Object-Oriented Analysis, The Domain Model

Unlike other engineers, software engineers work in different areas, with various needs and business rules.

For example, they develop software for airline companies, banks, and embedded systems like car engines.

Therefore, it is not sufficient to know about the *software domain*; a software engineer also needs to know about the *problem domain*.

A domain model illustrates concepts in a problem domain (real world).

UML class diagrams are used to present domain models.

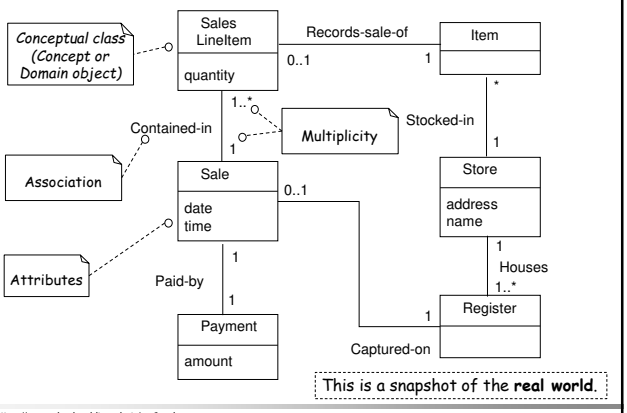
It may show three items:

1. Domain objects or conceptual classes
2. Associations between conceptual classes
3. Attributes of conceptual classes

Benefits of the domain model:

1. It helps us to understand the (real-world) system.
2. It acts as a source when we define software classes at the design level.

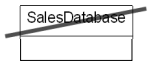
Example: A Partial Domain Model



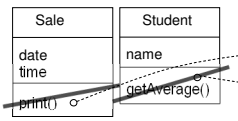
Domain model: real-situation conceptual classes, not software classes

Real-world concept:
OK for domain model

Software artifacts are not a part of domain model.



Avoid. Software artifact. It may be included in the design model.

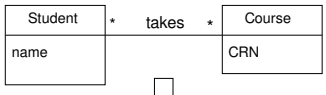


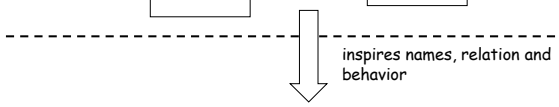
Avoid. Software classes. Responsibilities will be assigned in the design step.

Lower representational gap between real-world and software system

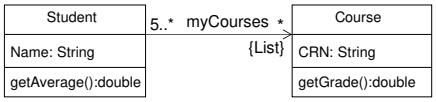
Names and responsibilities of software classes at the design level are inspired by the conceptual classes in the domain model.

Domain model
Conceptual classes:





Design model
Software classes:



The domain (analysis) model and software (design) model will not always be the same, but they will be similar (low representational gap).

How to Create the Domain Model?

1. Find the conceptual classes.
2. Add associations and attributes.
3. Draw them as classes in a UML class diagram.

How to Find Conceptual Classes?

Three strategies to find conceptual classes:

1. Reuse or modify existing models.

   If there is an existing model from a previous project, it can be modified.

   There are also published domain models for many common domains, such as inventory, finance, health, etc.
2. Use a category list.

   You can define conceptual classes in your application domain using the list containing many common categories.
3. Identify noun phrases in the use cases.

Finding Conceptual Classes with Noun Phrase Identification

Identify the nouns and noun phrases in textual descriptions of a domain (use cases), and consider them as candidate conceptual classes or attributes.

Main Success Scenario (or Basic Flow):

1. **Customer** arrives at a **POS checkout** with **goods** and/or **services** to purchase.
2. **Cashier** starts a new **sale**.
3. Cashier enters **item identifier**.
4. System records **sale line item** and presents **item description**, **price**, and running **total**. Price calculated from a set of price rules.
   Cashier repeats steps 3-4 *until indicates done.*
5. System presents total with **taxes** calculated.
6. Cashier tells Customer the total, and asks for **payment**.
7. Customer pays and System handles payment.
8. System logs completed sale and sends sale and payment information to the external **Accounting** system (for accounting and **commissions**) and **Inventory** system (to update inventory).
9. System presents **receipt**.
10. Customer leaves with receipt and goods (if any).

Extensions:

7a. Paying by cash:

   1. Cashier enters the cash **amount tendered**.
   2. System presents the **balance due**.

Eliminating unnecessary noun phrases

All noun phrases in use cases do not represent conceptual classes.

The following noun phrases should be eliminated:

1. Different noun phrases may represent the same conceptual class.
   For example, the customer and user are redundant. Use "customer" because it is more descriptive.
2. Some noun phrases may refer to conceptual classes that are ignored in this iteration (for example, "accounting" and "commissions").
3. Some noun phrases may refer to attributes. Attributes should be basic data types such as numbers and text.

This method can be used in combination with the "Conceptual Class Category List" technique.

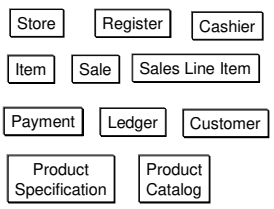
The Mapmaker Approach

A domain model is a kind of map of concepts or things in an application domain.

Make a domain model in the spirit of how a cartographer or mapmaker works:

- **Use the existing names** in the territory.
  Mapmakers do not change the names of cities on a map.
  Use the vocabulary of the domain when naming conceptual classes and attributes.
- **Exclude irrelevant features**.
  For example, on a physical map, the borders of cities are not shown.
  Do not put classes or attributes on the model if they do not have any obvious noteworthy role—for example, the keyboard and the age of the cashier.
- **Do not add things that are not there**.
  A mapmaker does not show things that are not there, such as a mountain that does not exist.
  Similarly, the domain model should exclude things *not* in the problem domain under consideration—for example, the owner of the store.

Example:
Conceptual classes of NextGen POS system for the firs iteration



- Register
- Item
- Store
- Sale
- Sales Line Item
- Cashier
- Customer
- Ledger
- Payment
- Product Catalog (next slide)
- Product Specification (next slide)

The class "Ledger" can be discovered in this step because of the statement in the use case: "System logs completed sale."

If we did not think of a Ledger during analysis, we would discover it when we designed the operation about logging a completed sale (slide 5.11).

There is no such thing as a "correct" list.
However, by following the identification strategies, different modelers will produce similar lists.

Need for description (specification) classes

In some systems, **description** (or **specification**) classes should take place in the domain model, even though they are not mentioned in the use cases.

Example:

Assume that information about physical items in a store is written on these items, such as serial number and price.

It seems logical because these data are attributes of these items.

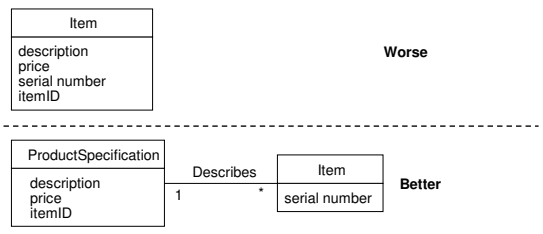
However, some data may be lost when all items are sold out.

Another problem arises when we want to change properties, such as the price of products. In such a case, we must update all items (objects).

In such systems, it is necessary to keep these data in separate description classes.

Description objects are stored in a **catalog**.

Need for description (specification) classes (cont'd)

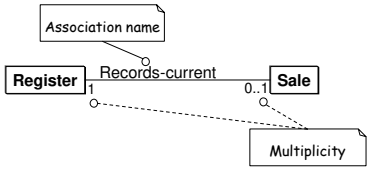


Add a description class (for example, ProductSpecification) when:

- We need the description of an item even though the examples of this item currently do not exist in the system.
- Deleting instances of things they describe (e.g., Item) results in a loss of information that needs to be maintained.
- It reduces redundant or duplicated information.

Associations

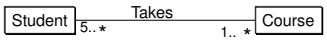
An **association** is a relationship between classes that indicates some meaningful connection .



- Because the domain model displays conceptual classes in the real world, associations also refer to real situations.
- Associations are not function calls between software classes.
- Associations in the domain model are mostly bidirectional.
  Example: Register records current the Sale (from left to right).
  The current Sale is recorded by Register (from right to left).

Multiplicity

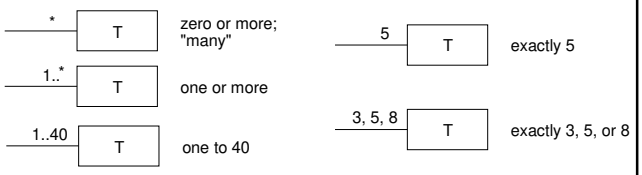
Multiplicity defines how many instances (objects) of class A can be associated simultaneously (at a particular moment) with one instance of class B.



Left to the right: One student takes at least one or more courses.

Right to the left: One course is taken at least by five or more students.

Multiplicity numbers are obtained from the requirements of the stakeholders.

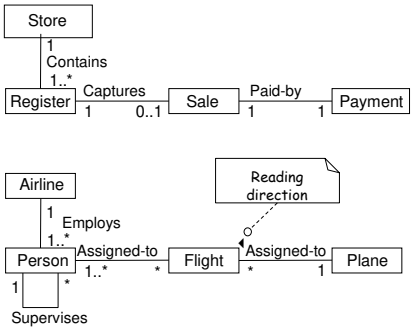


Finding Associations

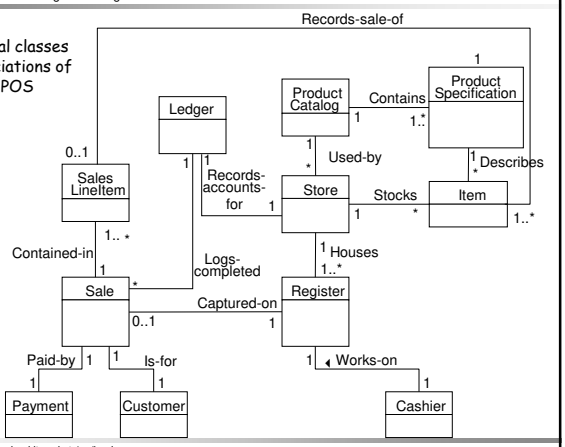
Associations can be defined

1. by using the common associations list
2. by using verbs in use cases

Examples:



Example:
Conceptual classes and associations of NextGen POS system



Attributes

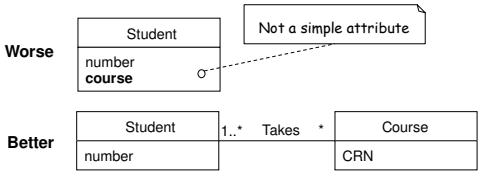
Identify attributes of conceptual classes (real-world attributes, not software data).

Include attributes that the requirements (for example, use cases) suggest or imply a need to remember information.

For example, the register number of a student and the date and time of a sale.

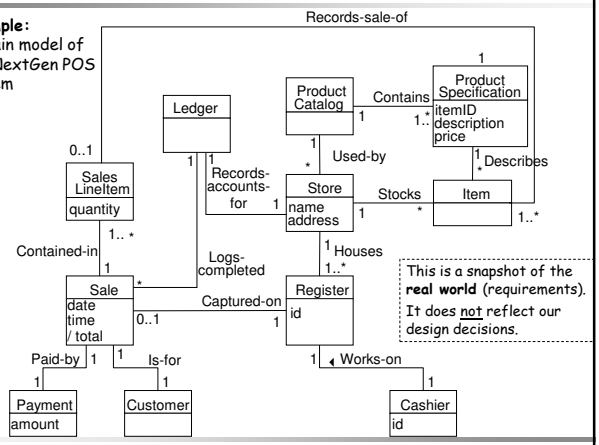
Attribute types should be "primitive" data types, such as numbers, characters, and booleans.

The type of an attribute should not normally be a complex domain concept.



If a concept has properties and behavior, it is not a simple attribute but a separate conceptual class.

Example:
Domain model of the NextGen POS system



Operation Contracts

Use cases and domain models are usually sufficient to understand the requirements of the stakeholders and the expected features of the system under discussion.

Now, it is possible to start with design.

However, for complex system operations (statements in a use case), a more detailed or precise description of system behavior may be necessary.

An **operation contract** is written for each **complex system operation** (statement) in the use cases to describe its details.

Examples of system operations: "Make a new sale", "Enter Item ID", and "End sale".

An **operation contract** describes changes in the state of objects in the domain model when the related operation (e.g., Make a new sale) has finished.

In other words, it describes what happened to the objects in the system during the execution of the related operation (e.g., Make a new sale).

Remember, we are still in the real world (application domain), not talking about software objects or attributes.

Operation contracts help us to find the **responsibilities** of the system.

Format of an operation contract

Contract number and name
Operation: Name and parameters (signature) **Reference:** The related use case **Preconditions:** What must be true to run this operation.
Postconditions: Changes in the state of objects in the domain model.

The **postconditions** describe changes in the state of objects in the domain model when the related operation has finished.

Postconditions are divided into three categories:

1. Instance (object) creation and deletion.
2. Attribute change of value.
3. Associations (links, connections) formed and broken.

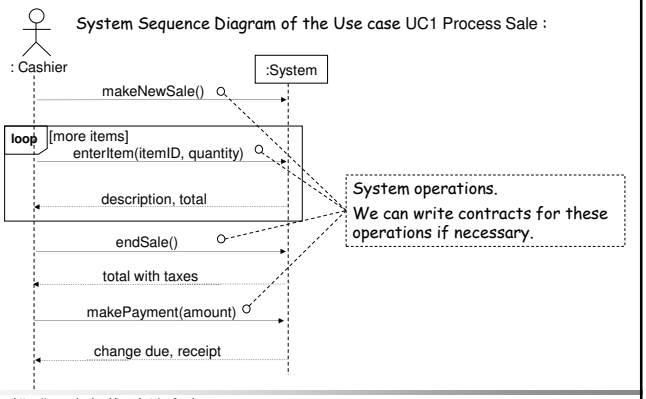
Remember: we are looking for the answer to "what".

How these operations are performed is an issue that we deal with in the design step.

Postconditions give us the **responsibilities** we must assign to the objects in the design.

Examples: The given examples are related to the Use Case UC1: Process Sale of NextGen POS.

System Sequence Diagram of the Use case UC1 Process Sale :



How to write postconditions?

Postconditions are not actions to be performed during the operation;

instead, they are observations about the domain model objects that are true when the operation has finished.

What happened to the objects in the system (real world) after the operation?

We are still interested in **what** happened, not **how** it is performed.

How these contracts are realized is the issue of the design level.

Express postconditions in the **past tense** to emphasize that they are observations about state changes.

Analogy: The Stage of a Theater (Taken from Larman)

The system and its objects are presented on a theatre stage.

1. Before the operation, take a picture of the stage.
2. Close the curtains on the stage and apply the system operation (background noise of clanging, screams, and screeches…).
3. Open the curtains and take a second picture.
4. Compare the before and after pictures and express as postconditions the changes in the state of the stage (A SalesLineItem was created…).

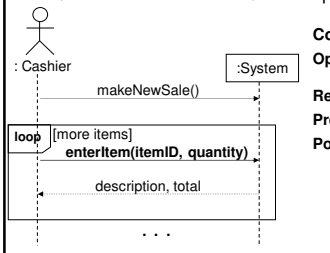
Now we know the changes, but not how (by whom) they are made.

Example: enterItem

The statement in the use case "Cashier enters item identifier." seems to be simple.

However, associated operations can be complicated.

Therefore we write a contract for this operation.



All objects and classes (for example, sli, Sale, Product Spec.) mentioned in contracts are related to the domain model (3.17). We are not writing the program.

Contract CO2: enterItem

Operation:
enterItem(itemID: ItemID, quantity: integer)

Reference: Use Cases: Process Sale

PreCond.: There is a sale underway

PostConditions:

- A SalesLineItem instance sli was created (instance creation)
- sli was associated with the current Sale (association formed)
- sli.quantity became quantity (attribute modification)
- sli was associated with a Product Spec. based on itemID match (association formed)

Example: endSale

Assume that in the NextGen POS system, completed sales are not deleted; they are only marked as "completed" and logged in the system.

Contract CO3: endSale

Operation:	endSale()
Cross References:	Use Cases: Process Sale
PreConditions:	There is a sale underway
PostConditions:	- Sale.isComplete became true (attribute modification)