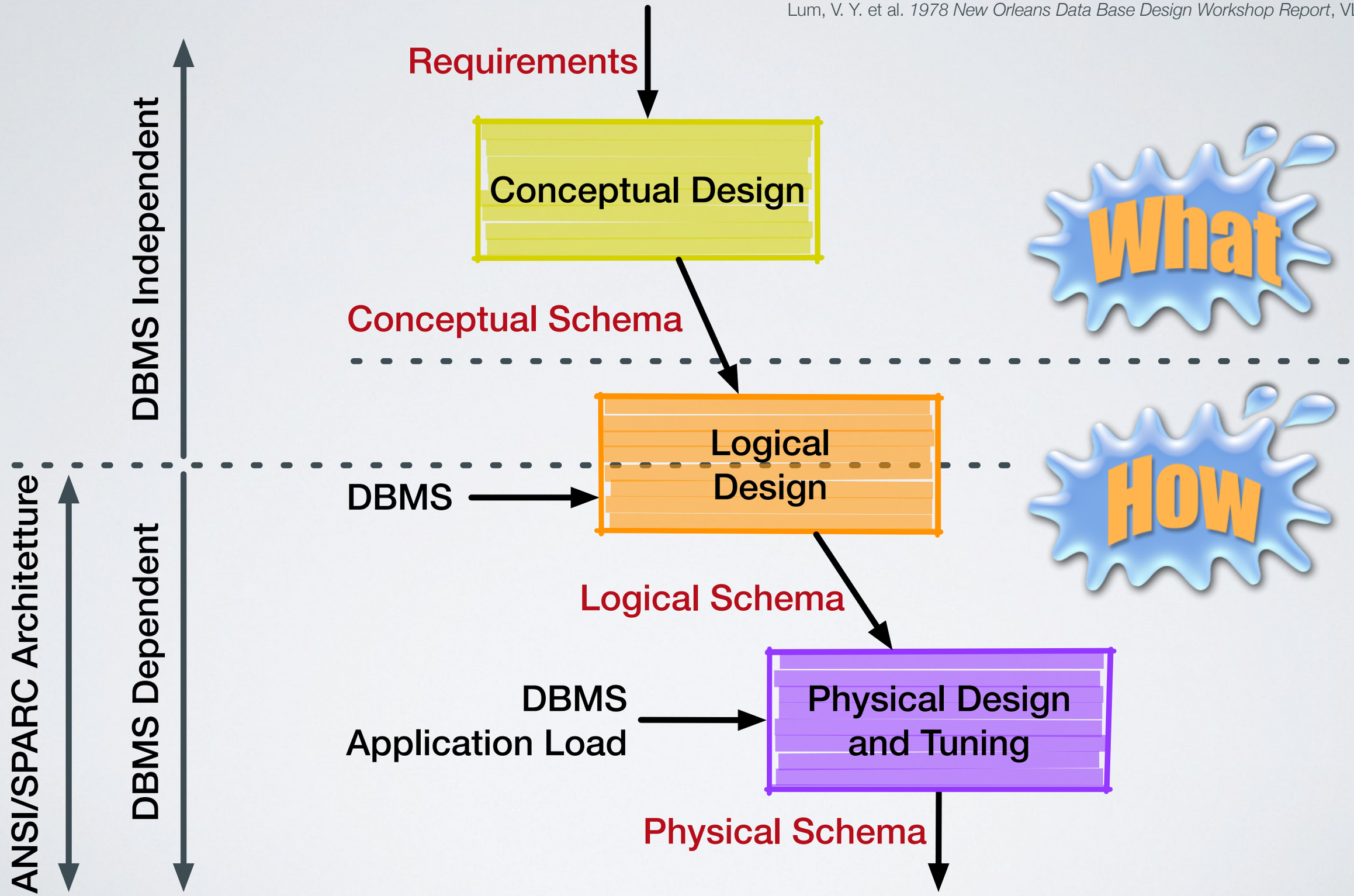
Goals of the Database Design

The **database design** aims at defining the **logical schema** and the **physical schema** (see the ANSI/SPARC architecture) of a database, according to the outcomes of the **requirement analysis**

- **Scenario I**: database design is part of a broader process, i.e. the design of the whole information system
- **Scenario II**: database design is a stand-alone process

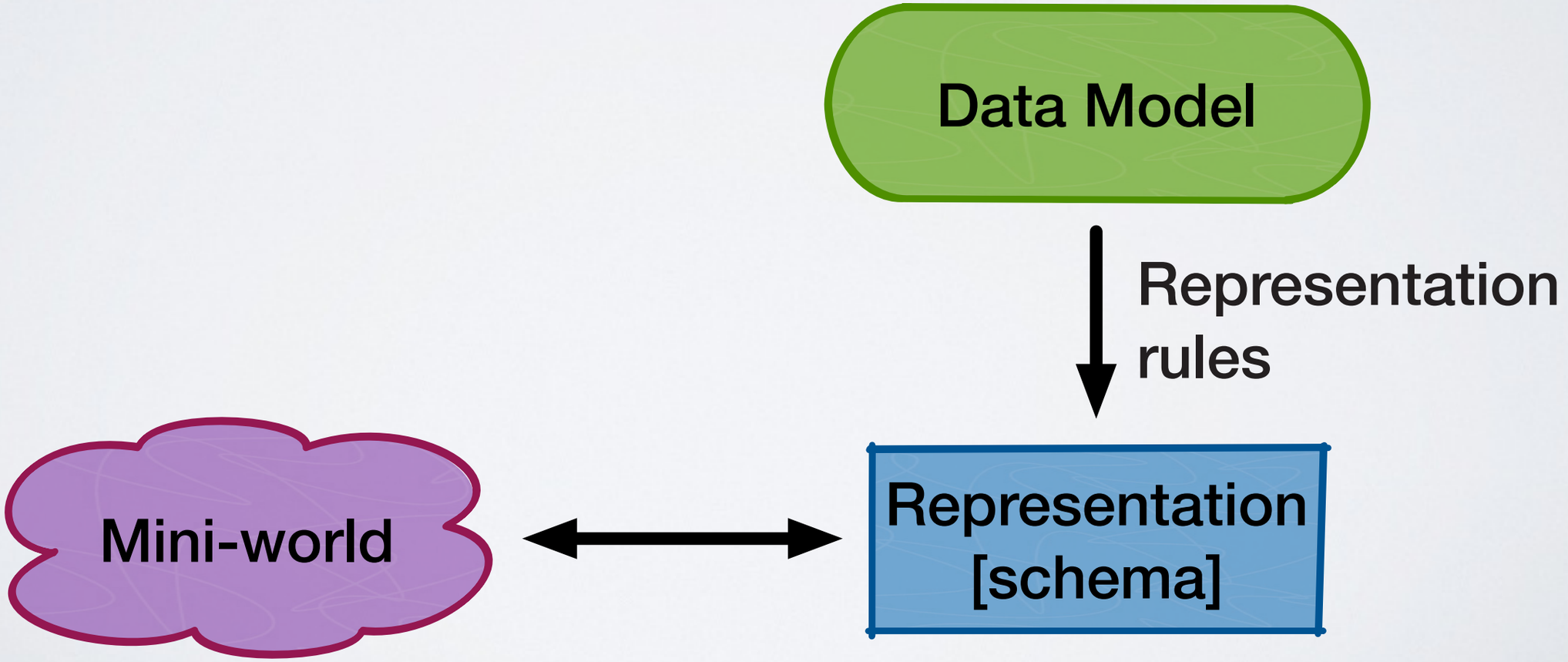
Database Design

Lum, V. Y. et al. *1978 New Orleans Data Base Design Workshop Report*, VLDB 1979



Data Model

A **(data) model** is a set of **symbolic structures** used to describe the **representation** of a **mini-world** of interest.
This representation is called **schema**



Schema and Instance

- A **schema** describes the structure of a database and represents the **intensional** level of a database

- An **instance** consists of the actual data and represents the **extensional** level of a database

Quality of a Schema

- **Completeness**: the schema must represent all the concepts (and their properties) relevant to the mini-world and identified in the requirements
- **Correctness**: the representation structures must be used properly and according to the prescribed semantics
- **Minimality**: each concept must be represented only once
  - you may still have duplications of concepts but they must be carefully motivated and documented
- **Readability**: the schema should be easy to read and self-explaining

Conceptual Design

Representation of the mini-world by means of a **high-level formal model**, integrating all the relevant concepts and **independent from the DBMS**

- **Input**: description of the mini-world resulting from the requirement analysis
- **Output**: conceptual schema plus additional constraints
- **Quality**: completeness; correctness; minimality; readability

Why the Conceptual Design?

- The designer reason to the right level of abstraction, independently from any DBMS and specific applications but focussing just on the mini-world to be represented
- The conceptual schema is understandable also by the stakeholders of the application which are actively involved in its design, reducing the risk of misunderstandings
- The conceptual schema is the most important source of documentation for the application and its subsequent modifications and extensions

Logical Design

Representation of the mini-world by means of **logical structures**, **independent** from **physical structures** and characteristic of a **class of DBMS**

- **Input:** conceptual schema; class of DBMS; estimated application load
- **Output:** logical schema plus additional constraints
- **Quality:** completeness; correctness; efficiency

Physical Design

Representation of the mini-world by means of **physical data structures** specific to a **given DBMS**

- **Input:** logical schema; a specific DBMS; estimated application load
- **Output:** physical schema plus tuning on the specific DBMS;
- **Quality:** correctness; efficiency

Wrap-up on Design

- Conceptual model → conceptual schema
  - Entity-Relationship (ER) model
- Logical model → logical schema
  - Relational model
- Logical model + physical parameters → physical schema
  - Structured Query Language (SQL) and its database-dependent extensions

Further Readings (1/2)

- Batini, C., De Petra, G., Lenzerini, M., and Santucci, G. (2002). *La progettazione concettuale dei dati*. Franco Angeli, Milano.
- Chen, P. P. (1976). The Entity–Relationship Model – Towards a Unified View of Data. *ACM Transactions on Database Systems (TODS)*, 1(1):9– 36.
- Codd, E. F. (1970). A Relational Model of Data for Large Shared Data Banks. *Communications of the ACM*, 12(6):377–387.
- Lum, V. Y., Ghosh, S. P., Schkolnick, M., Taylor, R. W., Jefferson, D., Su, S. Y. W., Fry, J. P., Teorey, T. J., Yao, B., Rund, D. S., Kahn, B., Navathe, S. B., Smith, D., Aguilar, L., Barr, W. J., and Jones, P. E. (1979). 1978 New Orleans Data Base Design Workshop Report. In Furtado, A. L. and Morgan, H. L., editors, *Proc. 5th International Conference on Very Large Data Bases (VLDB 1979)*, pages 328–339. IEEE Computer Society, Los Alamitos, CA, USA.

Further Readings (2/2, software engineering)

- Gezzi, C., Jazayeri, M., and Mandrioli, D. (2004). *Ingegneria del software. Fondamenti e principi*. Pearson Italia, Milano, 2nd edition.
- Pressman, R. S. (2010). *Software Engineering: A Practitioner's Approach*. McGraw-Hill, New York, USA, 7th edition.
- Sommerville, I. (2010). *Software Engineering*. Addison-Wesley, USA, 9th edition.

Questions?


WE INTERVIEWED HUNDREDS OF USERS AND TURNED ALL OF THEIR SUGGESTIONS INTO FEATURES.
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Dilbert.com
AS IT TURNS OUT, EVERY USER WE TALKED TO WAS AN IDIOT, AND THEIR DUMB SUGGESTIONS RUINED OUR PRODUCT.
5-7-12 ©2012 Scott Adams, Inc./Dist. by Universal Uclick
IN HINDSIGHT, WE PROBABLY SHOULD HAVE TALKED TO PEOPLE WHO WORK OUTSIDE THIS BUILDING.