Textbook: Object-Oriented Analysis & Design

Chapter 2: Part-B
The Object Model

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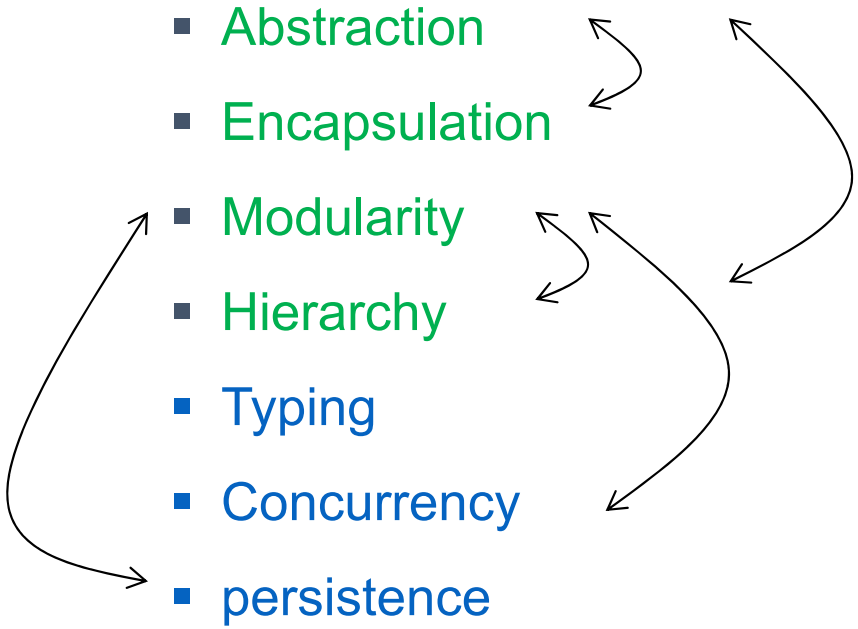
Object Model and Key Relationships

The Object Model is the collection of principles that form the foundation of object-oriented analysis and design and tools.

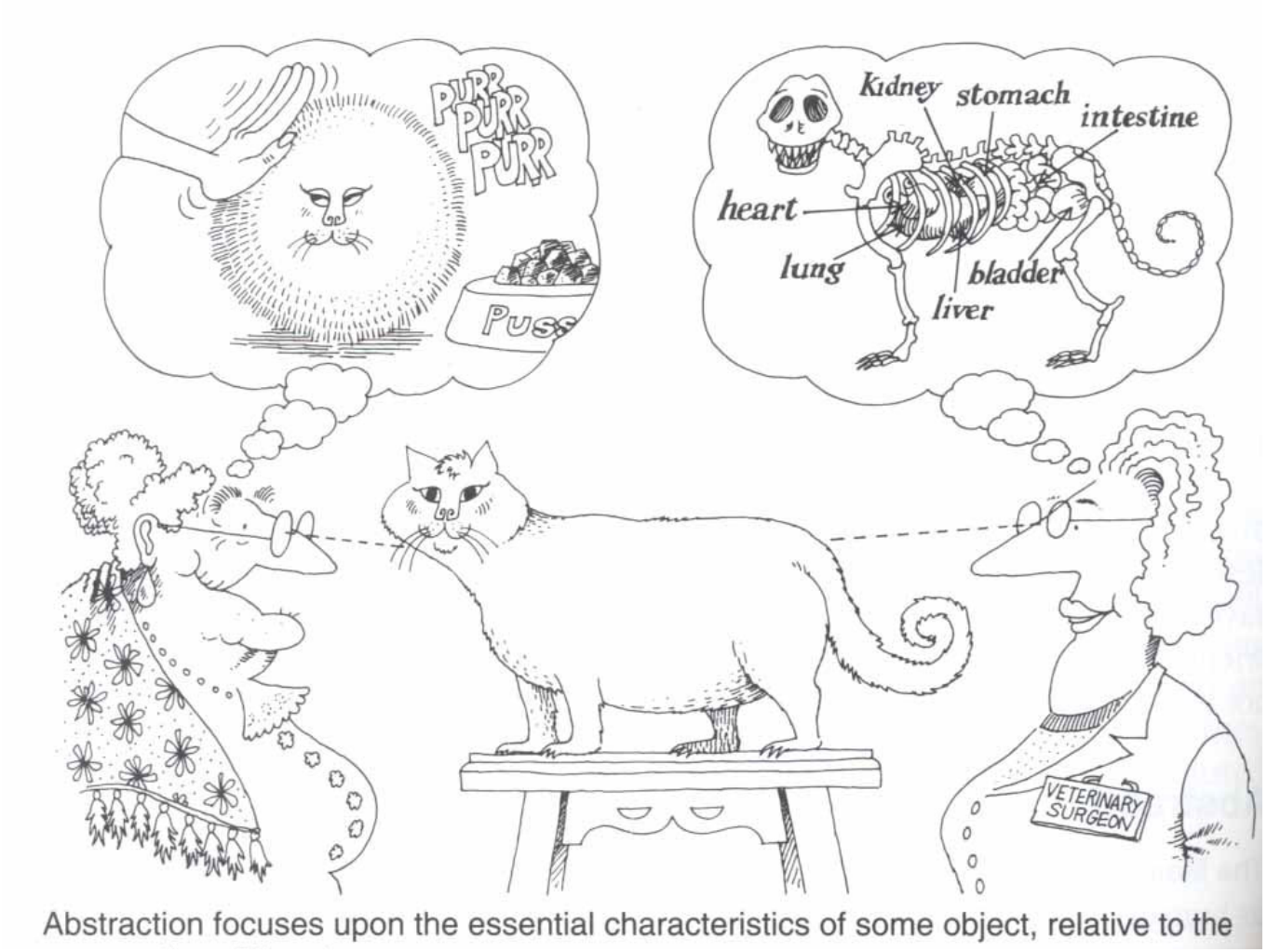
Object model provides a paradigm for software engineering emphasizing the principles of:



key relationships underpinning the "goodness" of software analysis, design, …

Many software engineering tools are founded on the principles of the Object Model.

Abstraction Caricature



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abstraction focuses upon the *essential characteristics* of **some object**, relative to the *perspective of the viewer*

Abstraction Definition

- An abstraction denotes the ***essential characteristics*** of an object that distinguish it from all other kinds of ***objects***.
- An abstraction provides crisply defined ***conceptual boundaries***, relative to the perspective of the user.
  - Abstraction arises from a recognition of similarities between certain *objects*, *situations*, or *processes* in the real-world and the decision to concentrate upon these while ignoring their differences.
  - An abstraction is a simplified description, or specification, of a system that emphasizes some of its details or properties while suppressing others.

Abstraction Definition (cont.)

Any abstraction has static as well as dynamic properties.

Ex: Data file object (e.g., bank account statement):

- A data object has name and content – these are its static properties
- The values of any static properties can change (dynamic); the values are subject to change depending on the state of the object – e.g., bank account balance may increase.

Abstraction Definition (cont.)

Each abstraction satisfies some ***invariance*** – conditions which it should preserve. For example, operations of an abstraction may be defined in terms of ***pre-conditions*** and ***post-conditions***. These pre- and post-conditions provide the **contractual basis** for the abstraction.

Ex: Consider Client/Server *Objects* of a website:

Invariance of the server object: client object will use a known data transmission rate (e.g., 10^3 gbps) to interact with the server object. A server object incapable of supporting the specified bandwidth fails to satisfy its contract!

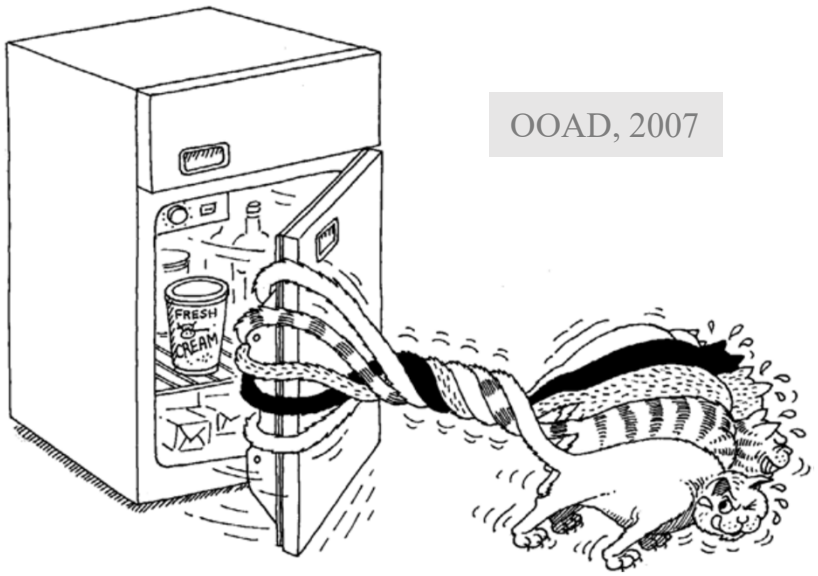
Hydroponics Farm

- A hydroponics farm refers to a type of farming where plants are grown in nutrient solutions – sand or other kinds of soil are not used.
- An automated system (gardener) is necessary to monitor and control temperature, humidity, light, nutrient concentrations, etc.
- An automatic gardener obtains information and controls growth of the plants under varying conditions and requirements

Kinds of Abstractions

- Entity: an object that represents a useful model of a problem-domain or solution-domain entity.
- Action: An object that provides a generalized set of operations, all of which perform the same kind of function.
- Virtual Machine: An object that groups together operations that are all used by some superior level of control or operations that all use some lower-level set of operations.
- Coincidental: An object that packages a set of operations that have no relation to one another.

data and function abstractions are fundamental to software engineering



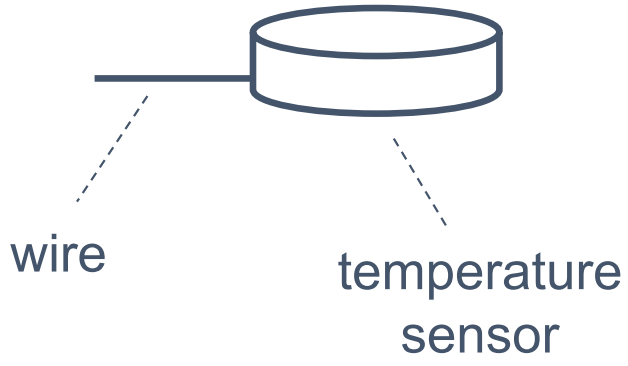
OOAD, 2007

Abstraction Example

Hydroponics Farm

- Sensors: temperature, light, humidity, …

- Temperature sensor
  - Operations:
    - measure and report temperature
    - calibrate



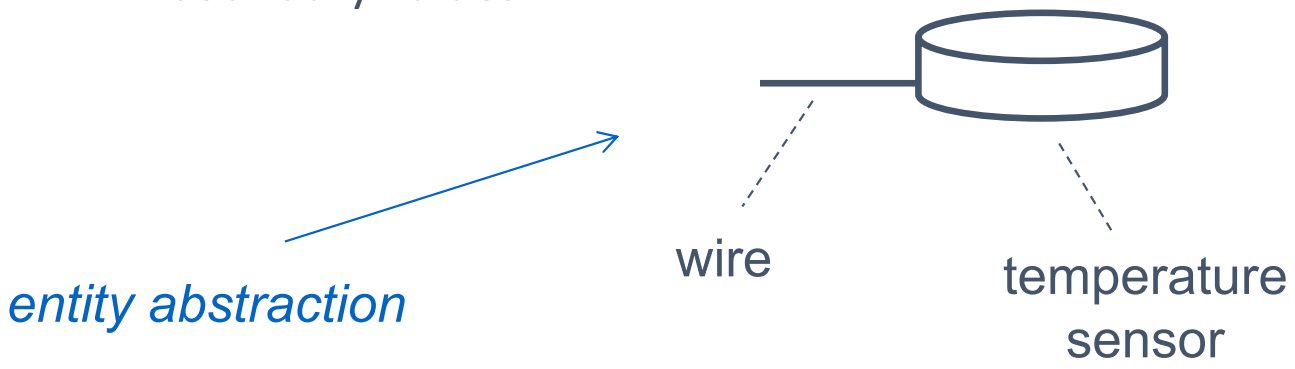
Abstraction Example (cont.)

Abstraction 1 (*passive*):

Temperature sensor

action abstraction

- Operations:
  - measure and report temperature *upon request*
- Attributes:
  - Name – string
  - Location – location can be a name, a number, …
  - Range – a specified set of values with minimum and maximum boundary values



entity abstraction

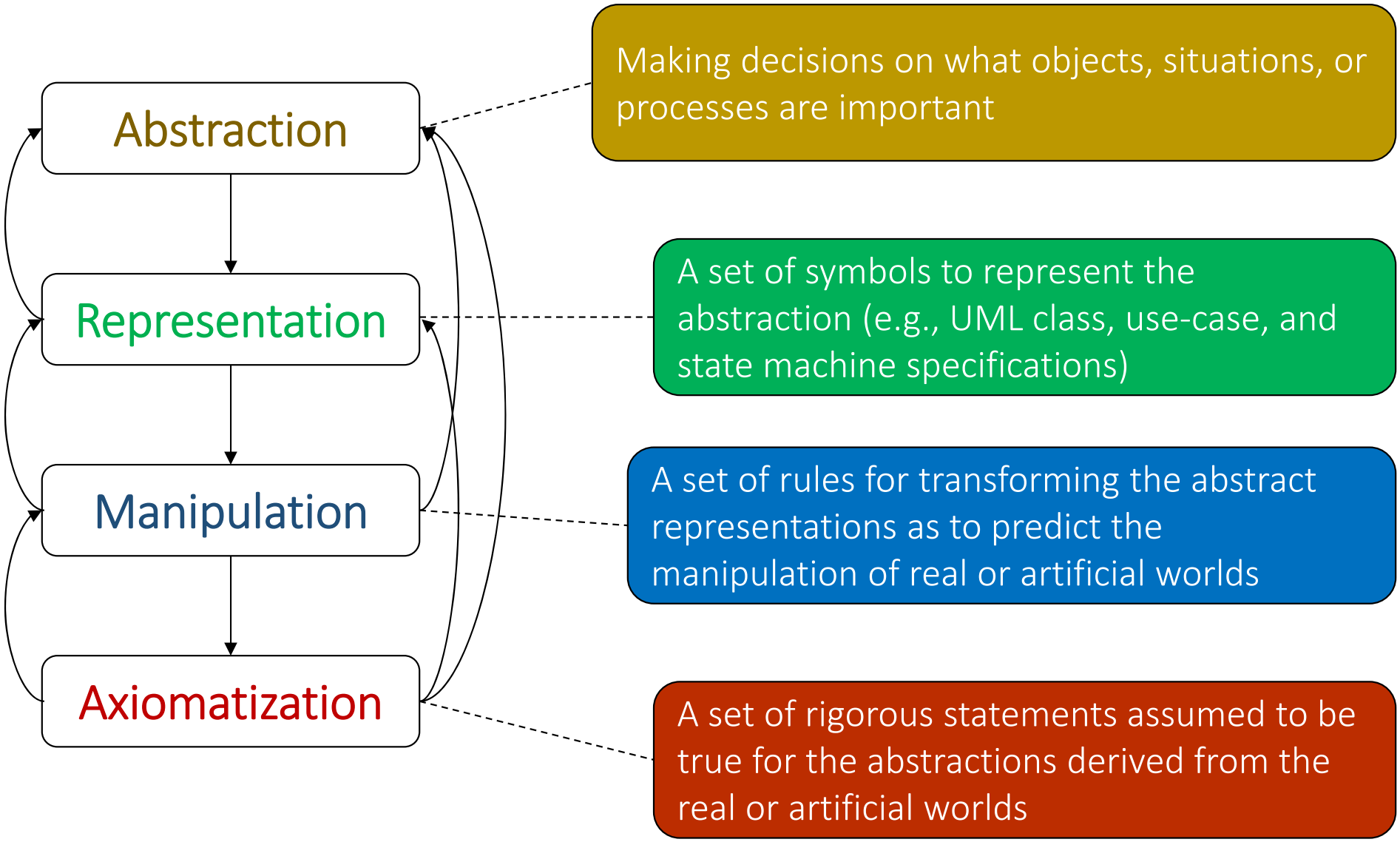
Abstraction Example (cont.)

Abstraction 2 (*active*):

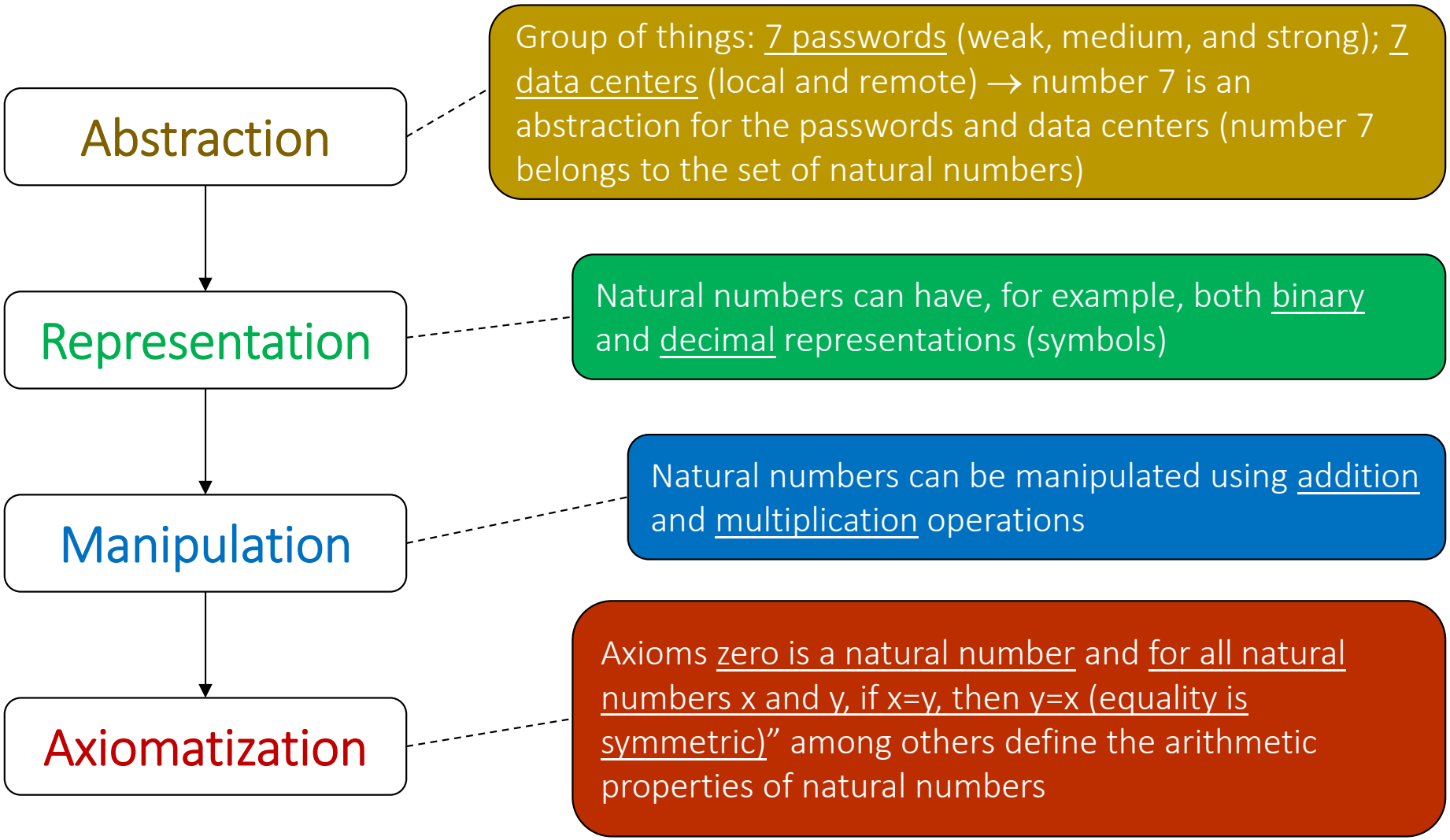
Temperature sensor

- Operations:
  - measure and notify an object *when temperature exceeds a certain set point value*
- Attributes:
  - Name – string
  - Location – location can be a name or a number
  - Range – a specified set of values with minimum and maximum boundary values

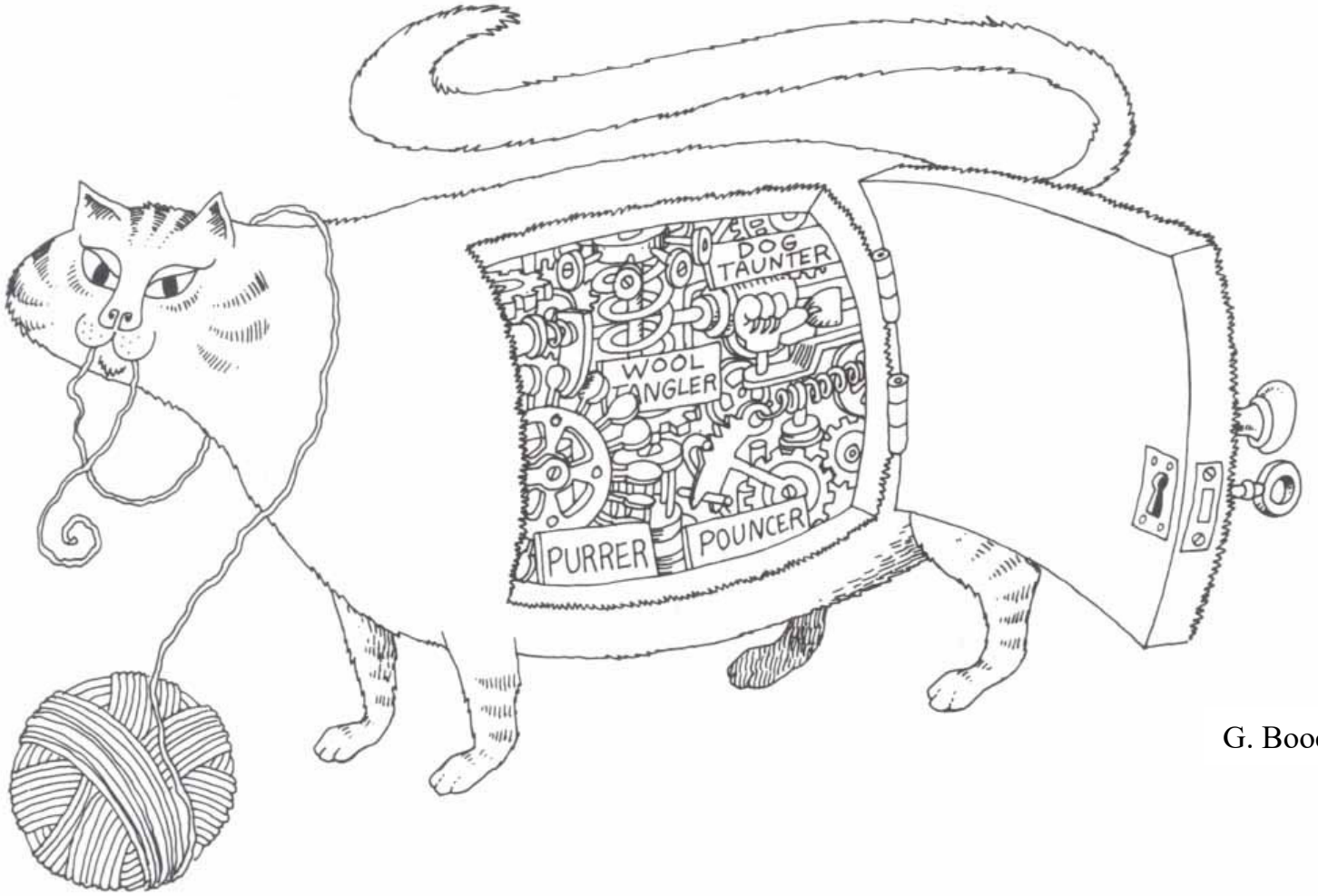
A Process for Abstraction: Concept



A Process for Abstraction: An example



Encapsulation Caricature



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encapsulation **hides the details** of the *implementation of the object*

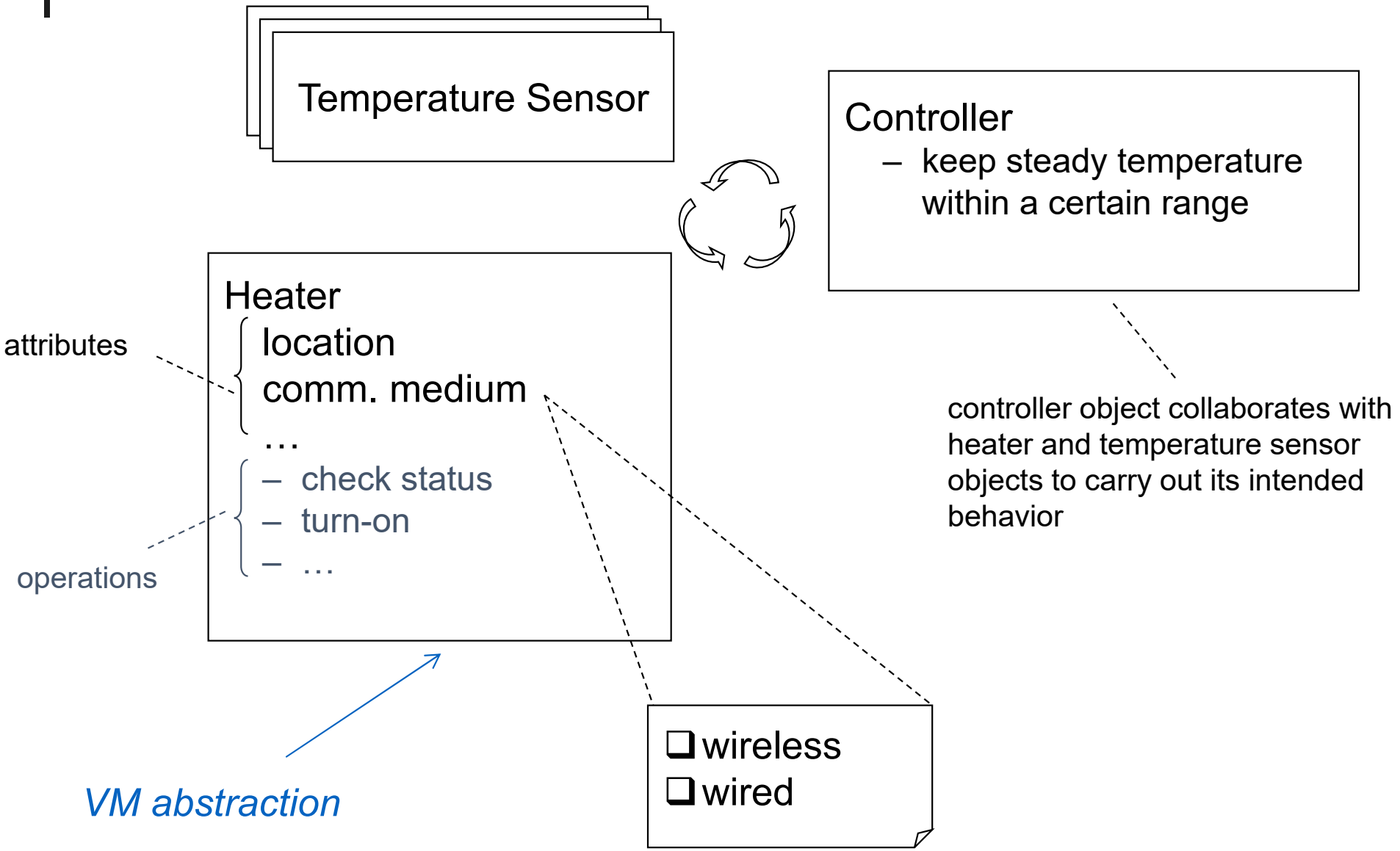
Encapsulation Definition

- Encapsulation is the process of compartmentalizing the elements of an abstraction that constitute its structure and behavior
- Encapsulation serves to separate the *contractual interface* of an abstraction and *its implementation*

Encapsulation and abstraction are complementary concepts

- Abstraction focuses on observable behavior of an object
- Encapsulation focuses upon the implementation that gives rise to some desired observable behavior

Encapsulation Examples (1)



Encapsulation Examples (2)

- An *abstraction* of an object should precede the decisions about its *implementation*. [OOAD (page 50)]
  - Operations (refers to functions or methods)
  - Objects
- Once an implementation is selected, it should be treated as a secret of the abstraction and hidden from most clients. [OOAD (page 50)]

Encapsulation Examples (3)

- Example: Weather Channel App for the city of Tempe, Arizona
  - **operation**
    - A sensor measures temperature every 1 minute (or less frequently)
    - A sensor measurement can be the average of multiple sensor readings
  - **object**
    - A heater can be turned on/off and be queried about its status (running or not)
    - A heater can be maintain the temperature of an enclosure to remain within some lower and upper limits

Modularity Caricature

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modularity packages abstractions into discrete units

Modularity Definition

Modularity is the property of a ***system (software)*** that has been decomposed into ***a set of cohesive and loosely*** coupled modules

Modularity, encapsulation, and abstraction are complementary concepts

- An object provides a crisp boundary around a single abstraction
- Modularity and encapsulation provide barriers around this abstraction

choices of modules are based on domain knowledge, patterns, …

What is a Module?

- A unit of code that serves as a building block for the physical structure of a system – it consists of interface and implementation

- A program that contains declarations, expressed in the vocabulary of a particular programming language, that form the physical realization of some or all of the classes and objects in the logical design of the system

*modules are necessary to support **structural changes***

Modularity Example

Hydroponics example

- Module for plans of how to grow various plants
- Module for graphical user of the system
- Module for monitoring sensor readouts
- Module for control of greenhouse environment
- …

choices of modules are based on requirements, domain knowledge, …

Hierarchy Caricature

abstractions form a hierarchy

Abstractions form a hierarchy.

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Hierarchy Definition

Hierarchy is a ranking or ordering of abstractions

- *Part-Of* hierarchy – aggregation
- *Is-A* hierarchy (inheritance) – generalization & specialization

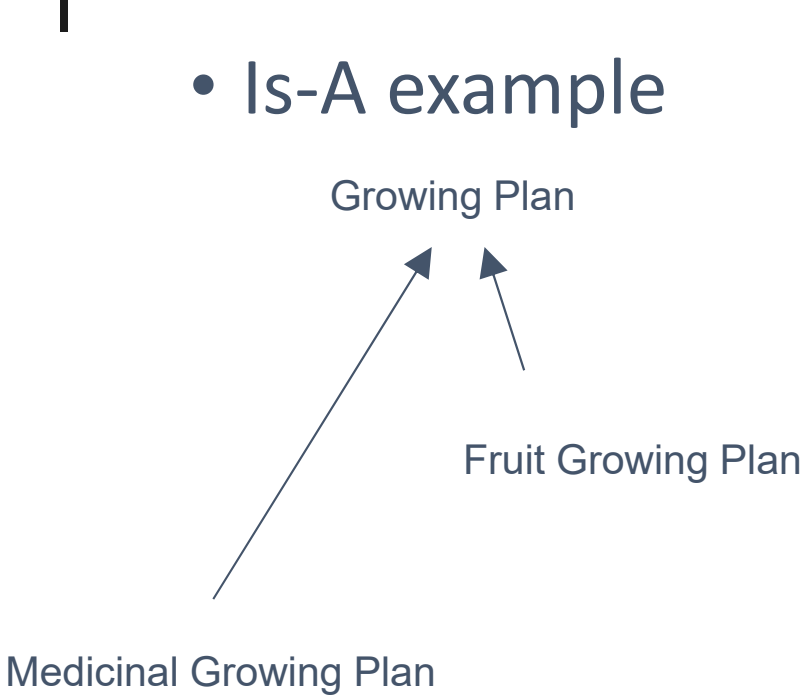
- Single inheritance: one class shares the structure and behavior of one class

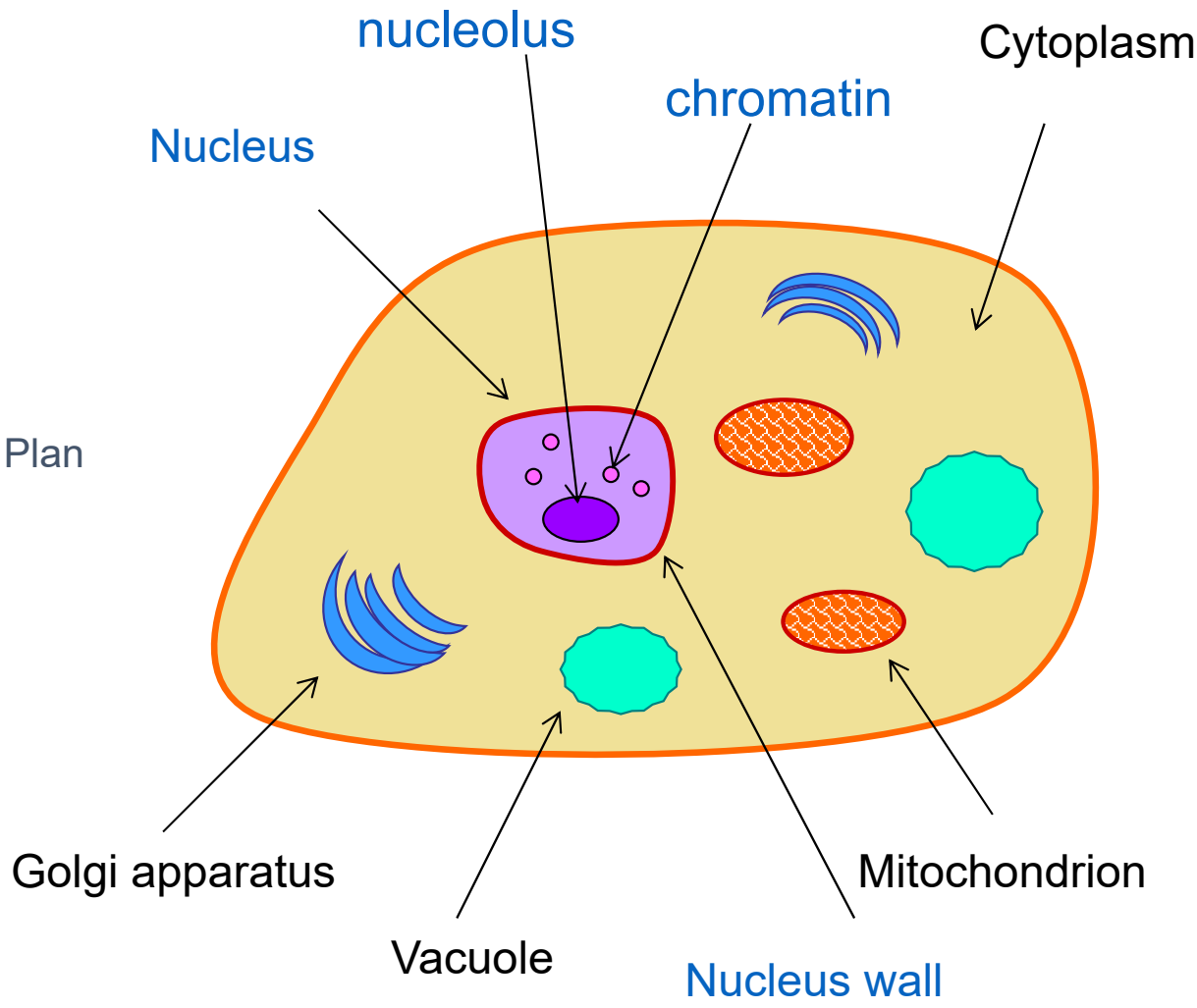
- Multiple inheritance: one class shares the structure and behavior of multiple classes

the principles of abstraction, encapsulation, modularity, and hierarchy work together.

Hierarchy Example

- Is-A example





plant cell structure

Exercise

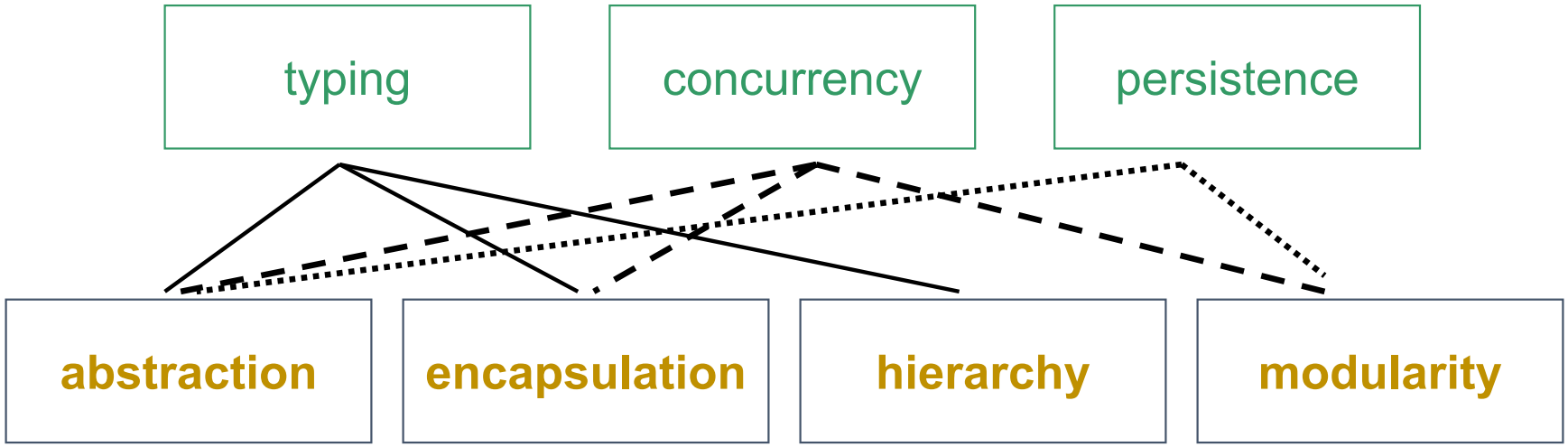
Characterize the different hierarchical relationships implied for:

- A soccer team consists of 18 players 11 of which can play at any time during a game. One scheme is to have three defensive players, four midfielder players, three offensive players, and one goalkeeper. Only one goalkeeper is allowed. A team must have a captain who is a member of a team and is a player on the field (i.e., not a player sitting on the reserve bench!).

The Object Model

The Object Model is based on seven principles which collectively provide the foundation for object-oriented software development

higher-level elements



lower-level elements

——— directly related to the Object Model

– – – – somewhat directly related to the Object Model

..... indirectly related to the Object Model