A Student Guide to Object-Oriented Development

Chapter 5 The Class Diagram

The Class Diagram

The class diagram appears through successive iterations at every stage in the development process.

- **It is used first to model things in the application domain as part of requirements capture.**
- **It is used to design a solution.**
- **Finally it is used to design the program code.**

Stages in building a class diagram

There are several approaches depending on

- **the size and type of system being developed**
- **the experience and ability of the team**
- **procedures of the organisation concerned.**

Stages in building a class diagram

Two approaches:

- **Use case realisation – identify classes needed to perform functionality identified in use cases. Proceed use case by use case.**
- **A domain model – model classes for the whole problem domain**

Stages in building a class diagram

- identify the objects and derive classes from them;
- identify attributes of classes;
- identify relationships between the classes;
- write a data dictionary to support the class diagram;
- identify class responsibilities using CRC cards;
- separate responsibilities into operations and attributes;
- iterate and refine the model.

Identify the objects and derive classes

- various techniques can be used for object identification
- none can be guaranteed to produce a definitive list of objects and classes
- they are just guidelines that might help
- search for nouns in the documentation a good starting point

Object identification using nouns

1. **Find a complete description of system requirements**
2. **Underline all the nouns and noun phrases (person, place or thing)**
3. **This gives a list of candidate objects**
4. **Reject objects that will not make suitable classes**

Description of problem:

- R1 keep a complete list of all bikes and their details including bike number, type, size, make, model, daily charge rate, deposit; (this is already on the Wheels system);
- R2 keep a record of all customers and their past hire transactions;
- R3 work out automatically how much it will cost to hire a given bike for a given number of days;
- R4 record the details of a hire transaction including the start date, estimated duration, customer and bike, in such a way that it is easy to find the relevant transaction details when a bike is returned;
- R5 keep track of how many bikes a customer is hiring so that the customer gets one unified receipt not a separate one for each bike;
- R6 cope with a customer who hires more than one bike, each for different amounts of time;
- R7 work out automatically, on the return of a bike, how long it was hired for, how many days were originally paid for, how much extra is due;
- R8 record the total amount due and how much has been paid;
- R9 print a receipt for each customer;
- R10 keep track of the state of each bike, e.g. whether it is in stock, hired out or being repaired;
- R11 provide the means to record extra details about specialist bikes.

Underline the nouns and noun phrases

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List of *nouns*:

- list of bikes
- details of bikes: bike number, type, size, make, model, daily charge rate, deposit
- Wheels system
- record of customers
- past hire transactions
- bike
- number of days
- details of a hire transaction: start date, estimated duration
- customer
- receipt
- different amounts of time
- return of a bike
- total amount due
- state of each bike
- extra details about specialist bikes

Remove *attribute nouns*:

list of bikes
details of bikes: *bike number*, *type*, *size*, *make*, *model*, *daily charge rate*, *deposit*
Wheels system
record of customers
past hire transactions
bike
number of days
details of a hire transaction: *start date*, *estimated duration*
customer
receipt
different amounts of time
return of a bike
total amount due
state of each bike
extra details about specialist bikes

… information about a class, not a class itself

Remove *redundancy/duplicates*

list of bikes
Wheels system
record of customers
past hire transactions
bike
hire transaction
customer
receipt
return of a bike
specialist bike

list of bikes
Wheels system
record of customers
bike
hire transaction
customer
receipt
return of a bike
specialist bike

… different names for the same thing

Remove *vague* nouns:

list of bikes
Wheels system
record of customers
bike
hire transaction
customer
receipt
return of a bike
specialist bike

list of bikes
Wheels system
record of customers
bike
hire transaction
customer
receipt
specialist bike

… words without precise meaning

Remove nouns too tied up with physical inputs and outputs:

list of bikes
Wheels system
record of customers
bike
hire transaction
customer
receipt
specialist bike

… data inputs or system products

Remove *association* nouns:

- **Is hires an association or a class?**
- **If there is data associated, probably a class**
- **Hire: start date, number of days, so**
- **Keep Hire as a class**

Remove nouns that represent the whole system:

Wheels system
bike
hire
customer
specialist bike

… we want to divide the system into separate objects

Remove nouns outside scope of system:

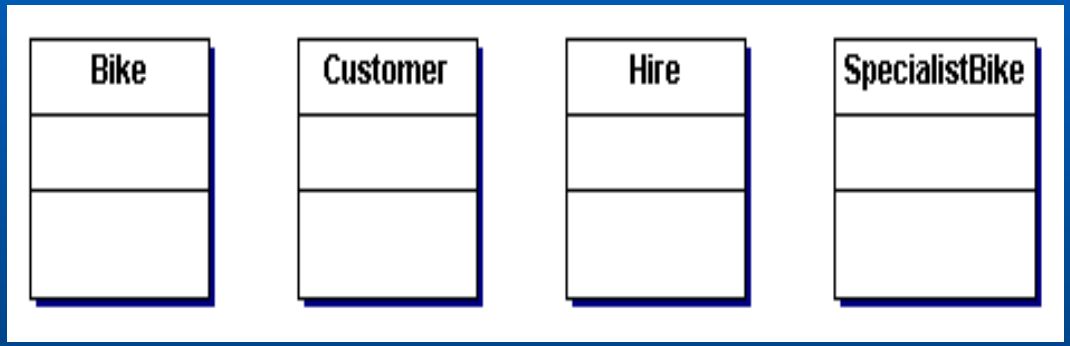
From the Problem Definition (Chapter 2) we know that the system will not cover:

- payroll
- personnel
- general accounting

… not part of the intended system

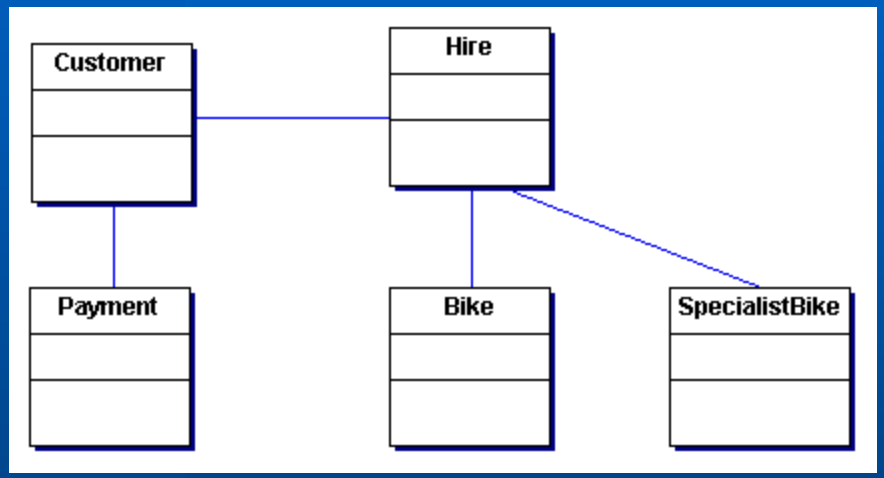
Identified objects, derive classes

bike
customer
hire
specialist bike



… these nouns are left as potential classes

Add missing classes



- **Add Payment class**
- **Not all classes appear as nouns in the problem description**
- **Apply common sense**

Identify attributes of classes

- **Many nouns will appear in the text being analysed e.g. bike number, available, type etc are attributes of bike.**

Avoid

- **Attributes not relevant to current system – e.g. Customer passport number**
- **Derivable attributes – e.g. cost of hire (dialyHireRate*numberOfDays)**
- **Implementation attributes - pointers**

Identify relationships between classes

- **During analysis we have not yet got an exact notion of how objects will need to communicate with each other**
- **The relationships that we include at this stage model real-life relationships that we think might be useful**
- **We will not have an exact idea of the navigable paths we need to build in until after looking at the interaction diagram.**

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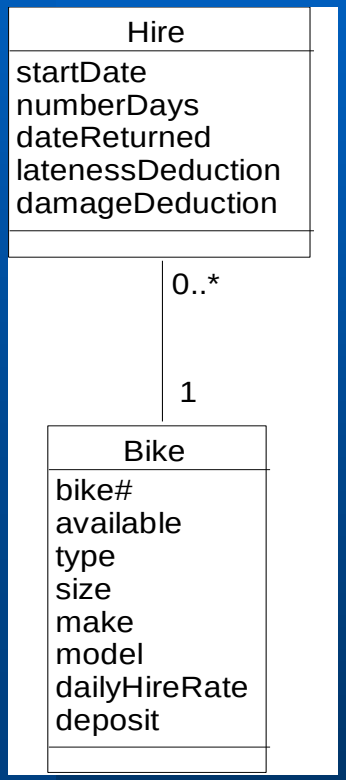
Associations and Multiplicity

The Hire class holds data about the hiring of a bike. It needs to communicate with the Bike class to work out the cost of a hire (numberDays*dailyHireRate)

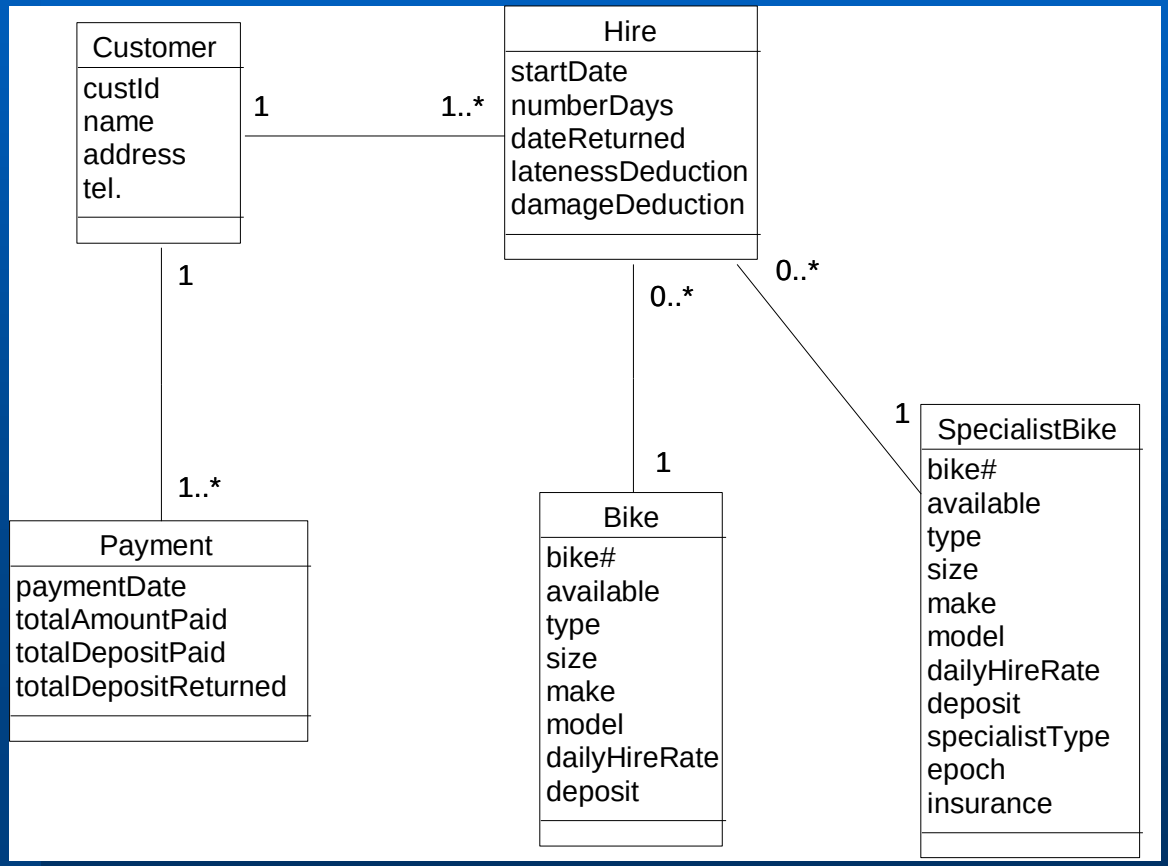
To perform this calculation there must be a relationship between Hire and Bike

Associations and Multiplicity

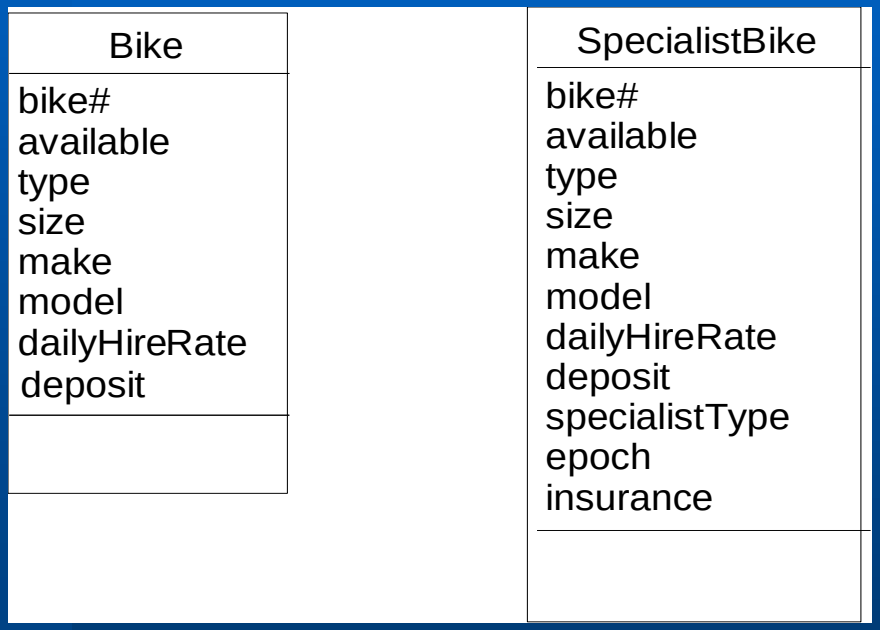


Relationship between Hire and Bike showing that a :Hire is for only one :Bike but a :Bike can be hired 0, 1 or many times

Wheels class diagram with initial associations

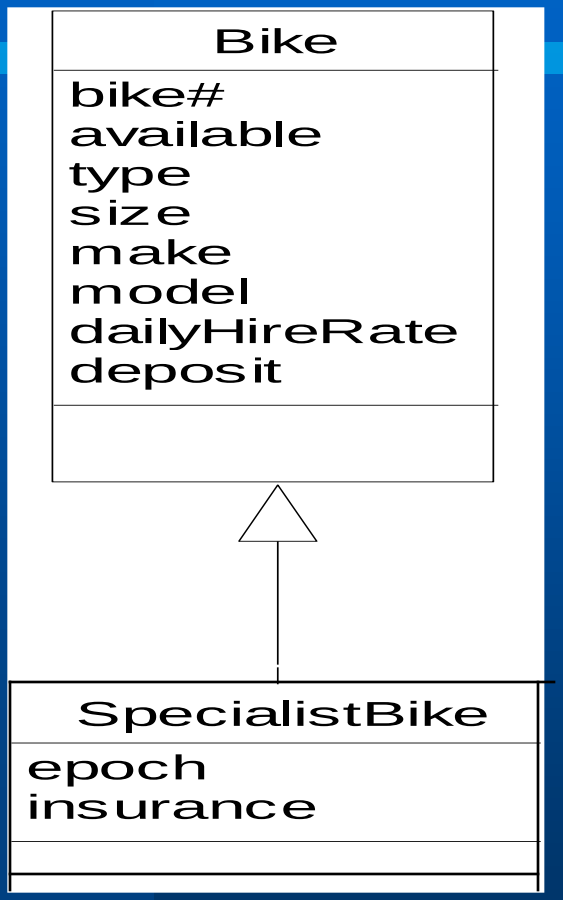


Generalization and inheritance

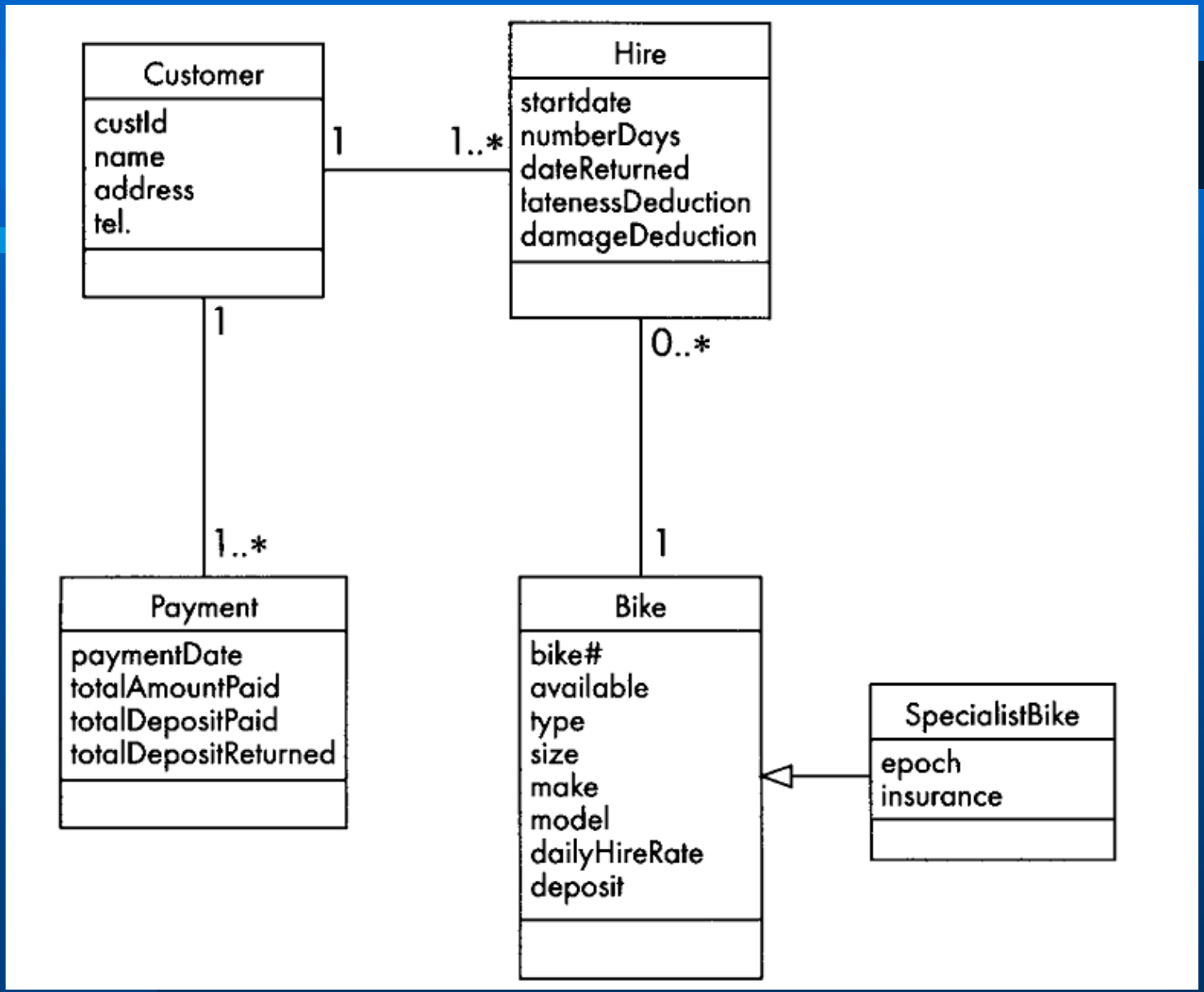


- Many shared attributes
- type same as specialistType ,

Inheritance



- Shared attributes inherited by SpecialistBike
- Distinguishing attributes (epoch and insurance) are unique to SpecialistBike


Customer
custId
name
address
tel.
Hire
startdate
numberDays
dateReturned
latenessDeduction
damageDeduction
1
1..*
1
0..*
1..*
1
Payment
paymentDate
totalAmountPaid
totalDepositPaid
totalDepositReturned
Bike
bike#
available
type
size
make
model
dailyHireRate
deposit
SpecialistBike
epoch
insurance

Data dictionary to support class diagram

- **The data dictionary notation that we use in this book is semi- formal, and suitable for documenting the data of a small information system.**
- **We want to be able to define classes in terms of their attributes including:**

Data dictionary to support class diagram

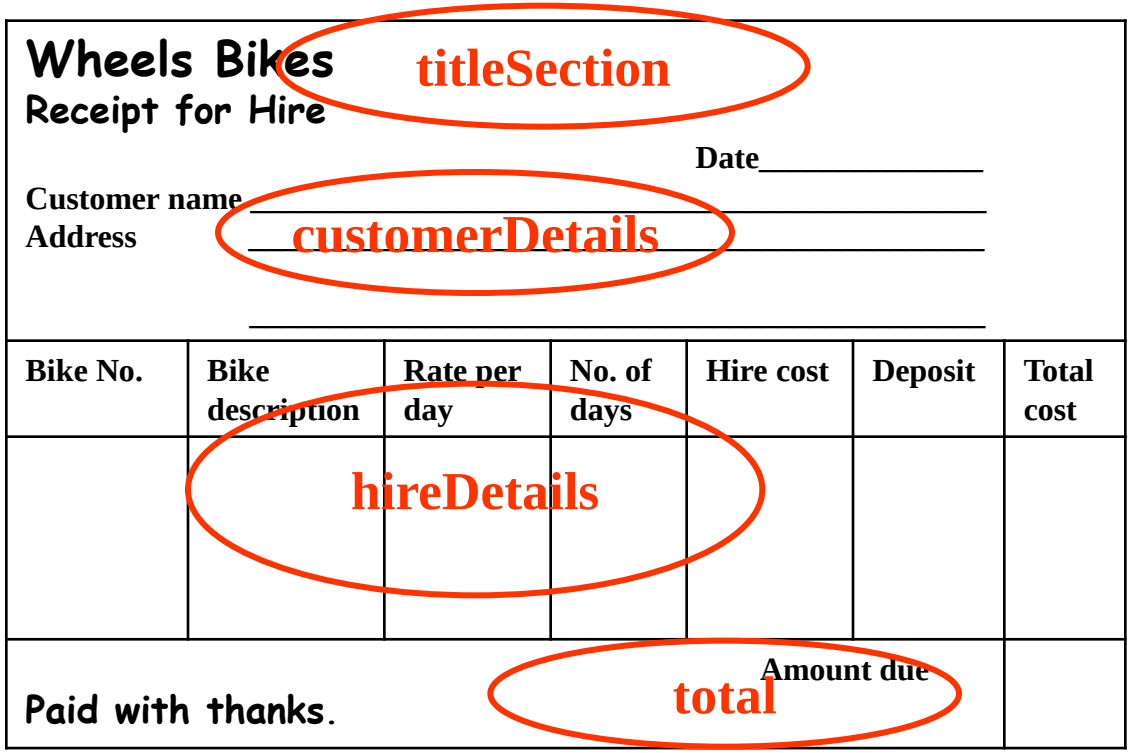
- **The order in which they are listed (e.g. name, address, phone number)**
- **Whether an attribute is repeated (e.g. a customer may have more than one phone number)**
- **Any restrictions on the number of repetitions**
- **Whether an attribute is optional (e.g. a customer may or may not have an email address)**
- **The set of possible values for an attribute (e.g. in some businesses a customer may be individual or wholesale)**
- **Selection between alternative values for an attribute (e.g. a customer is either individual or wholesale).**

Data dictionary to support class diagram

- **the data dictionary is constructed in parallel with the other models,**
- **details are added to the dictionary definitions as more information becomes available,**
- **the main UML models are cross-referenced via entries in the data dictionary as a means of ensuring consistency between them.**
- **more detail will be needed as we move closer to implementation**

Data dictionary notation

MEANING	SYMBOL	DESCRIPTION	EXAMPLE
consists of	=	introduces the definition of a data item	Customer =
and	+	joins components of the definition in sequence	Customer = name + address
one or more	{ }	attribute may be repeated; any restrictions on the number of repetitions are written in subscript	Customer = name + address + $\{phone\}_2$
zero or one	( )	attribute is optional	Customer = name + address + $\{phone\}_2$ + (email)
alternatives	[ ]	selection is indicated by enclosing the alternative attributes in square brackets [ ]	Name = [initial | firstname] + surname
either.. or	|	alternatives for selection in [ ] are separated by a vertical bar	
specific value	" "	indicates specific values	"individual", "wholesale"
…	comment	comments are enclosed between asterisks	Customer = name + address + $\{phone\}_2$ + (email) + ["individual" | "wholesale"] *Wholesale customers are entitled to special discounts*



receipt = titleSection + customerDetails + {hireDetails} *a customer may hire more than one bike at a time* + total

titleSection = "Mikes Bikes Receipt for Hire" + receiptDate
customerDetails = customerName + customerAddress
hireDetails = bikeNo. + bikeDescription + ratePerDay + noOfDays + hireCost + deposit + totalCost
total = amountDue + "Paid with thanks“

We can decompose to further levels as needed, for example we could add:
bikeDescription = make + model + type + size

What makes a good class?

- ***Problem domain*** During analysis, classes should correspond to things in the real world of the problem domain
- ***Functionality*** A class (at least during analysis) usually has both attributes and behaviour.
- ***Cohesion*** One of the qualities of a good software construct, listed at the beginning of this chapter, is cohesion. A class is cohesive if it is concerned with only one thing, if all its attributes and operations relate to the same topic.

Summary

- The class diagram defines the software architecture and the internal structure of the objects in an object-oriented system
- the classes we model in the class diagram form the basis of the classes in the code
- The stages in the construction of a class diagram are
  - identifying objects and deriving classes
  - identifying attributes
  - identifying relationships
  - writing a data dictionary
  - identifying operations
  - writing operation specifications.