ĐẠI HỌC ĐÀ NẴNG
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SYSTEMS ANALYSIS AND DESIGN

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Design principles

- General Responsibility Assignment Software Principles/Patterns - GRASP

Understanding responsibilities is key to object-oriented design.

Martin Fowler

Responsibilities-Driven Design

- RDD is a metaphor for thinking about object-oriented design.
- Think of software objects similar to people with responsibilities who collaborate with other people to get work done.
- RDD leads to viewing an OO design as a community of collaborating responsible objects.

GRASP

- General Responsibility Assignment Software Patterns or Principles (GRASP)
  - Pattern is a solution which can be applied to a problem in a new context
- A learning aid for OO Design with responsibilities.
- A collection of patterns/principles for achieving good design - patterns of assigning responsibility.

Responsibility

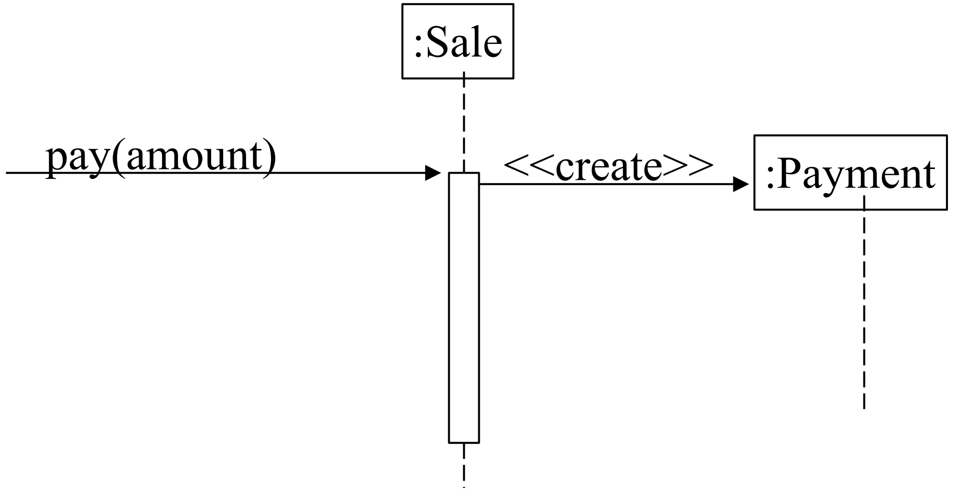
- A **responsibility** is an duty or a contract of a class
- The determination of the attributes and operations of a class is essentially based on its responsibilities
- The responsibilities of an object relate to the behaviour of an object
- Two main types of responsibility
  - **Do**
    - The object accomplishes something itself
    - The object initiates an action of another object
    - The object controls or coordinates activities of other objects
  - **Know**
    - The object knows private encapsulated data
    - The object knows the objects to which it is linked
    - The object has data that it can calculate or derive

Responsibility

- **The responsibilities are assigned to classes during the design phase**
  - Example
    - An object of *Sale* class is responsible for creating an object of *Payment* class (do)
    - An object of *Sale* class is responsible for knowing its total (know).
- The translation of responsibilities into methods of classes depends on the granularity of the responsibilities
  - A responsibility can be translated by several methods of several classes
    - Responsibility “offer access to the database” can be translated to several methods of several classes
  - A responsibility can be translated by one method
    - Responsibility “create a *Sale*” can be translated by only one method.

Assignment and discovery of responsibilities

- The assignment of responsibilities to objects is very important in object-oriented design.
- **The discovery of responsibilities is achieved when building interaction diagrams**

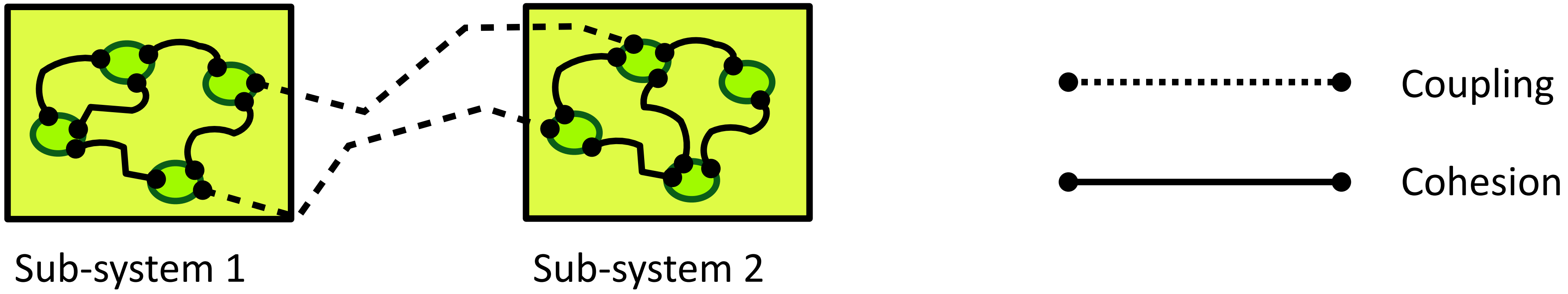


GRASP patterns

- We consider 5 among 9 GRASP patterns/principles
  - **Low Coupling**: assigning responsibilities in a low coupling way
  - **High Cohesion**: assigning the responsibilities to ensure that cohesion remains high
  - **Creator**: assigning the creation responsibility of an object to another object
  - **Information Expert**: the common principle when assigning responsibilities to classes
  - **Controller**: assigning the responsibility for management of the system event messages
  - **Polymorphism**
  - **Indirection**
  - **Pure fabrication**
  - **Protected variations**

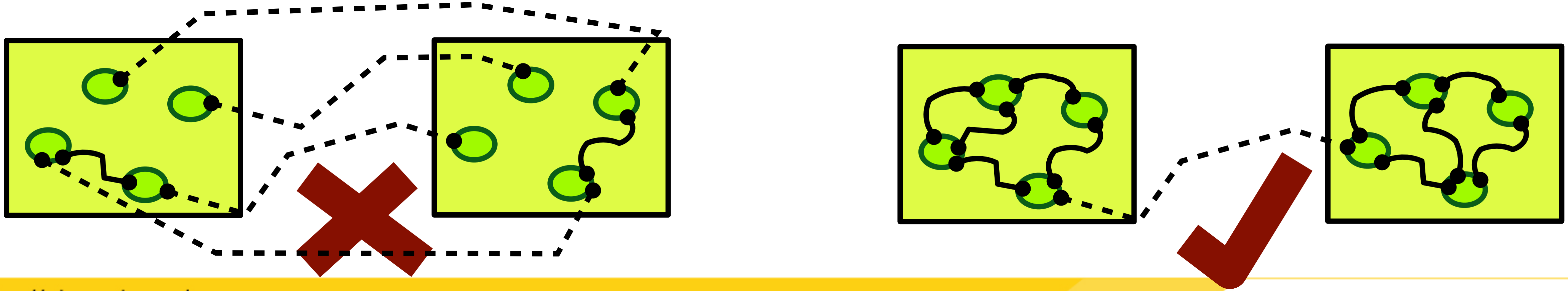
Coupling and Cohesion

- **Coupling**: Amount of relations between objects/sub-systems
- **Cohesion**: Amount of relations within sub-system



Properties of a good architecture

- Minimises coupling between modules
  - Goal: modules don’t need to know much about one another to interact
  - Low coupling makes future change easier
- Maximises cohesion within modules
  - Goal: the content of each module are strongly inter-related
  - High cohesion makes a module easier to understand



Low coupling

- Problem: How to support low dependency, low change impact, and increase reuse?
- Coupling:
  - Measure how strongly one element is connected to, has knowledge of or relies on other elements
  - An element with low (or weak) coupling is not dependent on two many other elements

When are two classes coupled?

- Common forms of coupling from TypeX to TypeY
  - TypeX has an attribute that refers to a TypeY instance
  - A TypeX object calls on services of TypeY object
  - TypeX has a method that references an instance of TypeY (parameter, local variable, return type)
  - TypeX is a direct or indirect subclass of TypeY
  - TypeX is an interface and TypeY implements that interface

High coupling (Bad)

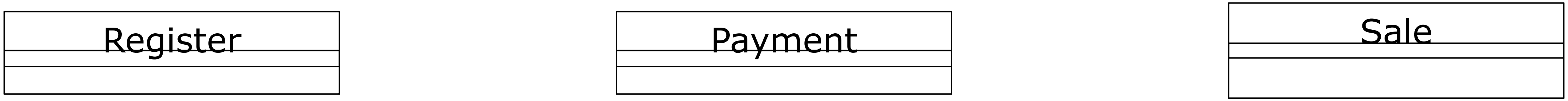
- A class with high (or strong) coupling relies on many other classes. Such classes may be undesirable and suffer from the following problems:
  - Force local changes because of changes in related classes
  - Harder to understand in isolation
  - Harder to reuse because its use requires the additional presence of the classes on which it is dependent

Solution

- Assign responsibility so that coupling remain low
- Use this principle to evaluate alternatives

Example

- We have three following classes in the Cash Register system



Register

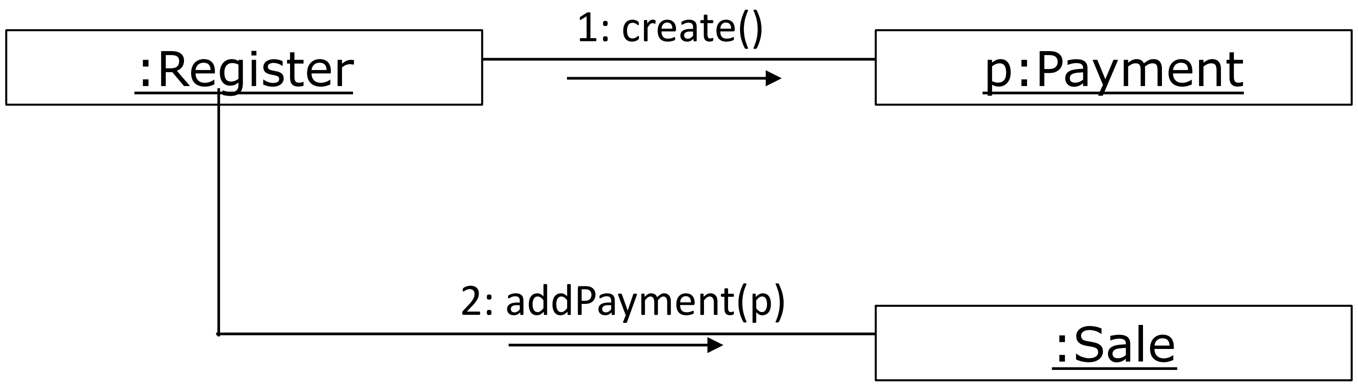
Payment

Sale

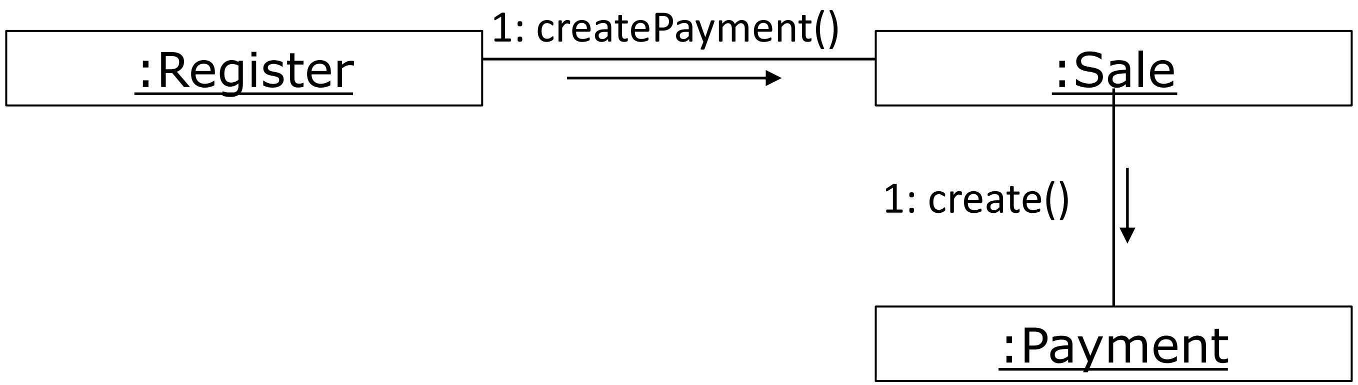
- Supposing that we would like to create an instance of Payment and associate it with Sale.
- How can we assign responsibilities to adhere to Low Coupling pattern?

Solutions

- Solution 1

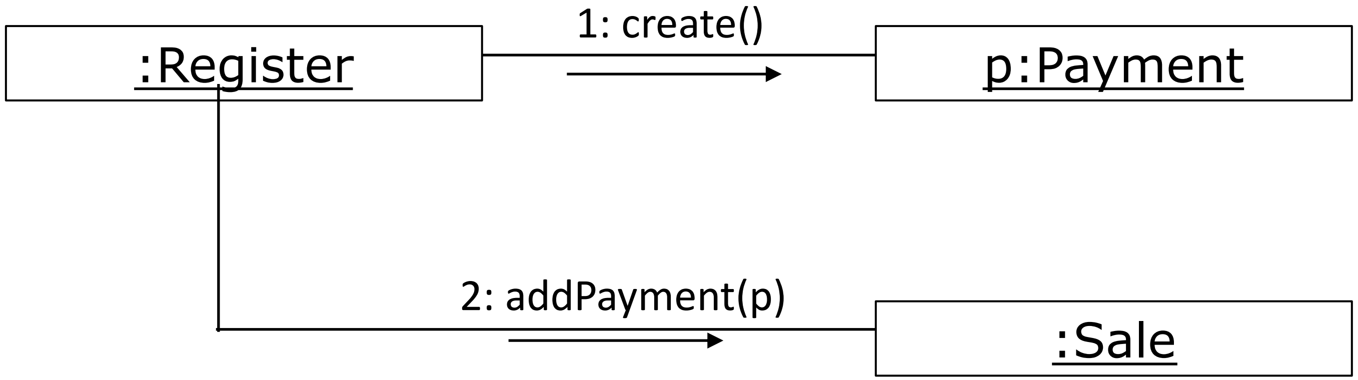


- Solution 2

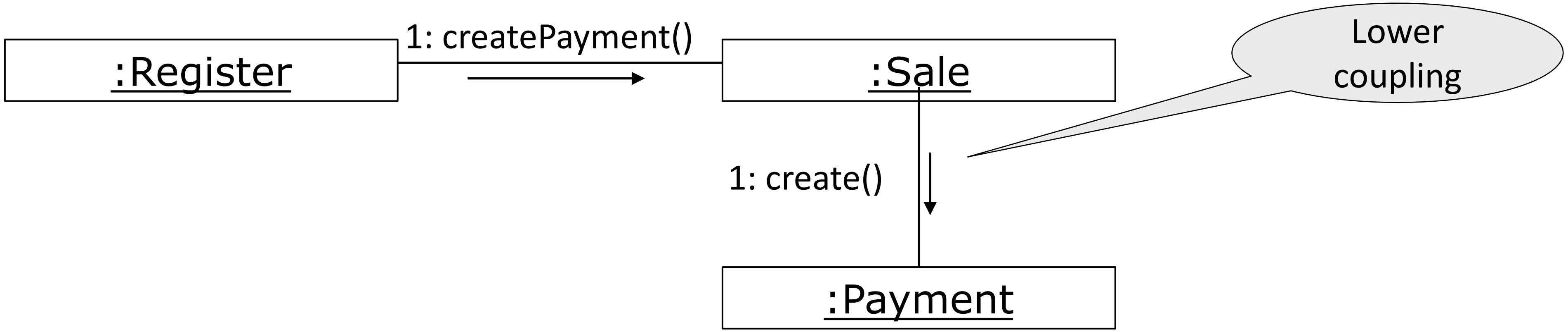


Solutions

- Solution 1: *Register* knows both *Payment* and *Sale*. *Register* depends on both *Payment* and *Sale*.



- Solution 2: *Register* and *Sale* are coupled, *Sale* and *Payment* are coupled.



High Cohesion pattern

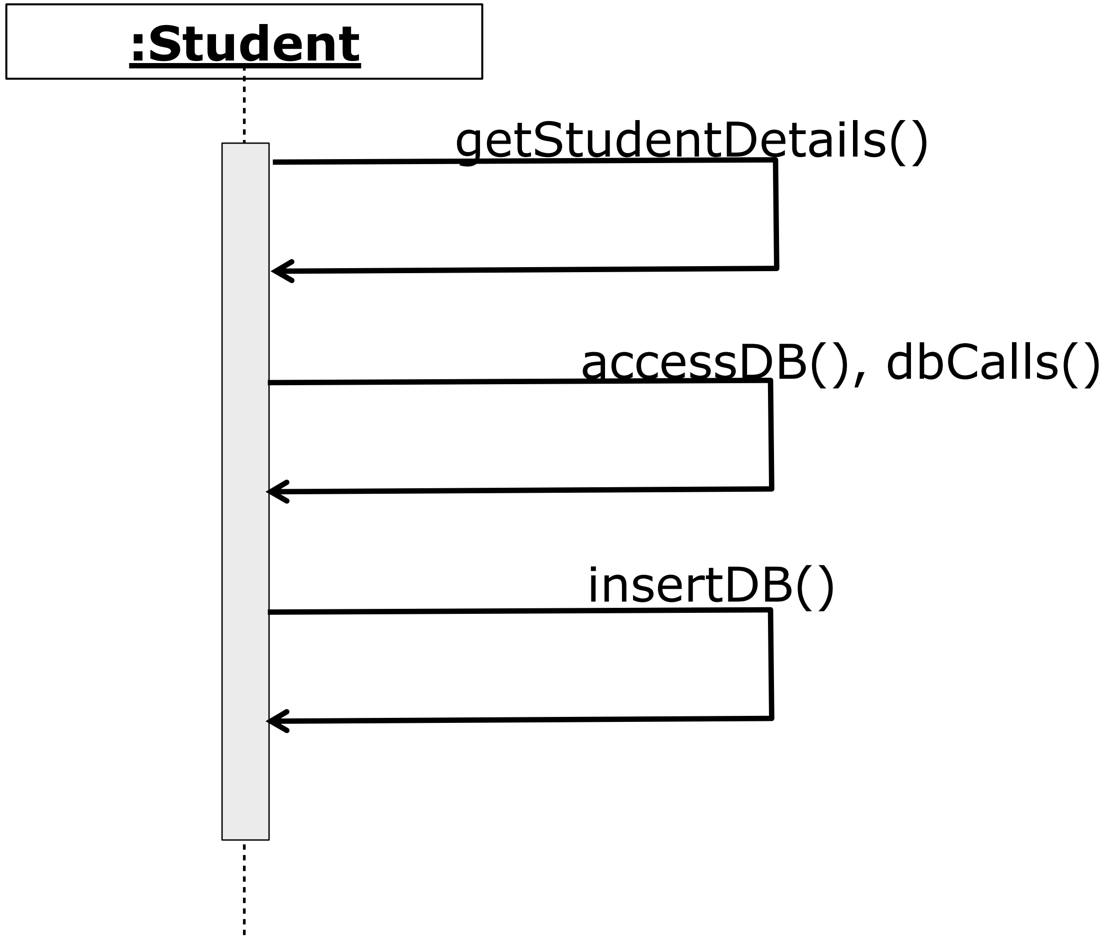
- Problem
  - How to ensure that the operations of any element are functionally related?
- Solution
  - Clearly define the purpose of the element
  - Gather related responsibilities into an element
- Benefit
  - Easily to understand and maintain

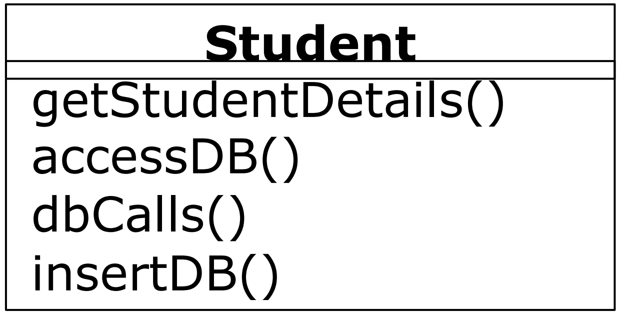
Low cohesion

- A class with low cohesion does many unrelated things or does too much work. Such classes are undesirable; they suffer from the following problems:
  - hard to comprehend
  - hard to reuse
  - hard to maintain
  - constantly affected by change

High Cohesion pattern

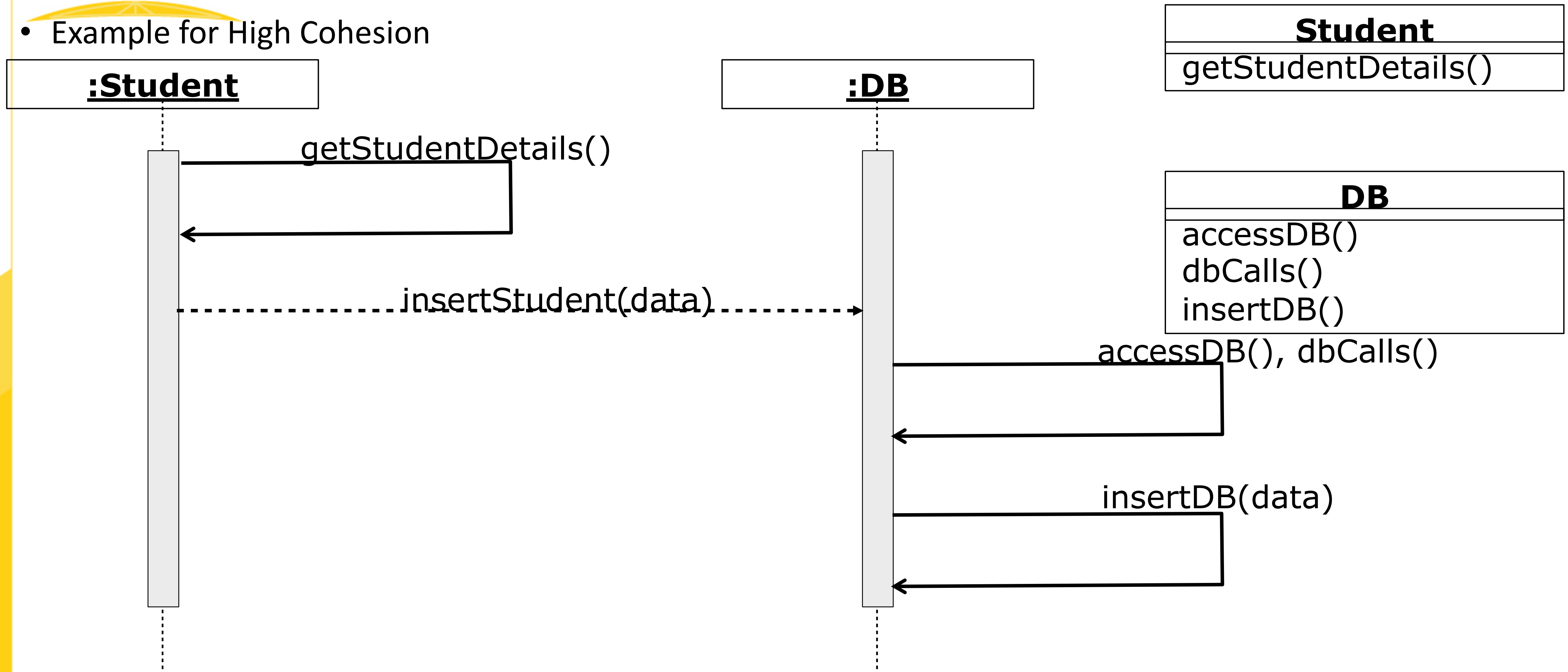
- Example for Low Cohesion





High Cohesion pattern

- Example for High Cohesion

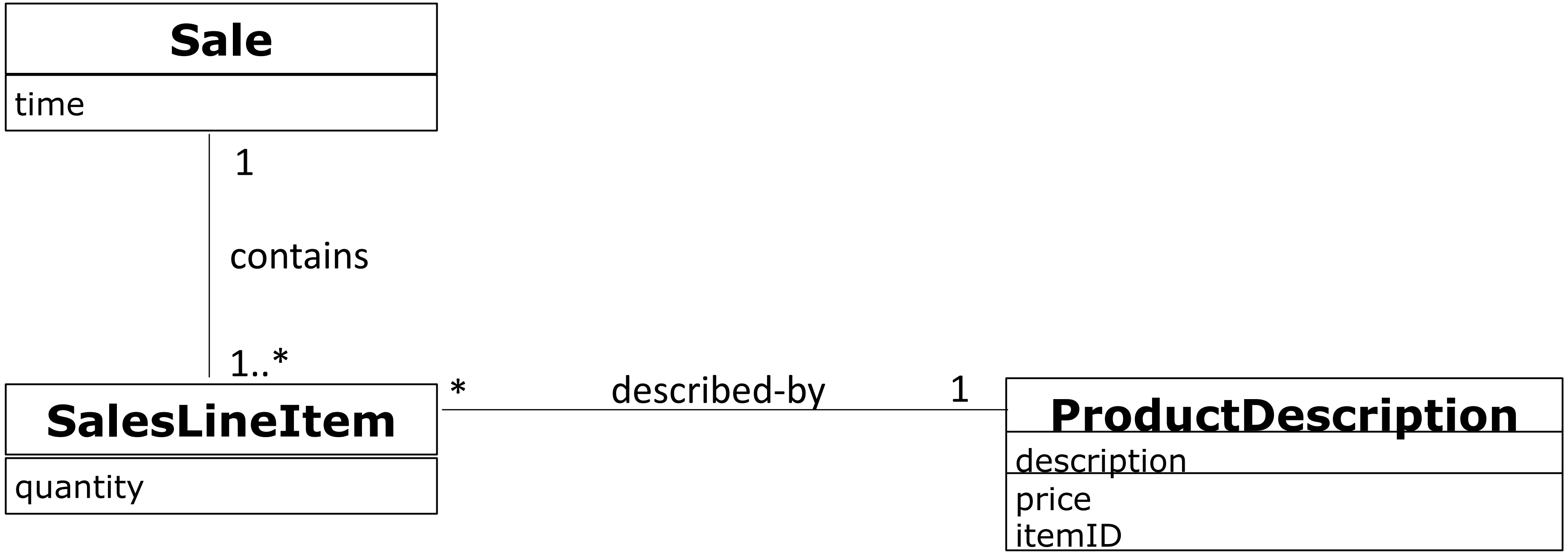


Rules of thumb

- For high cohesion, a class must
  - have few methods
  - have a small number of lines of code
  - not do too much work
  - have high relatedness of code

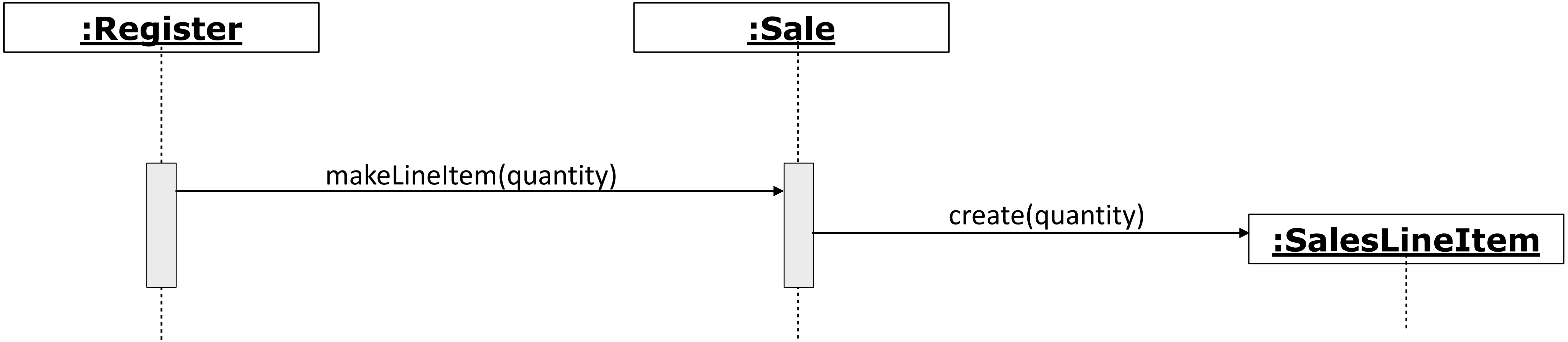
“creator” pattern

- Problem
  - Who is responsible for creating objects/instances of a class?
- Example
  - Who should be responsible for creating a SalesLineItem instance?



“creator” pattern

- Example (continue)
  - *Sale* contains *SalesLineItem*, so *Sale* should be responsible for creating objects of *SalesLineItem*



  - *“makeLineItem(quantity)”* method will be introduced to *Sale* class

“creator” pattern

- Discussion
  - Basic idea is to find a creator that needs to be connected to the created object in any event
  - Also need initialisation data to be nearby - sometimes requires that it is passed into client. e.g., *ProductionDescription* needs to be passed in.

  - Assign class B the responsibility to create an instance of class A if one of these is true
    - B contains A
    - B aggregates A
    - B has data for initialising A
    - B closely uses A

“creator” pattern

- Application
  - Guide in the assigning responsibility for creating objects
  - Help to find the class who is responsible for creating objects

- Advantages
  - The “creator” pattern supports the low coupling between classes
    - Fewer dependencies and more reusability
    - The coupling is not increased because the created class is visible to the “creator” class

Information Expert pattern

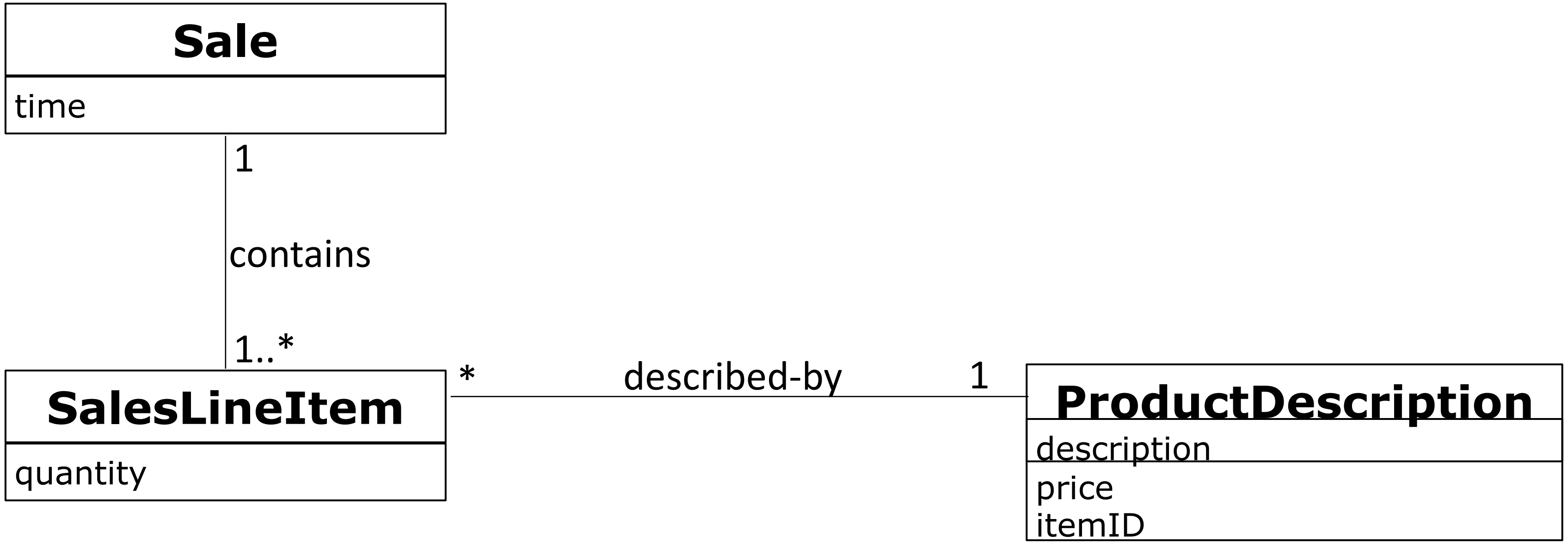
- Problem
  - What is the general principle of assigning responsibilities to objects?
    - Consider that there may be 100s or 1000s of classes
    - To which ones do we assign a particular functionality?
    - Assigning well makes our design easier to understand, maintain, extend and reuse.

- Solution
  - Assign responsibility to the information expert - the class that has the information to fulfil the responsibility

- Application
  - One of the most used patterns in object-oriented design
  - Accomplishing of a responsibility can request information distributed among several objects or classes, this implies several “partial experts” working together to fulfil the responsibility

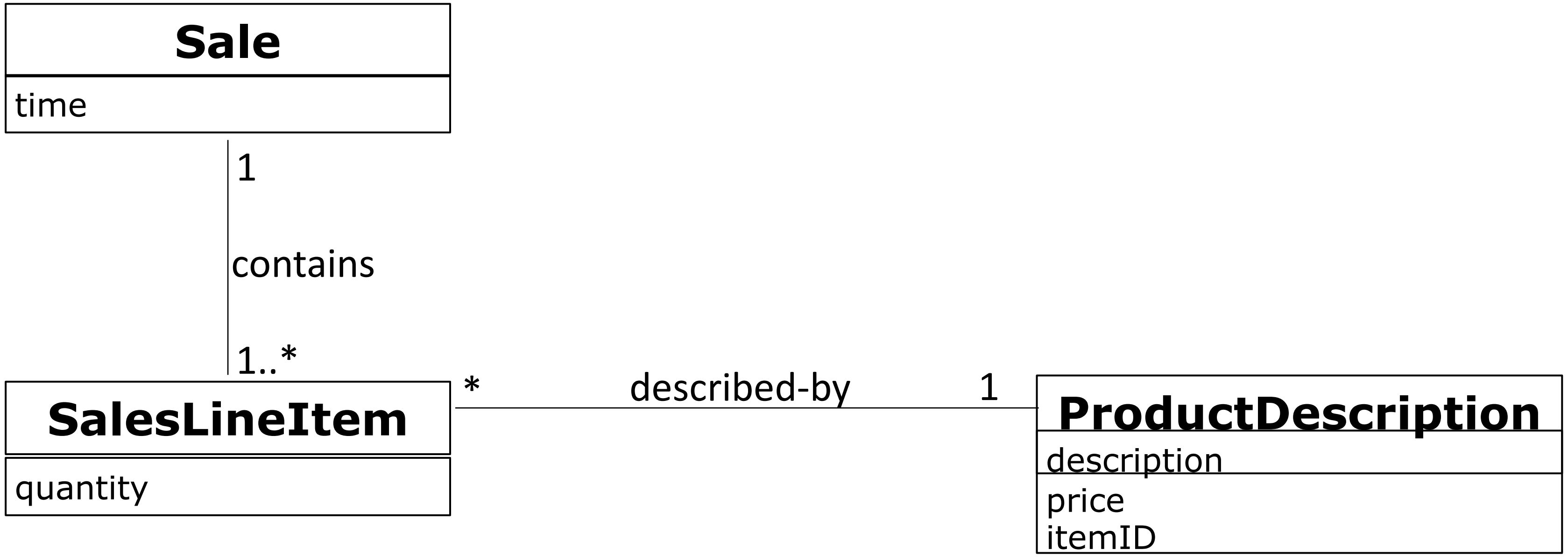
Information Expert pattern

- Example
  - In the *CashRegister* system, who is responsible for knowing the grand total of a *Sale*?



Information Expert pattern

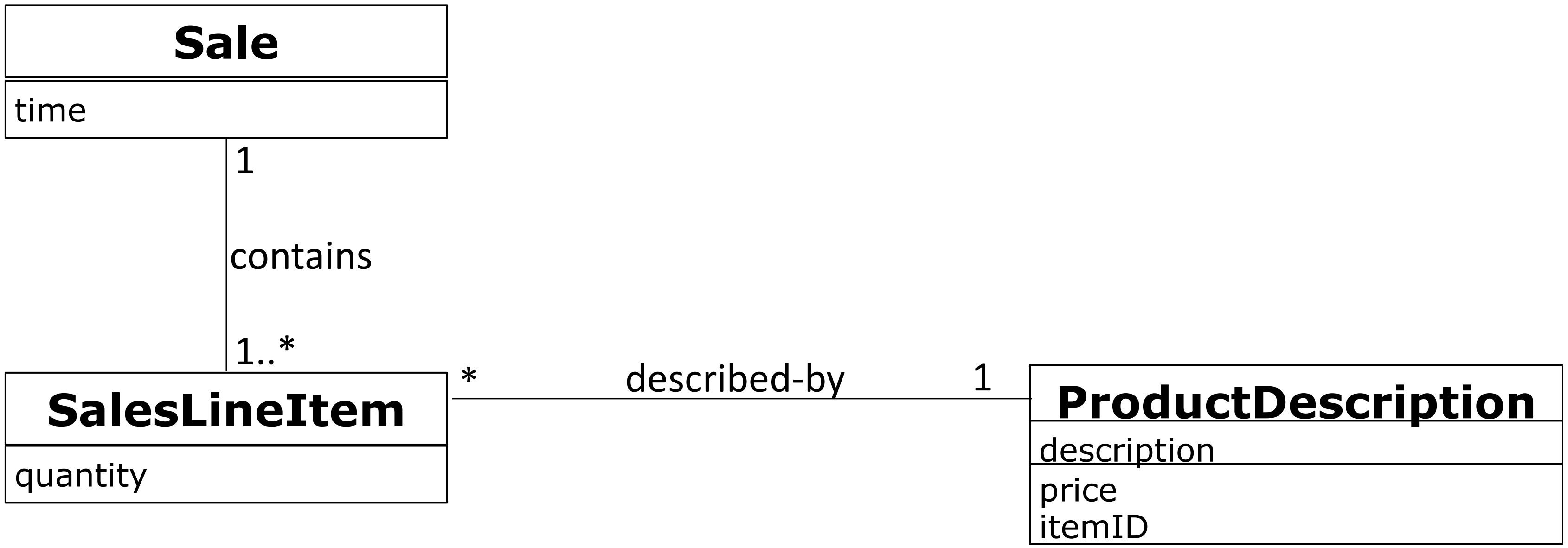
- Example: Responsibilities



Class	Responsibility
Sale	knows sale total
SaleLineItem	knows line items subtotal
ProductDescription	knows product price

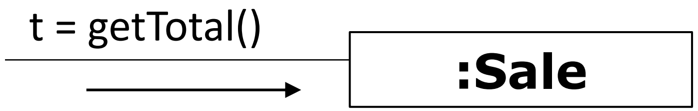
Information Expert pattern

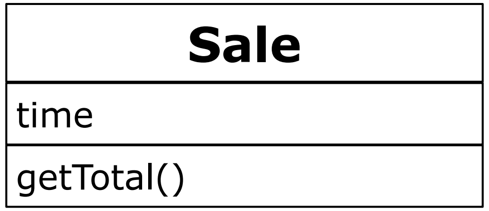
- Example (continue)
  - To calculate **grand total** of a *Sale*, it is necessary to know the instances of *SalesLineItem* and the sub-total of each instance.
  - According to the pattern, *Sale* knows the information



Information Expert pattern

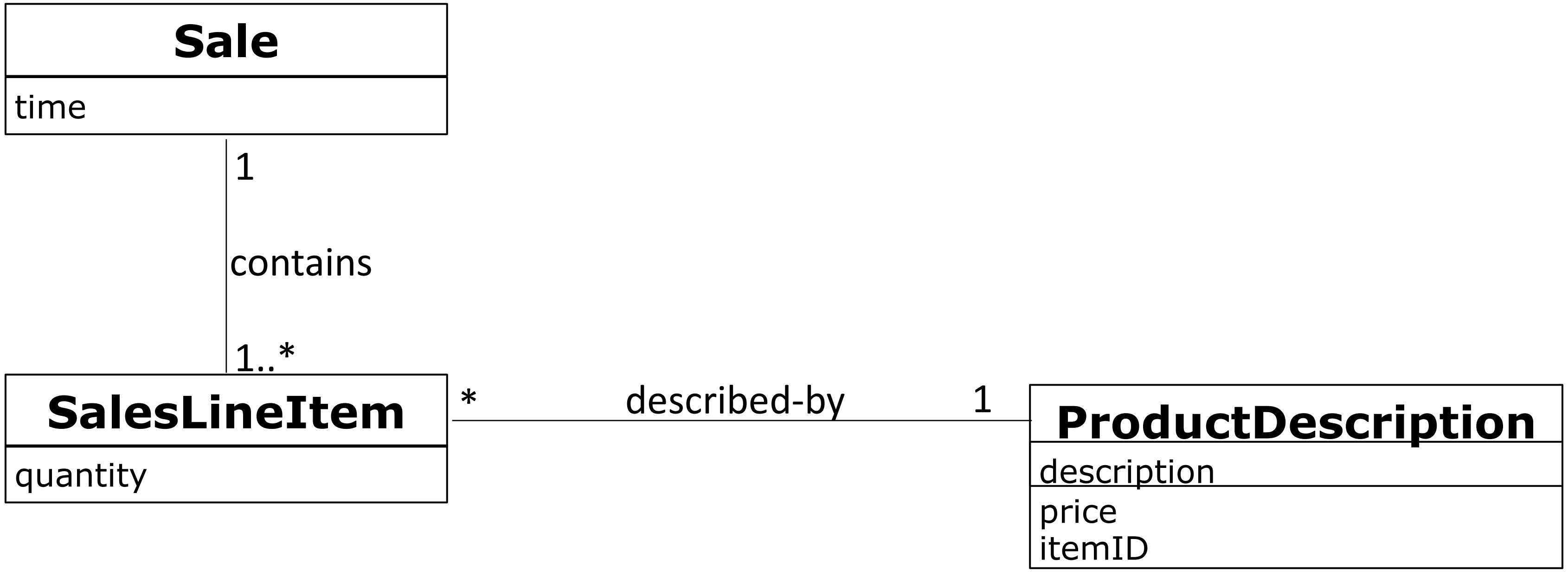
- Example (continue)
  - Introduce “*getTotal()*” method to *Sale* class





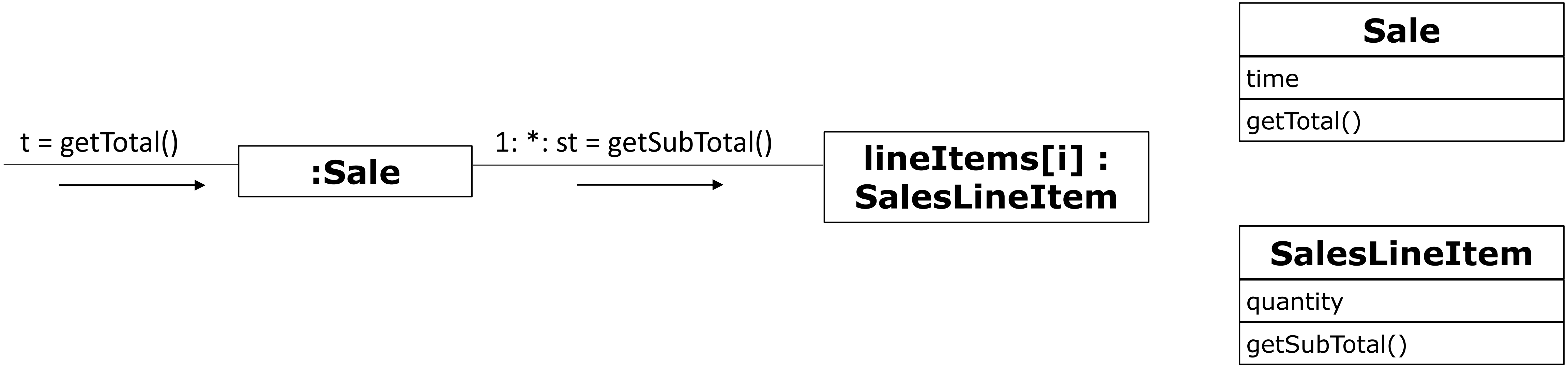
Information Expert pattern

- Example
  - Then, we need to determine the sub-total of each *SalesLineItems*. To do so, we need to know the number of *ProductDescription*
  - According to the pattern, *SalesLineItem* is the expert.



Information Expert pattern

- Example
  - Introduce the “get*SubTotal()*” method to *SalesLineItem* class



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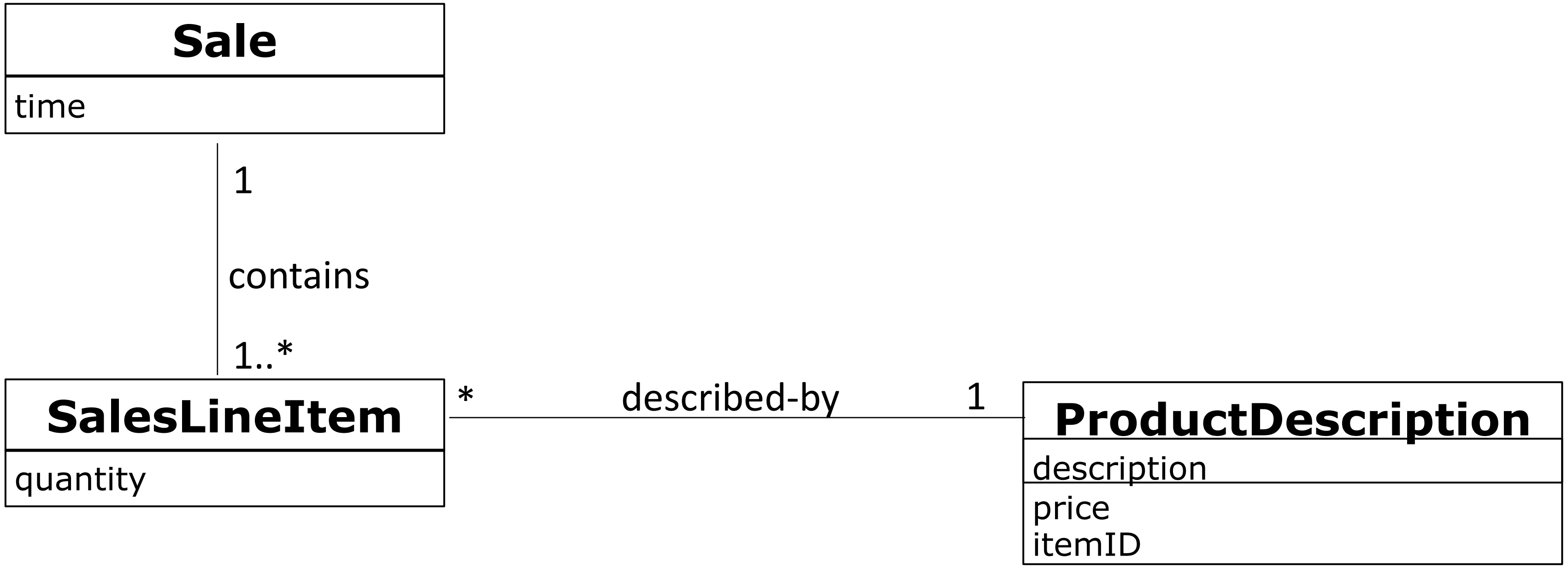
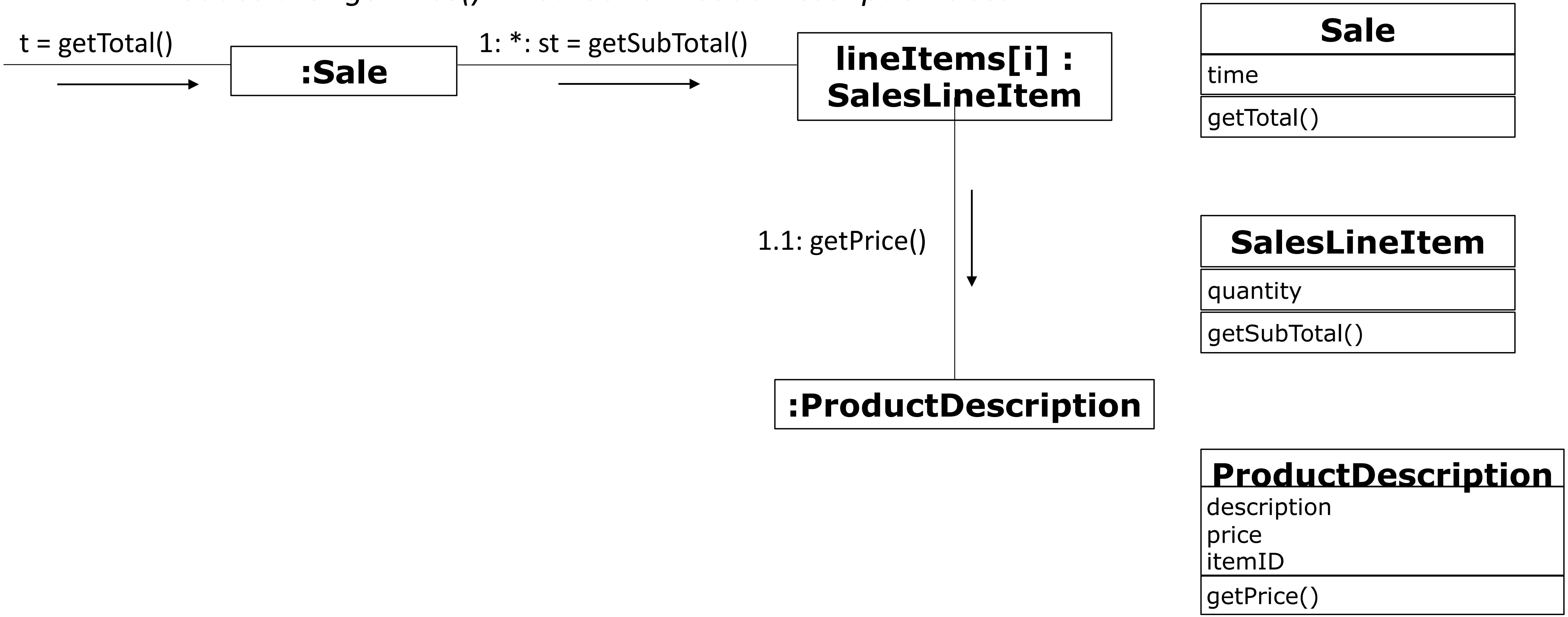
Information Expert pattern

- Example
  - To calculate the sub-total, *SalesLineItem* needs to know the price of each product.
  - *ProductionDescription* est expert.



Information Expert pattern

- Example
  - Introduce the “*getPrice()*” method to *ProductDescription* class

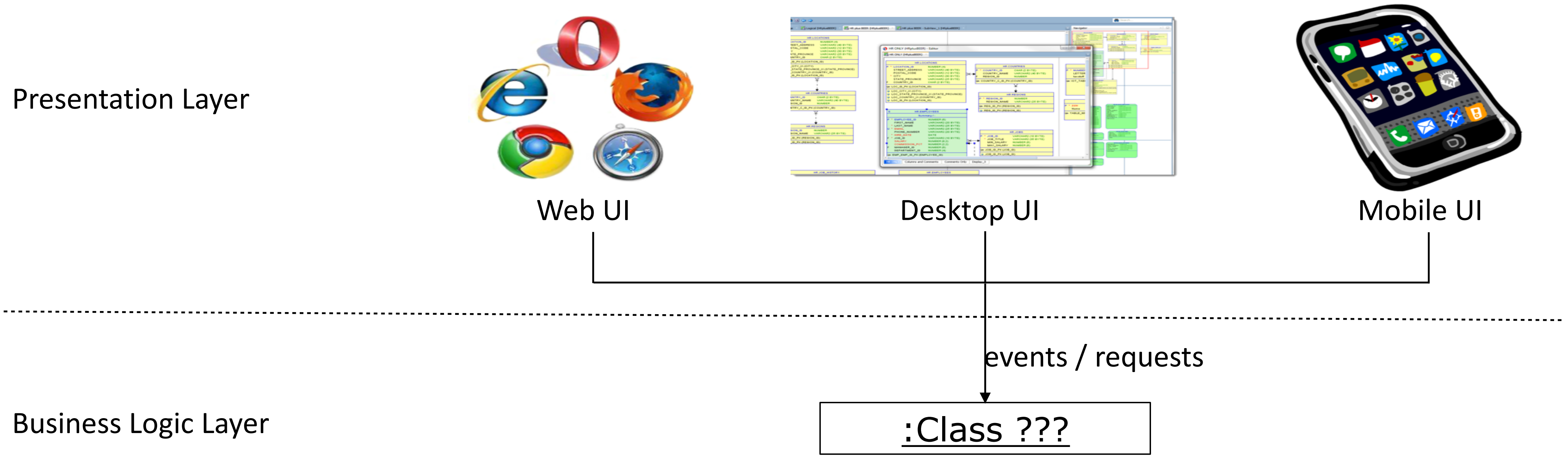


Information Expert pattern

- Advantages
  - The encapsulation is maintained since objects use their own information to satisfy responsibility
  - This pattern supports loose coupling, this allows the system to be more robust and easier to maintain
  - The behaviour is distributed among the classes that possess the necessary information, it encourages more coherent and smaller definitions are easier to understand and maintain

Controller pattern

- Problem
  - Which first object beyond the User Interface (UI) layer receives and coordinates ("controls") a system operation?



Presentation Layer

Web UI

Desktop UI

Mobile UI

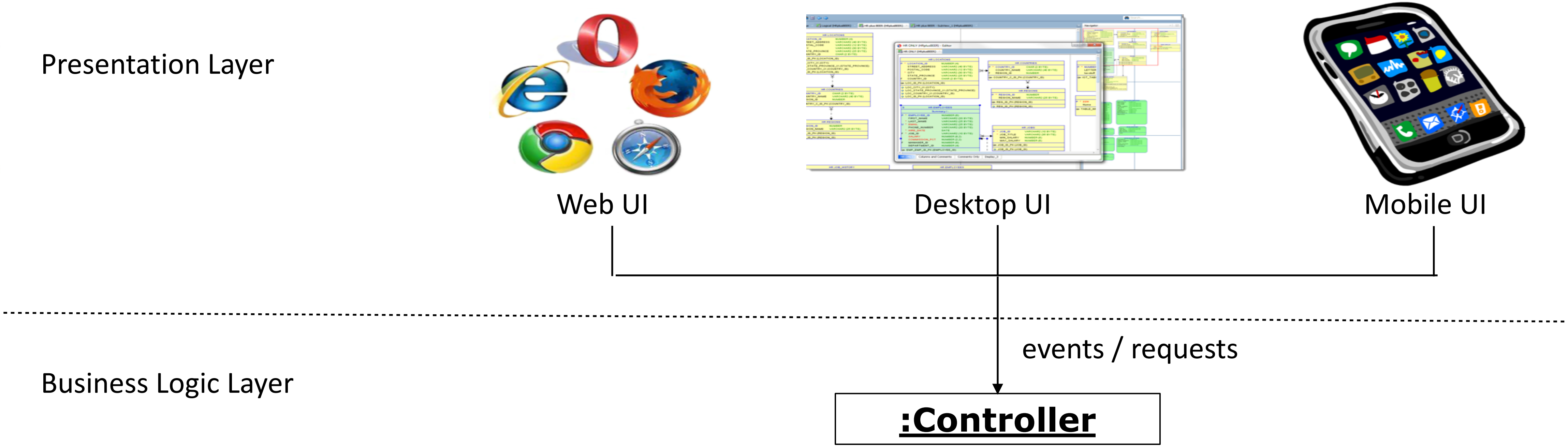
events / requests

Business Logic Layer

:Class ???

Controller pattern

- Solution
  - A **Controller** is the first object beyond the UI layer that is responsible for receiving and handling a system operation.
  - A controller should delegate the work to other objects. The controller only receives the requests but doesn’t not actually solve them.



Presentation Layer

Web UI

Desktop UI

Mobile UI

events / requests

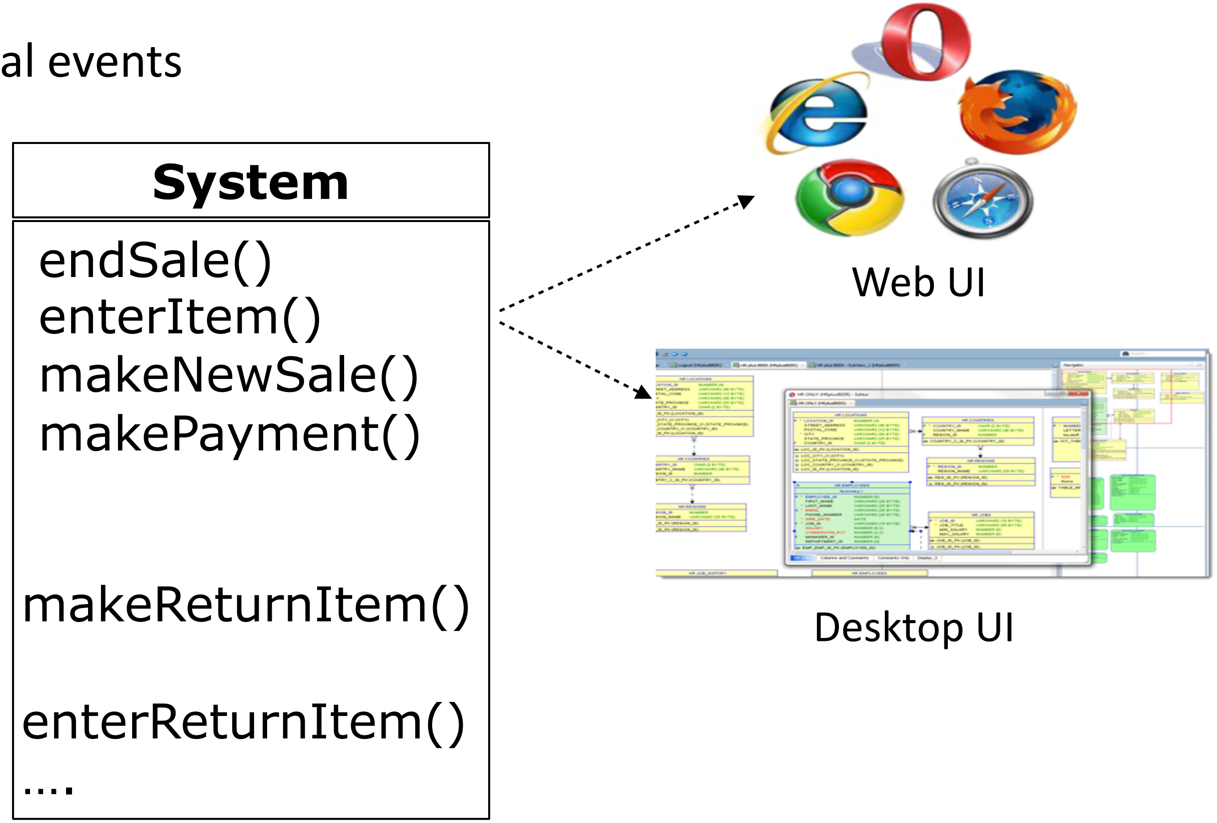
Business Logic Layer

:Controller

Controller pattern

- Application
  - The Controller pattern can be applied to all the systems that need to process external events
  - A controller class is selected to process the events
- Example
  - The Cash Register system has several events

Presentation Layer



System

endSale()
enterItem()
makeNewSale()
makePayment()

makeReturnItem()

enterReturnItem()
....

Web UI

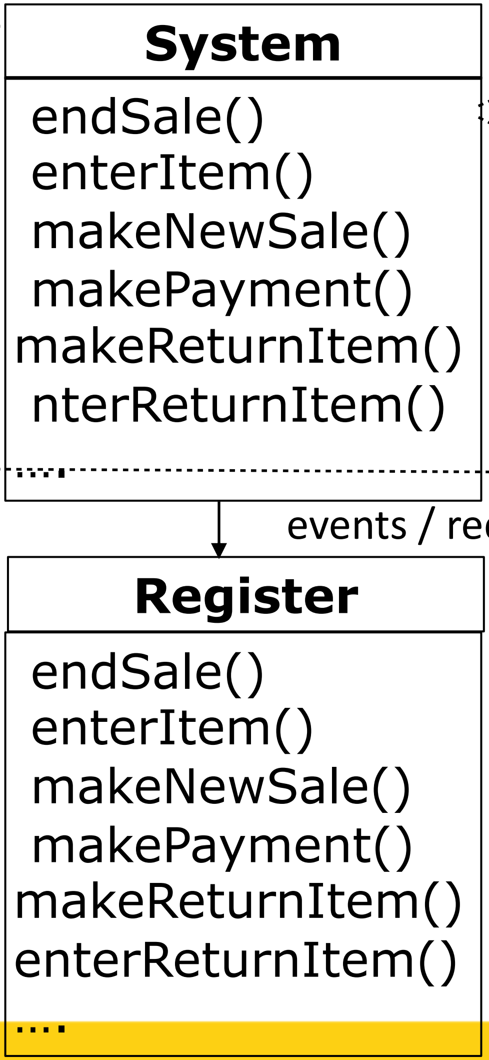
Desktop UI

  - What class can be the controller (i.e., what class processes the events)?

Controller pattern

- Example: Cash Register system
  - Solution 1: use one controller

Presentation Layer



System

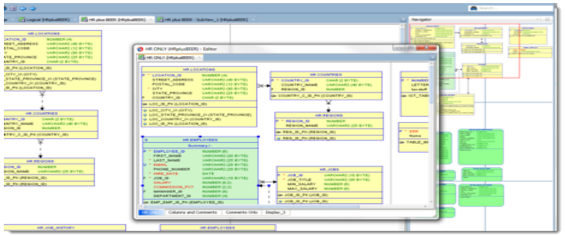
endSale()
enterItem()
makeNewSale()
makePayment()
makeReturnItem()
nterReturnItem()
....

events / requests

Register

endSale()
enterItem()
makeNewSale()
makePayment()
makeReturnItem()
enterReturnItem()
....

Web UI

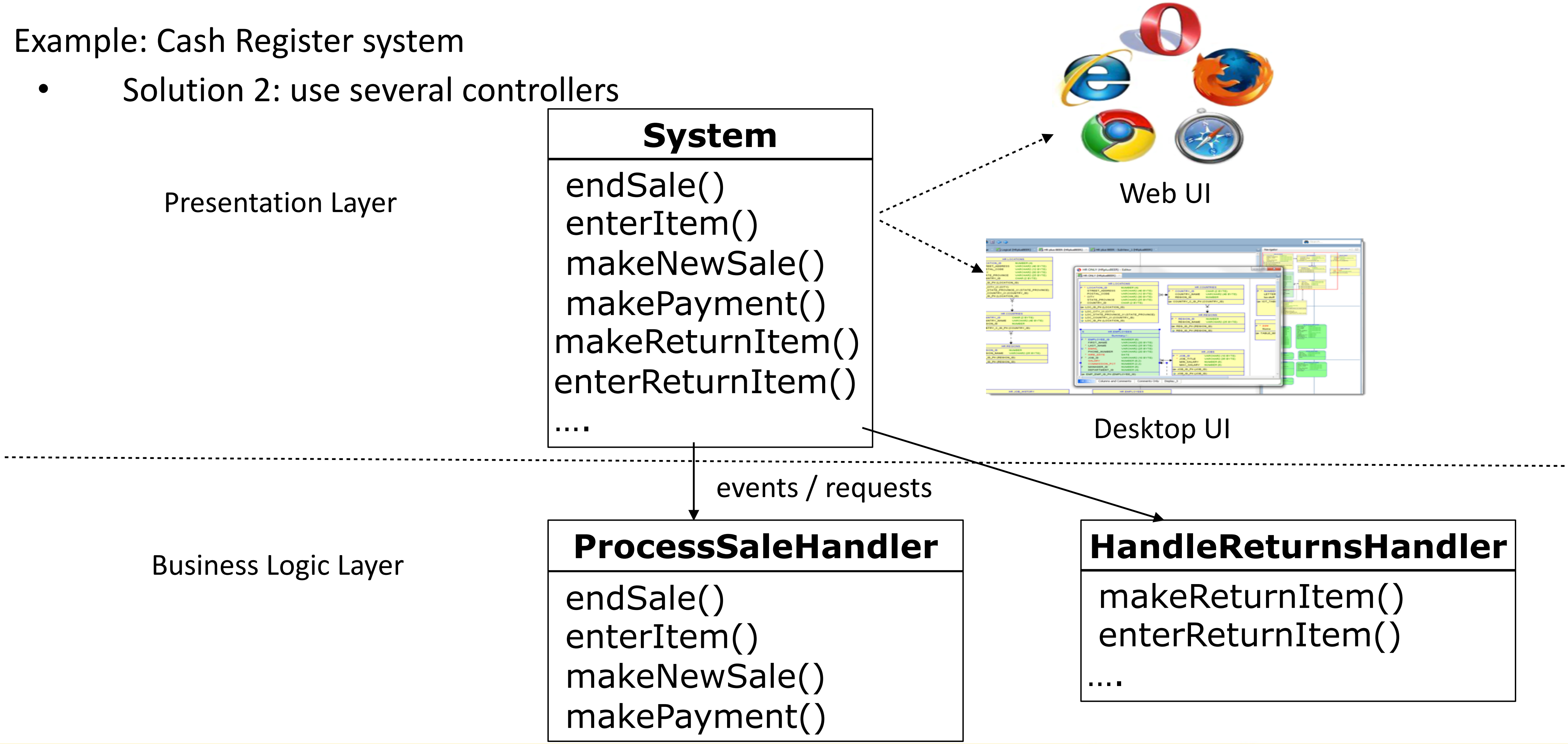


Desktop UI

Business Logic Layer

Controller pattern

- Example: Cash Register system
    - Solution 2: use several controllers



Presentation Layer

System

endSale()
enterItem()
makeNewSale()
makePayment()
makeReturnItem()
enterReturnItem()
....

Web UI

Desktop UI

events / requests

Business Logic Layer

ProcessSaleHandler

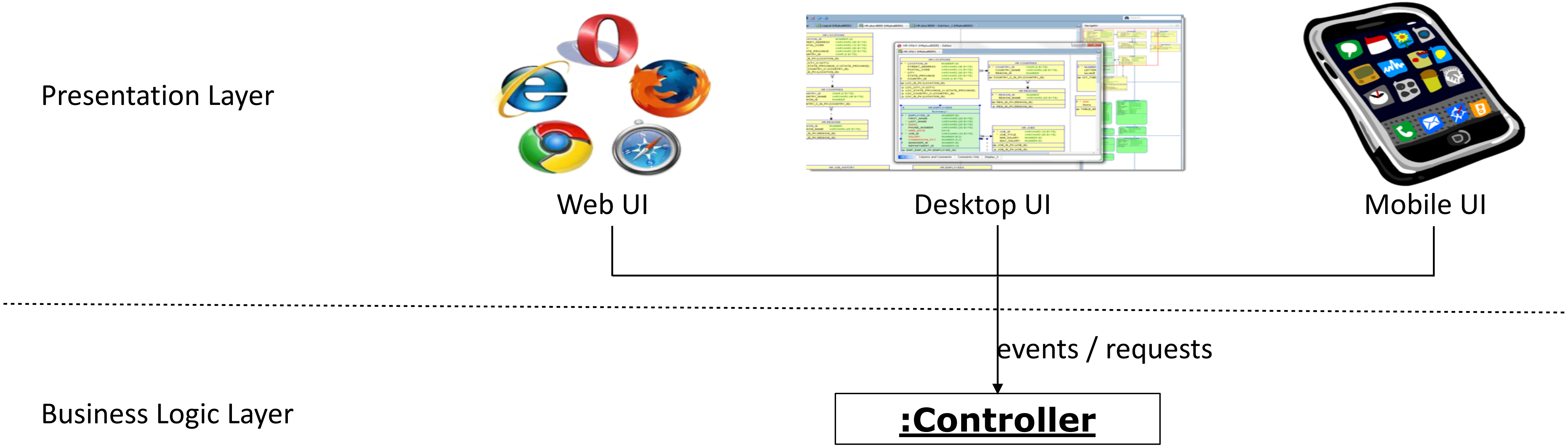
endSale()
enterItem()
makeNewSale()
makePayment()

HandleReturnsHandler

makeReturnItem()
enterReturnItem()
....

Controller pattern

- Discussion
  - Advantages
    - This is simply a delegation pattern - the UI should not contain application logic
    - Increase potential for reuse and pluggable interfaces
    - Creates opportunity to reason about state of a use-case, for example, to ensure that operations occur in a legal sequence.



Presentation Layer

Web UI

Desktop UI

Mobile UI

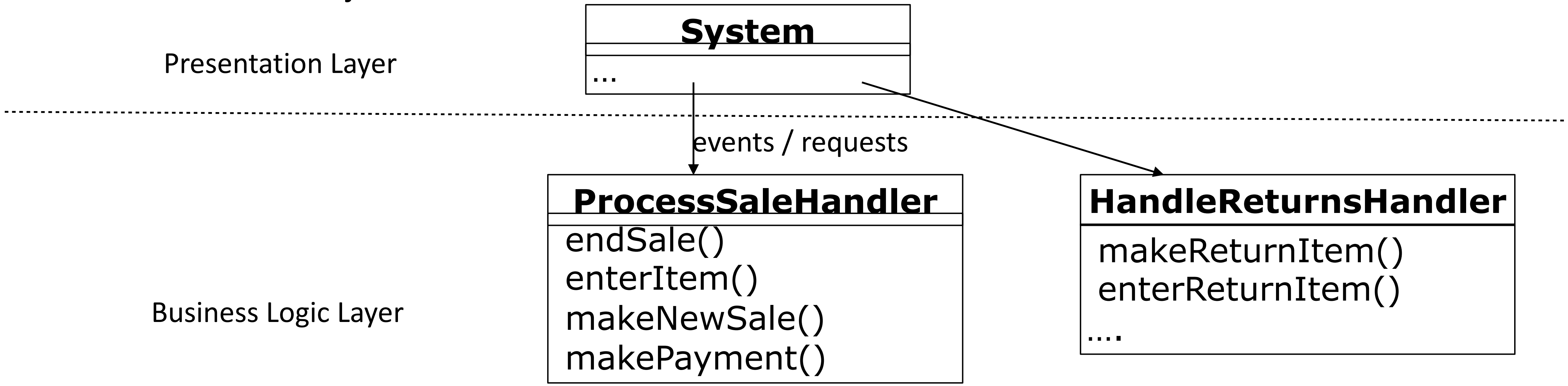
events / requests

Business Logic Layer

:Controller

Controller pattern

- Discussion
  - Difficulty: **Bloated controllers**
    - a single controller that receives all system events, does too much of the work handling events, has to many attributes (duplicating information found elsewhere), etc.
    - Remedies
      - Add more controllers
      - Design controller so that it primarily delegates the fulfilment of each system operation to other objects.



Conclusions

Conclusions

- Distinction between functional approach and object-oriented approach
- Master the basic object-oriented concepts

- UML: a modelling language
  - Need a development process
  - Different views
  - Different models
  - Use of the models in different development activities

- Master the main diagrams
  - Use-case diagram
  - Class diagram
  - Interaction diagram

Conclusions

- The UML concepts can be extended
  - The extensions
- Transformation of models to code
  - Models independent of programming language
- The automatic code generation is only a supplement
  - The models guide the coding process
- Master design principles
  - GRAPS principles/patterns
  - Some design patterns