System models

- Abstract descriptions of systems whose requirements are being analysed

Objectives

- To explain why the context of a system should be modelled as part of the RE process
- To describe behavioural modelling, data modelling and object modelling
- To introduce some of the notations used in the Unified Modeling Language (UML)
- To show how CASE workbenches support system modelling

Topics covered

- Context models
- Behavioural models
- Data models
- Object models
- CASE workbenches

System modelling

- System modelling helps the analyst to understand the functionality of the system and models are used to communicate with customers
- Different models present the system from different perspectives
  - External perspective showing the system's context or environment
  - Behavioural perspective showing the behaviour of the system
  - Structural perspective showing the system or data architecture

Structured methods

- Structured methods incorporate system modelling as an inherent part of the method
- Methods define a set of models, a process for deriving these models and rules and guidelines that should apply to the models
- CASE tools support system modelling as part of a structured method

Method weaknesses

- They do not model non-functional system requirements
- They do not usually include information about whether a method is appropriate for a given problem
- The may produce too much documentation
- The system models are sometimes too detailed and difficult for users to understand

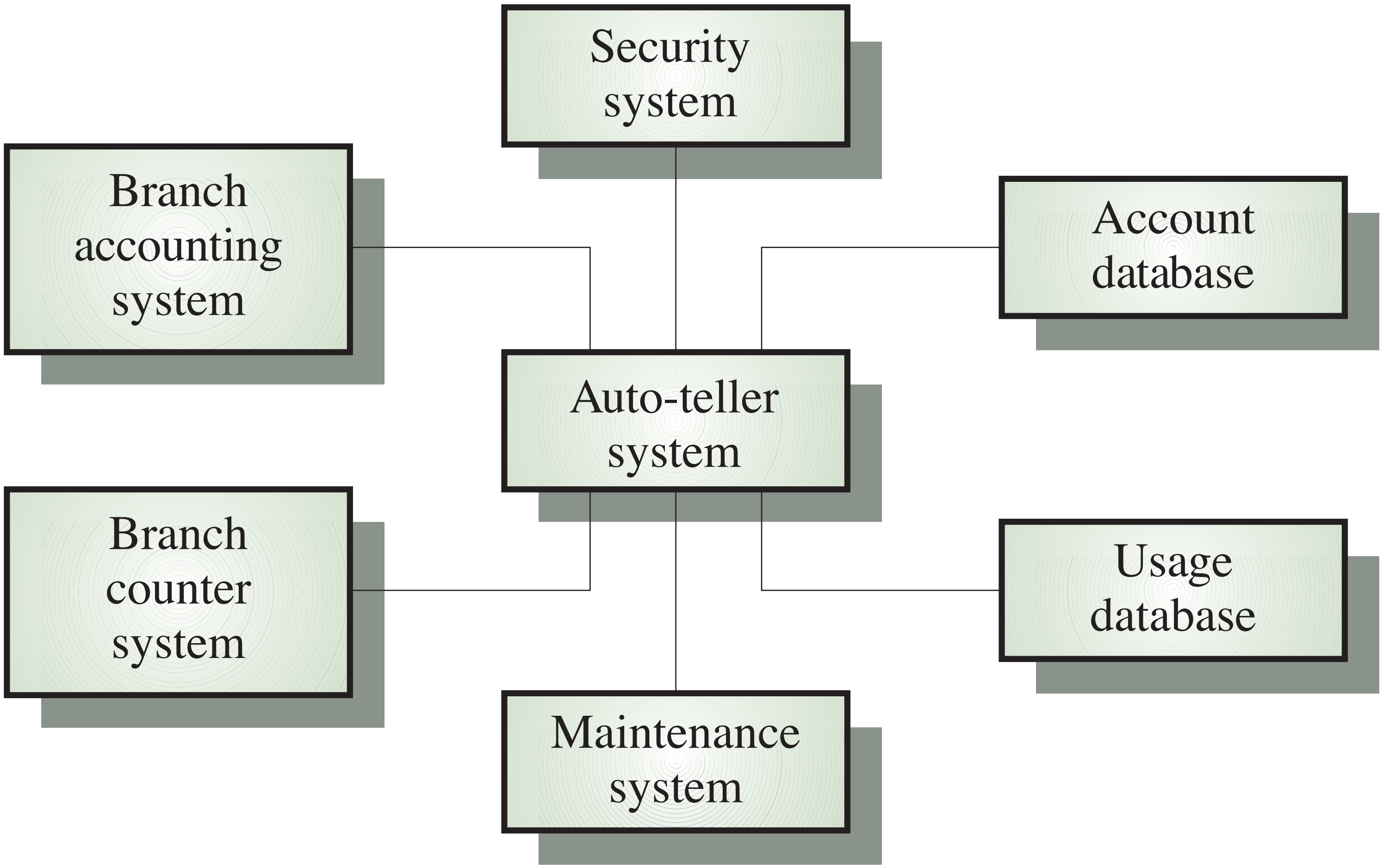
Model types

- Data processing model showing how the data is processed at different stages
- Composition model showing how entities are composed of other entities
- Architectural model showing principal sub-systems
- Classification model showing how entities have common characteristics
- Stimulus/response model showing the system's reaction to events

Context models

- Context models are used to illustrate the boundaries of a system
- Social and organisational concerns may affect the decision on where to position system boundaries
- Architectural models show the a system and its relationship with other systems

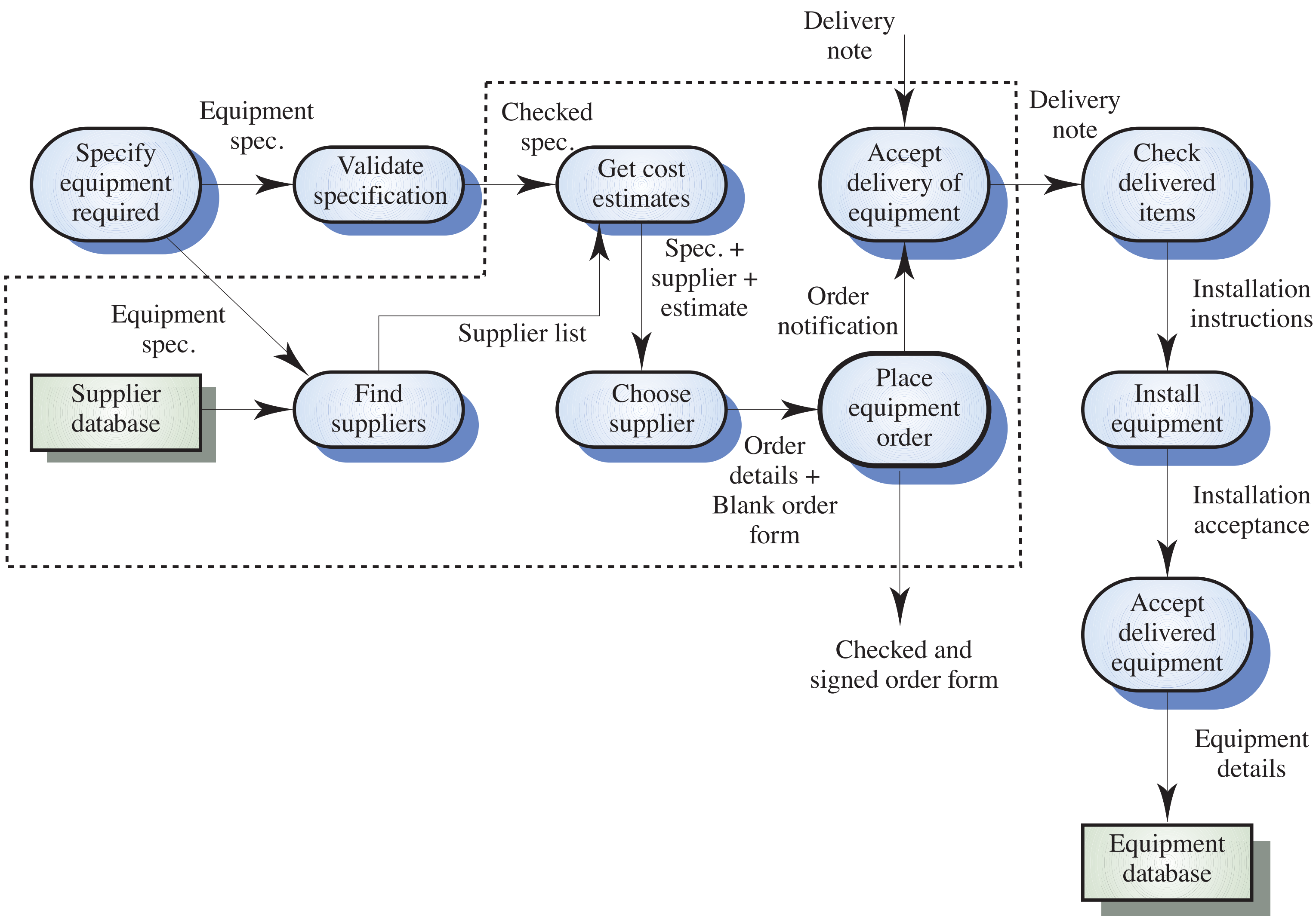
The context of an ATM system



Process models

- Process models show the overall process and the processes that are supported by the system
- Data flow models may be used to show the processes and the flow of information from one process to another

Equipment procurement process



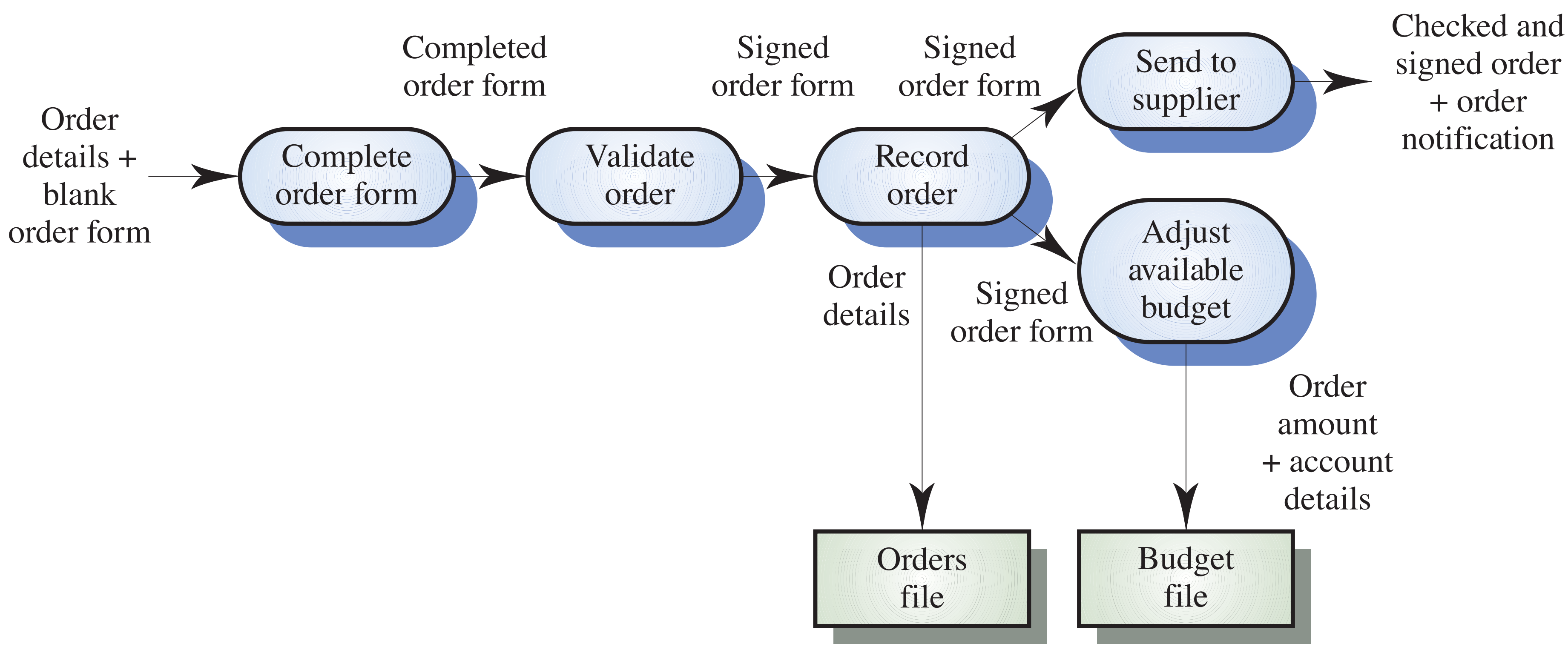
Behavioural models

- Behavioural models are used to describe the overall behaviour of a system
- Two types of behavioural model are shown here
  - Data processing models that show how data is processed as it moves through the system
  - State machine models that show the systems response to events
- Both of these models are required for a description of the system's behaviour

Data-processing models

- Data flow diagrams are used to model the system's data processing
- These show the processing steps as data flows through a system
- Intrinsic part of many analysis methods
- Simple and intuitive notation that customers can understand
- Show end-to-end processing of data

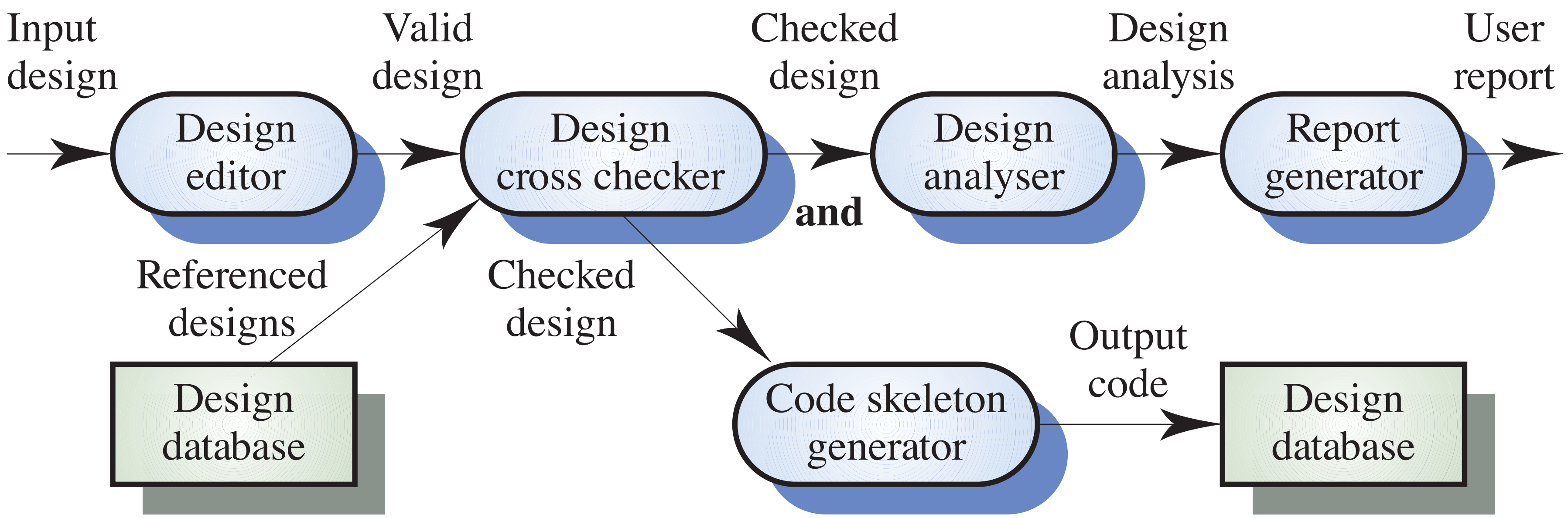
Order processing DFD



Data flow diagrams

- DFDs model the system from a functional perspective
- Tracking and documenting how the data associated with a process is helpful to develop an overall understanding of the system
- Data flow diagrams may also be used in showing the data exchange between a system and other systems in its environment

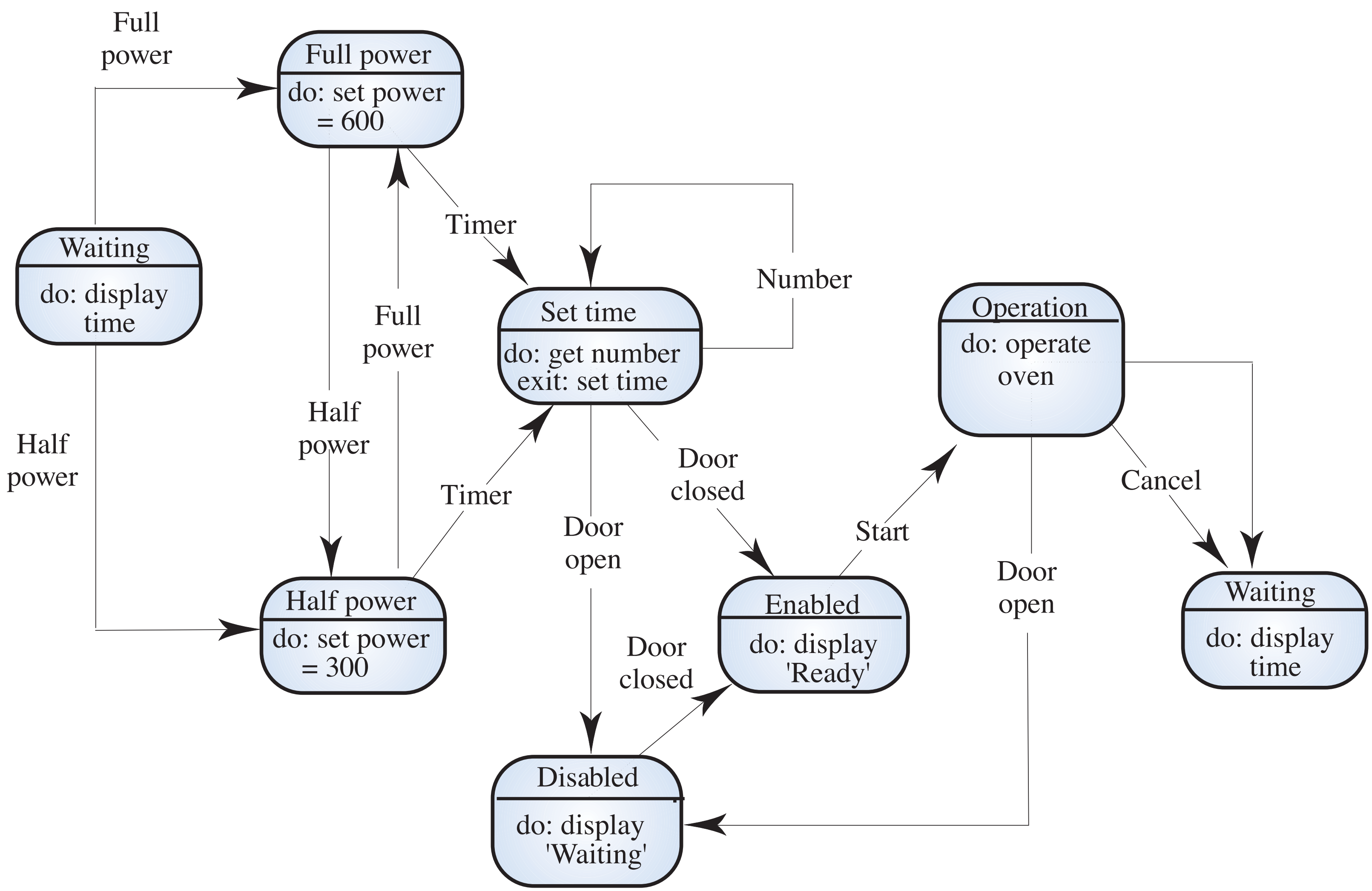
CASE toolset DFD



State machine models

- These model the behaviour of the system in response to external and internal events
- They show the system's responses to stimuli so are often used for modelling real-time systems
- State machine models show system states as nodes and events as arcs between these nodes. When an event occurs, the system moves from one state to another
- Statecharts are an integral part of the UML

Microwave oven model



Microwave oven state description

State	Description
Waiting	The oven is waiting for input. The display shows the current time.
Half power	The oven power is set to 300 watts. The display shows ‘Half power’.
Full power	The oven power is set to 600 watts. The display shows ‘Full power’.
Set time	The cooking time is set to the user’s input value. The display shows the cooking time selected and is updated as the time is set.
Disabled	Oven operation is disabled for safety. Interior oven light is on. Display shows ‘Not ready’.
Enabled	Oven operation is enabled. Interior oven light is off. Display shows ‘Ready to cook’.
Operation	Oven in operation. Interior oven light is on. Display shows the timer countdown. On completion of cooking, the buzzer is sounded for 5 seconds. Oven light is on. Display shows ‘Cooking complete’ while buzzer is sounding.

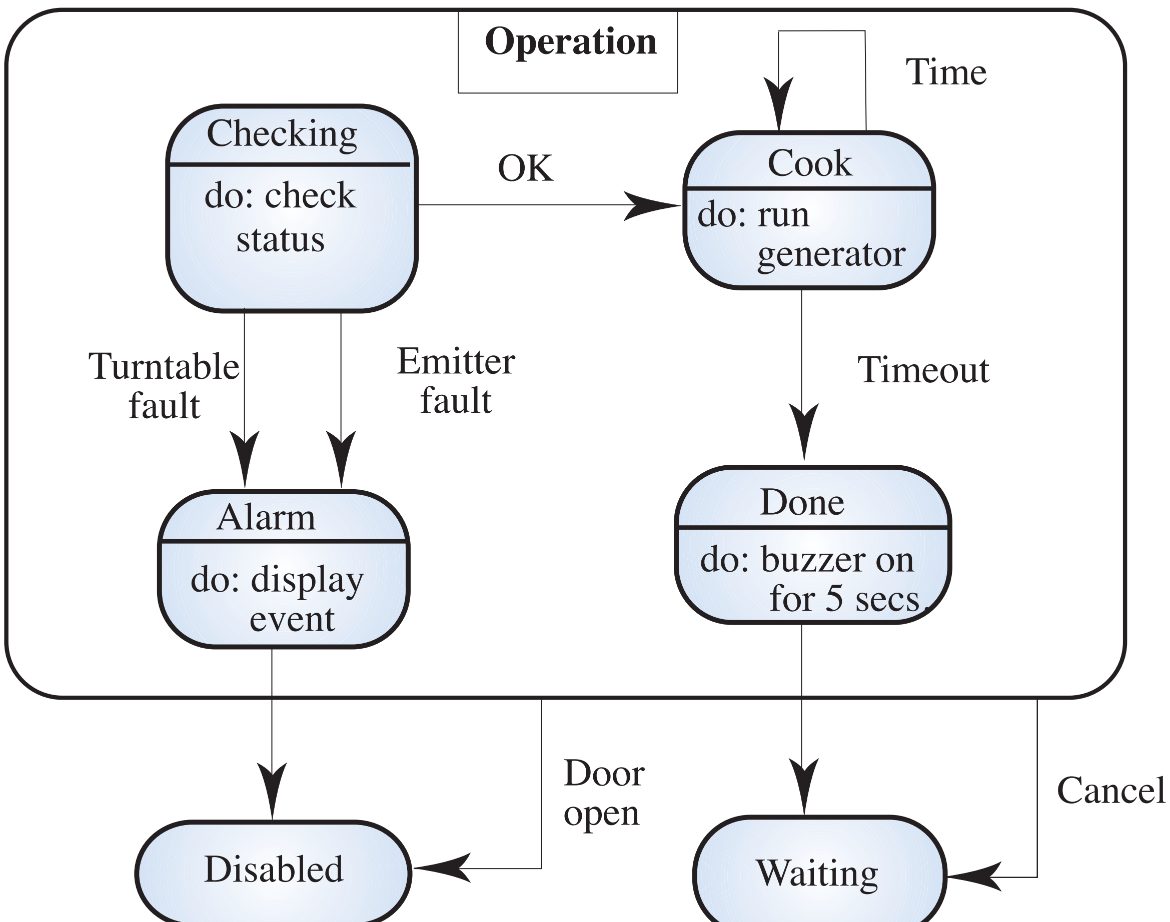
Microwave oven stimuli

Stimulus	Description
Half power	The user has pressed the half power button
Full power	The user has pressed the full power button
Timer	The user has pressed one of the timer buttons
Number	The user has pressed a numeric key
Door open	The oven door switch is not closed
Door closed	The oven door switch is closed
Start	The user has pressed the start button
Cancel	The user has pressed the cancel button

Statecharts

- Allow the decomposition of a model into sub-models (see following slide)
- A brief description of the actions is included following the ‘do’ in each state
- Can be complemented by tables describing the states and the stimuli

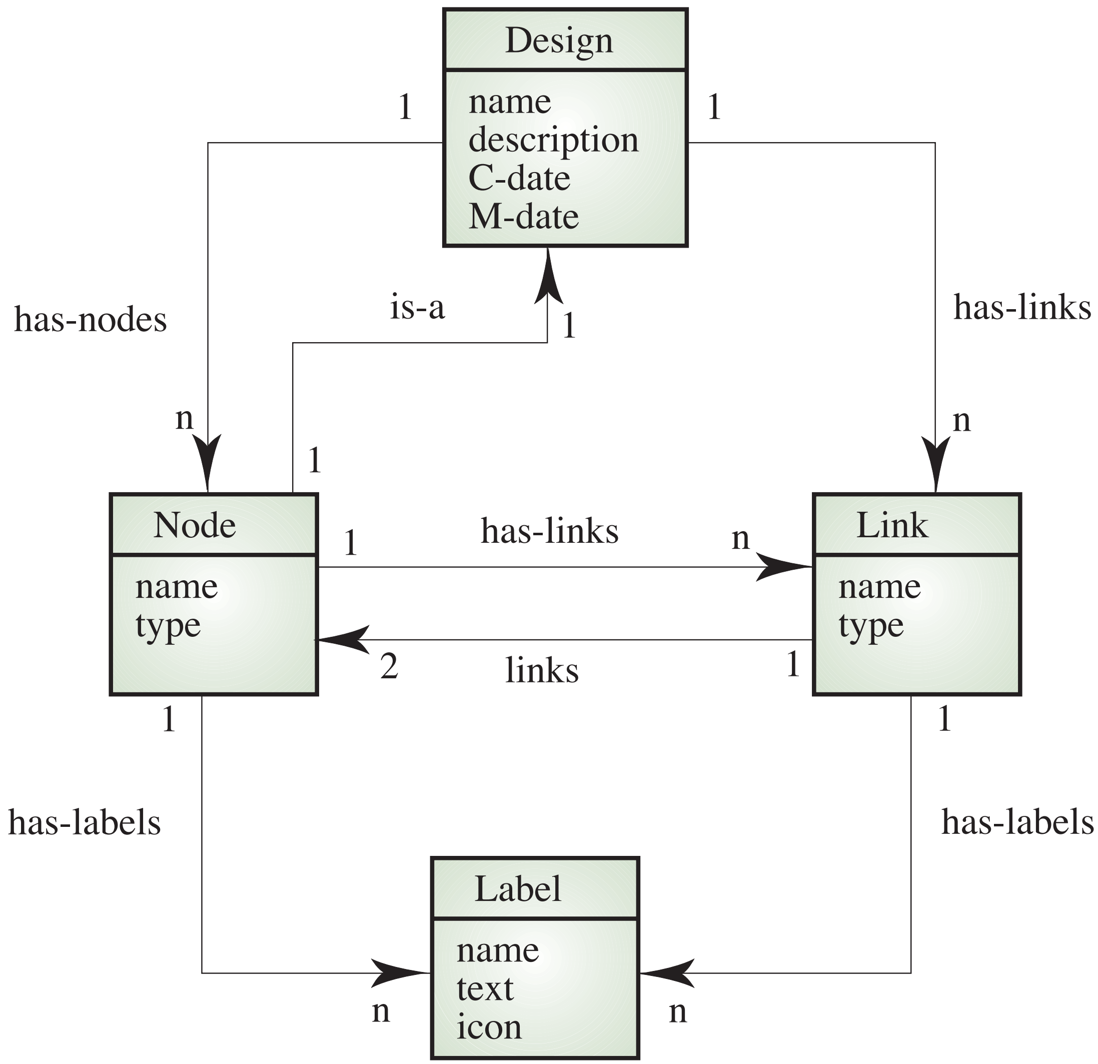
Microwave oven operation



Semantic data models

- Used to describe the logical structure of data processed by the system
- Entity-relation-attribute model sets out the entities in the system, the relationships between these entities and the entity attributes
- Widely used in database design. Can readily be implemented using relational databases
- No specific notation provided in the UML but objects and associations can be used

Software design semantic model



Data dictionaries

- Data dictionaries are lists of all of the names used in the system models. Descriptions of the entities, relationships and attributes are also included
- Advantages
  - Support name management and avoid duplication
  - Store of organisational knowledge linking analysis, design and implementation
- Many CASE workbenches support data dictionaries

Data dictionary entries

Name	Description	Type	Date
has-labels	1:N relation between entities of type Node or Link and entities of type Label.	Relation	5.10.1998
Label	Holds structured or unstructured information about nodes or links. Labels are represented by an icon (which can be a transparent box) and associated text.	Entity	8.12.1998
Link	A 1:1 relation between design entities represented as nodes. Links are typed and may be named.	Relation	8.12.1998
name (label)	Each label has a name which identifies the type of label. The name must be unique within the set of label types used in a design.	Attribute	8.12.1998
name (node)	Each node has a name which must be unique within a design. The name may be up to 64 characters long.	Attribute	15.11.1998

Object models

- Object models describe the system in terms of object classes
- An object class is an abstraction over a set of objects with common attributes and the services (operations) provided by each object
- Various object models may be produced
  - Inheritance models
  - Aggregation models
  - Interaction models

Object models

- Natural ways of reflecting the real-world entities manipulated by the system
- More abstract entities are more difficult to model using this approach
- Object class identification is recognised as a difficult process requiring a deep understanding of the application domain
- Object classes reflecting domain entities are reusable across systems

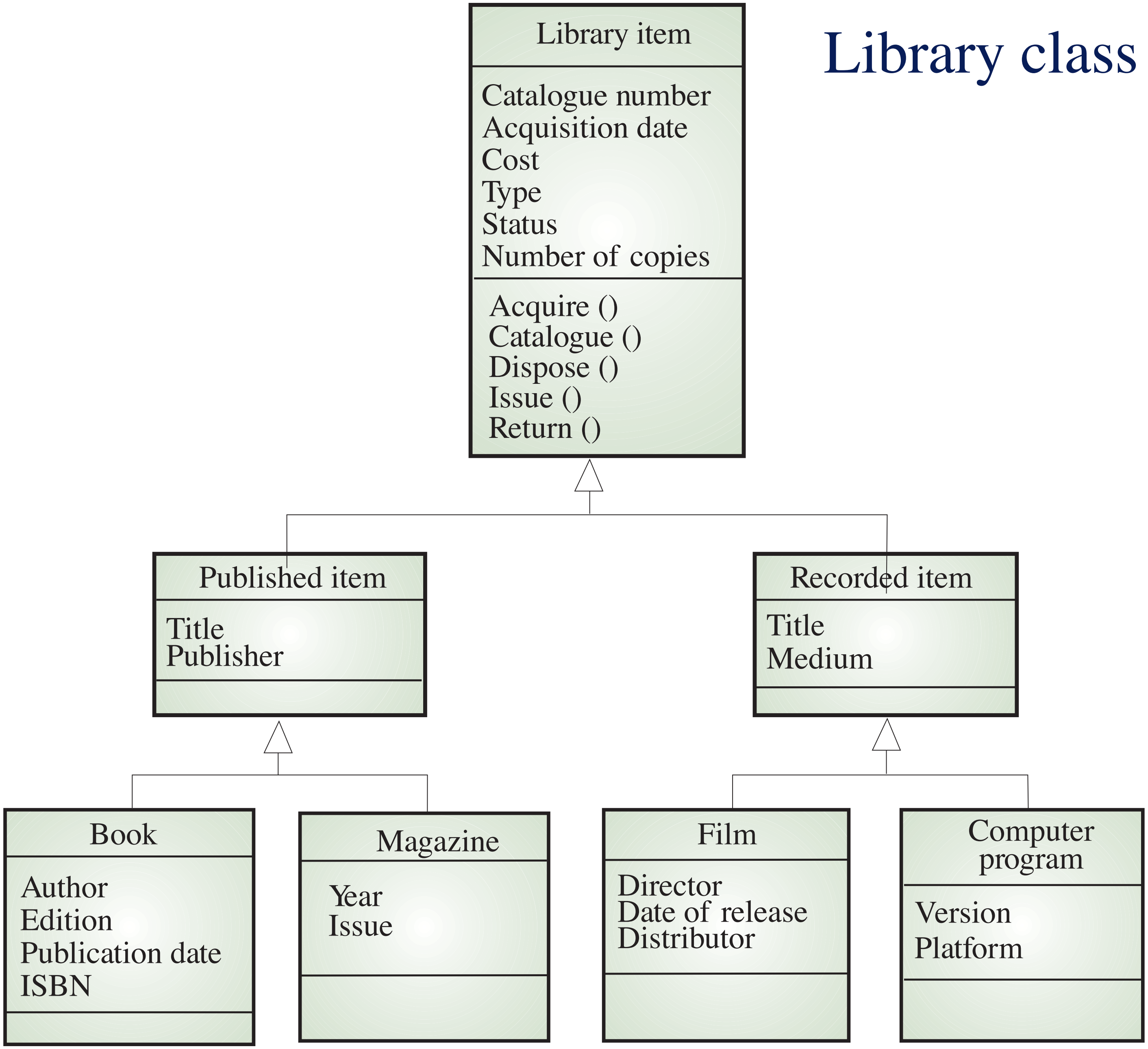
Inheritance models

- Organise the domain object classes into a hierarchy
- Classes at the top of the hierarchy reflect the common features of all classes
- Object classes inherit their attributes and services from one or more super-classes. these may then be specialised as necessary
- Class hierarchy design is a difficult process if duplication in different branches is to be avoided

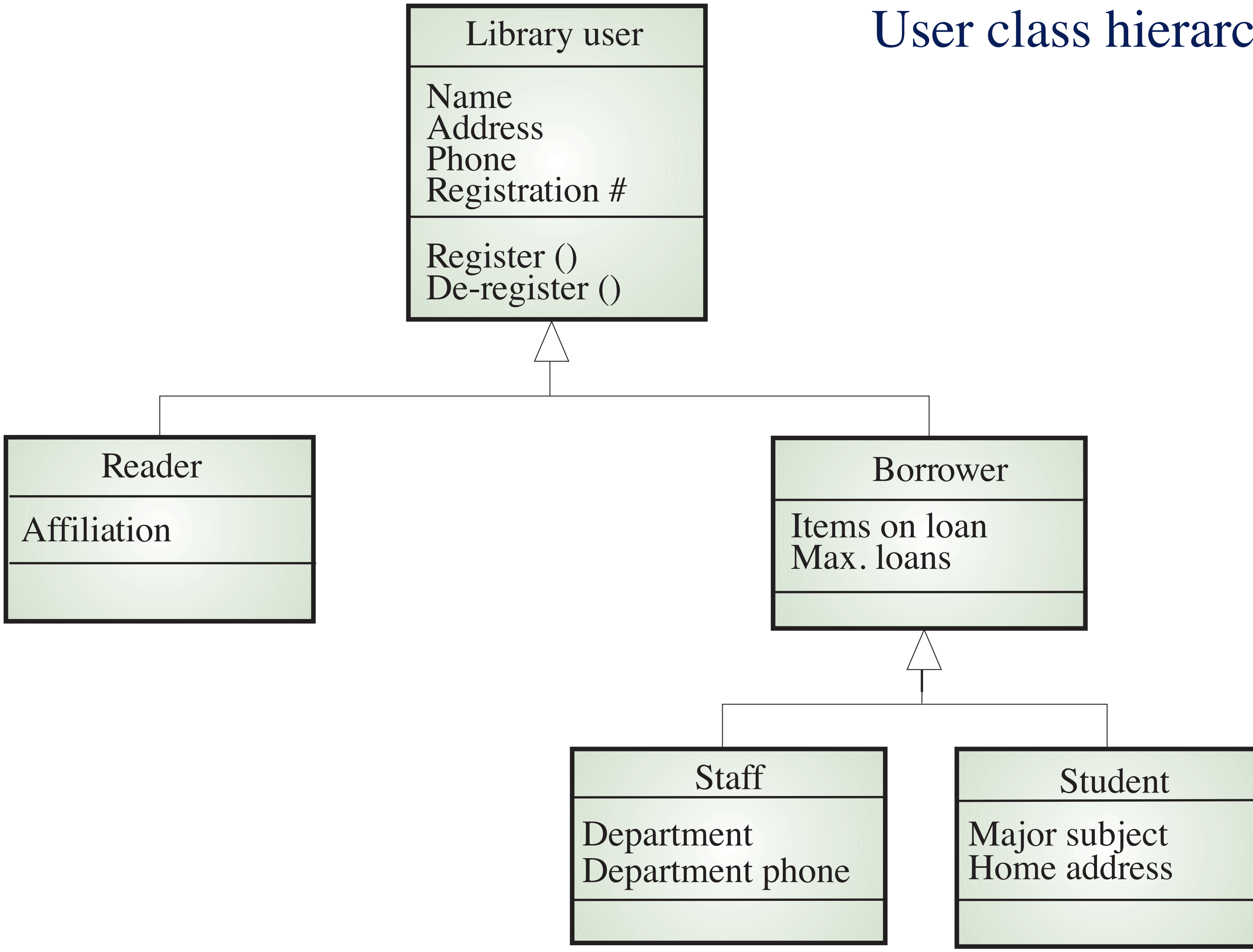
The Unified Modeling Language

- Devised by the developers of widely used object-oriented analysis and design methods
- Has become an effective standard for object-oriented modelling
- Notation
  - Object classes are rectangles with the name at the top, attributes in the middle section and operations in the bottom section
  - Relationships between object classes (known as associations) are shown as lines linking objects
  - Inheritance is referred to as generalisation and is shown 'upwards' rather than 'downwards' in a hierarchy

Library class hierarchy



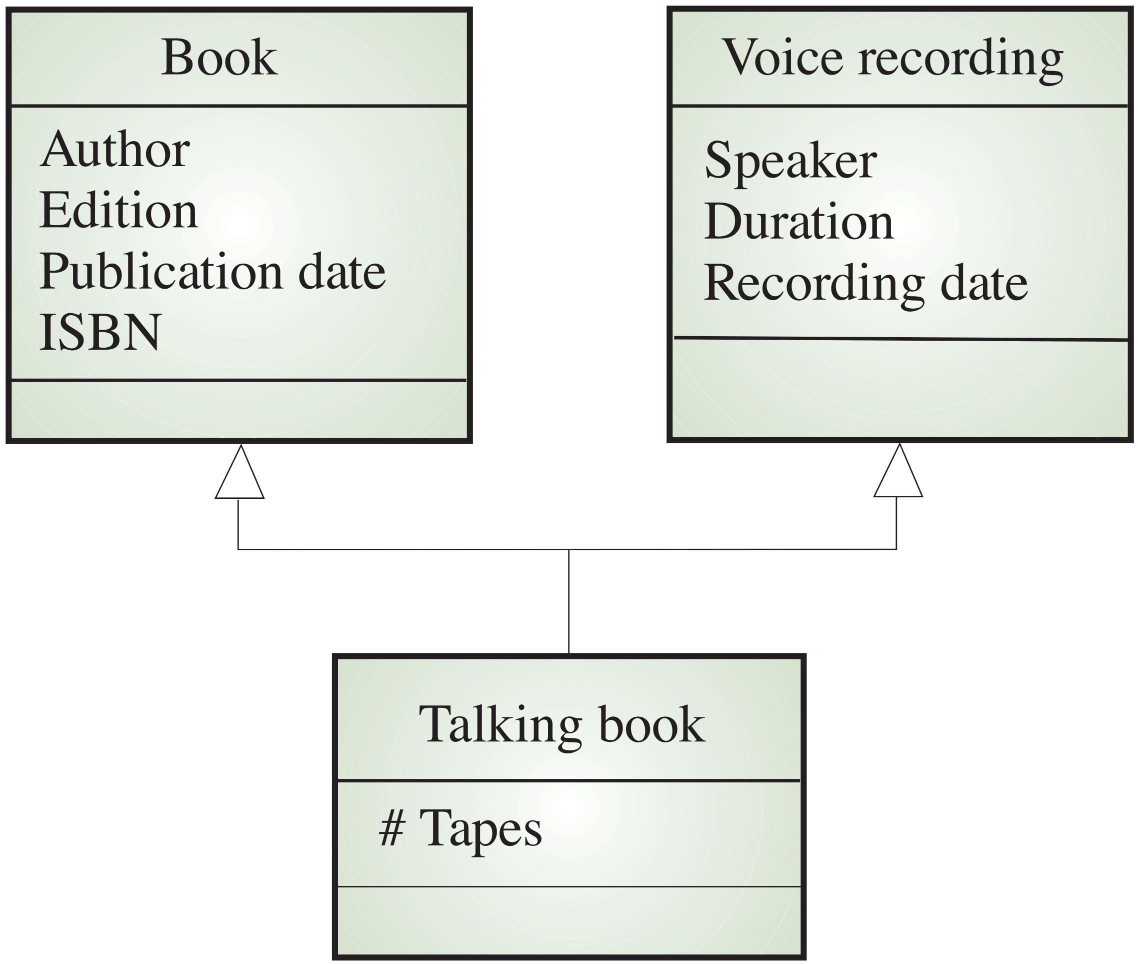
User class hierarchy



Multiple inheritance

- Rather than inheriting the attributes and services from a single parent class, a system which supports multiple inheritance allows object classes to inherit from several super-classes
- Can lead to semantic conflicts where attributes/services with the same name in different super-classes have different semantics
- Makes class hierarchy reorganisation more complex

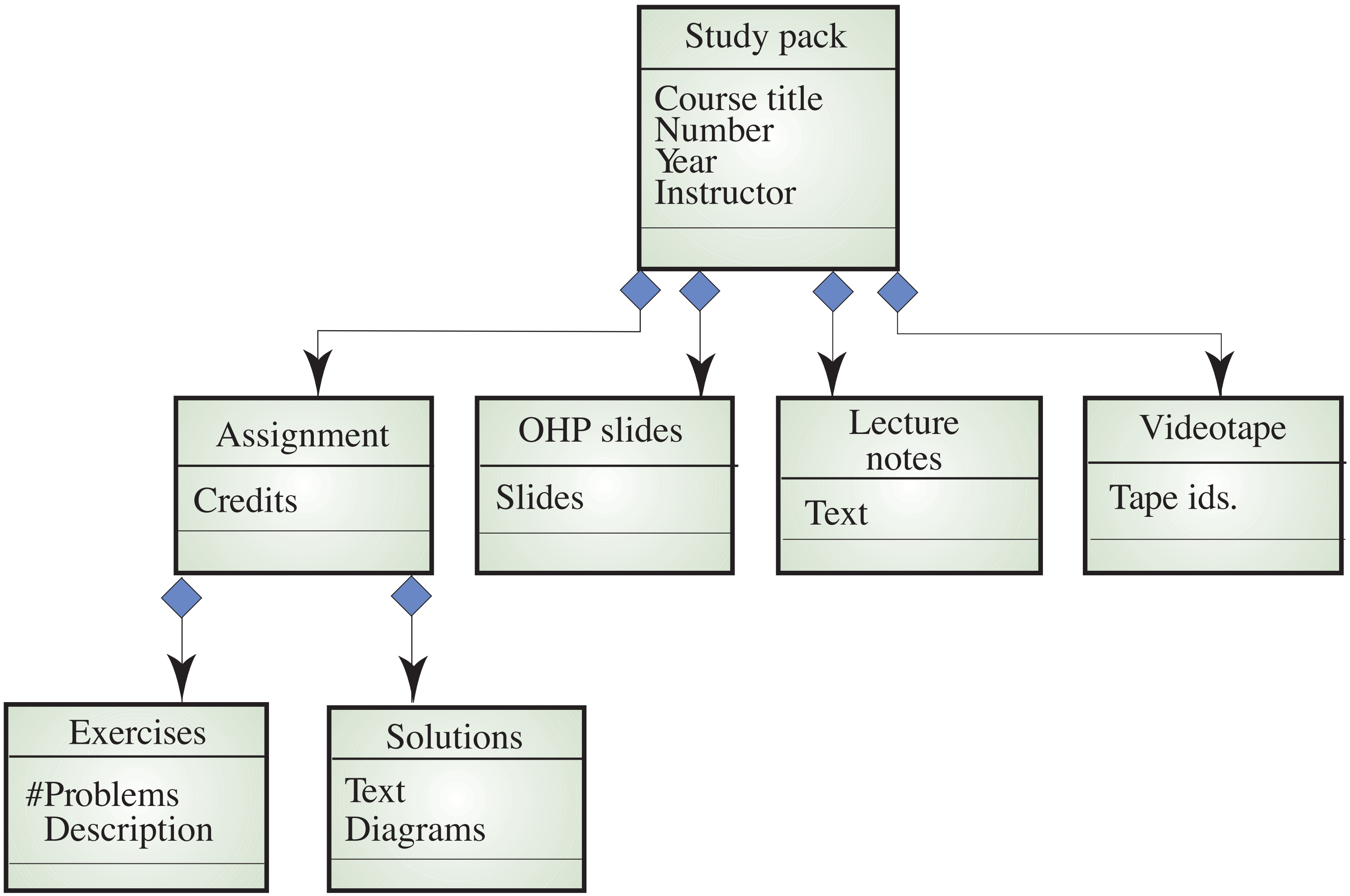
Multiple inheritance



Object aggregation

- Aggregation model shows how classes which are collections are composed of other classes
- Similar to the part-of relationship in semantic data models

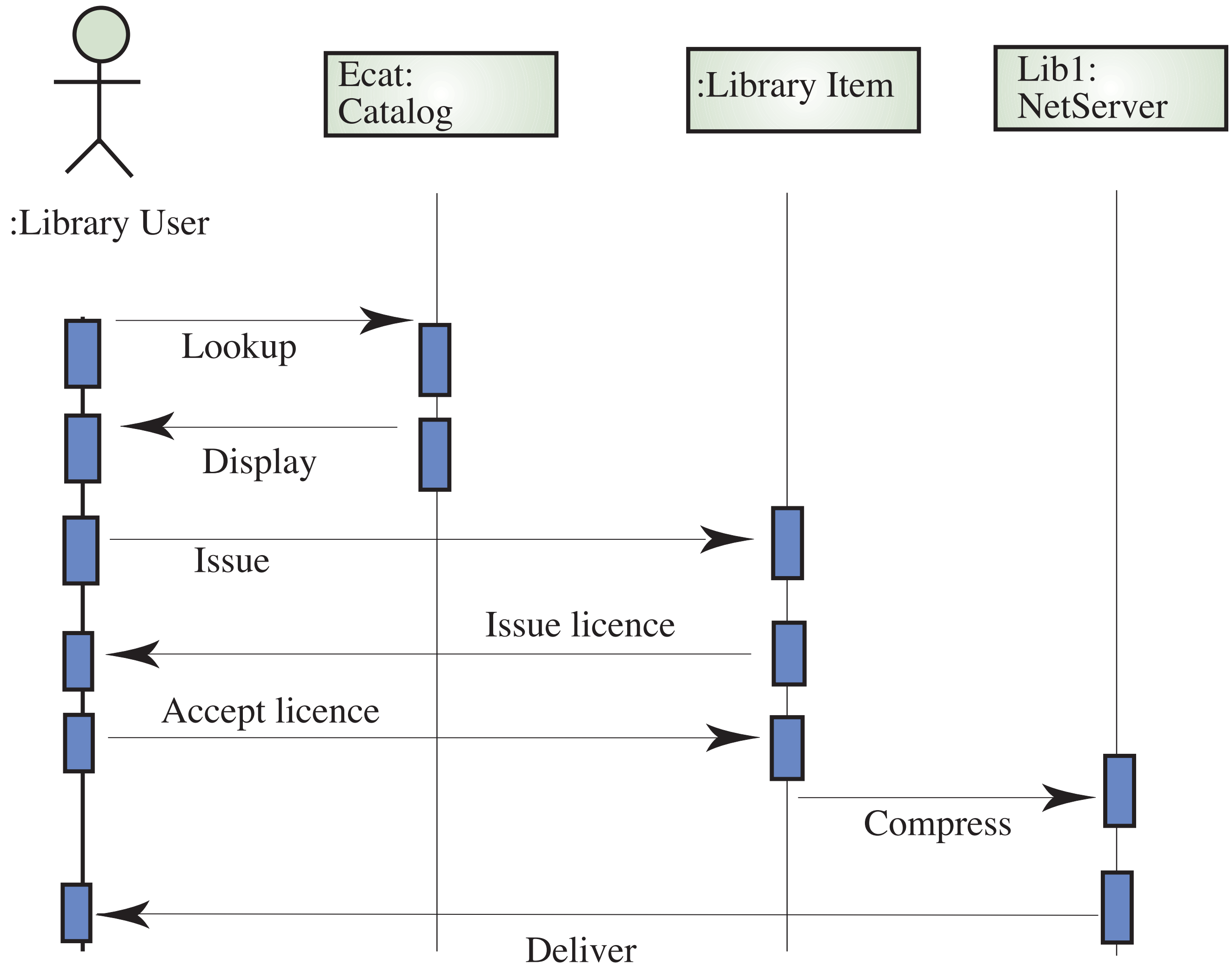
Object aggregation



Object behaviour modelling

- A behavioural model shows the interactions between objects to produce some particular system behaviour that is specified as a use-case
- Sequence diagrams (or collaboration diagrams) in the UML are used to model interaction between objects

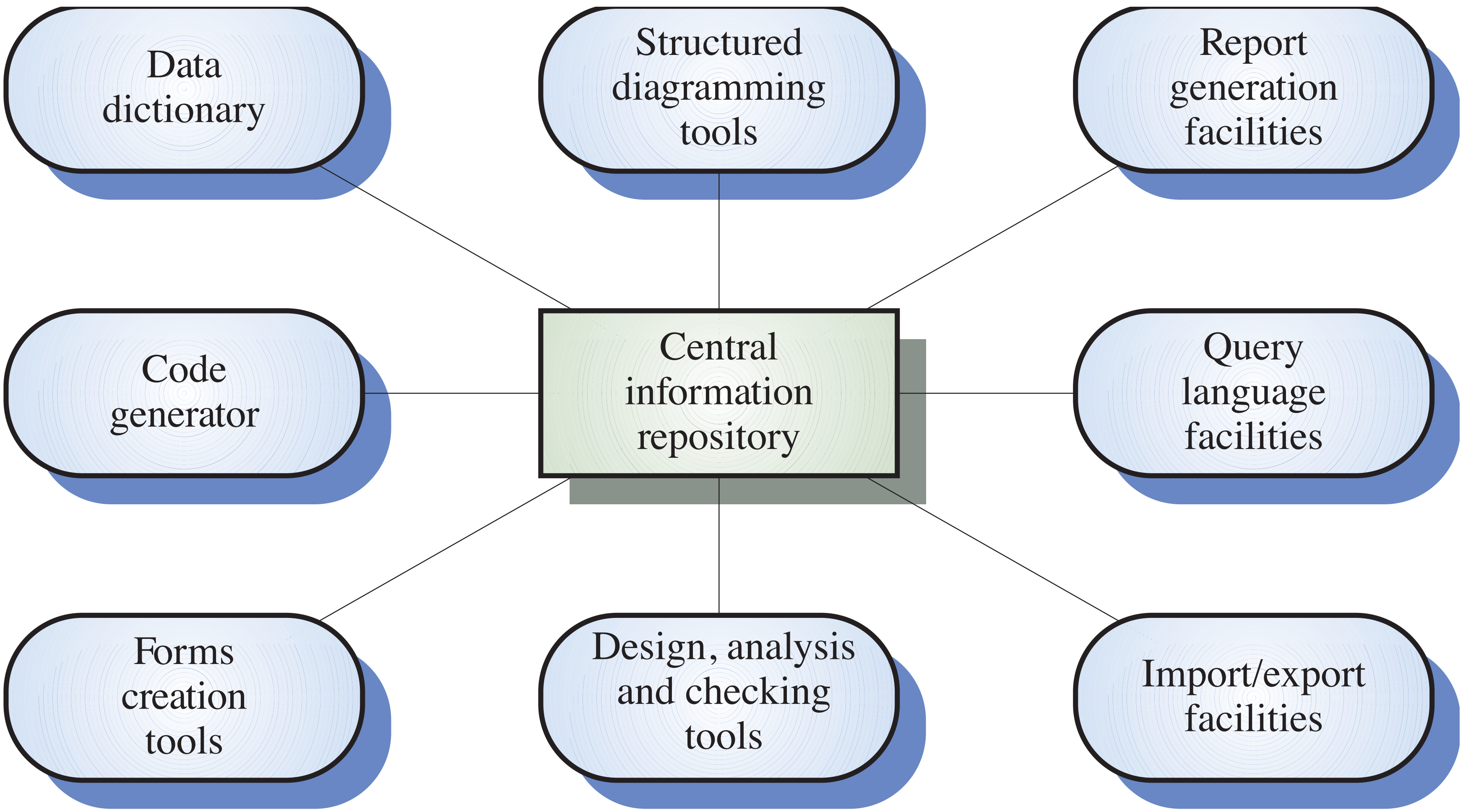
Issue of electronic items



CASE workbenches

- A coherent set of tools that is designed to support related software process activities such as analysis, design or testing
- Analysis and design workbenches support system modelling during both requirements engineering and system design
- These workbenches may support a specific design method or may provide support for a creating several different types of system model

An analysis and design workbench



Analysis workbench components

- Diagram editors
- Model analysis and checking tools
- Repository and associated query language
- Data dictionary
- Report definition and generation tools
- Forms definition tools
- Import/export translators
- Code generation tools

Key points

- A model is an abstract system view. Complementary types of model provide different system information
- Context models show the position of a system in its environment with other systems and processes
- Data flow models may be used to model the data processing in a system
- State machine models model the system's behaviour in response to internal or external events

Key points

- Semantic data models describe the logical structure of data which is imported to or exported by the systems
- Object models describe logical system entities, their classification and aggregation
- Object models describe the logical system entities and their classification and aggregation
- CASE workbenches support the development of system models