

Exercises¹

► Exercise 1.

Analyse the right-hand association in Figure 2. Discuss other multiplicities that could have been considered.

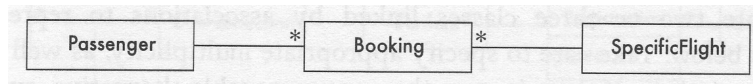


Figure 2: Associations related to booking passengers on a flight

► Exercise 2.

Create two or three classes linked by associations to represent the situations below. Take care to specify appropriate multiplicity, as well as labels for the associations. If there is more than one reasonable alternative, explain the advantages and disadvantages of each.

- (a) Vehicles possessing wheels.
- (b) A video rental shop, where you must purchase a membership before renting something.
- (c) Countries and their heads of state.
- (d) A student taking courses in a school.
- (e) People registering for fitness activities at a gym.
- (f) A library lending books to patrons.
- (g) A repertory theatre company planning presentations of various plays.

► Exercise 3.

Explain the consequences of the associations in exercise 2 in terms of the creation and destruction of instances. Think about the order in which instances can be created or destroyed.

► Exercise 4.

For each of the associations you created in exercise 2, write a few sentences showing how you would read the association in both directions.

► **Exercise 5.** Add association classes to the three many-to-many associations in the following diagrams (see Figure 3).

¹for Chapter 5 from the ‘lloseng’ book.

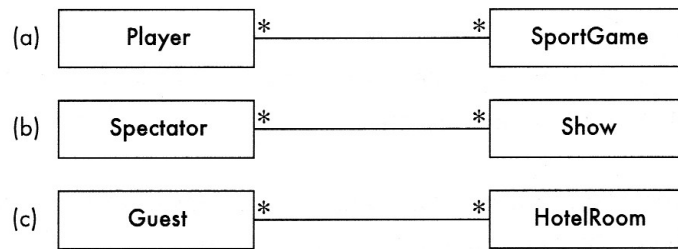


Figure 3: Diagrams for exercise 5.

► **Exercise 6.**

Add association classes to the two many-to-many associations in Figure 4. Show the attributes that might be found in these association classes.

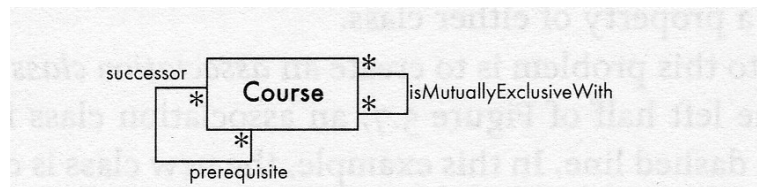


Figure 4: Two examples of reflexive associations

► **Exercise 7.**

Apply the transformation shown in Figure 5 to your answer to the last exercise.

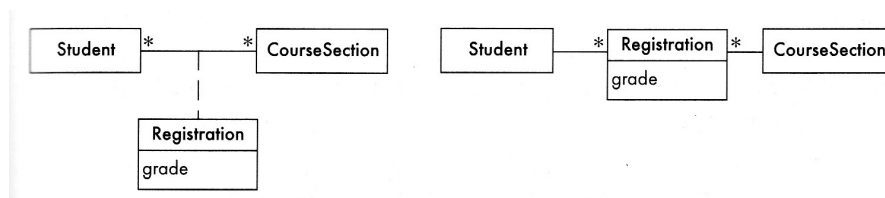


Figure 5: A many-to-many association with an association class, and an equivalent diagram using two one-to-many associations

► **Exercise 8.**

An organisation has three categories of employees: professional staff, technical staff and support staff. The organisation also has departments and divisions. Each employee belongs to either a department or a division. Draw a class diagram corresponding to this. Assume that there will be different attributes or operations in all the classes, and that people will never need to change from one category to another.

► **Exercise 9.**

Draw a class diagram that could generate the instance diagram shown in Figure 6. Make reasonable choices for multiplicity.

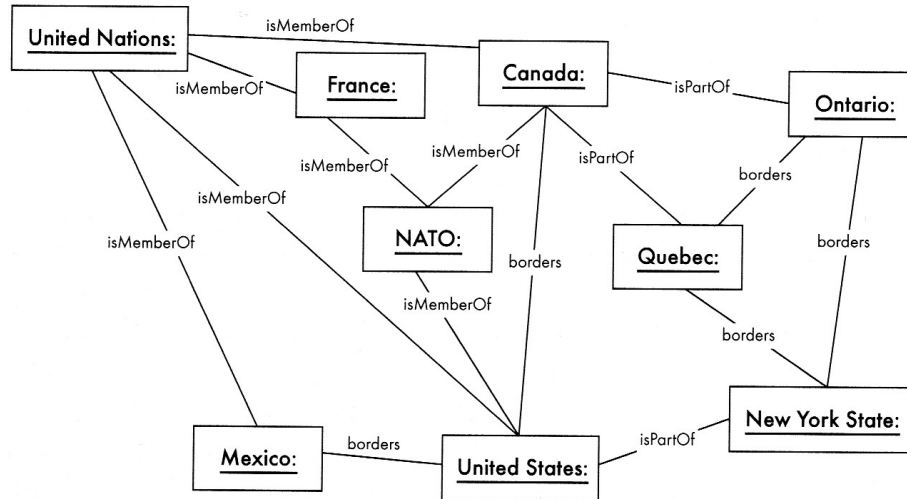


Figure 6: Instance diagram

► **Exercise 10.**

For each of the following associations, indicate whether it ordinary association, a standard aggregation, or a composition.

- A telephone and its handset.
- A school and its teachers.
- A book and its chapters.

► **Exercise 11.**

Write, in English, as many constraints as you can think of about shapes, that have not been expressed in Figure 7. Take at least three of these and write them in OCL.

► **Exercise 12.**

Write constraints using OCL that express the following constraints :

- In Figure 4, none of the mutually exclusive courses can also be successors or prerequisites.
- In Figure 4, a successor cannot also be a prerequisite.

► **Exercise 13.**

Using Figure 8(d), describe how the following operations of class Person would be performed. You do not need to write code; simply describe how the available information would be used to compute the result.

- getSiblings
- getHalfSiblings
- getStepSiblings
- isMarried

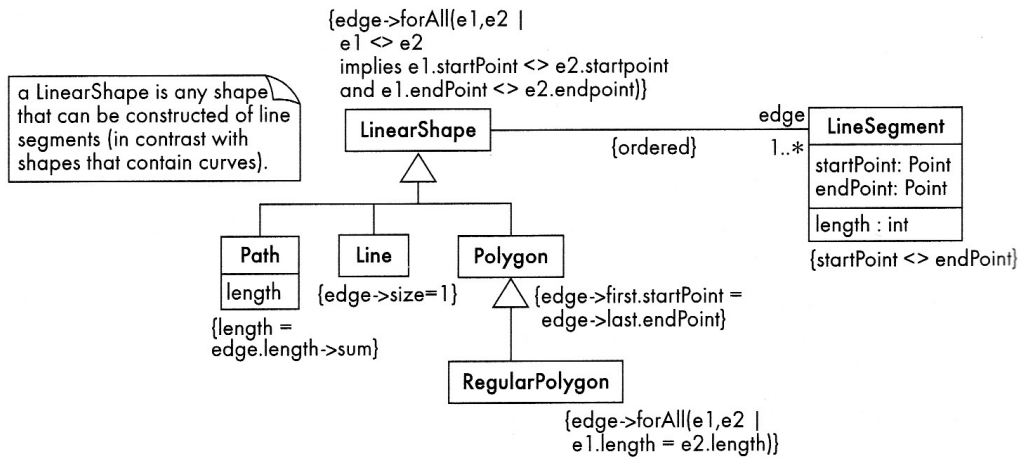


Figure 7: Constraints and notes on polygons and points

(e) getNumberOfMarriages

► **Exercise 14.**

Write OCL constraints expressing the following facts about Figure 8(d),

- (a) You cannot die before you are born.
- (b) The date of a marriage always precedes the date of that marriage's divorce.

► **Exercise 15.**

Give the advantages and disadvantages of Figure 8(d), as opposed to Figure 8(c).

► **Exercise 16.**

A possible variation of Figure 8(c) would be to create a class Marriage that is a subclass of union.

- (a) Describe the two classes union and Marriage in terms of their associations and attributes.
- (b) What would be the advantages and disadvantages of this change, as opposed to Figure 8(c) ?

► **Exercise 17.**

Extend the genealogical example to handle the following situations:

- (a) Adoption and adoptive parents.
- (b) Same-sex unions (but still ensuring that the biological parents of a child must be of opposite sex).

► **Exercise 18.**

This exercise is based on the short program descriptions, as found in Appendix A. Determine the nouns and noun phrases that might, in the end, become classes. While making your list, choose good names for each of the potential classes.

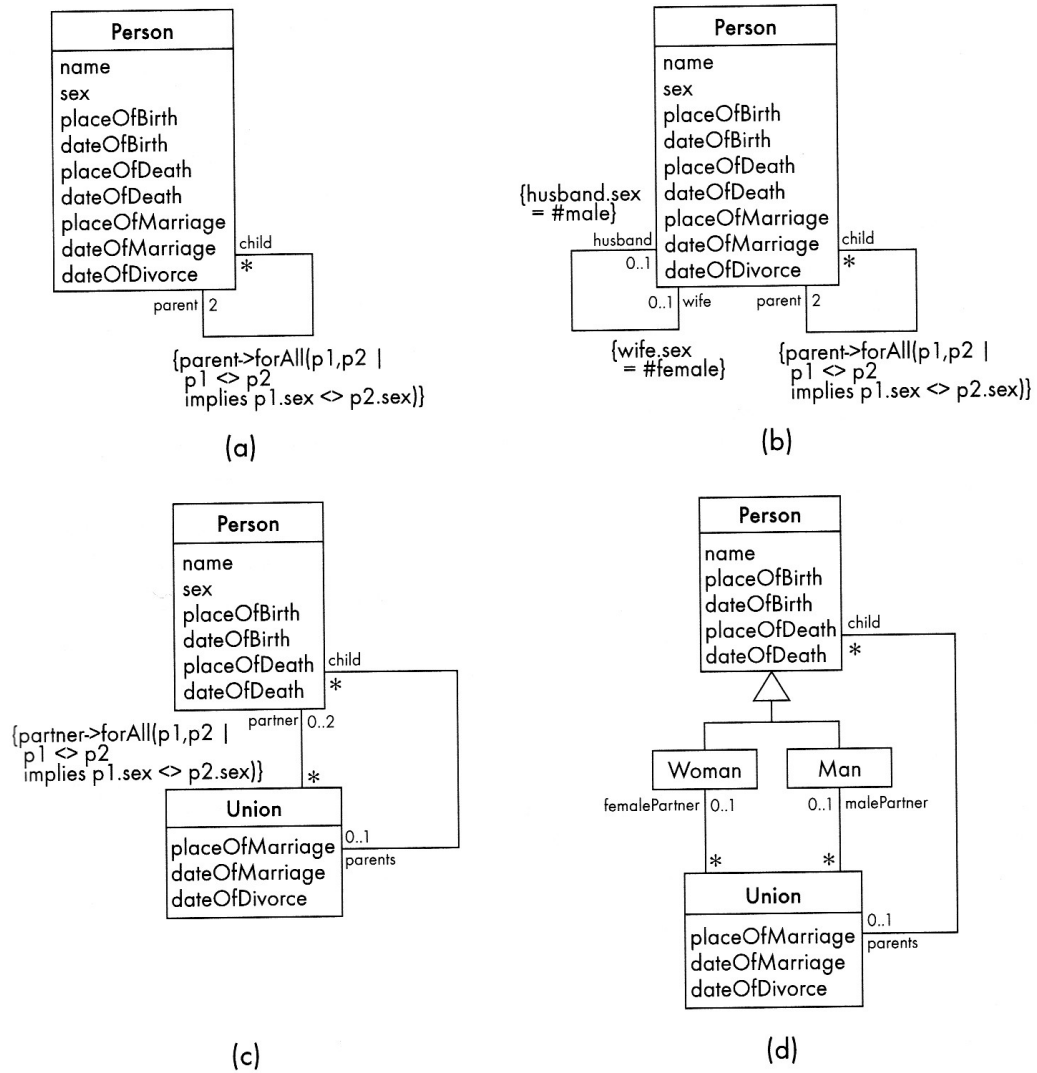


Figure 8: Alternatives for a genealogical class diagram. The first two are unacceptable since they have major problems.

- (a) Bank account management system
- (b) Election management system
- (c) Geographical information system
- (d) Investments system
- (e) Manufacturing plant controller

► **Exercise 19.**

For the system(s) you worked on in the last exercise, identify an initial list of attributes and associations. Add or delete classes as necessary. Draw a preliminary class diagram.

► **Exercise 20.**

For the system(s) you worked on in the last two exercises, identify any generalisations or interfaces. This may lead you to add or delete classes, associations and attributes. Modify your class diagram(s) accordingly.

► **Exercise 21.**

For the system(s) you worked on in the exercises 18 to 20, determine the responsibilities of each class. Update your class diagrams as necessary.

► **Exercise 22.**

Determine the responsibilities for each of the classes in the genealogical example: Figure 8(c).

► **Exercise 23.**

Add operations to the examples you worked on in exercises 18 to 20 and 21.

► **Exercise 24.**

Add operations to the genealogical example of Figure 8(c), that you also worked on in exercise 22.

► **Exercise 25.**

Use the techniques described in this section to extend the airline system. Your extended system should include the requirements listed below. You should produce a single class diagram showing classes, attributes and generalisations. Do not yet show operations.

(a) Flights fly from one airport terminal to another, but may also have several intermediate stops. A passenger can be booked onto one or more of the legs of a flight.

(b) Passengers can query the system to determine what times flights are available from their desired original city to their desired destination city (they do not care about which terminal or airport is used by the airline).

(c) Flights have scheduled departure and arrival times, but they can be late, so they have actual departure and arrival times as well.

(d) The airline may add charter flights that are not regularly scheduled.

(e) The airline publishes prices that apply between any pair of cities to which it flies. Business class, regular and seat-sale fares are available.

(f) Passengers buy tickets and are charged the prices in effect when their tickets were booked. Each ticket involves a complete itinerary, composed of a

sequence of one or more legs. The fare type is not necessarily the same for each leg of the flight.

(g) Passengers are automatically part of a frequent-flier plan. They accumulate points based on the distance they flew and their fare type (business class or not).

► **Exercise 26.**

(a) Determine the responsibilities needed to implement the requirements listed in the last exercise (omitting the responsibilities that merely involve setting and getting attributes).

(b) Determine all the operations needed to implement the responsibilities - specifying in which classes they belong.

A System descriptions

A.1 Police Information System

This system helps the Java Valley police officers keep track of the work they are assigned to do. Officers may be assigned to investigate particular cases, to patrol particular areas or to attend particular events such as court cases. Some work assignments are regular ongoing assignments, while others are for a particular period of time. The system information is updated by the logistics administrator, but individual officers have an interface to display their assigned work.

A.2 Household Alarm System

This software will be embedded in an alarm system controller built by Use Case Industries. In conjunction with various hardware devices, it will be able to detect and report such problems as intruders and fires.

A.3 GPS-Based Automobile Navigation System (GANA)

This system, manufactured by Use Case Industries, will be used by drivers to navigate around the state of Ootumlia. It uses GPS (Global Positioning System) technology and Internet access to a map database to provide a driver with route maps of various levels of detail, as well as spoken directions to guide the driver to his or her destination.

A.4 Airline Reservation System

Ootumlia Airlines runs sightseeing flights from Java Valley, the capital of Ootumlia. The reservation system keeps track of passengers who will be flying in specific seats on various flights, as well as people who will form the crew. For the crew, the system needs to track what everyone does, and who supervises whom. Ootumlia Airlines runs several daily numbered flights on a regular schedule. Ootumlia Airlines expects to expand in the future so the system needs to be flexible; in particular, it will be adding a frequent-flier plan.

A.5 Bank Accounts Management System

This system provides the basic services to manage bank accounts at a bank called OOBank. OOBank has many branches, each of which has an address and branch number. A client opens accounts at a branch. Each account is uniquely identified by an account number; it has a balance and a credit or overdraft limit. There are many types of accounts, including: a mortgage account (which has a property as collateral), a chequing account, and a credit card account (which has an expiry date and can have secondary cards attached to it). It is possible to have a joint account (e.g. for a husband and wife). Each type of account has a particular interest rate, a monthly fee and a specific set of privileges (e.g. ability to write cheques, insurance for purchases etc.). OOBank is divided into divisions and subdivisions (such as Planning, Investments and Consumer); the branches are considered subdivisions of the Consumer Division.

Each division has a manager and a set of other employees. Each customer is assigned a particular employee as his or her 'personal banker'.

A.6 Elections Management System

The Ootumlia Elections Commission is designing a system to manage elections. The system will manage elections for a variety of different elected bodies (e.g. school boards, city councils etc.). Each elected body can have various positions (also called seats, e.g. mayor, councillor etc.). Elections are scheduled for a specific date, and usually several (or all) positions are voted on together; however, sometimes there may be the need for a by-election (e.g. to elect a particular councillor because the incumbent - the previous person who held the position - has resigned).

The system will keep track of candidates for each seat. The system will also record who is the incumbent for a seat, since newspaper reporters are interested in reporting whether incumbents have won again or lost. The system records the name and address of each candidate and incumbent.

The system will also keep track of the list of eligible voters. Each voter can only vote for certain positions (e.g. a particular council seat that represents their area). Each voter is also assigned to vote at a specific poll - each poll has a number and is located in a polling station. The system records the name and address of each voter.

Finally, the system will keep track of the number of votes for each candidate at each poll. However, under no circumstance will it record which voter voted for which candidate, nor whether a voter voted at all.

A.7 Geographical Information System

A system used by map makers at the Government of Ootumlia contains information about various maps. Each map has a scale, a name and a set of features. Each map also has information that defines the latitude and longitude of the top left corner of the map, and the height and width of the map in metres.

Features can be of three types: point features, curve features and region features. In general, all features have a name that is displayed on the map next to the feature.

A point feature has a single coordinate, the location at which it is to appear on the map. Examples of point features include transmission towers, mountain peaks, etc. Each type of point feature has a special symbol associated with it; this symbol is a simple bitmap.

A curve feature contains a list of points that define its path. Examples of curve features are roads, railways and rivers. Each type of curve feature has a line pattern associated with it. The line pattern specifies the colour, the line thickness, the length of dashes in the line, and the length of gaps in the line.

A region feature is very similar to a curve feature, except that when drawn on the map, it encloses a complete region (the last point connects to the first point). Additionally, it has an optional fill pattern which is a simple bitmap or a colour.

A.8 Investments System for OOBank

OOBank has a separate investment division. This division manages various mutual funds in which investors may invest and also looks after the investment portfolios of investors.

An investor may at any point in time have several investment advisors. These help the investor decide in what to invest. Different investment advisors specialise in different types of investments.

Investors make a series of transactions and may have to pay a commission on each transaction. The commission is paid to the investment advisor that arranged the transaction.

For each investment the system must keep track of the number of shares (also called units) in addition to the amount the investment is worth today and the amount originally invested.

Each mutual fund invests its money in various securities. The securities can be stocks, bonds or other mutual funds. We must be able to calculate the original amount invested in each security as well as how much that investment is worth today. Each mutual fund may have several investment advisors that help the fund decide what securities in which to invest.

The mutual funds in which investors invest may be managed by OOBank or by some other company. Each mutual fund company may manage several mutual funds.

A.9 Manufacturing Plant Controller

This system will be used to manage and control the production processes at Use Case Industries' manufacturing plant. The plant makes several types of mechanical devices. It has 10 assembly lines, each of which can be used in the manufacturing of any of its products. An assembly line is allocated to a product for a fixed period of time (anywhere from a few hours to a few days) - this is called a product run. During a product run, the assembly line makes a specified number of units of the product.

Each product is assembled in several steps. As the product-under-construction moves down the assembly line, it will be worked on in turn by a series of robots.

Each robot completes one step before the product moves on to the next step (and a different robot). Each robot is dedicated to just one manufacturing step.

Each product is composed of parts. Parts may be bought from suppliers, or they may in fact be smaller products that are built by this company (in earlier product runs). In each manufacturing step, a given subset of these parts are put together. Parts waiting for assembly are kept in numbered bins, the robots know which bins to go to get the required parts.

Each completed assembly is given a serial number. When orders for products are filled, the serial numbers of the products sold are recorded with the order.

A.10 Corporate Event Information System

This program will allow the employees of Ootumlia airlines to keep informed of the various events that are organised by and for company management and employees. Events can be meetings as well as social events.