Design Smells and Refactoring

CS6.401 Software Engineering

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Acknowledgements

The materials used in this presentation have been gathered/adapted/generate from various sources as well as based on my own experiences and knowledge

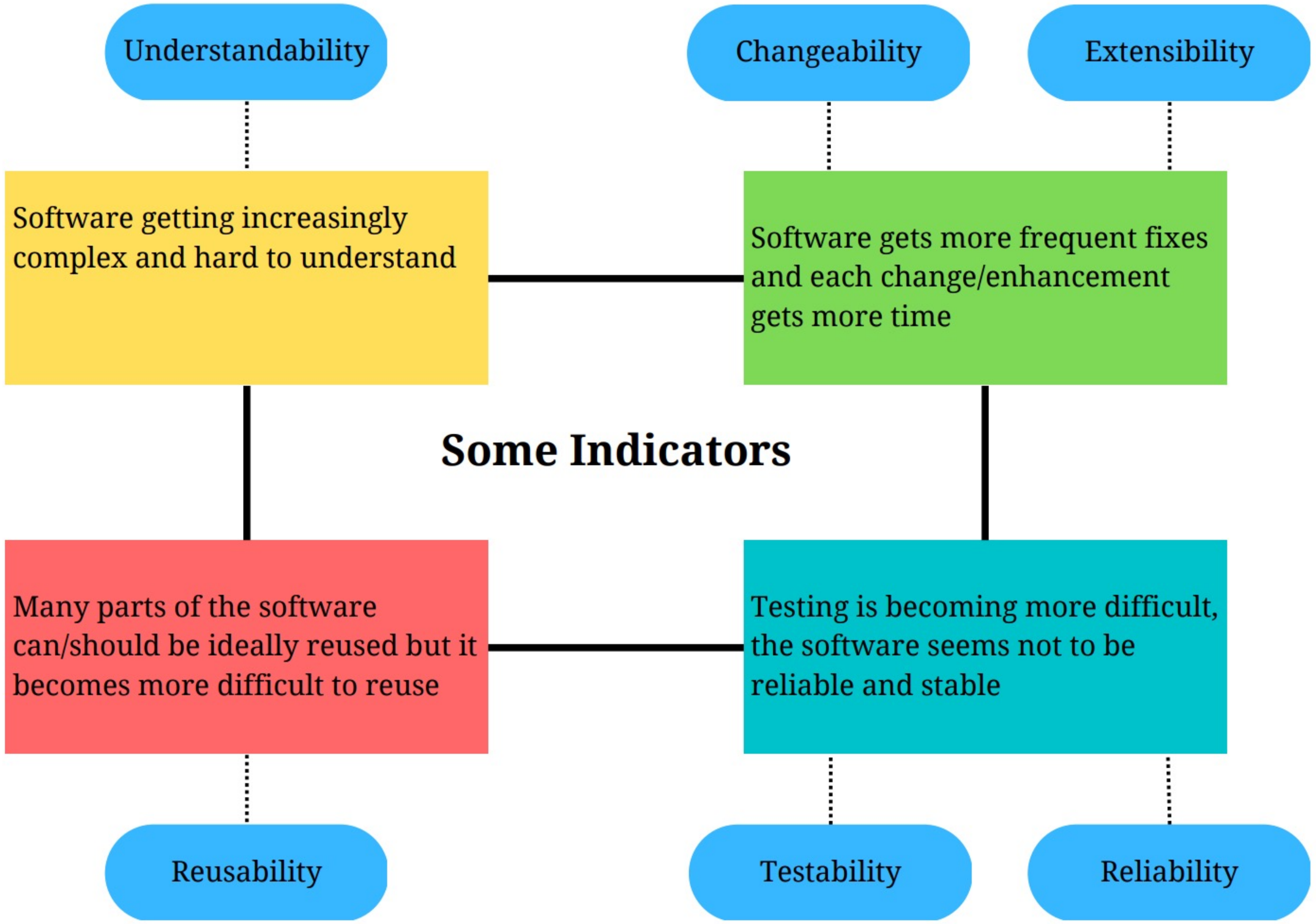
-- Karthik Vaidhyanathan

Sources:

1. Refactoring, Improving the design of existing code, Martin Fowler et al., 2000
2. Refactoring for Software design Smells, Girish Suryanarayana et al.
3. martinfowler.com
4. Few articles by Ipek Ozkaya and Robert Nord, SEI, CMU

How to Identify Technical Debts and Refactor?

Software Quality as an Indicator

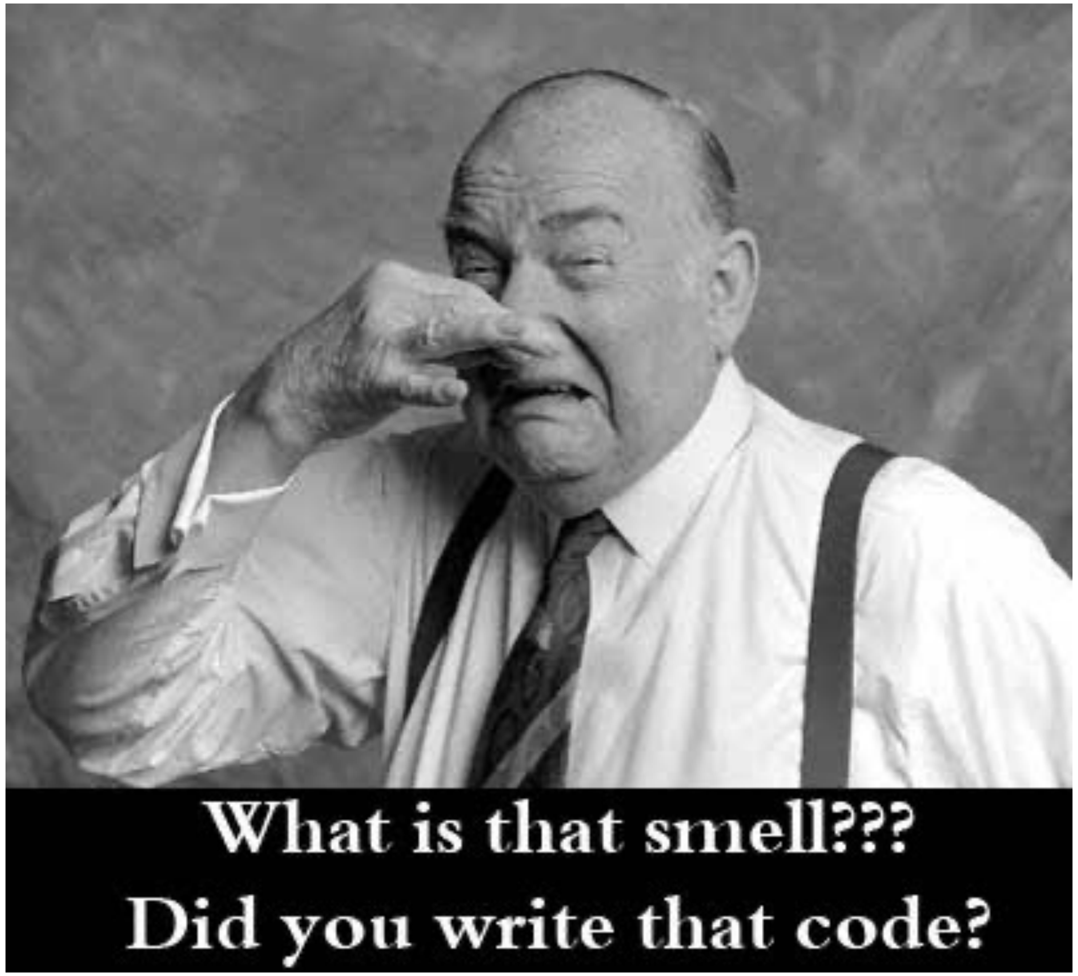

Understandability
Changeability
Extensibility
Software getting increasingly complex and hard to understand
Software gets more frequent fixes and each change/enhancement gets more time
Some Indicators
Many parts of the software can/should be ideally reused but it becomes more difficult to reuse
Testing is becoming more difficult, the software seems not to be reliable and stable
Reusability
Testability
Reliability

How to Refactor?

- Identify the refactoring points
- Create a refactoring plan
- Make a backup of the existing codebase: Versioning system
- Use semi-automated approach: Some tool support is always available
- Perform the refactoring
- Test if everything works like before! – Test extensively (new bugs, broken functionalities, etc.)
- Repeat the process

Remember: Refactoring is not just a one time activity!!

Code Smells? You heard that right!



Source: https://engineering.99x.io/natural-odor-of-a-developer-f7f7fbb838e3

Refactoring Points - Things starts to rot and **Smell**

Code Smells and so does design – You heard that right!!!

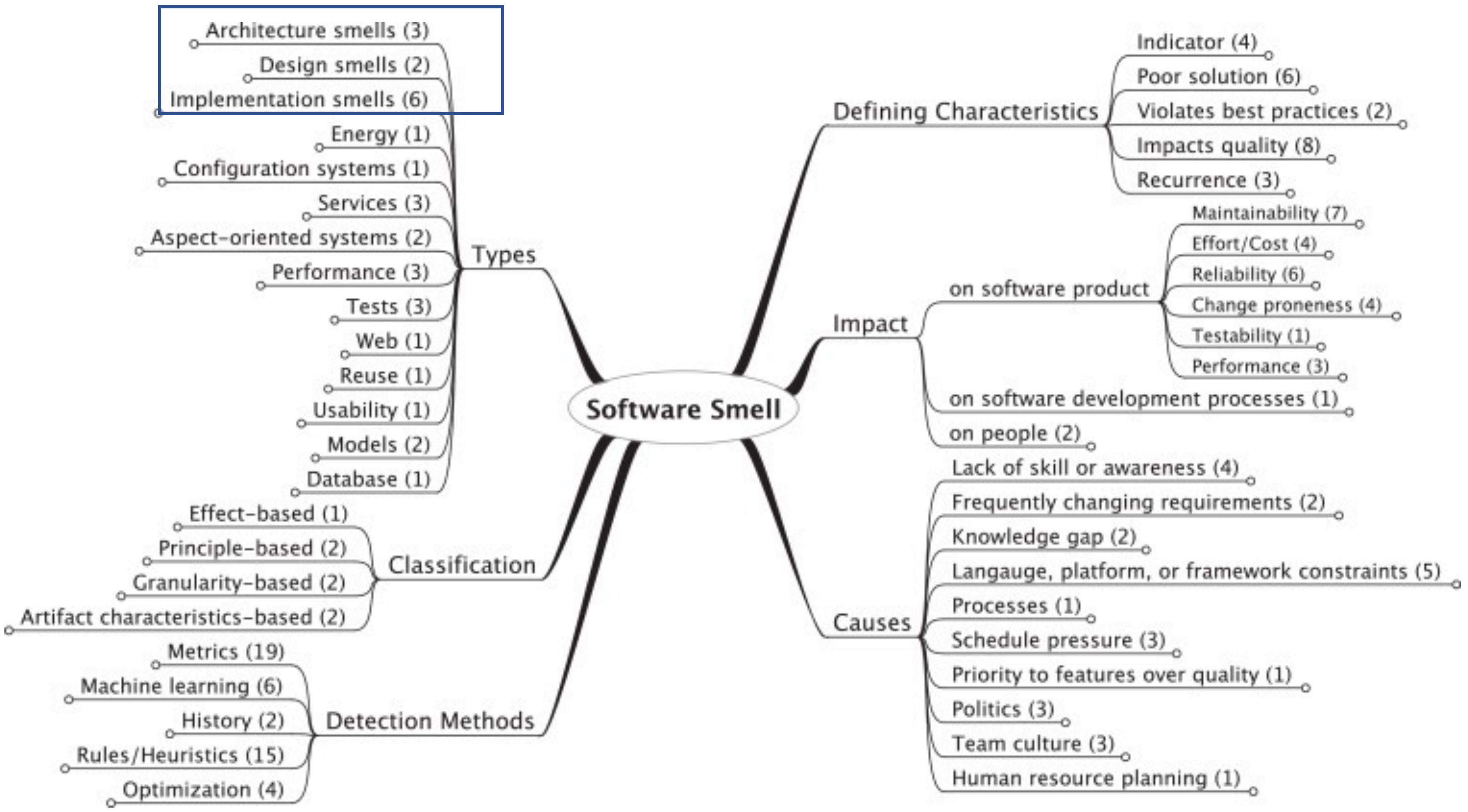
”smell”, Coined by Kent Beck in 1999

Smells are certain structures in the code that **suggest** (sometimes they scream for) the **possibility of refactoring**

A ”bad smell" describes a situation where there are hints that suggest there can be a **design problem**

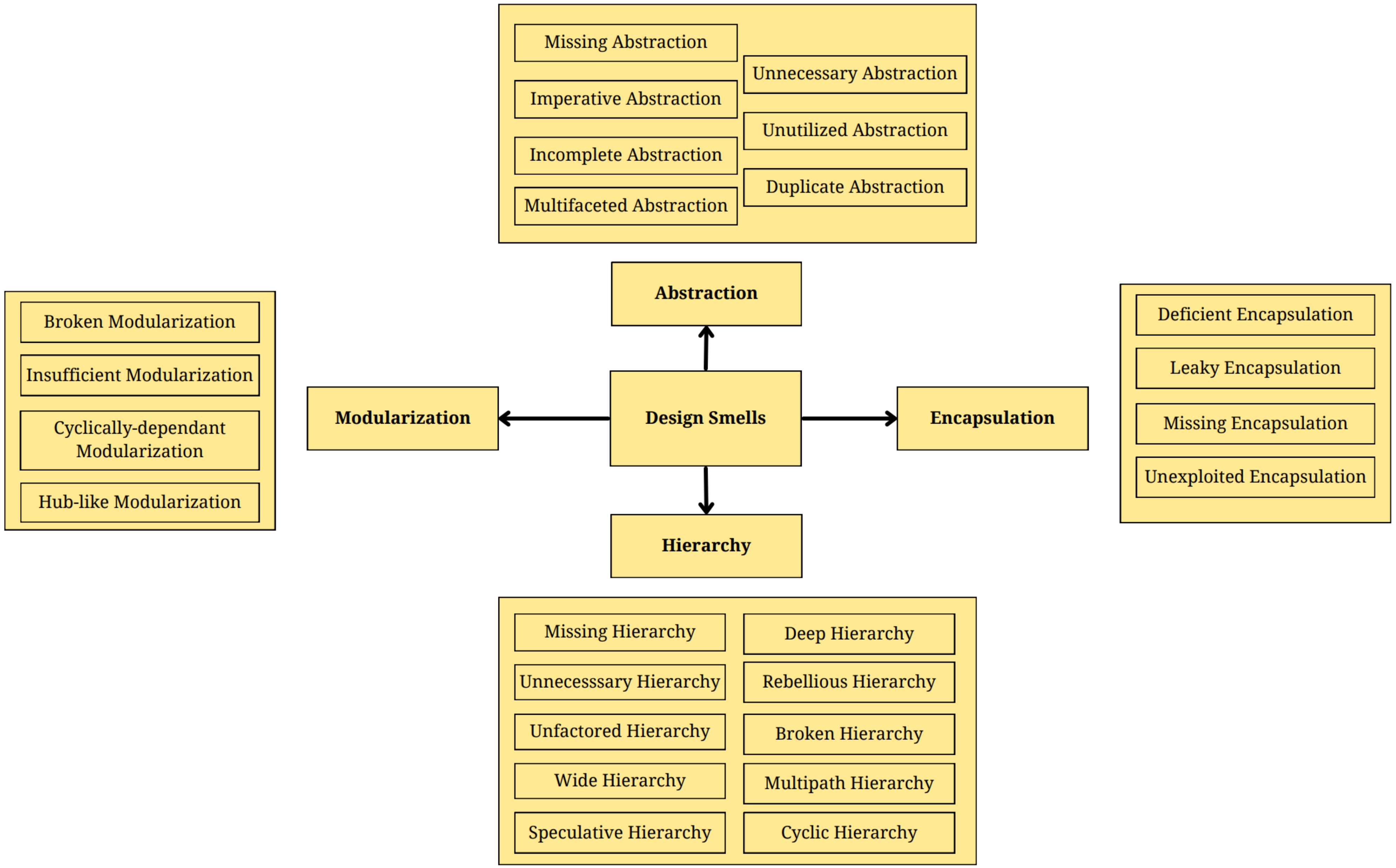
Many different definitions - https://zenodo.org/record/1066135#.Y8PcXS8RpQI

Many methods, reasons, ways to detect..



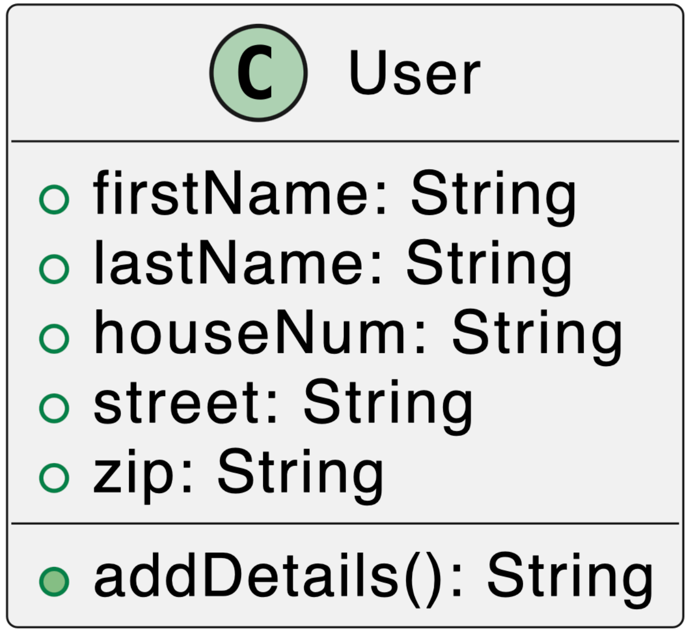
Tushar Sharma, Diomidis Spinellis, **A survey on software smells**, Journal of Systems and Software, Volume 138, 2018

Types of Design Smells



Missing Abstraction – Example Scenario

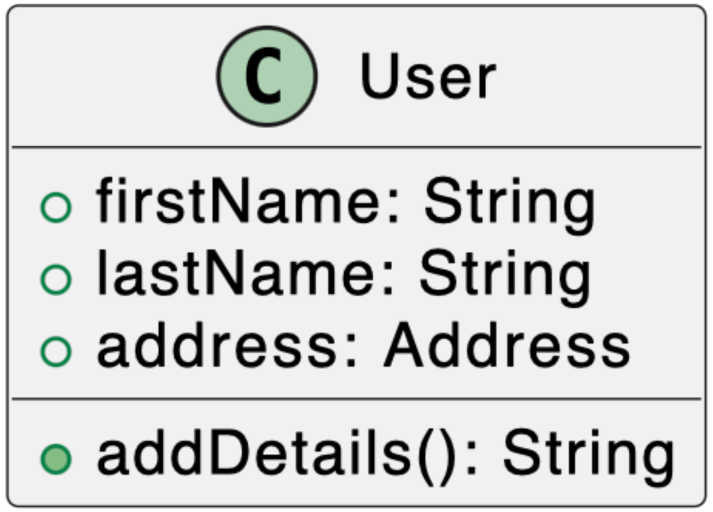
Scenario: Consider the e-bike system which requires to store address of every user

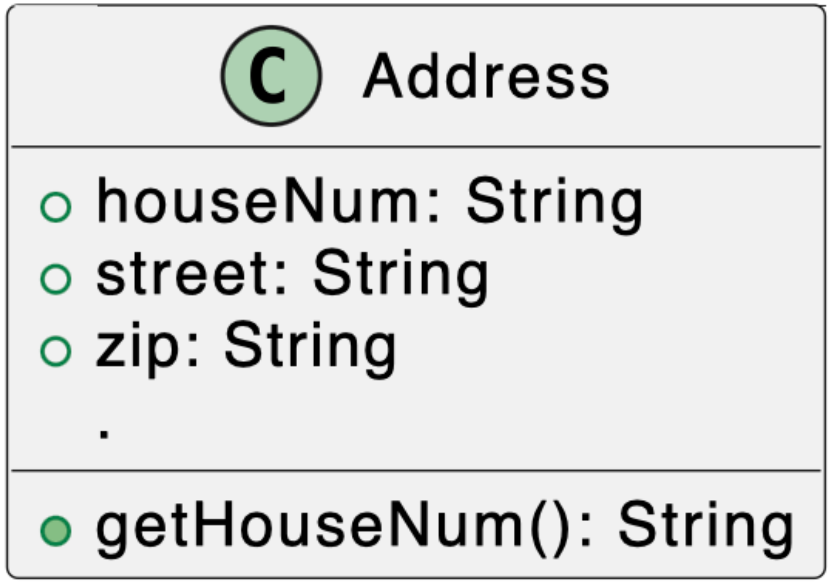


Data clumps!!

Missing Abstraction – Example Refactoring

Solution: Refactor the design, move collection of primitive types and form a separate class





Abstraction Smell – Missing Abstraction

Indication: Usage of clumps of data or strings used instead of class or interface

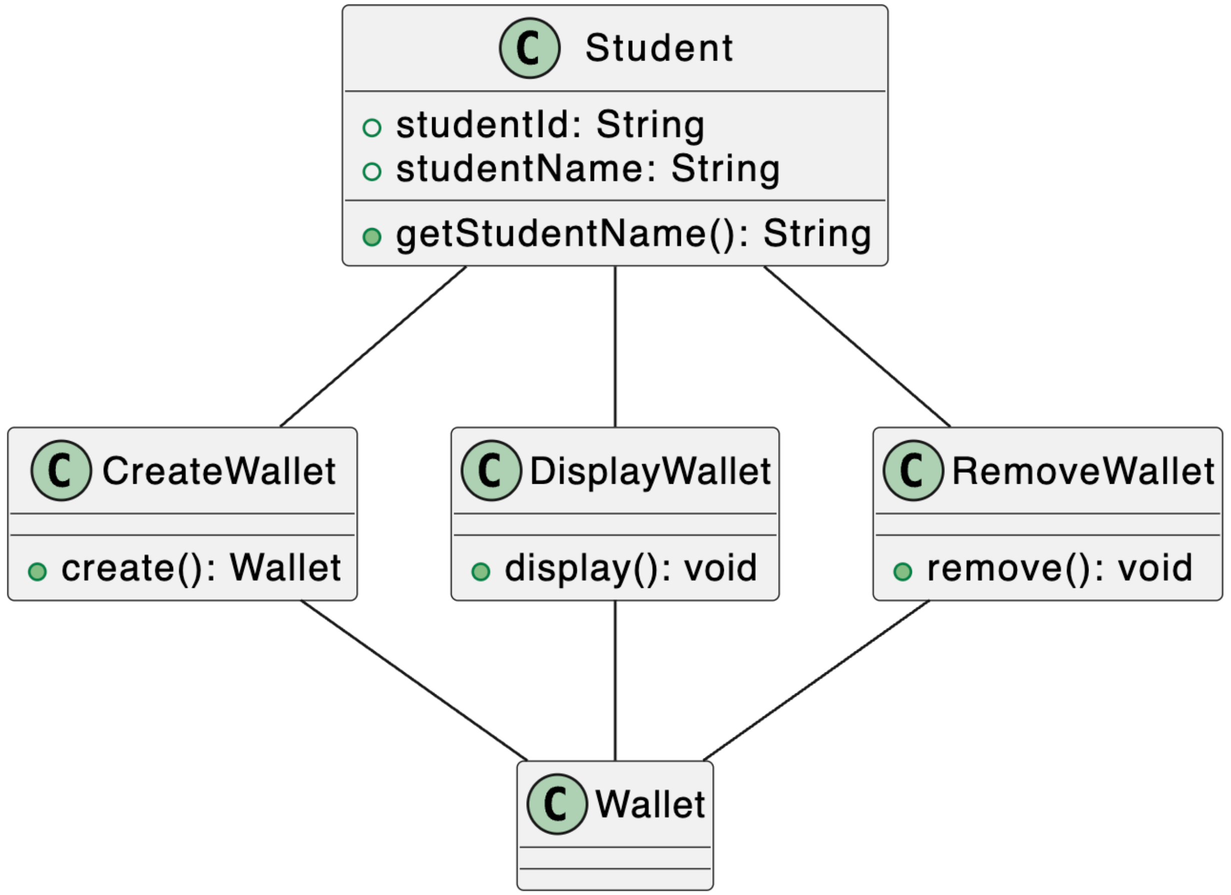
Rationale: Abstraction not identified and represented as primitive types

Causes: Inadequate design analysis, lack of refactoring, focus on minor performance gains

Impact: Affects understandability, extensibility, reusability, .

Abstraction Smell – Imperative Abstraction

Scenario: Consider the e-bike system where students have to perform different operations on their wallet

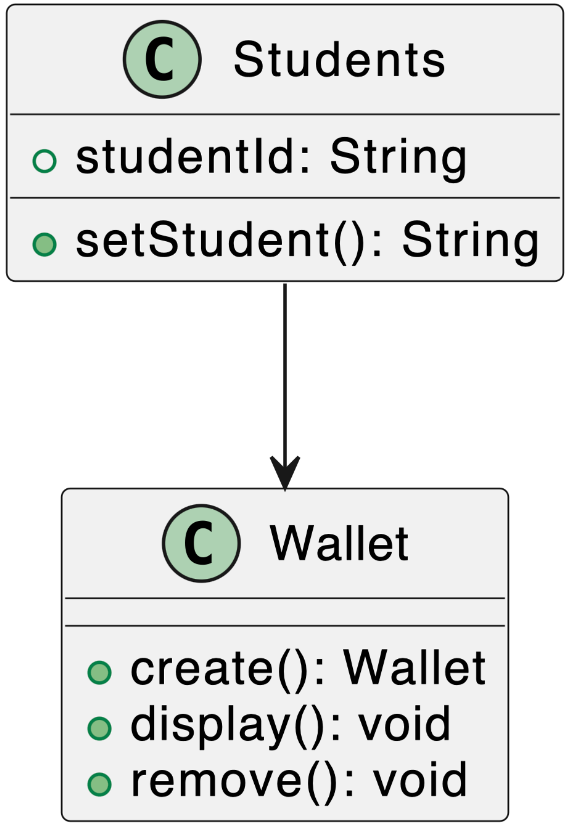


What all problems do you foresee?

Wallet will have different properties

Abstraction Smell – Example Refactoring

Solution: Refactor the design, move the functions into one class and bundle it with data



Remember abstraction is all about generalization
And specification of common and important characteristics!!

Abstraction Smell – Imperative Abstraction

Indication: Operation is turned into a class. A class that has only one method defined in it

Rationale: Defining functions explicitly as classes when data is located somewhere violates OOPS principles. Increases complexity, reduce cohesiveness

Causes: Procedural thinking (capture the bundled nature)

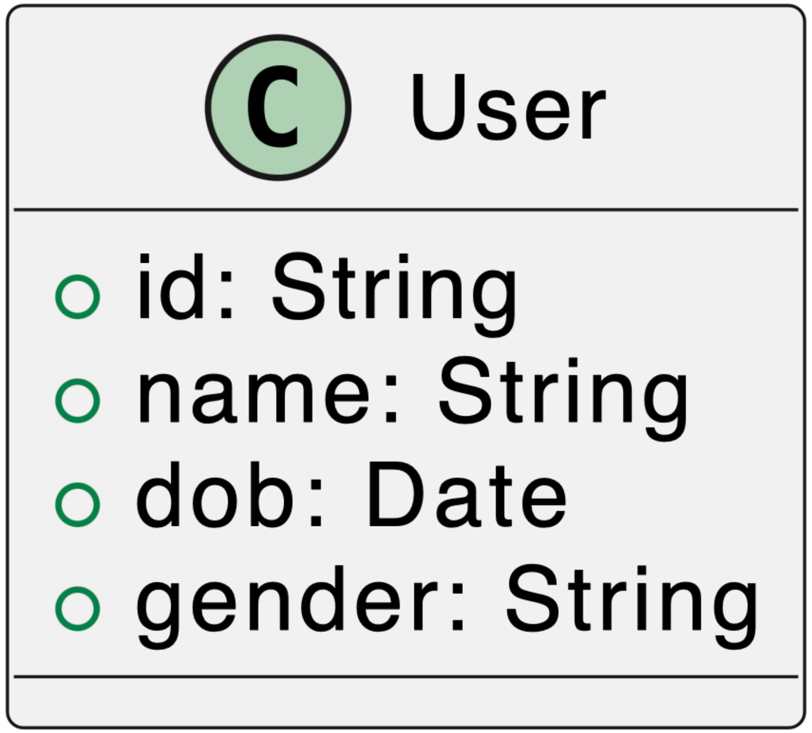
Impact: Affects understandability, extensibility, testability, reusability..

Abstraction - Enablers

- Crisp boundary and identity
  - Make abstractions when necessary and have clear boundaries
- Map domain entities
  - Vocabulary mapping from problem domain to solution domain
- Ensure coherence and completeness
  - Completely support a responsibility, don’t spread across
- Assign Single and Meaningful Responsibility
  - Each abstraction has unique and non-trivial responsibility
- Avoid Duplication
  - The abstraction implementation and the name appears only once in design

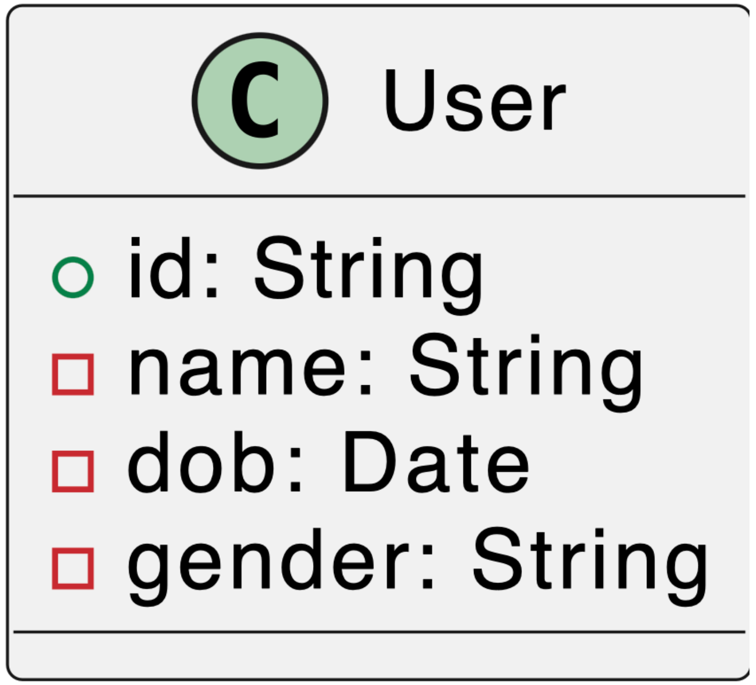
Encapsulation Smell – Deficient Encapsulation

Scenario: Consider the e-bike system where user details like DOB, gender, etc. are public



Encapsulation Smell – Example Refactoring

Solution: Refactor the design, modify the access specifiers without affecting others



Encapsulation Smell – Deficient Encapsulation

Indication: One or more members is not having required protection

(eg: public)

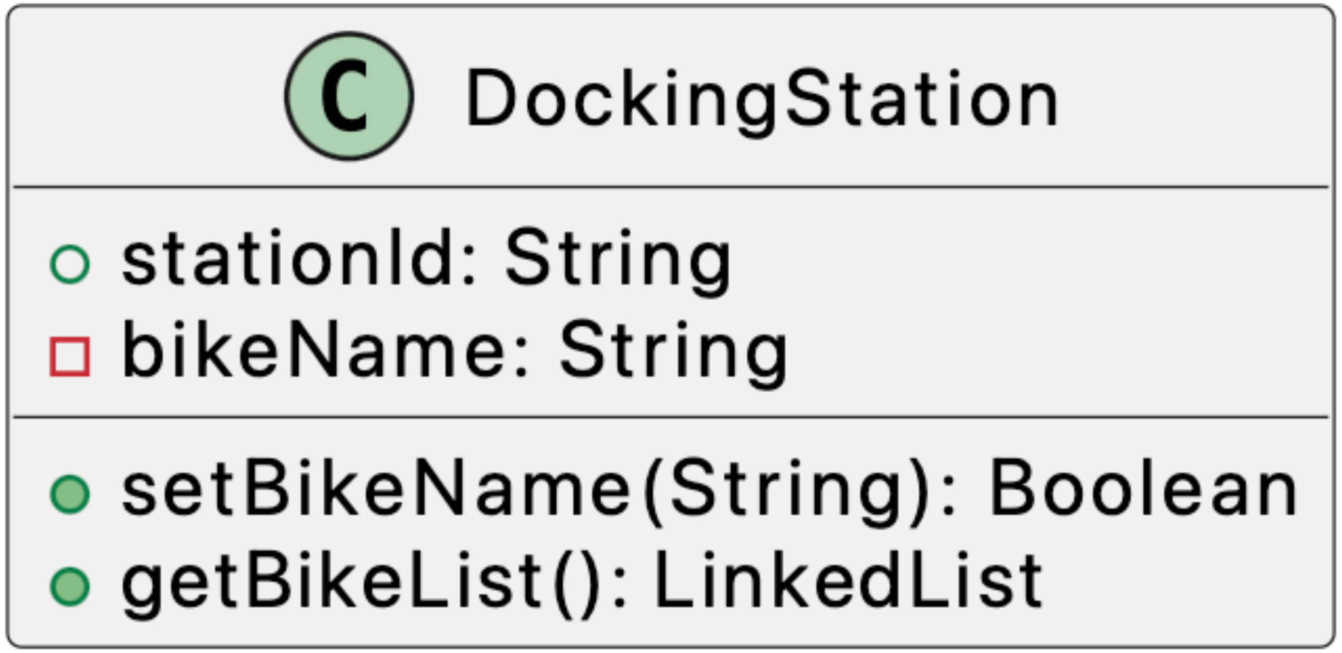
Rationale: Exposing details can lead to undesirable coupling. Each change in abstraction can cause change in dependent members

Causes: Easier testability, procedural thinking (expose data as global variables), quick fixes

Impact: Affects changeability, extensibility, reliability,…

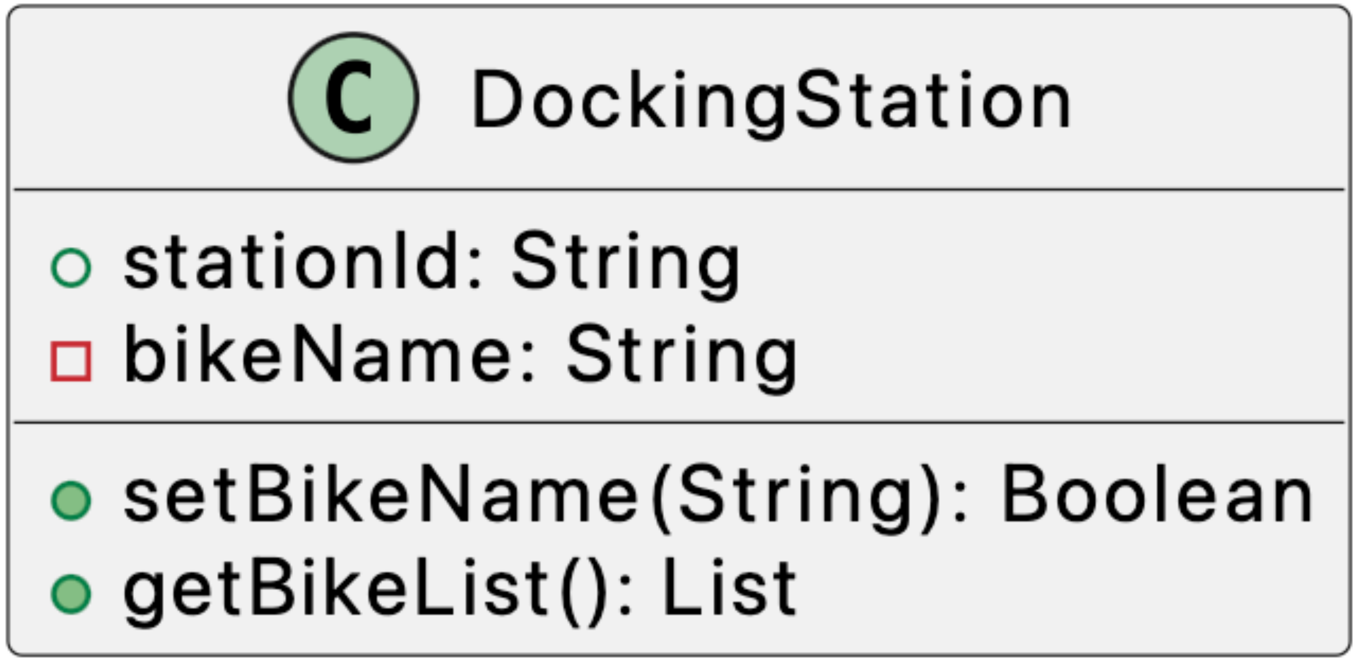
Encapsulation Smells – Leaky Encapsulations

Scenario: Consider the e-bike system where the docking station class provides list of bikes parked in that station



Encapsulation Smell – Example Refactoring

Solution: Refactor the design, make return types of public more abstract to support modifiability, ensure clients do not get direct access to change internal state



List can be anything, internally it can be ArrayList or TreeList, etc.

Encapsulation Smells – Leaky Encapsulations

Indication: Abstraction leaks implementation details (public methods)

Rationale: Implementation details needs to be hidden, Internal state can be corrupted due to open methods

Causes: lack of awareness, project pressure (quick hacks), too fine-grained public methods exposed (think of simple setter)

Impact: Affects changeability, reusability, Reliability

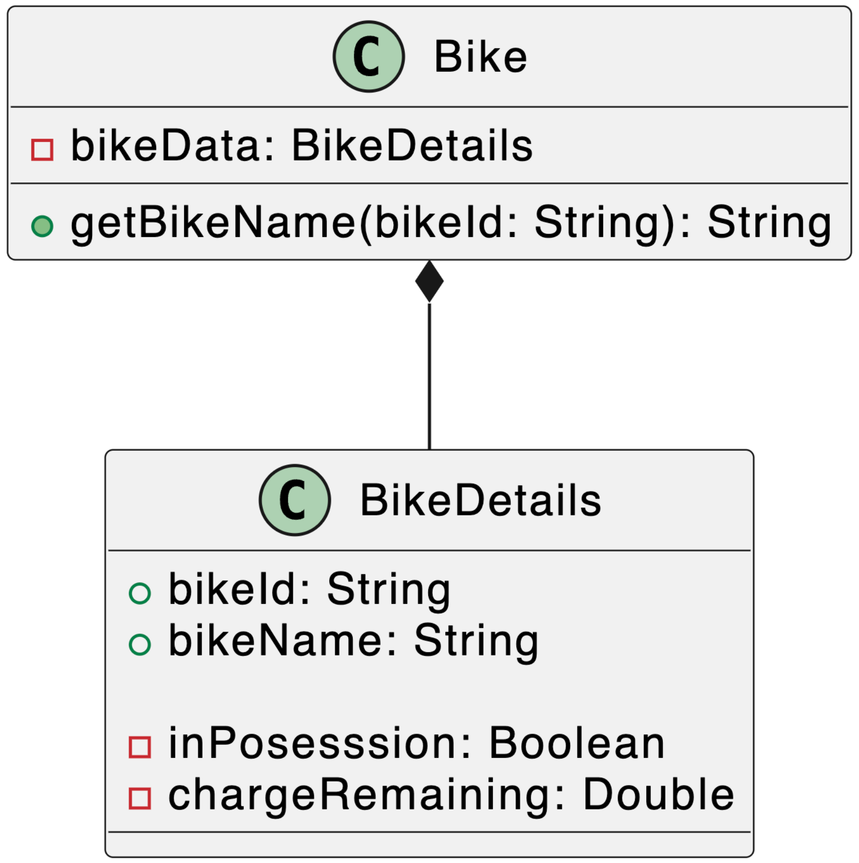
Encapsulation - Enablers

- Hide implementation details
  - Abstraction exposes only what abstraction offers and hides implementation
  - Hide data members and details on how the functionality is implemented

- Hide Variations
  - Hide implementation variations in types or hierarchies
  - Easier to make changes in abstraction implementation without affecting subclasses or collaborators

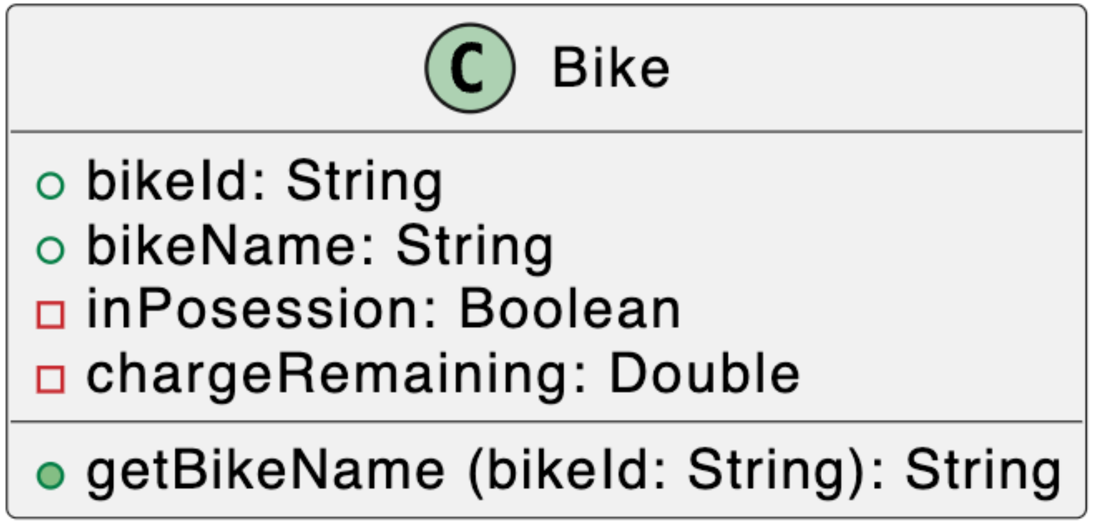
Modularization Smells – Broken Modularization

Scenario: Bike class gets all data from BikeDetails class but all operations resides in Bike Class



Modularization Smells – Example Refactoring

Solution: Refactor the design in such a way that the data and methods stay together as a unit. Enhancing cohesiveness is the key



Modularization Smells – Broken Modularization

Indication: Data and methods are spread across instead of being bundled

Rationale: Having data in one and methods in another results in tight coupling, violates modularity

Causes: Procedural thinking, lack of understanding of existing design

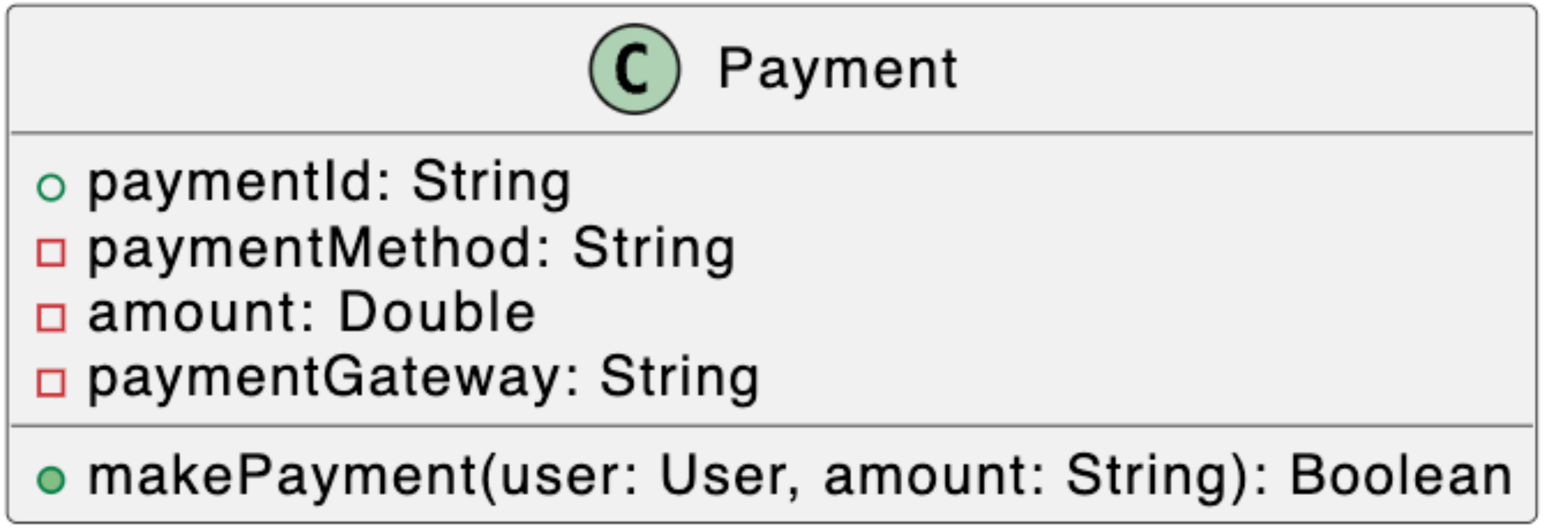
Impact: Affects changeability and extensibility, reusability, Reliability

Modularization Smells – Enablers

- Localize related data and methods
  - All the data and method related to one class should be kept in the same class
- Abstractions should of manageable size
  - Ensure classes are of manageable size – mainly affects maintainability, extensibility and understandability
- Ensure there are no cyclic dependencies
  - Graph of relationships between classes should be acyclic
- Limit Dependencies
  - Create classes with low fan-in and low fan out
    - Fan-in: number of incoming dependencies
    - Fan-out: number of outgoing dependencies

Hierarchy Smells – Missing Hierarchy

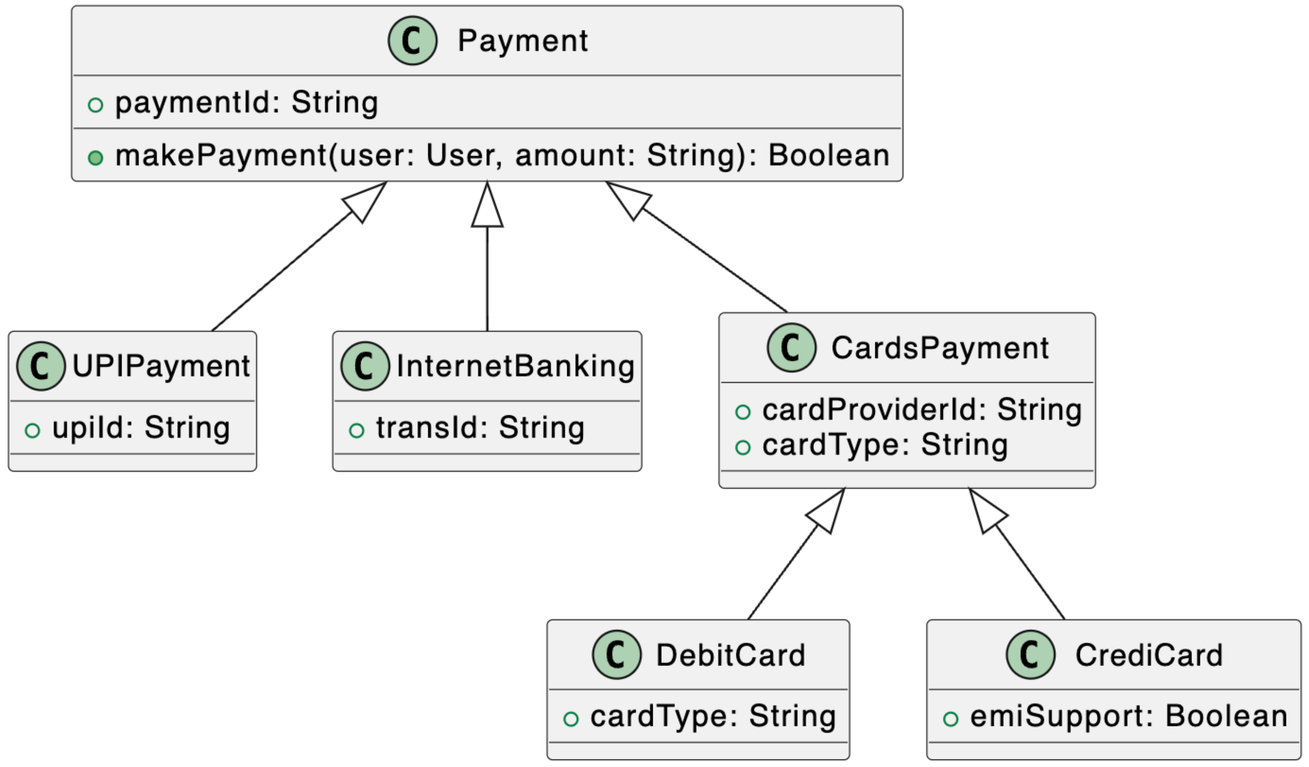
Scenario: In the e-vehicle scenario, user can pay in any mode of payment



One way to support different types of payment is to write them inside makePayment function

Hierarchy Smells – Example Refactoring

Solution: Refactor by creating hierarchies based on the behavior changes that comes under payment function. Put the common parts in parent class (think about abstract class or interfaces as well)



Note: DebitCard and CreditCard needs to be Specialized and generalized into Cards only if They have enough variation points

Hierarchy smells – Missing Hierarchy

Indication: Using if conditions to manage behavior variations instead of creating hierarchy

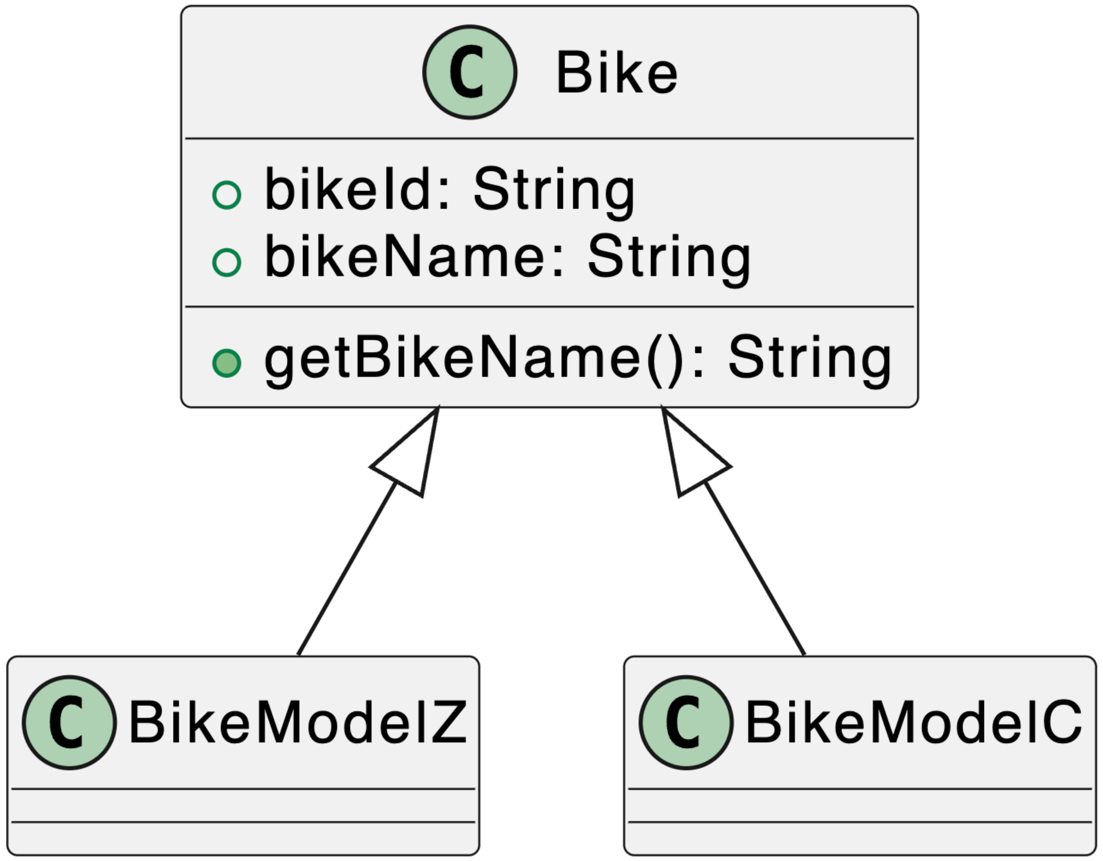
Rationale: Using chained if-else or Switch indicates issues with handling variations. Commonality among the types can also be used

Causes: ”simplistic design”, procedural approach, overlooking inheritance

Impact: Reliability, Testability, understandability, extensibility,..

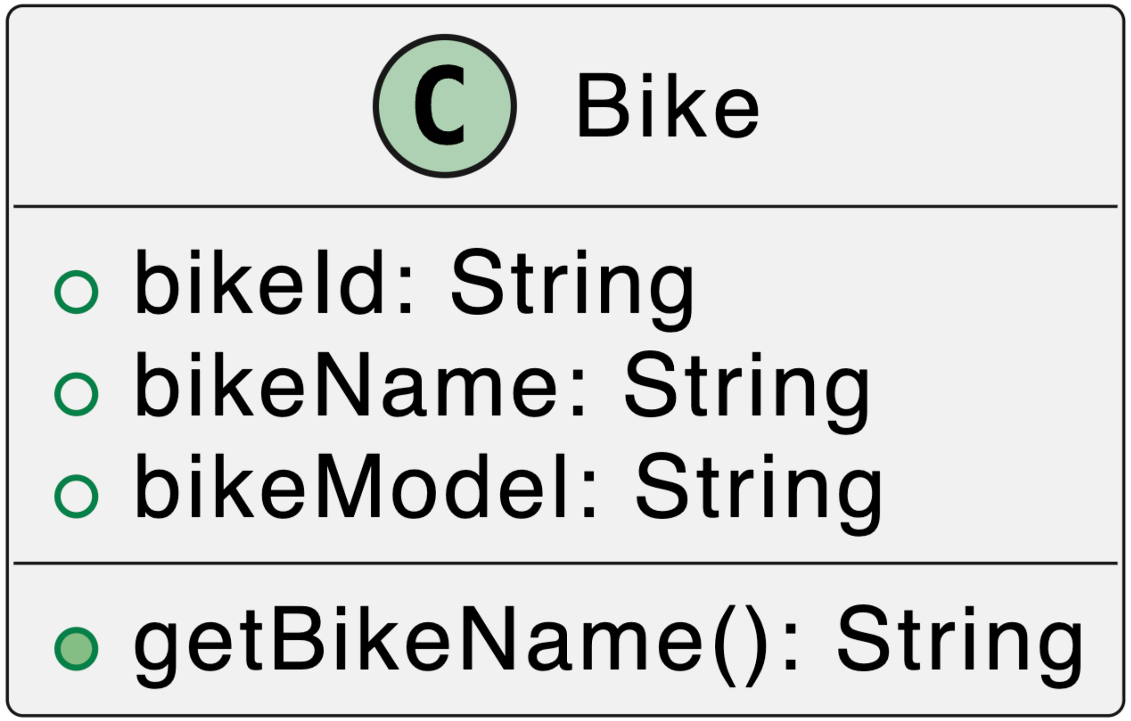
Hierarchy smells – Example Scenario

Scenario: Each bike can be of different model resulting in different design (shape, colour, etc.)



Hierarchy smells – Refactoring

Solution: Remove hierarchy and transform subtypes into instance variables



Hierarchy smells – Unnecessary Hierarchy

Indication: Inheritance has been applied needlessly for a particular context

Rationale: The focus should be more on capturing commonalities and variation in behavior than data. Violation results in unnecessary hierarchy

Causes: subclassing instead of instantiating, taxonomy mania (overuse of inheritance)

Impact: Understandability, Extensibility, Testability..

Hierarchy Smells - Enablers

- Apply meaningful classification
  - Identify commonalities and variations – Classify into levels
- Apply meaningful generalization
  - Identify common behavior and elements to form supertypes
- Ensure Substitutability
  - Reference of supertype can be substituted with objects of subtypes
- Avoid redundant paths
  - Avoid redundant paths in inheritance hierarchy
- Ensure proper ordering
  - Express relationships in a consistent and orderly manner

Some General Observations

- Analyze your design
  - Is this abstraction enough?
  - Is there some responsibility overload?
  - Have we made use of the right set of access modifiers?
  - Only expose what is necessary
  - Ensure high cohesiveness and loose coupling
  - Create hierarchies whenever necessary (only when necessary)
- Always remember, refactoring is not a one-time process
- The more it is delayed, the more debt is incurred!
- Combination of design smells exists
- Code can serve as good indicators of design smells – Code also smells!

Next up: Code Smells and Code Metrics!!

Group Activity

Thank You

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