Design principles and practices

Week 3 – Spring 2022

UML Vs Design Principles

- Knowing UML doesn't mean you know design
- UML is just a notation for representing your designs
- Designs may be represented/documented using other tools/languages/technologies…

" The critical design tool for software development is a mind well educated in **design principles**…"

OO principles such as GRASP, Gang-of-Four Design Patterns, etc. help achieve better design.

Responsibility Driven Design (RDD)

RDD – Thinking about how to assign responsibility to collaborating objects

- A *responsibility* is a contract or obligation of a class in terms of its role
- Responsibilities can be of two types
  - Doing
  - Knowing

For example:

" a *Sale* object is responsible for creating *SalesLineItems* objects "

" a *Sale* object is responsible for knowing its *total* "

Note that responsibility is not the same as a method !

→ Methods fulfill responsibilities alone or in collaboration with other methods/objects

Categories of responsibilities

- Setting and getting the values of attributes
- Creating and initializing new instances
- Loading to and saving from persistent storage
- Destroying instances
- Adding and deleting links of associations
- Copying, converting, transforming, transmitting or outputting
- Computing numerical results
- Navigating and searching
- Other specialized work

Assigning Responsibilities – Thumb rules

- All the responsibilities of a given class should be *clearly related*.
- If a class has too many responsibilities, consider *splitting* it into distinct classes
- If a class has no responsibilities attached to it, then it is probably *useless*
- When a responsibility cannot be attributed to any of the existing classes, then a *new class* should be created

- Use **"Patterns"** if applicable

Why Patterns?

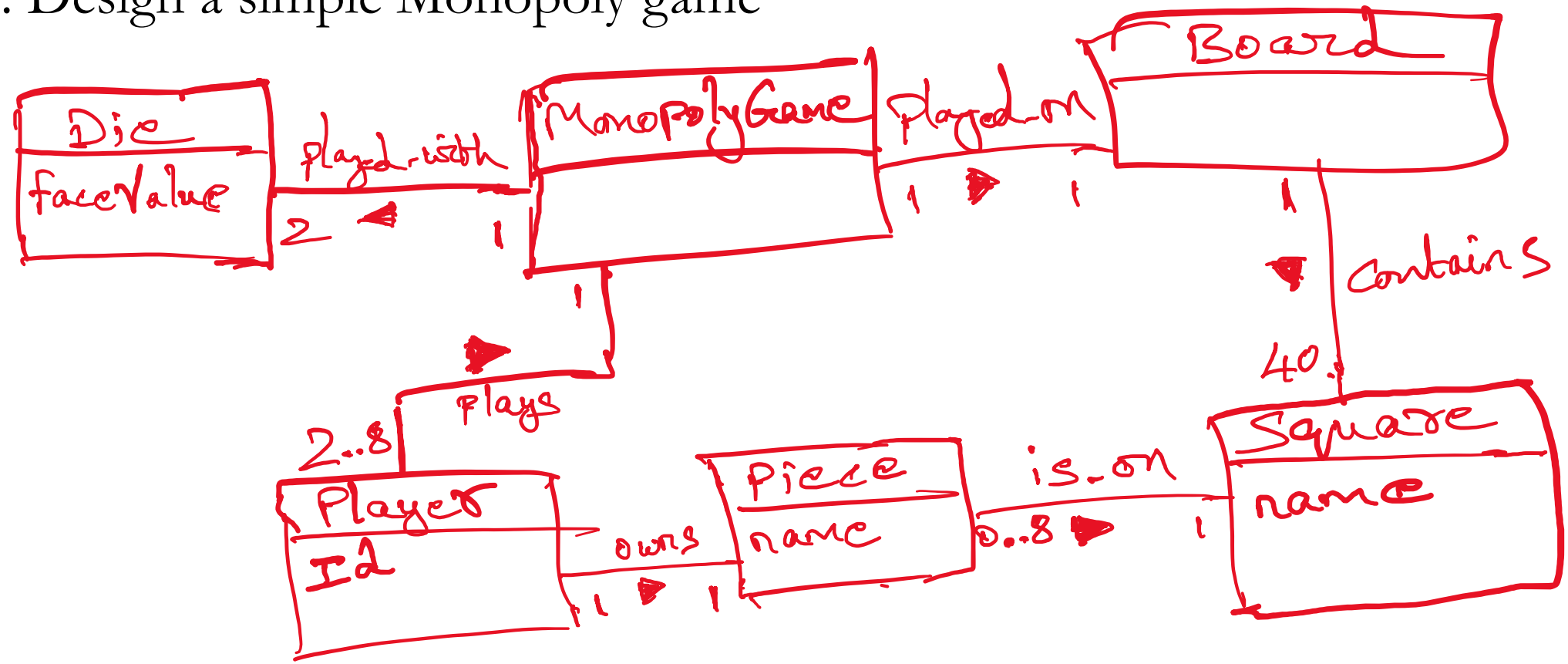
- Design for re-use is difficult
- Experienced designers:
  - Rarely start from first principles
  - Apply a working "handbook" of approaches
- Patterns make this ephemeral knowledge available to all
- Support evaluation of alternatives at higher level of abstraction

Discussion question:

"New Pattern" is an Oxymoron

OO Design Example

Problem: Design a simple Monopoly game



OO Design Example with GRASP – 1/5

Problem: In a Monopoly game, who creates the Square Object

➔**Doing** responsibility

➔What would you choose? And Why?

Name: CREATOR

Problem: Who creates an A?

Solution: Assign class B the responsibility to create an instance of class A if one of these is true:

(1) B contains A

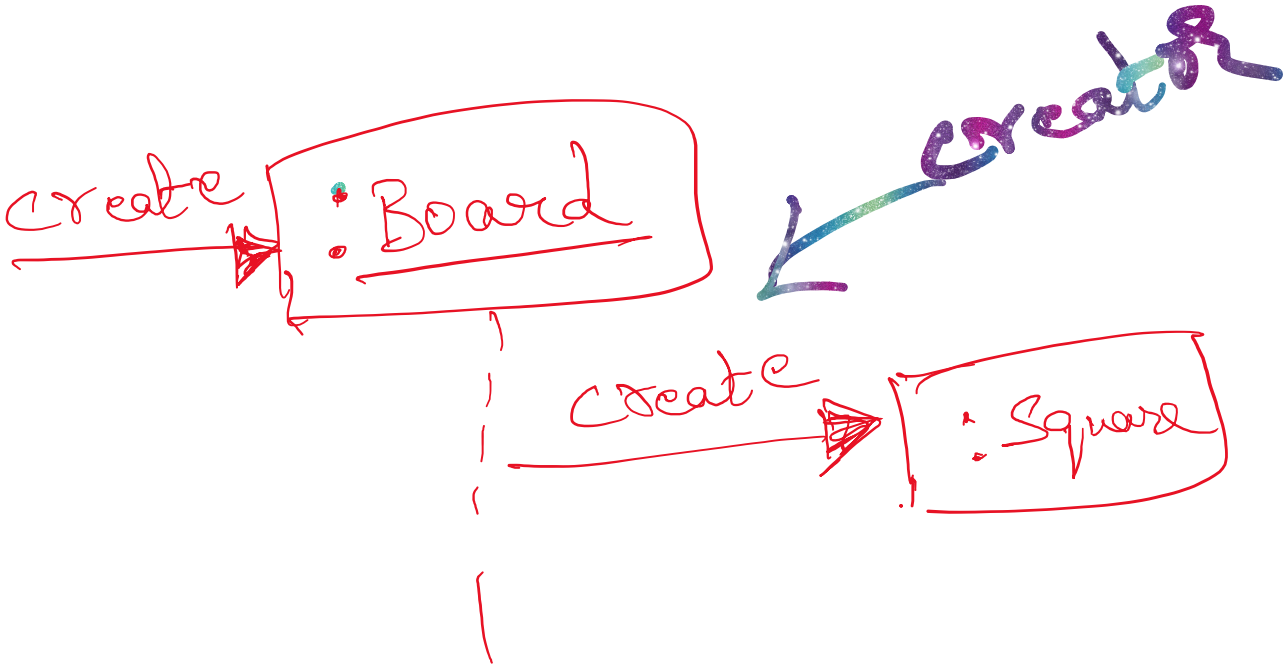
(2) B compositely aggregates A

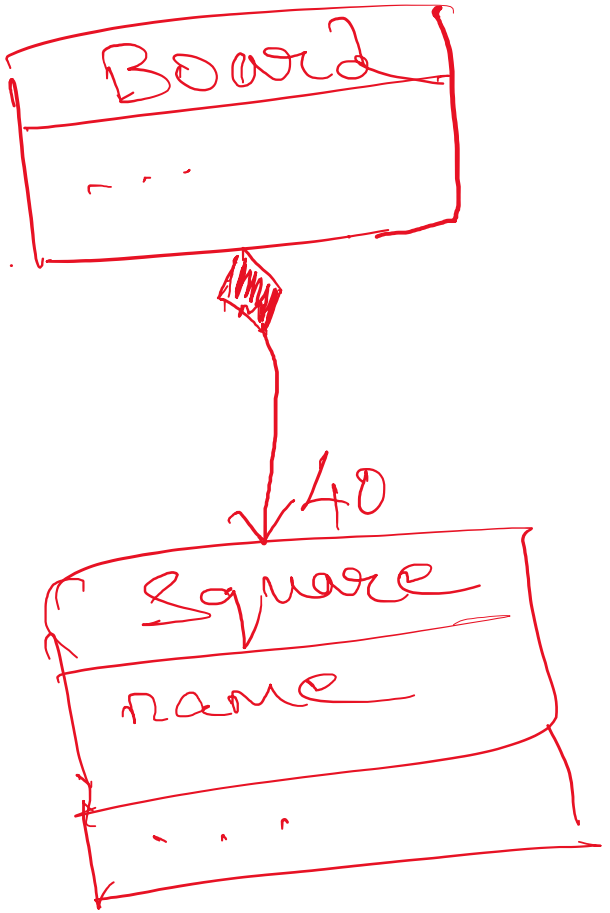
(3) B has the initializing data for A

(4) B records A

(5) B closely uses A

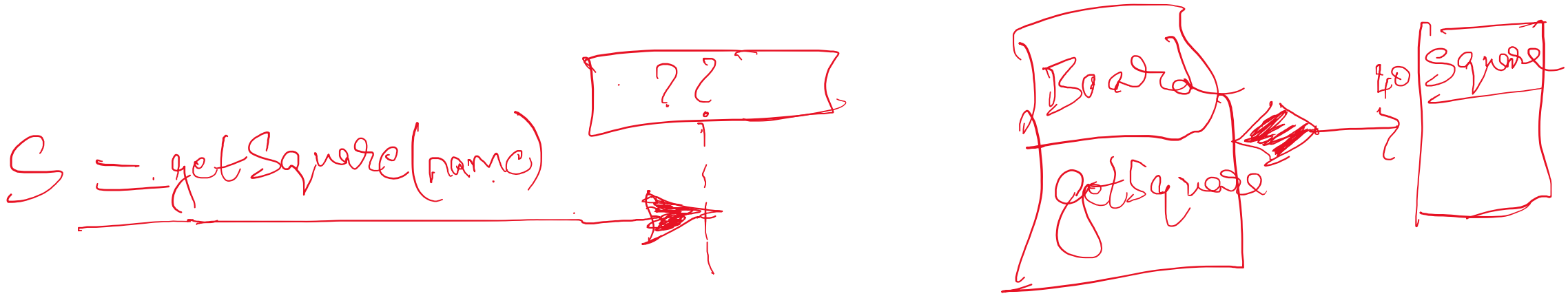
Applying creator pattern





OO Design Example with GRASP – 2/5

Problem: Who knows about a Square object, given a key?

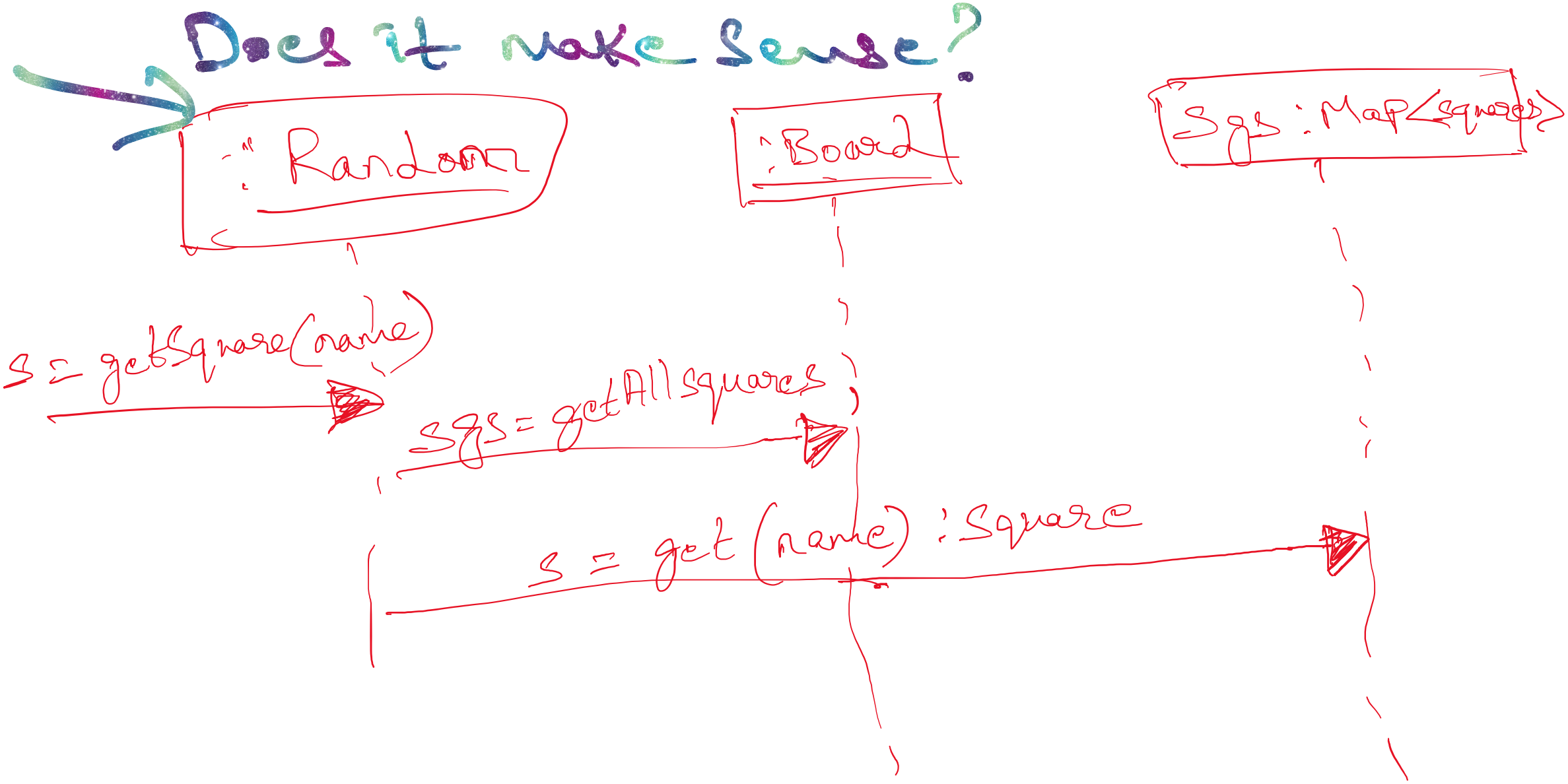


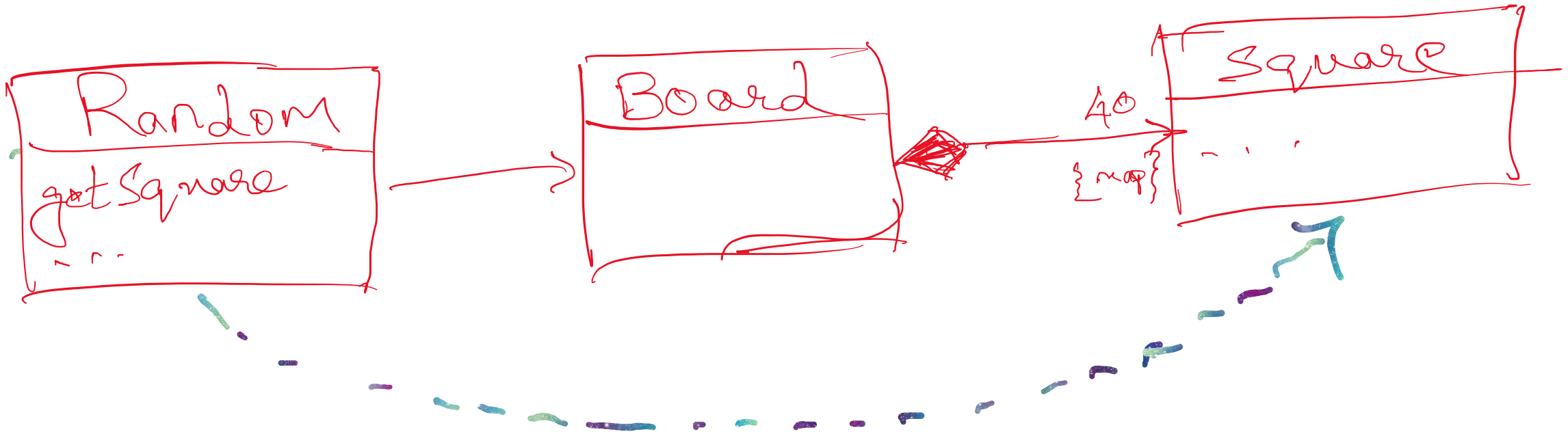
Name: Information Expert

Problem: What is the basic principle to assign responsibilities to objects

Solution: Assign a responsibility to the class that has the information needed to fulfill it

Does it make sense?





Poor design
(HIGH COUPLING?)

General Responsibility Assignment Software Patterns or Principles (GRASP)

Information Expert: A general principle of object design and responsibility assignment?

Assign a responsibility to the information expert – the class that has the information necessary to fulfill the responsibility

Creator: Who creates?

Assign class B the responsibility to creat an instance of class A if one of these is true:

(1) B contains A

(2) B aggregates A

(3) B has the initializing data for A

(4) B records A

(5) B closely uses A

Controller: What first object beyond the UI layer receives and coordinates ("controls") a system operation?

Assign the responsibility to an object representing one of these choices:

(1)Represents the overall "system", a "root object", a device that the software is running within, or a major subsystem (these are all variations of a façade controller)

(2)Represents a use case scenario

GRASP

Low Coupling: How to reduce the impact of change?

Assign responsibilities so that (unnecessary) coupling remains low. Use this principle to evaluate alternatives

High Cohesion: How to keep objects focused, understandable, and manageable, and as a side-effect, support low coupling?

Assign responsibilities so that cohesion remains high. Use this to evaluate alternatives

Polymorphism: Who is responsible when the behavior varies by type?

When related alternatives or behaviors vary by type (class), assign responsibility for the behavior – using polymorphic operations – to the types for which the behavior varies

Pure fabrication: Who is responsible when you are desperate, and do not want to violate high cohesion and low coupling?

Assign a highly cohesive set of responsibilities to an artificial or convenience "behavior" class that does not represent the problem domain concept – something made up, in order to support high cohesion, low coupling, and reuse.

GRASP

Indirection: How to assign responsibilities to avoid direct coupling?

Assign the responsibility to an intermediate object to mediate between other components or services, so that they are not directly coupled.

Protected Variations: How to assign responsibilities to objects, subsystems, and systems so that the variations or instability in these elements do not have an undesirable impact on other elements?

Identify points of predicted variations or instability; assign responsibilities to create a stable "interface" around them

Pattern Types

- **Requirements Patterns**: Characterize families of requirements for a family of applications
  - The checkin-checkout pattern can be used to obtain requirements for library systems, car rental systems, video systems, etc.

- **Architectural Patterns**: Characterize families of architectures
  - The Broker pattern can be used to create distributed systems in which location of resources and services is transparent (e.g., the WWW)
  - Other examples: MVC, Pipe-and-Filter, Multi-Tiered

- **Design Patterns**: Characterize families of low-level design solutions
  - Examples are the popular Gang of Four (GoF) patterns

- **Programming idioms**: Characterize programming language specific solutions

Example of a Software Development Pattern - The Model-View-Controller (MVC) Pattern

- The *Model* component: encapsulates core functionality; independent of input/output representations and behavior.
- The *View* components: displays data from the model component; there can be multiple views for a single model component.
- The *Controller* components: each view is associated with a controller that handles inputs; the user interacts with the system via the controller components.

The Gang of Four Catalog Method

- Pattern name and classification
  - Purpose classification: creational, structural, behavioral
  - Scope classification: class (compile time) or object (run-time)
- Creational
  - class => defer creation to subclasses
  - object => defer creation to another object
- Structural
  - class => structure via inheritance
  - object => structure via composition
- Behavioral
  - class => algorithms/control via inheritance
  - object => algorithms/control via object groups

Pattern Description - 1

- Intent
  - What does pattern do?
  - What is its rationale?
  - What issue/problem does it address?
- Also Known As = other names for pattern
- Motivation
  - Scenario illustrating problem and solution
  - A concrete exemplar
- Applicability
  - When to apply the pattern
  - Poor designs addressed by pattern

Pattern Description - 2

- Structure
  - Graphical representation – OMT/UML
- Participants
  - Classes, objects, and their responsibilities
- Collaborations
  - Class/object interactions
- Consequences
  - How does pattern meet its objectives
  - Tradeoffs and results
  - Flexibility: what parts can vary independently?
- Implementation & Sample Code
- Known Uses
- Related Patterns