Introduction to GRASP: Assigning Responsibilities to Objects

CS 4354
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Object Analysis & Design in the textbook

- Chapter 5 Analysis activities: from use cases to objects
  - ✦Gives good guidelines for identifying and assigning the following:
    - objects (classes)
    - attributes
    - associations, aggregations, inheritance relationships
    - Good start to a class diagram representing the domain model
  - ✦But what about operations?
    - Sequence diagrams are good tools to explore interactions and operations
    - But little advice is given on how to decide who does what.

The design of behavior

- What methods go in what classes? How should objects interact?
  - ✦These are critical questions in the design of behavior.
  - ✦Poor answers lead to abysmal, fragile systems with low reuse and high maintenance.

Responsibility-Driven Design

- Assign responsibilities to classes
- Methods are implemented to fulfill responsibilities.
- Methods may act alone or in collaboration to fulfill their obligations.

- Responsibilities of classes:
  - ✦Knowing: about attributes, related classes, computed values
  - ✦Doing: Calculating, coordinating, creating, controlling

GRASP Patterns

GRASP

- General Responsibility Assignment Software Patterns.
- These are well-known best principles for assigning responsibilities.
- Nine core principles that object-oriented designers apply when assigning responsibilities to classes and designing message interactions.
  - ✦We will look at 5 of these 9 principles
- Can be applied during the creation of sequence diagrams, or even during implementation.
- After or in tandem with developing the domain model.

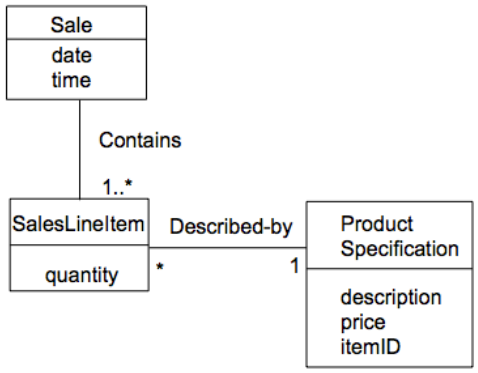
Patterns

- Named description of a problem/solution pair that can be applied in new contexts, with advice on how to apply it in novel situations, and discussion of its trade-offs.
- Notable benefits of patterns:
  - ✦ Simplifying: provides a named, generally understood building block
    - Facilitates communication
    - Aids thinking about the design
  - ✦ Accelerates learning to not have to develop concepts from scratch

Pattern: Information Expert

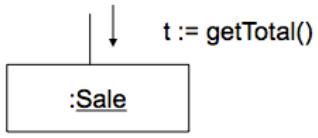
- Problem: What is most basic, general principle of responsibility assignment?
- Solution: Assign a responsibility to the object that has the information necessary to fulfill it.
  - ✦"That which has the information, does the work."
- In a "Point of Sale" application, who should be responsible for knowing the grand total of a sale?
- By Information Expert we should look for that class that has the information needed to determine the total.

POS domain model



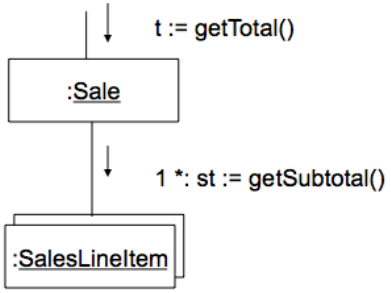
- It is necessary to know about all the SalesLineItem instances of a sale and the sum of the subtotals.
- A Sale instance contains these, i.e. it is an information expert for this responsibility.

POS Information Expert



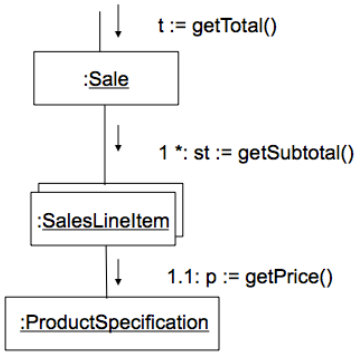
- This is a partial interaction diagram.
- It's a variation of a sequence diagram.

POS Information Expert



- What information is needed to determine the line item subtotal?
  - quantity and price.
- SalesLineItem should determine the subtotal.
- This means that Sale needs to send getSubtotal() messages to each of the SalesLineItems and sum the results.

POS Information Expert



- To fulfill the responsibility of knowing and answering its subtotal, a SalesLineItem needs to know the product price.
- The ProductSpecification is the information expert on answering its price.

POS Information Expert

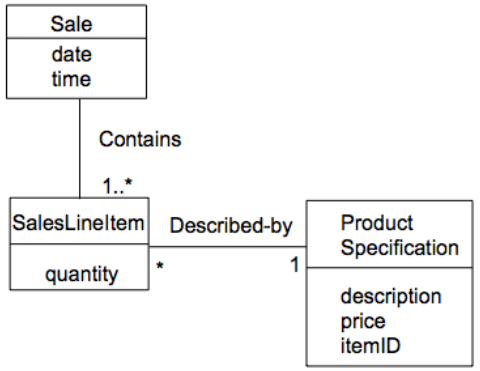
Class	Responsibility
Sale	Knows Sale total
SalesLineItem	Knows line item total
ProductSpecification	Knows product price

- To fulfill the responsibility of knowing and answering the sale's total, three responsibilities were assigned to three design classes
- The fulfillment of a responsibility often requires information that is spread across different classes of objects. This implies that there are many "partial experts" who will collaborate in the task.

Pattern: Creator

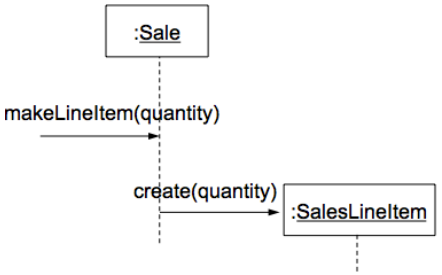
- Problem: Who should be responsible for creating a new instance of some class?
- Solution: Assign class B the responsibility to create an instance of class A if one or more of the following is true:
  - ✦B aggregates A objects.
  - ✦B contains A objects.
  - ✦B records instances of A objects.
  - ✦B has the initializing data that will be passed to A when it is created (thus B is an Expert with respect to creating A).
- The more, the better.

POS domain model



- In the POS application, who should be responsible for creating a SalesLineItem instance?
- Since a Sale contains many SalesLineItem objects, the Creator pattern suggests that Sale is a good candidate.

POS Creator



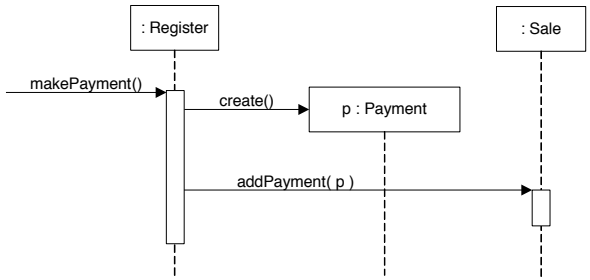
- This assignment of responsibilities requires that a makeLineItem method be defined in Sale.

Pattern: Low Coupling

- **Coupling** (in a class diagram) is a measure of how strongly one class is connected to, has knowledge of, or relies on other classes.
- A class with high coupling depends on many other classes (libraries, tools).
- Problems because of a design with high coupling:
  - ✦Changes in related classes force local changes.
  - ✦Harder to understand in isolation; need to understand other classes.
  - ✦Harder to reuse because it requires additional presence of other classes.
- Problem: How to support low dependency, low change impact and increased reuse?
- Solution: Assign a responsibility so that coupling remains low.

POS: Low Coupling

- Which class should be responsible for creating a Payment and associating it with a sale?



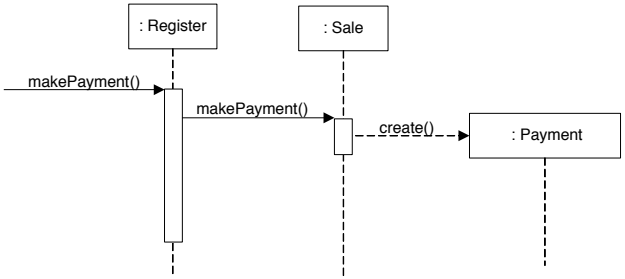
✦Since Register records a payment (in real life), it could be Register, by the Creator pattern

✦Register could then send an addPayment message to Sale, passing along the new Payment as a parameter.

✦This assignment of responsibilities couples the Register class to knowledge of the Payment class.

POS: Low Coupling

- An alternative solution is to create Payment and associate it with the Sale.
- No coupling between Register and Payment.

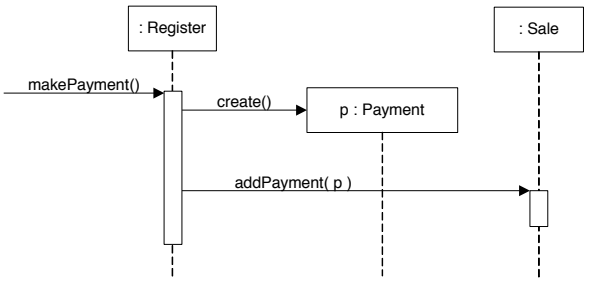


Pattern: High Cohesion

- **Cohesion** (in a class diagram) is a measure of how strongly related and focused the responsibilities of a class are.
- A class with low cohesion does many unrelated activities or does too much work.
- Problems because of a design with low cohesion:
  - ✦ Hard to understand.
  - ✦ Hard to reuse.
  - ✦ Hard to maintain.
  - ✦ Delicate, affected by change.
- Problem: How to keep complexity manageable?
- Solution: Assign a responsibility so that cohesion remains high.

POS High Cohesion

- Let's compare the same two examples as before with respect to cohesion:



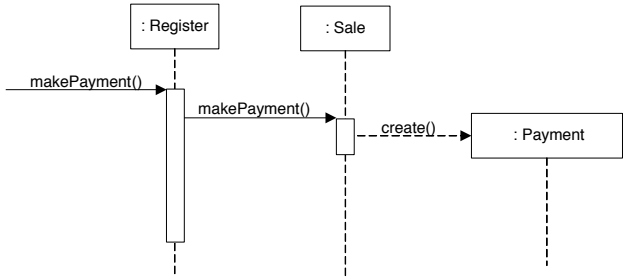
✦Since Register records a payment (in real life), it could be Register, by the Creator pattern

✦Register could then send an addPayment message to Sale, passing along the new Payment as a parameter.

✦Register may become bloated if it is assigned more and more system operations.

POS: High Cohesion

- An alternative design delegates the Payment creation responsibility to the Sale, which supports higher cohesion in the Register.
- No class has too much work (good delegation).
- This design supports high cohesion and low coupling.

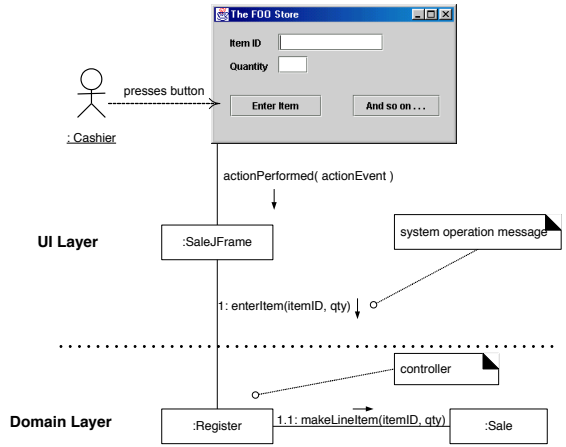


Pattern: Controller

- What class should handle system event messages (such as input from the user)?
- Solution: Choose a class whose name/job suggests:
  - ✦The overall "system," device, or subsystem
  - ✦OR, represents the use case scenario or session
- Recall: during analysis,we identified three types of objects:
  - ✦Entity Objects: persistent information tracked by system (domain objects)
  - ✦Boundary Objects: represent the interface between the actors and the system
  - ✦Control Objects: are in charge of realizing use cases
- Recall: MVC architectural pattern: the Controller component

POS: Controller

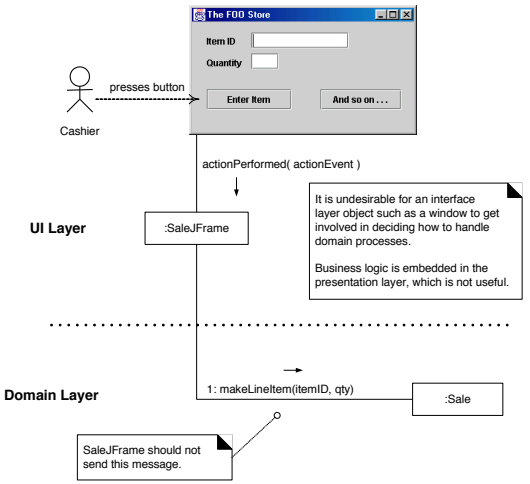
- In this example, the Register object (a controller) handles the input event.



POS: Controller

- In this example, SaleJFrame, a UI (boundary) object handles the input event

Don't want the UI objects tightly coupled with the entity objects (Sale)



Summary of Introduction to GRASP

- 5 principles for deciding how to assign responsibility (behavior) to classes:
  - ✦Information Expert
  - ✦Creator
  - ✦Low Coupling
  - ✦High Cohesion
  - ✦Controller
- These decisions are made during analysis and/or object design.
- These decisions are made (initially) when designing the sequence diagrams from the use cases (deciding which messages are handled by which objects)