# 16. Composite objects

Description

It remains to be decided whether or not we include a StickMan.
En grund til at inkludere Stickman er at vi bare har MFprinter som eksempel på composition af objekter; Line og GlobalPosition er Value-objekter.

In the this chapter, we show how to define *composite objects*. For objects this is done by means of part-objects – objects that are fixed parts of the composite object. A part-object is be described using the keyword **obj**. For value objects this done using **var** or **val**. In the following examples, we show how to represent a whole/part-hierarchy using part-objects. +++ evt composition-hierarchy, men det kræver en nærlæsning/omformulering i teksten længere nede hvor vi snakker om *whole* and *parts*. Vi får sikkert brug for disse ord.

A first very simple example of object composition is a model of a multi-function printer, that is a printer that in addition to printing also can scan and copy. It consists of a `Printer` part-object and a `Scanner` part-object.
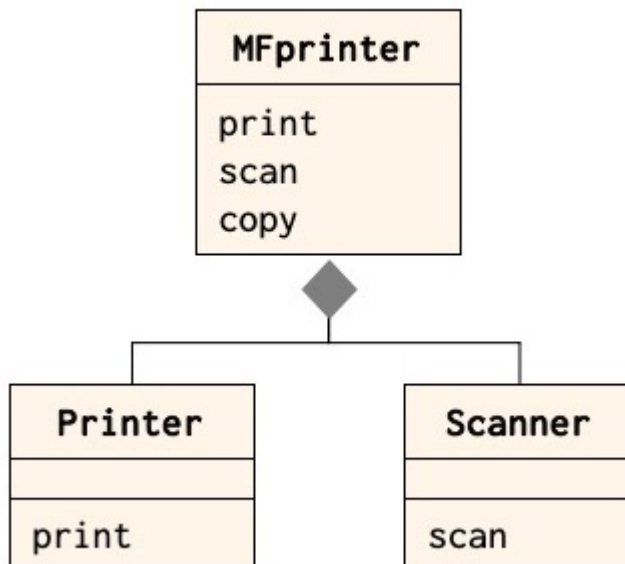

```
class Printer:
   print(doc: ref Document):
      ...
class Scanner:
   scan -> doc: ref Document:
      ...
class MultiFunctionPrinter:
   thePrinter: obj Printer
   theScanner: obj Scanner

   print(doc: var Document):
      thePrinter.print(doc)
   scan -> doc: ref Document:
      doc := theScanner.scan
   copy:
```

```
thePrinter.print(theScanner.scan)
```

The `copy` method of the composite `MutiFunctionPrinter` uses the properties of the two parts, and it is usually a function that is used directly by a human user. The method `print` is invoked by computers linked to a multi-function printer. The `scan`-method is typically used by a human who places a document in the scanner and activate the scanner, which sends the scanned document to an email address.

Representing a position on earth

A position of earth is defined using latitude and longitude which both are coordinates from -90 to 90 or shown as 0-90 followed by North/South and East/West. These coordinates may be further spilt into minutes and seconds – often abbreviated *DMS* standing for degrees, minus and seconds.

We may represent these values using composition of value objects as follows:

```
GlobalPosition: Value
   la: var Latitude
   lo: var Longitude
```
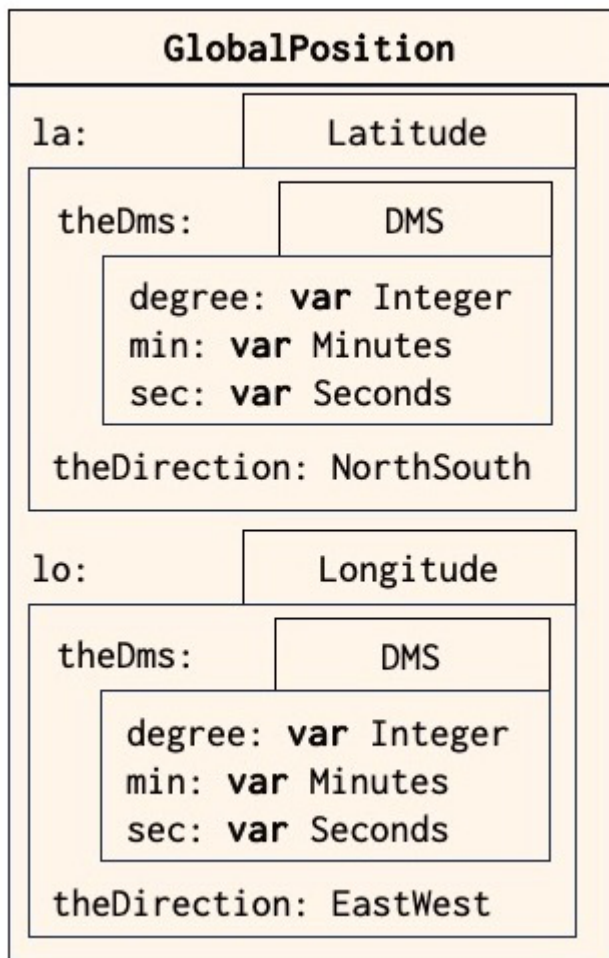
A latitude and longitude may be represented by :

```
Latitude: Value
   theDms: var DMS
   theDirection: var NorthSouth
Longitude: Value
   theDms: var DMS
   direction: var EastWest
```

And finally a `DMS` may be represented by:

```
DMS: Value
   degree: var float
   min: var Time.Minutes
   sec: var Time.Seconds
```

The figure illustrates the whole/part hierarchy of a `GlobalPosition`-object:

Note that `min` and `sec` are defined using units of dimension `Time` as described in section . The variable `degree` has no unit. We leave the definition of `NorthSouth` and `EastWest` to the reader.

A model of a university

Xiaoping Jia: OO software development using Java has an example with
Student is part of a department, faculty member is part of department, department is part of college, college is part of university.
They say that student and faculty exists independent of the university whereas this is not the case for department and college.

The next example shows part of a representation of a university with the purpose of representing the educations given by the university. A university consists of a number of faculties. Each faculty consist of a number of departments. In this model, a university offers the degrees bachelor, masters and PhD. This structure may be represented in the following way:

```
class University:
    class Faculty:
        ...
    class Department:
        ...
    class Degree:
        ...
    class Bachelor: Degree
        ...
    class Masters: Degree
```

```
        ...
    class PhD: Degree
        ...
    arts: obj Faculty
        ...
    naturalScience: obj Faculty
        computerScience: obj Department
            bachelorInCS: obj Bachelor
                ... properties special for bachelors in CS ? Find et eksempel
            mastersInCS: obj Masters
                ...
        ...
        physics: obj Department
            bachelorInPhysics: obj Bachelor
                ...
            ...
    ...
```

Note that the faculties Arts, and Natural Science, etc. are represented by singular objects being subclassed from `Faculty`. Each faculty has departments belonging to the faculty. Within each department is an objects representing the degrees (bachelor, masters, PhD) offered by the department.

The above example is quite sketchy and we leave to the reader to fill it out to a complete example.

Representing composition

In section , we discussed classification as a fundamental means for organizing and understanding phenomena and concepts. *Composition* is another fundamental means for organizing and understanding phenomena. Composition is a means to organize phenomena in terms of other phenomena.

In many situations it is useful to consider a *whole* as constructed from *parts*. The parts may again consist of smaller, simpler parts i.e. there is a distinction between whole phenomena and their *component* phenomena. The notion of a *whole/part composition* is an important means of understanding and organizing complex phenomena.

The *part-of relation* gives rise to a *whole/part hierarchy*. Figure xxx above shows an example of such a hierarchy for the stick figure consisting of parts like head, body, arms and legs. In turn, the legs consist of lower leg, foot, etc. vi kan jo innføre alm stickman

A car may be considered as consisting of parts like steering wheel, motor, body and wheels, i.e. wheel is a *part of* a car, a motor is a part of a car, etc. These components are physical parts of the car. We may represent a car as shown below.

```
class Car:
    aSteeringWheel: obj SteeringWheel
    aMotor: obj Motor
    aBody: obj Body
    wheels: obj Array(4, #Wheel)
```
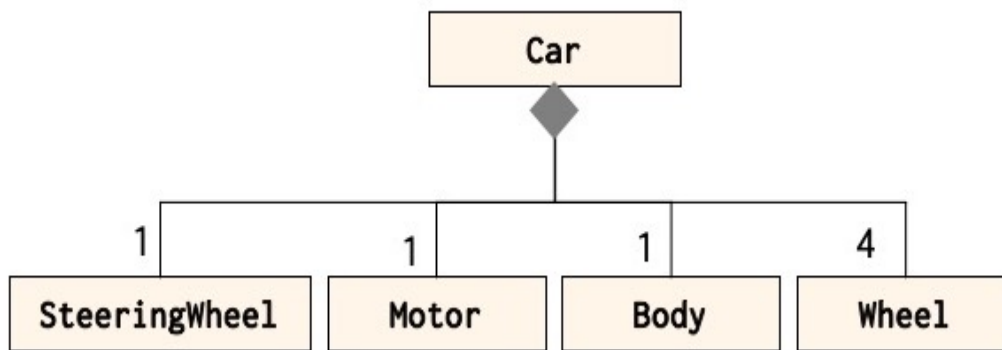
There are numerous other examples of whole/part hierarchies:

- A tree may be viewed as consisting of branches, a trunk, roots and leaves.
- A Hotel Reservation may be viewed as a composition of a Person, a Hotel, a Room and a Date. It is, however, not meaningful to view, for instance, the person as a physical part of the hotel reservation. The corresponding attribute is better viewed as a reference to a person.
- A Person may naturally be viewed as consisting of parts like Head, Body, Arms and Legs. In turn, the Legs consist of Lower leg, Foot, etc.

We define composition in the following way:

Definition xxx To *compose* is to form a compound phenomenon by means of a number of component phenomena. Properties in the intension of the compound phenomenon are described using the component phenomena. The extension of the compound phenomenon consists of phenomena which have components belonging to the extension of the component phenomena.

To *decompose* is to identify a component phenomenon of a phenomenon. Decomposition is the inverse of composition.

Composition gives rise to the following relations:

Definition xxx The *component-of* relation is a relationship between a phenomenon and one of its component phenomena.

Definition xxx The *part-of relation* is a relation between a phenomenon and one of its part phenomena.

Composition of activities

It is not just physical phenomena as shown in the above examples that may be organised in terms of wholes and parts. This is also the case for activities. An activity described by a method may consist of other activities.

A activity of making a pizza may be understood as a composition of several sub-activities, including: making the dough, making the tomato sauce, preparing the topping, etc.

From the bank domain: Transfer consisting of withdraw and deposit