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System models- Lecture I

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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



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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.

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 operational context of a system - they show what lies outside the system boundaries.
- Social and organisational concerns may affect the decision on where to position system boundaries.
- Architectural models show the system and its relationship with other systems.

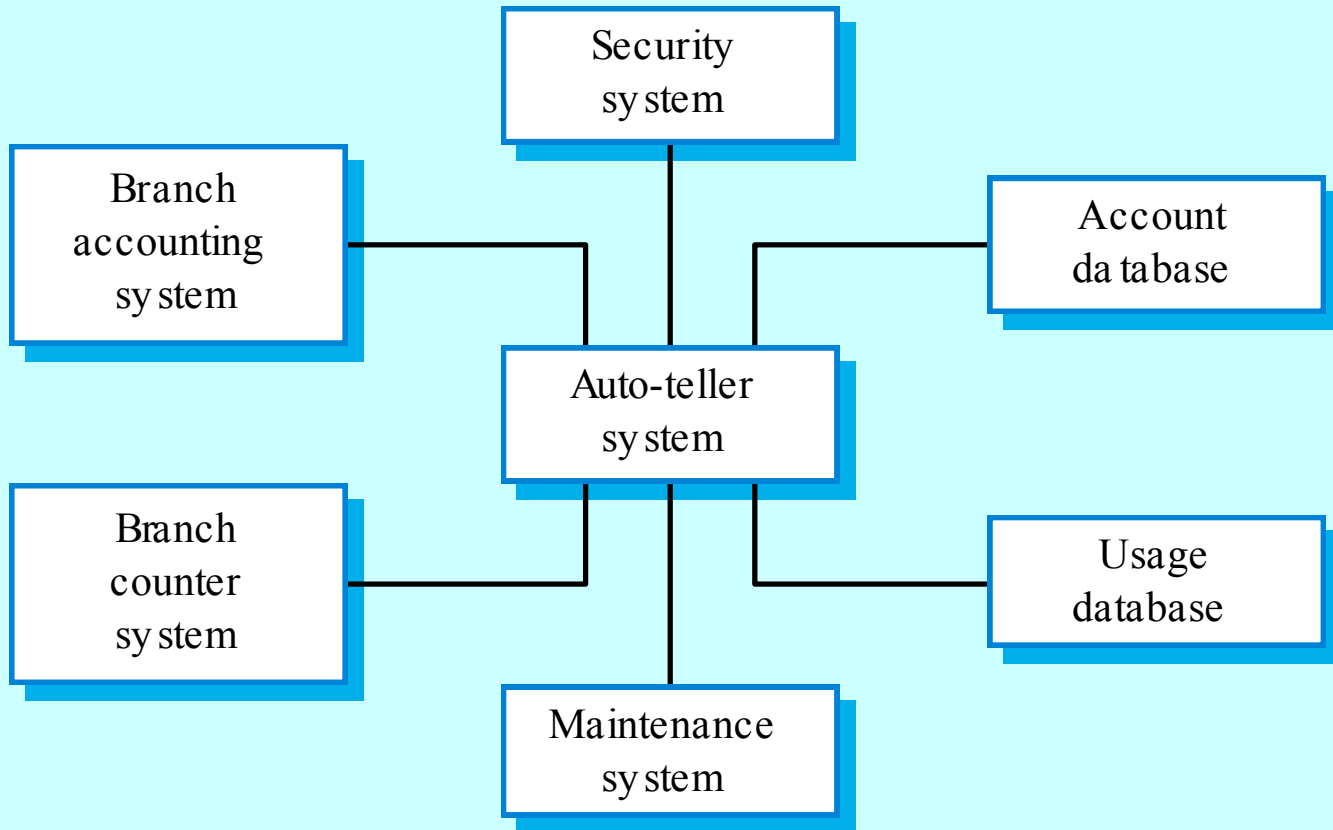


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The context of an ATM system

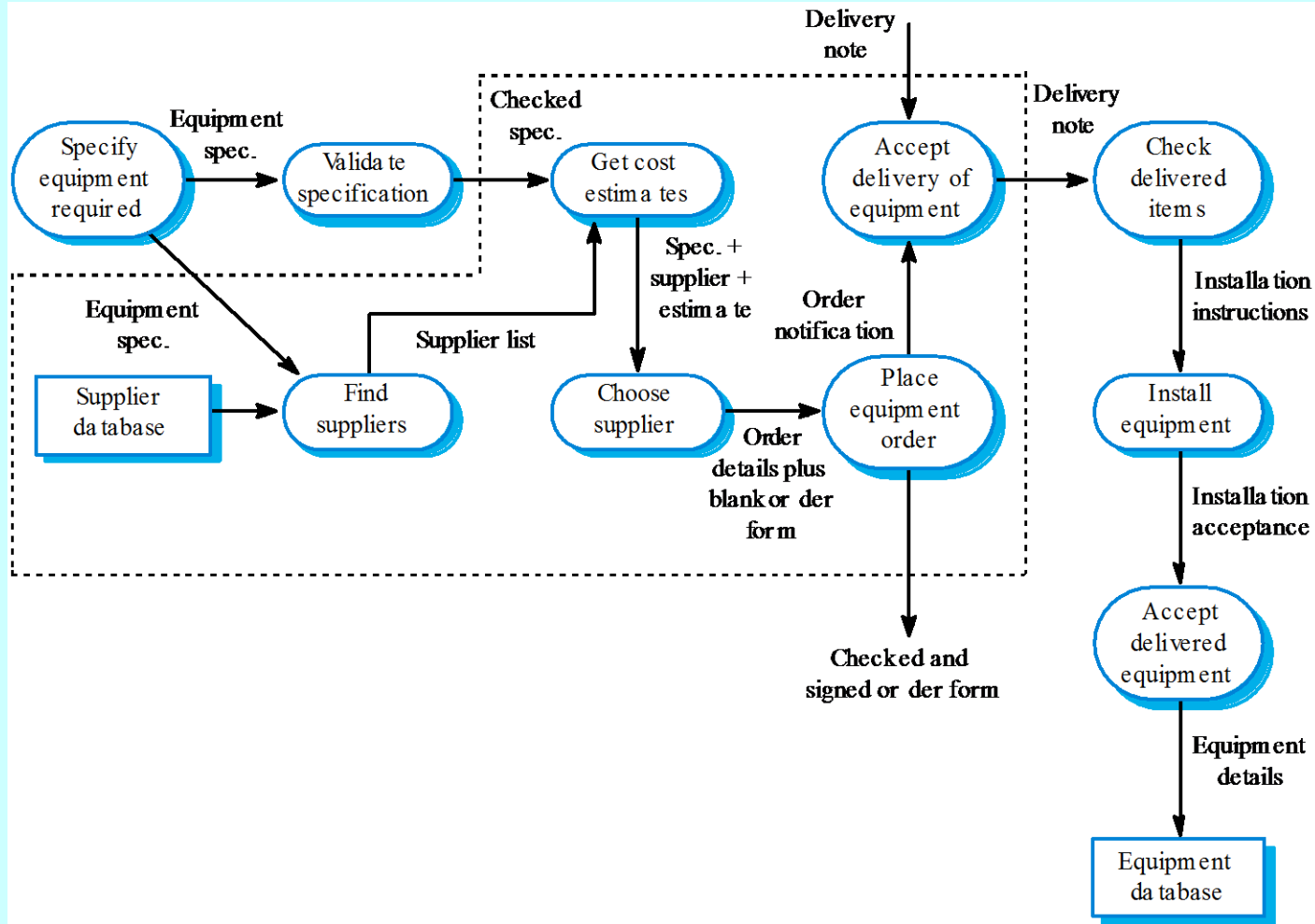


Process models

- 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

ISC



Behavioural models

- Behavioural models are used to describe the overall behaviour of a system.
- Two types of behavioural model are:
 - 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.
- These models show different perspectives so both of them are required to describe the system's behaviour.

Data-processing models

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

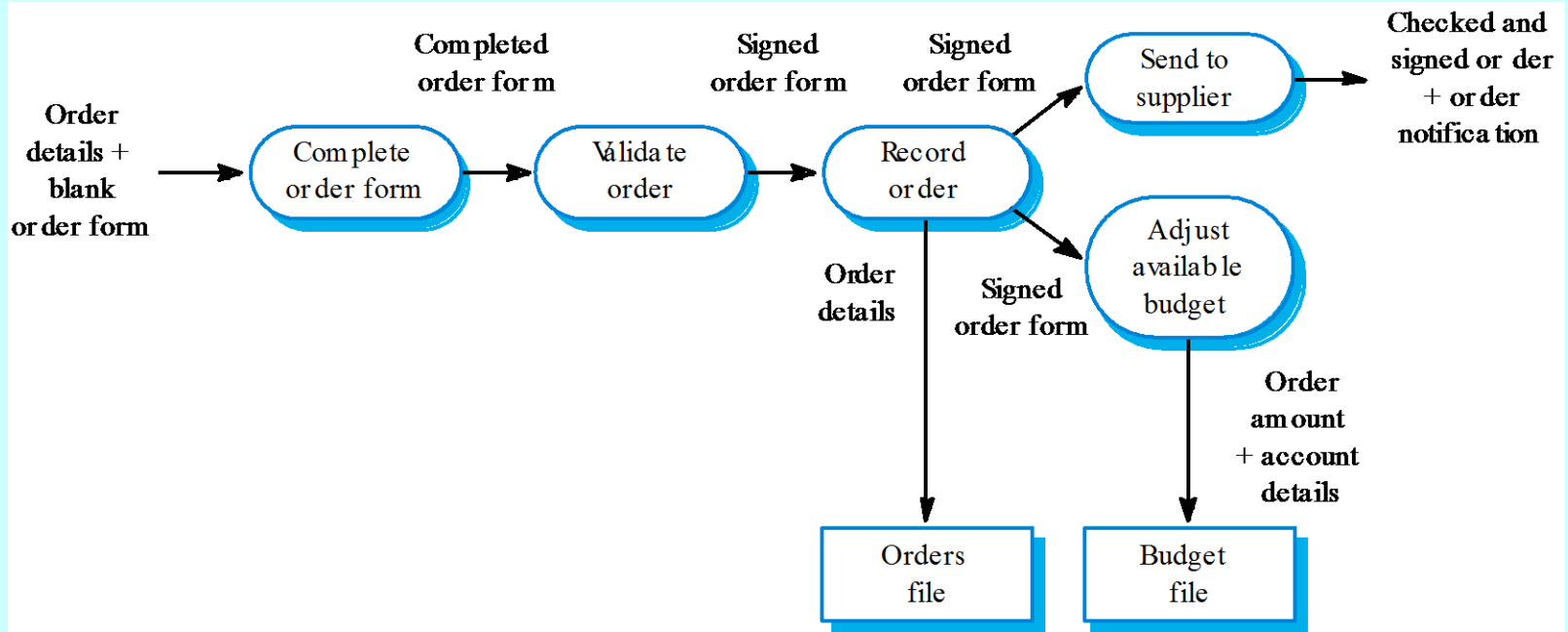


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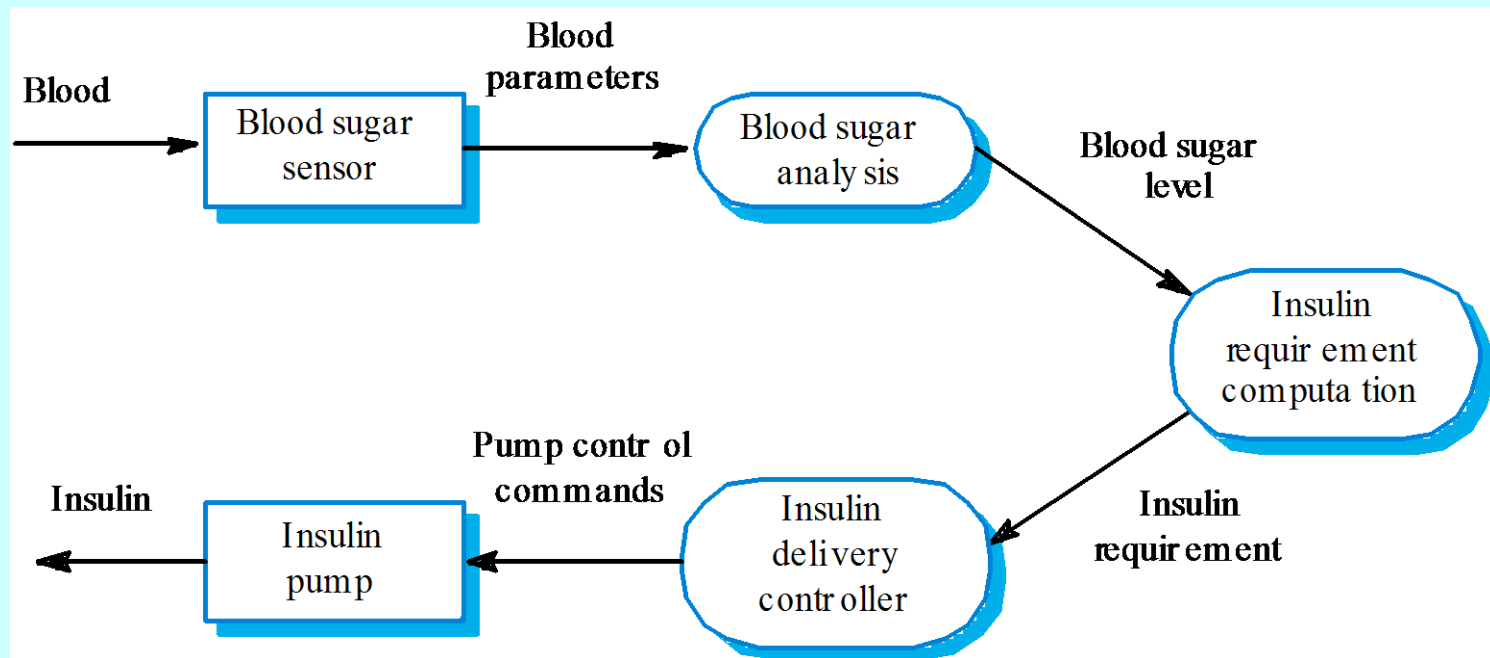
Order processing DFD



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.

Insulin pump DFD





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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 and are used to represent state machine models.



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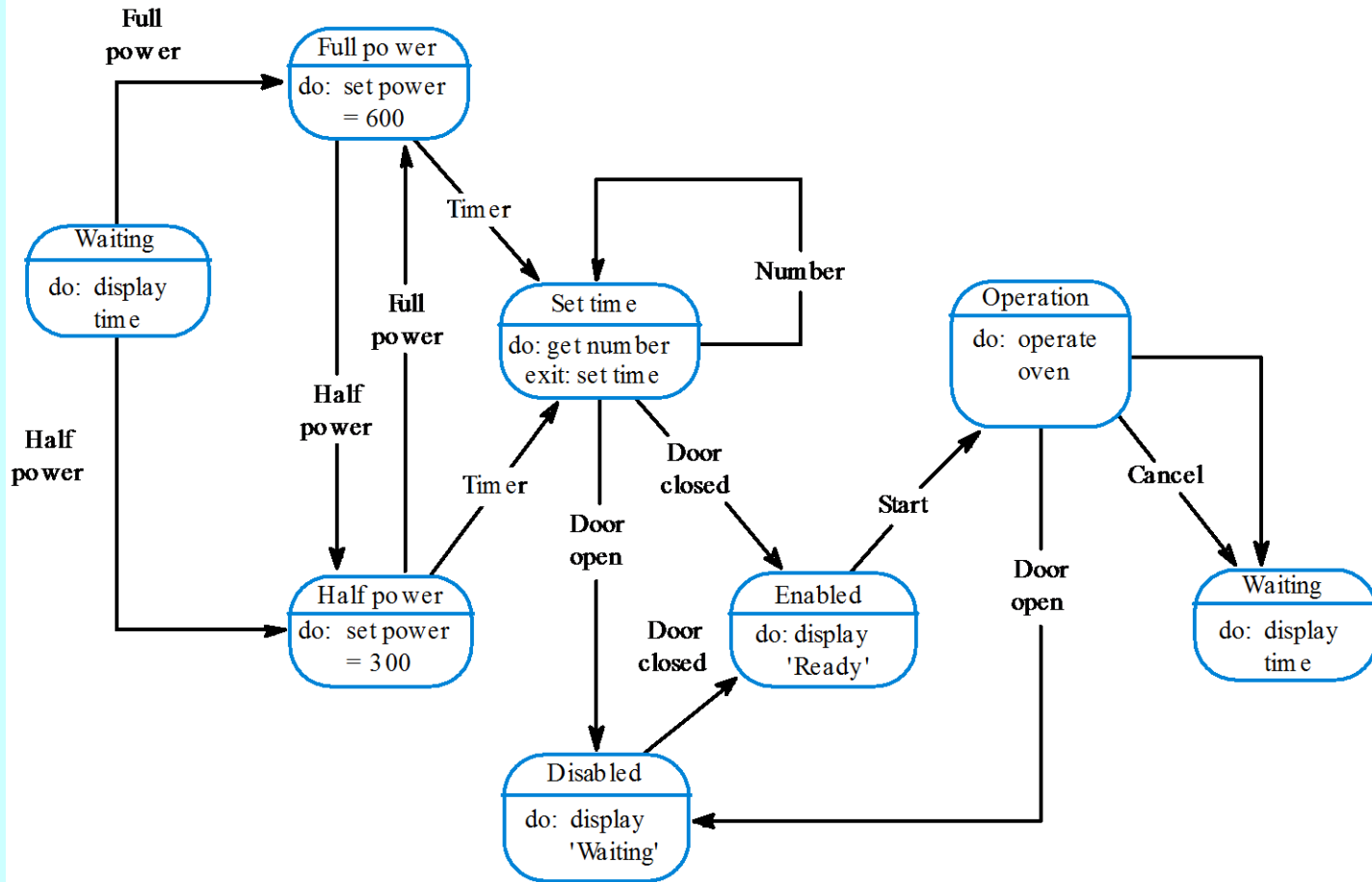
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Statecharts

- 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 model





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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. |

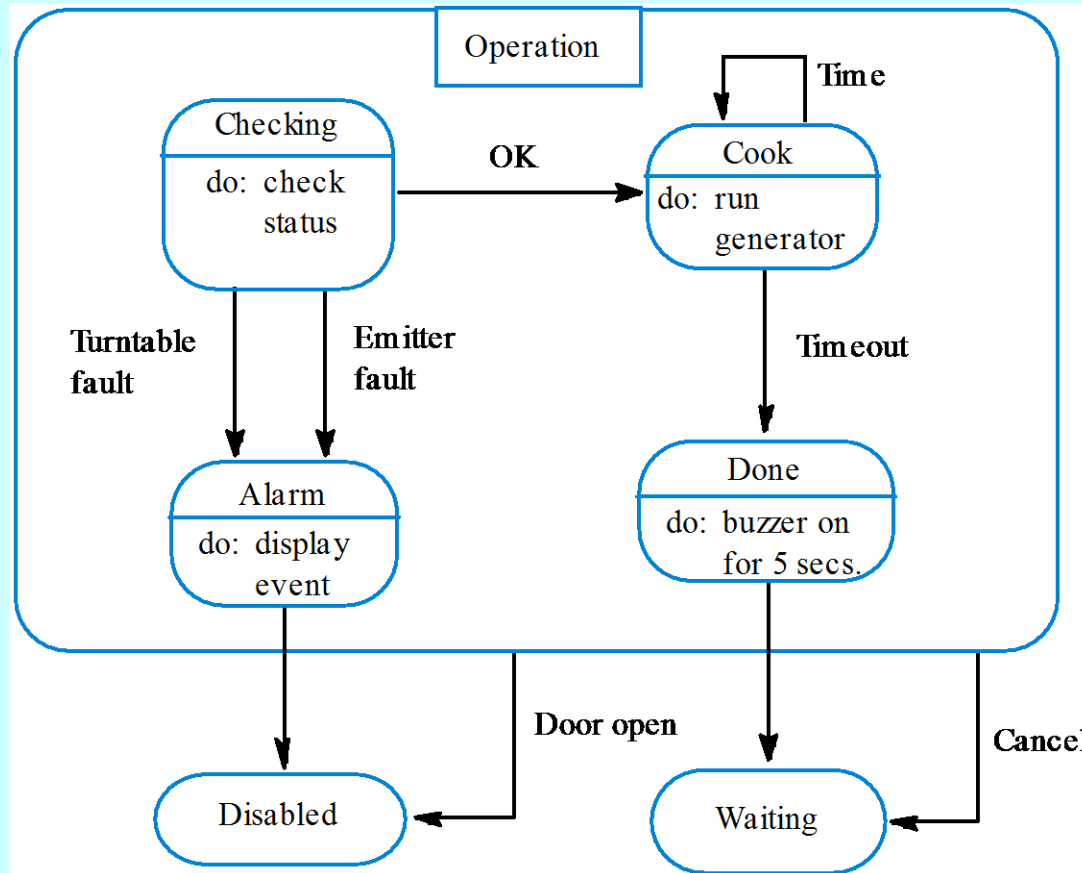
Microwave oven stimuli

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 |

Microwave oven operation



Semantic data models

- Used to describe the logical structure of data processed by the system.
- An 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.

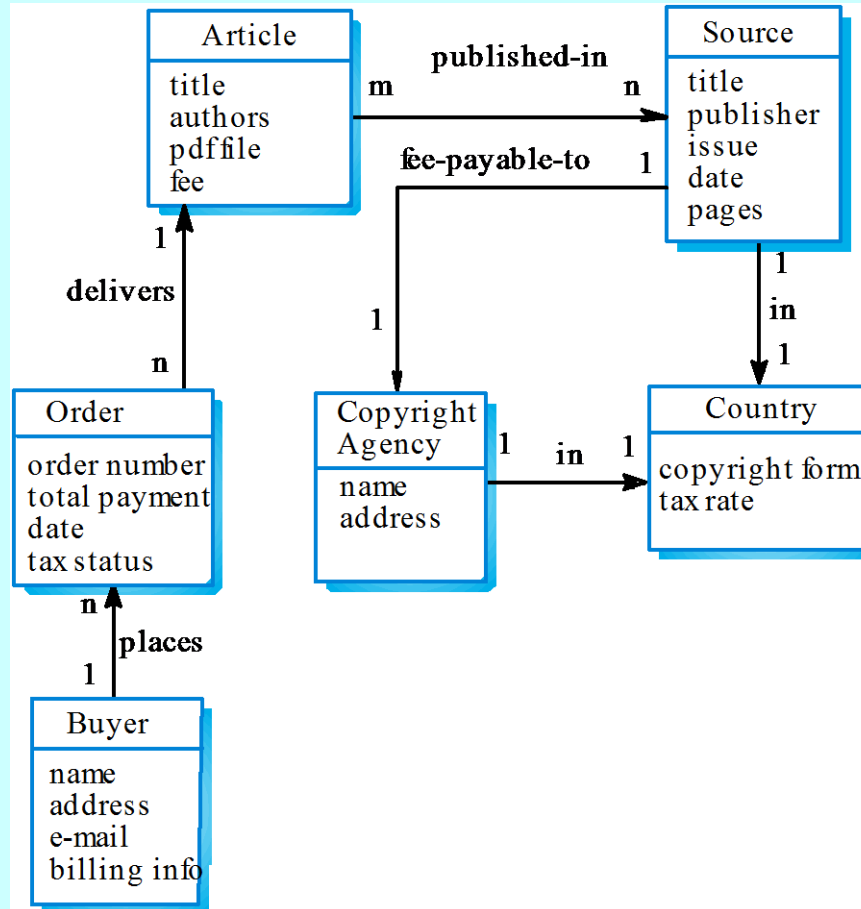


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Library semantic model



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.



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Data dictionary entries

| Name | Description | Type | Date |
|-----------------|---------------------------------------------------------------------------------------------------|-----------|------------|
| Article | Details of the published article that may be ordered by people using LIBSYS. | Entity | 30.12.2002 |
| authors | The names of the authors of the article who may be due a share of the fee. | Attribute | 30.12.2002 |
| Buyer | The person or organisation that orders a copy of the article. | Entity | 30.12.2002 |
| fee-payable-to | A 1:1 relationship between Article and the Copyright Agency who should be paid the copyright fee. | Relation | 29.12.2002 |
| Address (Buyer) | The address of the buyer. This is used to any paper billing information that is required. | Attribute | 31.12.2002 |

Object models

- Object models describe the system in terms of object classes and their associations.
- 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 can be a difficult process if duplication in different branches is to be avoided.

Object models and the UML

- The UML is a standard representation devised by the developers of widely used object-oriented analysis and design methods.
- It 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.

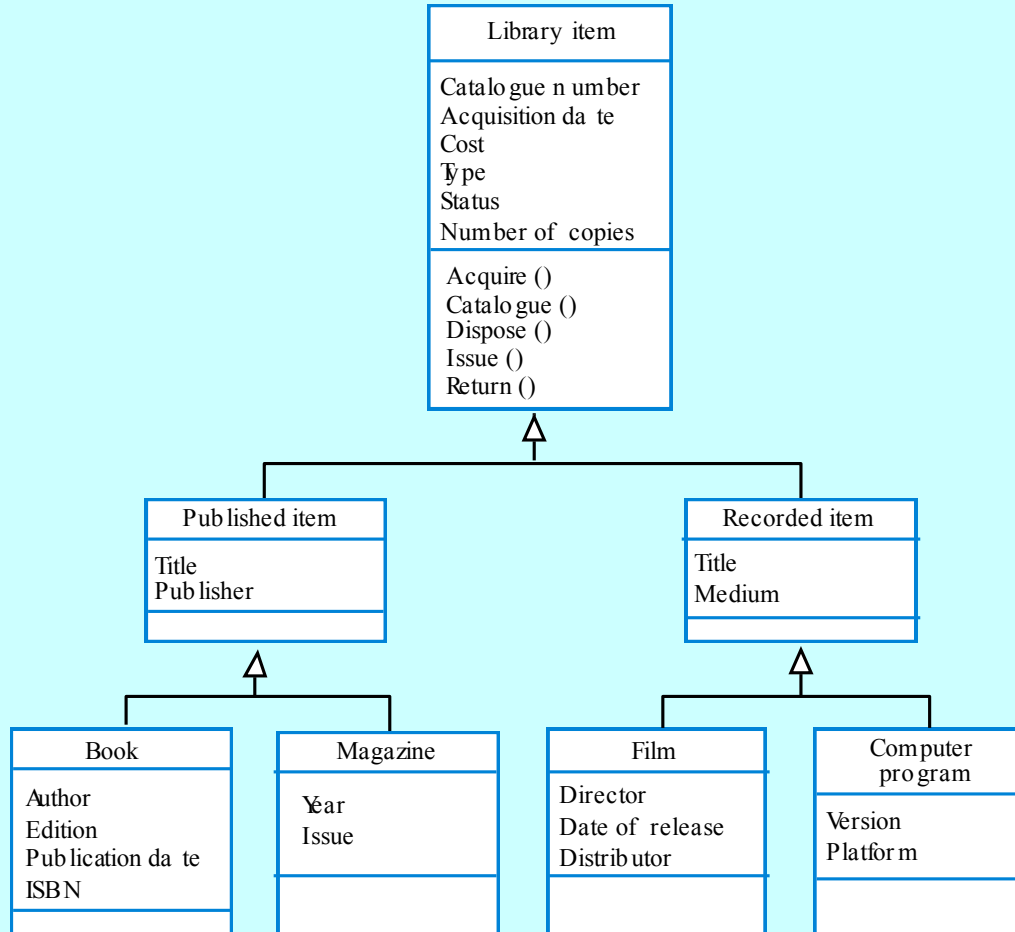


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Library class hierarchy



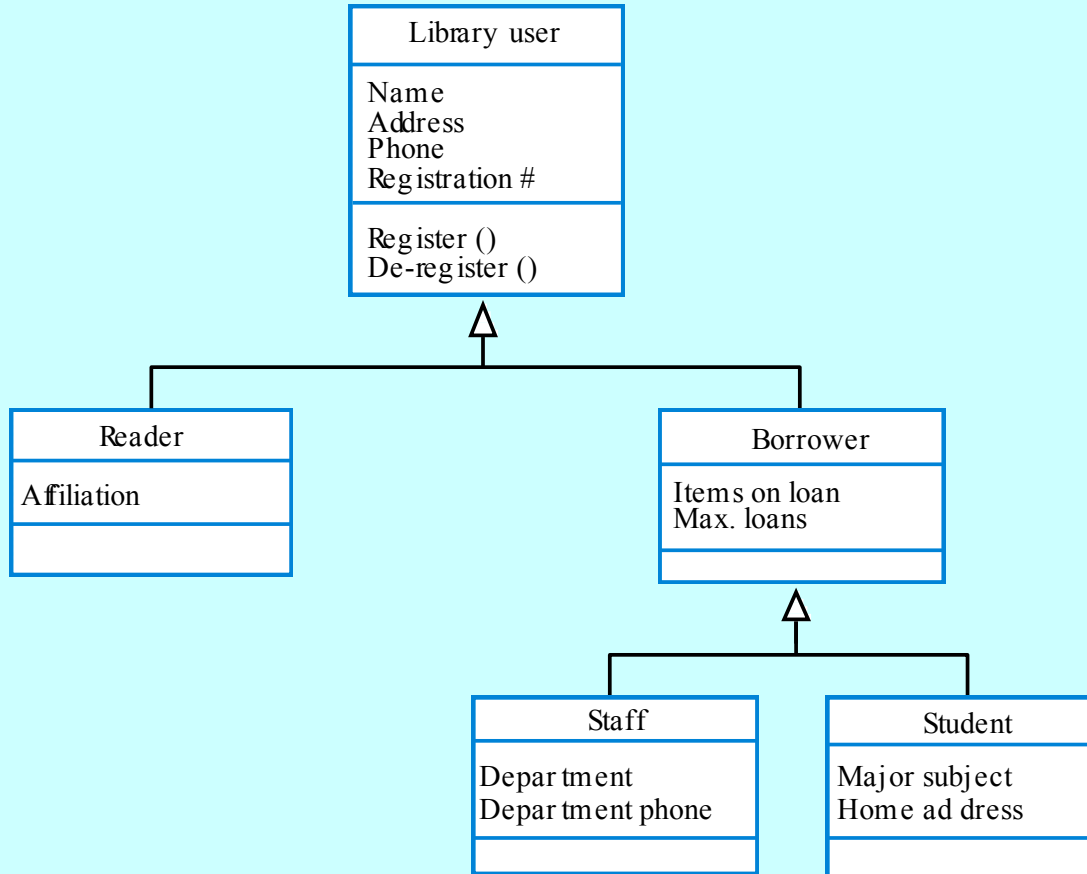


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User class hierarchy





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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.
- This can lead to semantic conflicts where attributes/services with the same name in different super-classes have different semantics.
- Multiple inheritance makes class hierarchy reorganisation more complex.

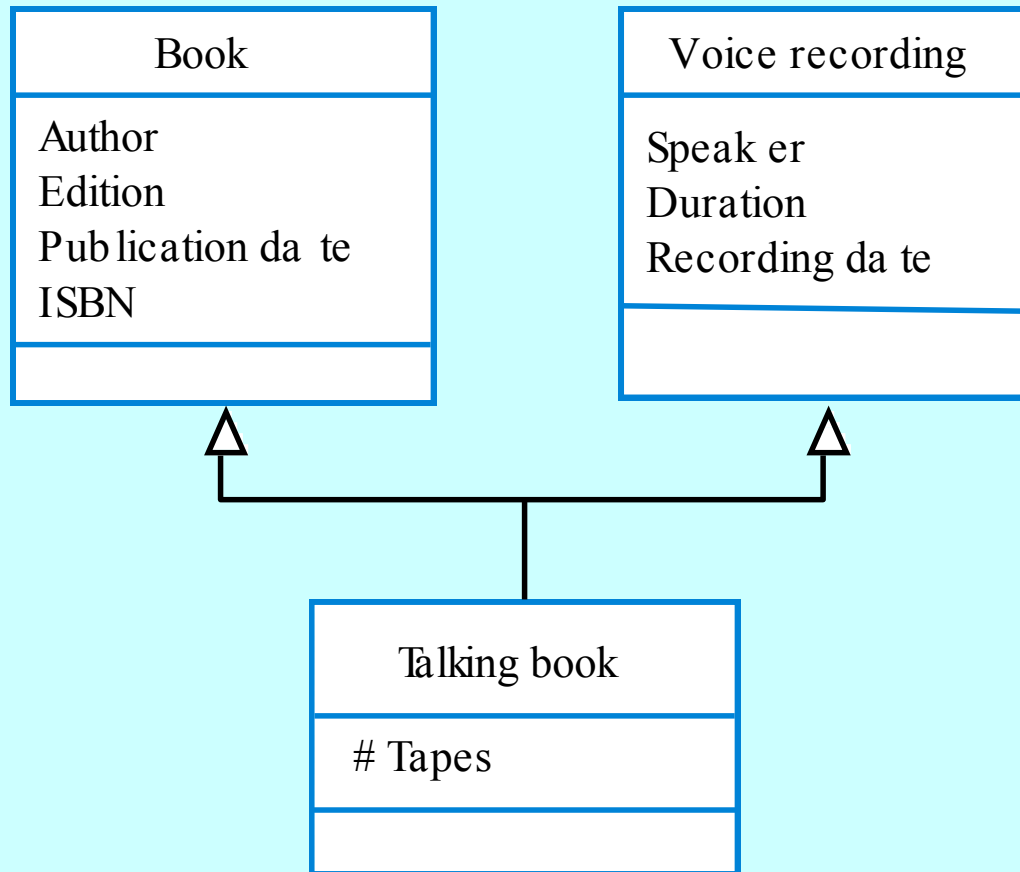


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Multiple inheritance



Object aggregation

- An aggregation model shows how classes that are collections are composed of other classes.
- Aggregation models are similar to the part-of relationship in semantic data models.

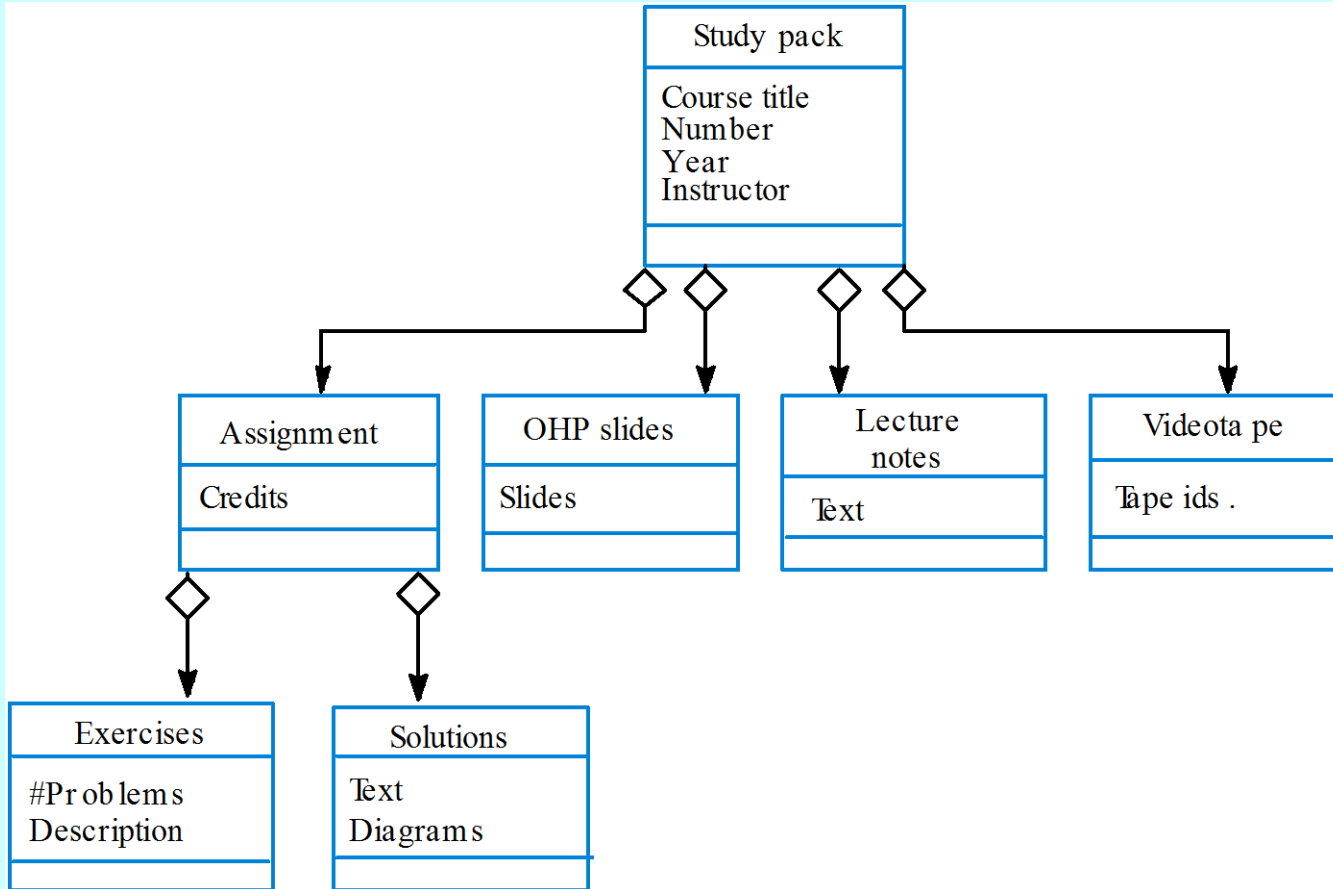


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Object aggregation





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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.

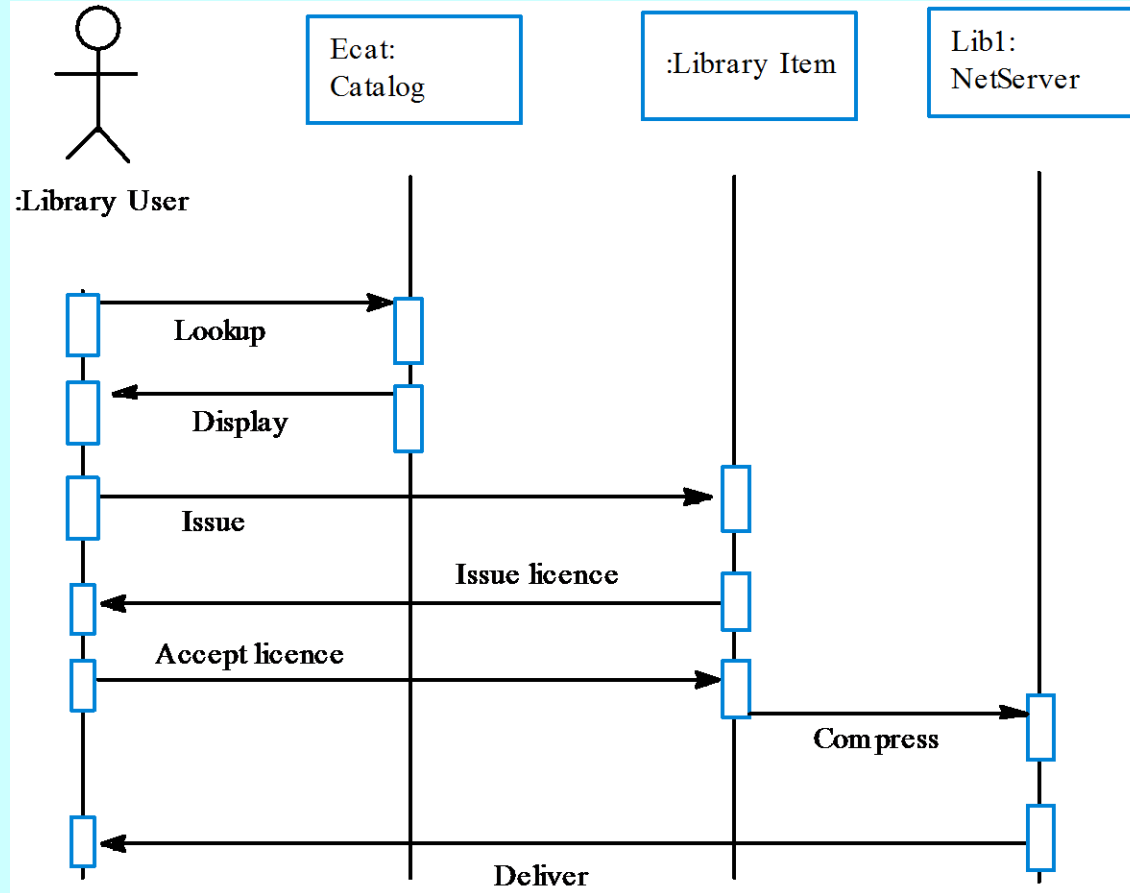


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Issue of electronic items



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.
- They may produce too much documentation.
- The system models are sometimes too detailed and difficult for users to understand.



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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.

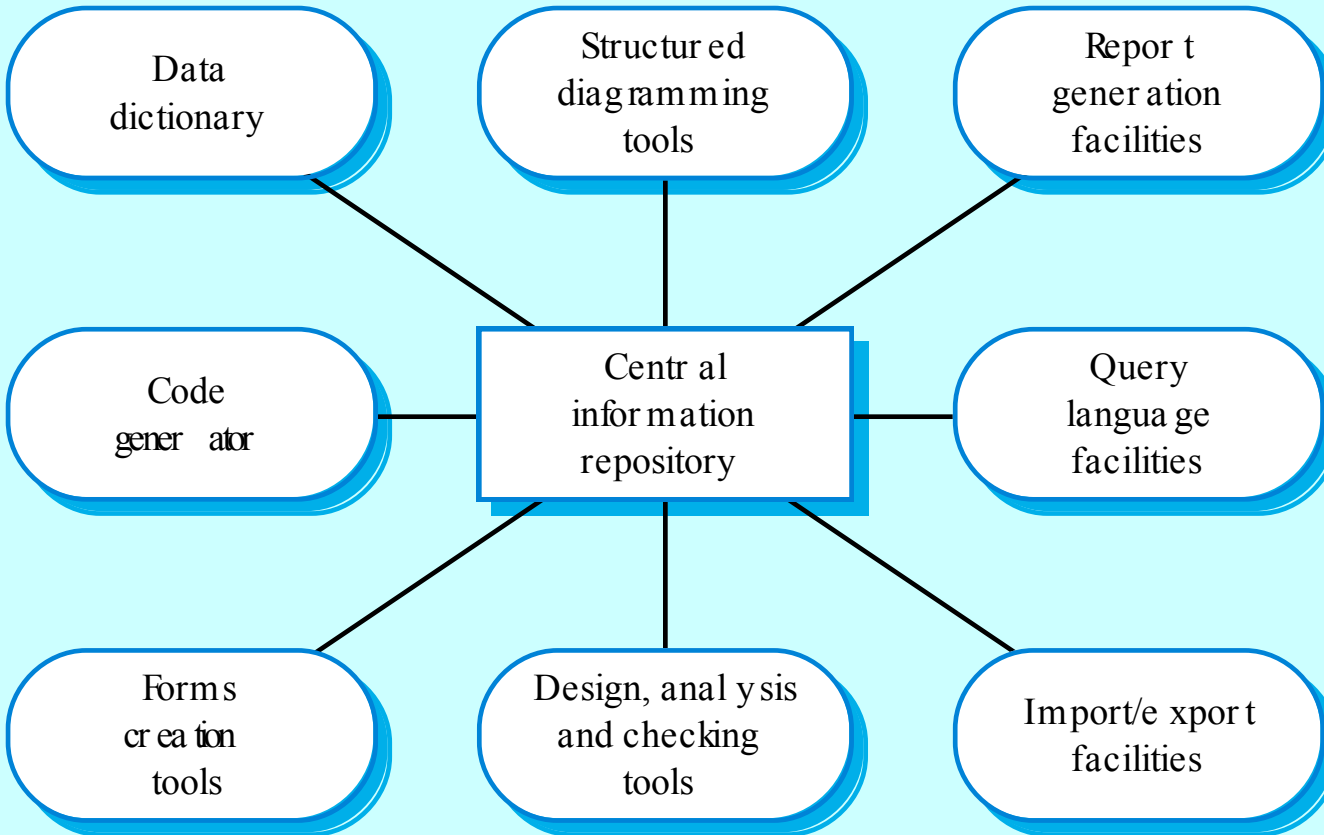


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An analysis and design workbench



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.
- Sequence models show the interactions between actors and the system objects that they use.
- Structured methods provide a framework for developing system models.