Detailed Design

Overview

- What is detailed design?
- What is OO design?
- How should we do OO design?

Detailed Design

- To decompose subsystems into modules
- Two approaches of decomposition
  - Procedural
    - system is decomposed into functional modules which accept input data and transform it to output data
    - achieves mostly procedural abstractions
  - Object-oriented
    - system is decomposed into a set of communicating objects
    - achieves both procedural + data abstractions

Abstraction

- To focus on important, inherent properties while suppressing unnecessary details
  - Permits separation of concern
  - Allows postponement of design decision
- Two abstraction mechanisms
  - Procedural abstraction
    - Specification describes input/output
    - Implementation describes algorithm
  - Data abstraction
    - Specification describes attributes, values
    - Implementation describes representation and manipulation

OOD

- To identify responsibilities and assign them to classes and objects
- Responsibilities for doing
  - E.g., create an object, perform calculations, invoke operations on other objects
- Responsibilities for knowing
  - E.g., attributes, data involved in calculations, parameters when invoking operations

How Do Developers Design Objects?

- Code
  - Design-while-coding, ideally with powerful tools such as refactorings. From mental model to code
- Draw, then code
  - UML Diagrams
- Only draw
  - The tool generates everything from diagrams

How Much Time Spent Drawing UML before Coding?

- Spend a few hours or at most one day (with partners) near the start of the iteration
- Draw UML for the hard, creative parts of the detailed object design
- Stop and transition to coding
- UML drawings
  - inspiration as a starting point
  - the final design in code may diverge and improve

Work Results

- Dynamic models
  - help design the logic or behaviors of the code
  - UML interaction diagrams
    - (Detailed) sequence diagrams, or
    - Communication diagrams
- Static models
  - help design the definition of packages, class names, attributes, and method signatures
  - (Detailed) UML class diagrams

Guidelines

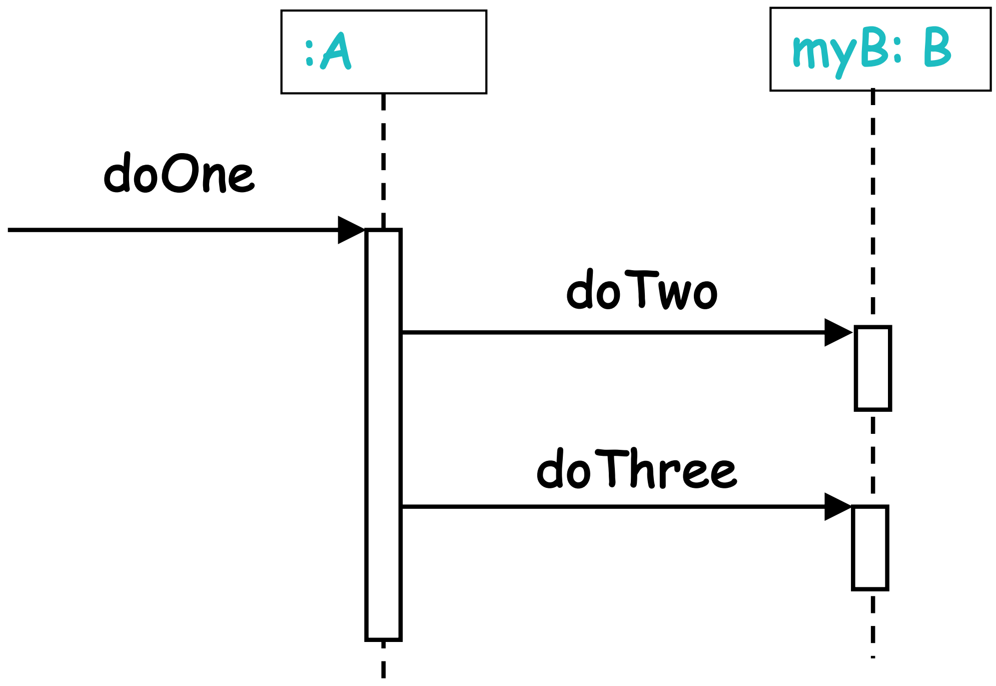
- Spend significant time doing interaction diagrams, not just class diagrams
- Apply responsibility-driven design and GRASP principles to dynamic modeling
- Do static modeling after dynamic modeling

UML Interaction Diagrams

- To illustrate how objects interact via messages
- Two types of interaction diagrams
  - Sequence diagrams
  - Communication diagrams

Sequence diagram

- Illustrate interactions in a kind of fence format, in which each new object is added to the right

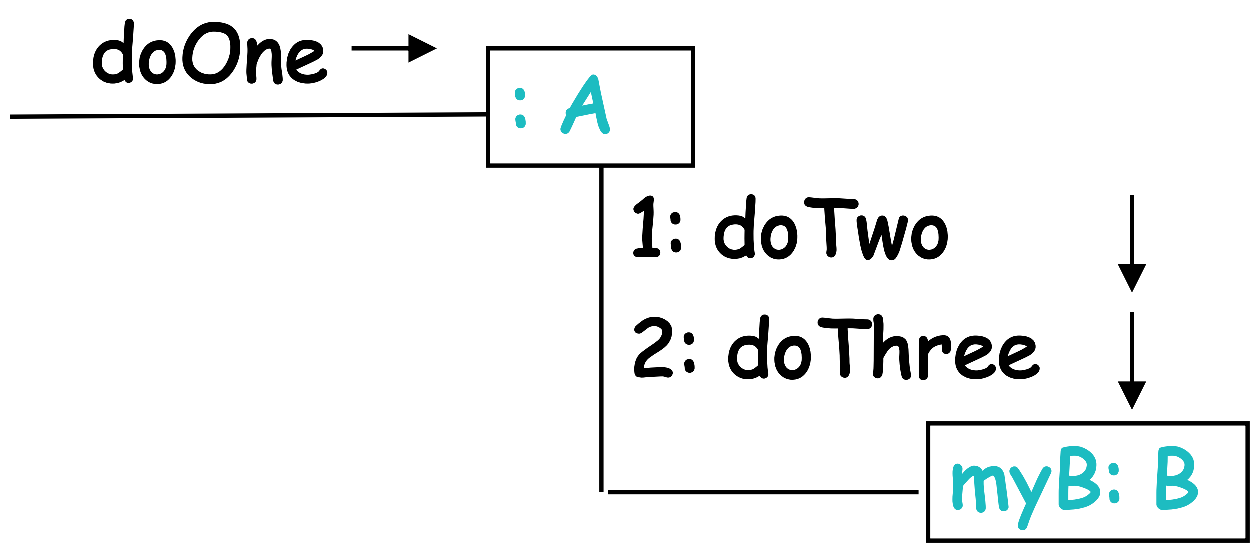


What Is The Possible Representation in Code?

```
public class A
{
    private B myB = new B();
    public void doOne()
    {
        myB.doTwo();
        myB.doThree();
    }
}
```

Communication Diagram

- To illustrate object interactions in a graph or network format, in which objects can be placed anywhere on the diagram



Sequence vs. Communication

- Sequence diagram
  - Tool support is better and more notation options are available
  - Easier to see the call flow sequence
- Communication diagram
  - More space-efficient
  - Modifying wall sketches is easier

How Should We Do OO Design?

- Responsibility-driven design (RDD)
  - Think about how to assign responsibilities to collaborating objects
  - Think about following questions
    - What are the responsibilities of an object?
    - Who does it collaborate with?
    - What design patterns should be applied?

Responsibilities

- Obligations or behaviors of an object in terms of its role
- Two types of responsibilities:
  - Doing responsibilities
  - Knowing responsibilities

Doing Responsibilities

- Doing something itself, such as creating an object or doing a calculation
  - "a Sale object is responsible for **creating** its SalesLineItem objects"
- Initiating action in other objects
- Controlling and coordinating activities in other objects

Self-behaviors and collaborations or interactions with others

Guideline

- The transition of responsibilities into classes and methods is influenced by the granularity of the responsibility
  - Big responsibilities take hundreds of classes and methods
    - "provide access to relational databases" may involve two hundred classes and thousands of methods
  - Little responsibilities take one method
    - "create a Sale" may involve only one method in one class

Knowing Responsibilities

- Knowing about private encapsulated data
- Knowing about related objects
- Knowing about things it can derive or calculate
  - "a Sale object is responsible for **knowing** its total"

Self-data and relevant objects/data

Guideline

- The attributes and associations illustrated by domain objects in a domain model often inspire the responsibilities
  - If the domain model Sale class has a time attribute, it's natural that a software Sale class knows its time.
  - Design classes do not always have identical attributes as domain classes

GRASP: A Methodical Approach to OOD

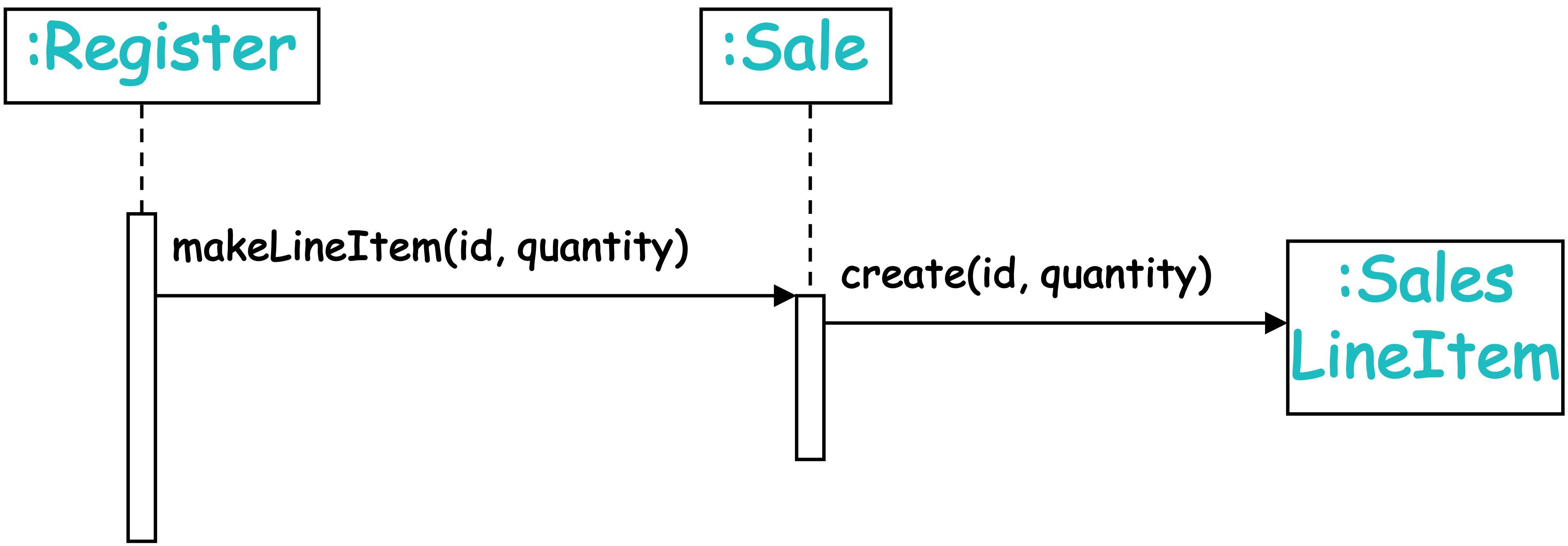
- Principles (Patterns) to guide choices about assigning responsibilities
  - Creator
  - Information expert
  - Low coupling
  - Controller
  - High cohesion
- Applicable to design and implementation

Principle 1: Creator (doing)

- Problem: Who creates an A?
- Advice: Assign class B the responsibility to create an instance of class A if:
  - B "contains" or compositely aggregates A
    - Whole-part; Assembly-part (e.g., body-leg)
  - B records A
  - B closely uses A
  - B has the initializing data for A

Example

- Who should be responsible for creating a SalesLineItem?
- Sale aggregates SalesLineItem objects



Summary

- Usually, the container or recorder of objects are creators
- Contraindications: complex creation
  - E.g. using recycled objects for performance
    - Both trucks and buses aggregate tires, so apply a Factory pattern to **get** instead of **creating** tires

Principle 2: Information Expert (knowing)

- Problem: Who knows the information to fulfill a responsibility?
- *Advice: Assign* the responsibility to class *A* if the information:
  - is about *A*'s attributes
  - is derivable by *A*, sometimes may depend on some attributes of relevant classes

Example

- Who knows the information about a Sale's total amount of money?

Sale
date time
getTotal()

Example

- Who knows the information about a Sale line item's subtotal?

Sales LineItem
quantity
getSubtotal()

Example

- Who knows the information of an item's price?

Product Specification
description price itemID
getPrice()

Summary

- Objects fulfill tasks using their info or the info of objects they know of
- It is crucially important to separate concerns between collaborative objects
  - E.g., getTotal() & getSubTotal()
  - Related to low coupling and high cohesion (discuss later)

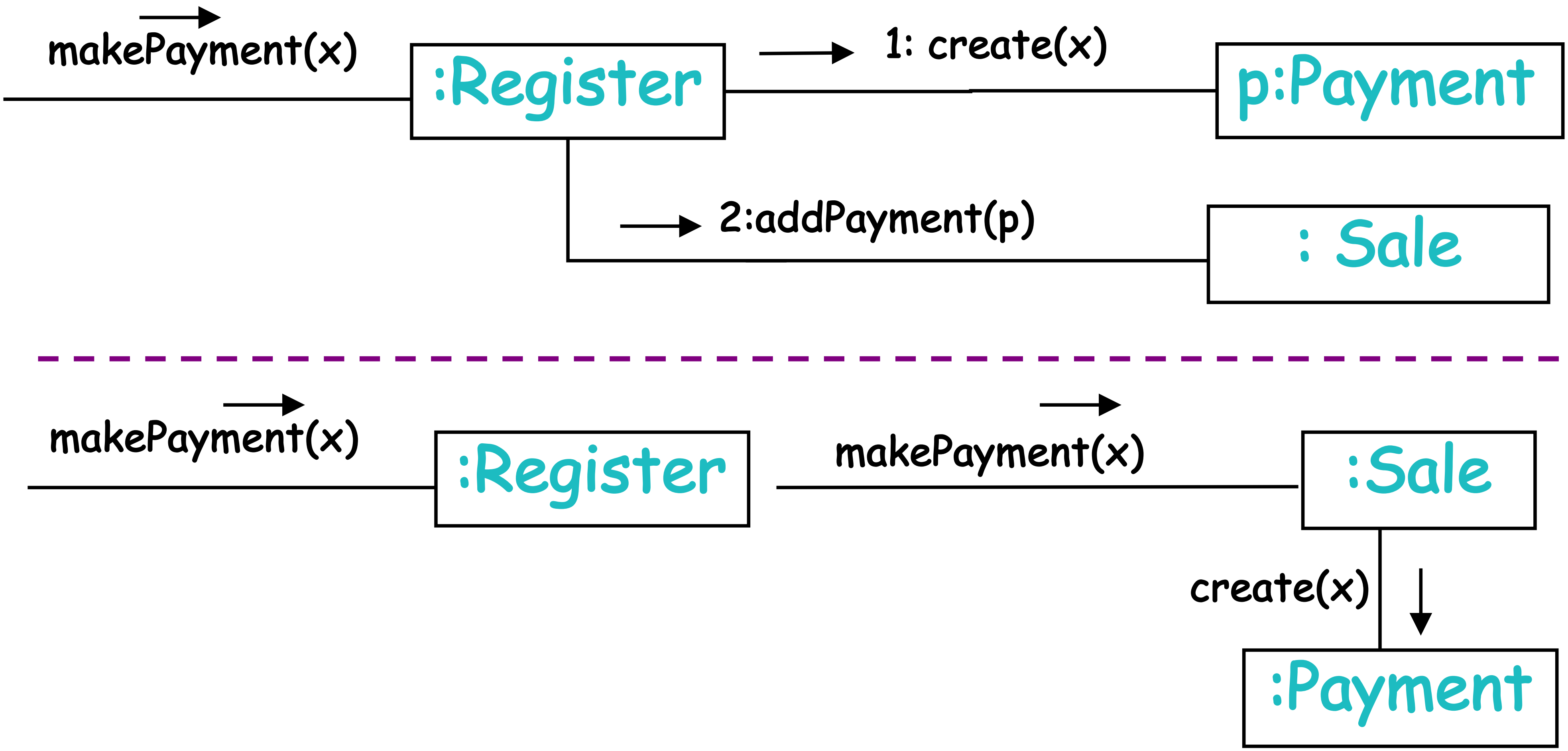
Principle 3: Low Coupling (relations)

- Problem: How to reduce the impact of change?
- Advice: put data and operations together
  - Goal: Avoid unnecessary coupling

Examples of Coupling

- Class A has an attribute (field) of class B
- An instance of A calls an instance of B
- A has a method that references B instances
  - local variable/parameter/return value is a reference (i.e., pointer) to a B object
- A is a direct or indirect subclass of B

Example: Two Alternatives



The second is better

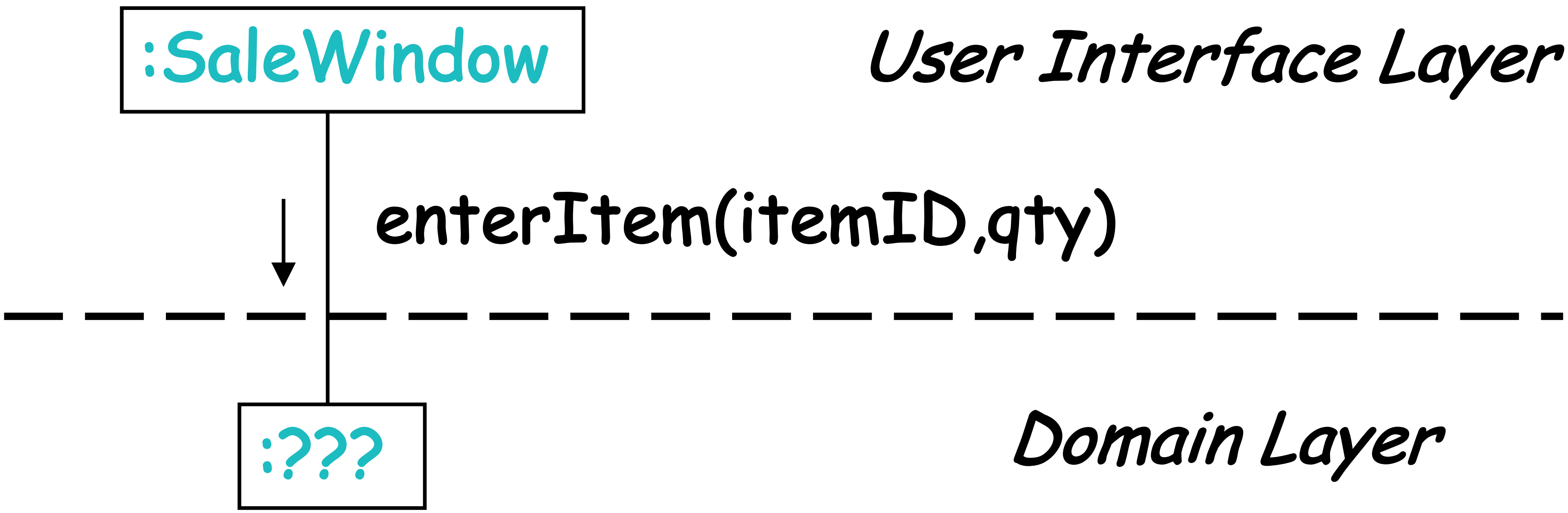
- Sale needs to know payment. The coupling is always there.
- Register simply delegates Sale to create the payment, without creating the payment itself

Principle 4: Controller (doing)

- Problem: What first object beyond the UI layer receives and coordinates ("controls") a system operation?
- Advice: Assigns "control" to class *A* if it is:
  - Facade controller: a class representing the entire system or device
  - Use case controller: a class representing a use case within which the event occurs
    - E.g., XyzHandler, XyzCoordinator, XyzSession
      - Xyz=name of the use case

Example

- System events in POS system
  - endSale(), enterItem(), makeNewSale(), makePayment(), …
  - Typically generated by the GUI



Using Facade Controller

- Facade controller: entire system/device
  - POS_System, Register
- Used when there are NOT too many system events
  - Avoid "bloated" controllers (e.g., too many responsibilities)

Using Use-case Controllers

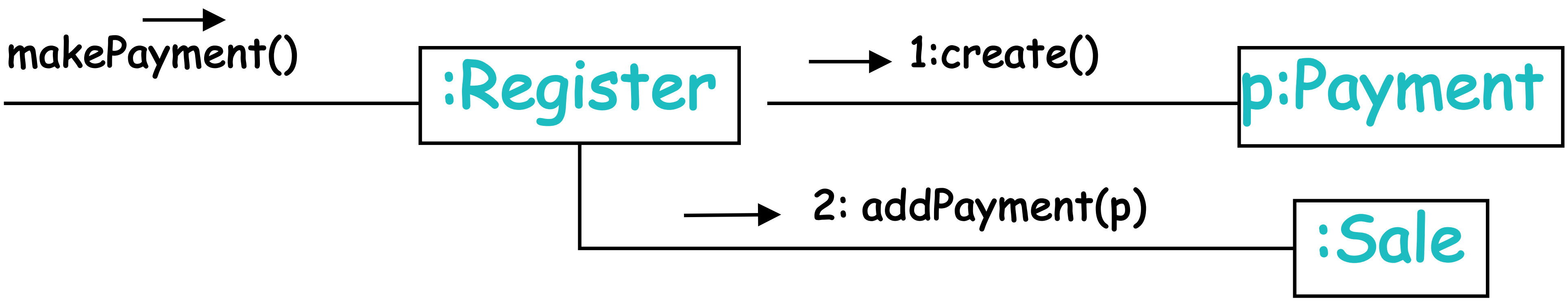
- Use-case controller: handler for all system events in a use case
- Used when there are MANY system events
  - Several manageable controller classes
  - Track the state of the current use-case scenario

Principle 5: High Cohesion (relations)

- Problem: How to keep object focused, and manageable?
- Advice: DON'T put too much data and operations into the same class
  - Goal: avoid unnecessary responsibilities

Example

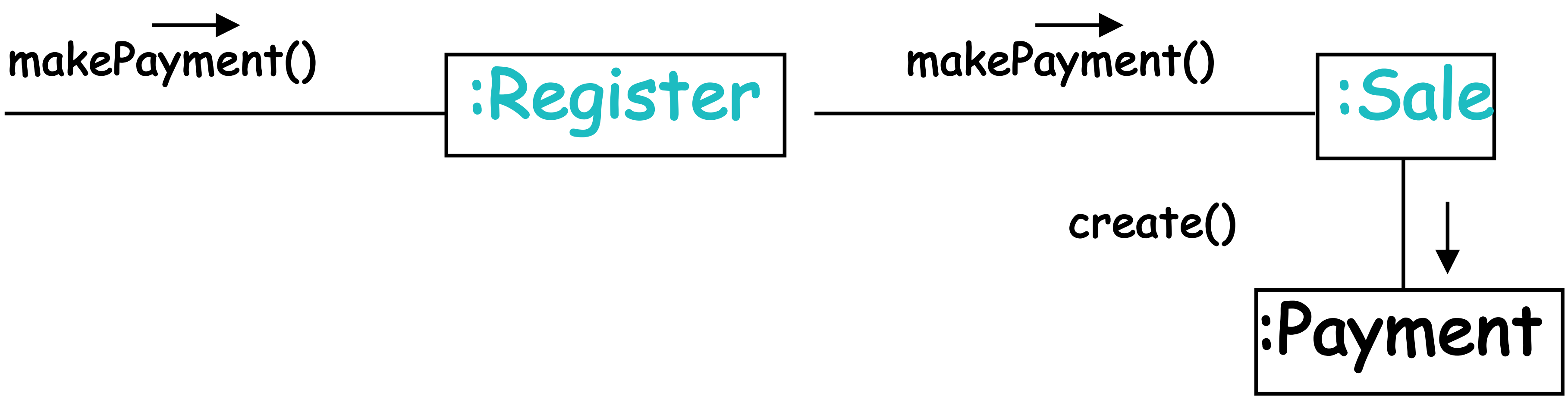
- *Who creates Payment objects?*



- If Register does the work for all system events, it will become bloated and not cohesive

A better solution: delegation

- Our better solution: delegate Payment creation to Sale
  - Higher cohesion for Register
  - Also reduces coupling



Rule of thumb

- Class with high cohesion has relatively small number of methods with highly related functionality, and does not do too much work (LAR, p 317)

Benefits

- Clear separation of concerns
  - Easy to comprehend, reuse, and maintain
- Often results in low coupling
- Contraindications:
  - Distributed server objects need to be larger, w/ coarse-grained operations
    - Reduces the number of remote calls
  - To simplify maintenance by an expert developer