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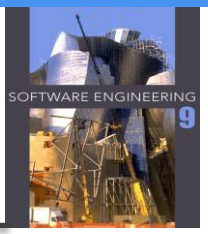

Chapter 5 – System Modeling

Software Engineering (9th edition), Ian Sommerville

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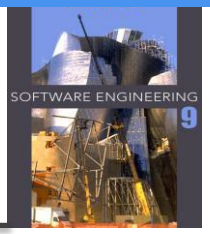
Topics covered



- Context models
- Interaction models
- Structural models
- Behavioral models

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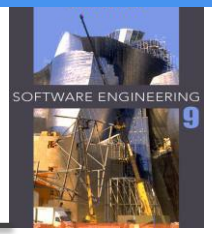
Why modelling important



- Modelling simplify the complex system by abstracting the complex system into appropriate level of details

Year	Operating system	SLOC (million)
1993	Windows NT 3.1	4–5[3]
1994	Windows NT 3.5	7–8[3]
1996	Windows NT 4.0	11–12[3]
2000	Windows 2000	more than 29[3]
2001	Windows XP	45[4][5]
2003	Windows Server 2003	50[3]

1991	Linux kernel 0.01	0.010239
2001	Linux kernel 2.4.2	2.4[6]
2003	Linux kernel 2.6.0	5.2
2009	Linux kernel 2.6.29	11.0
2009	Linux kernel 2.6.32	12.6[11]
2010	Linux kernel 2.6.35	13.5[12]
2012	Linux kernel 3.6	15.9[13]
2015-06-30	Linux kernel pre-4.2	20.2[14]

- Failure of software development mostly contributed by: -
  - Poorly understood requirements
  - Problems often discovered late in the development
  - Complexity lead to performance issues

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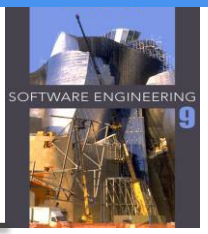
System modeling



- System modeling is the process of developing abstract models of a system, with each model presenting a different view or perspective of that system.
- System modeling has now come to mean representing a system using some kind of graphical notation, which is now almost always based on notations in the Unified Modeling Language (UML).
- System modelling helps the analyst to understand the functionality of the system and models are used to communicate with customers.

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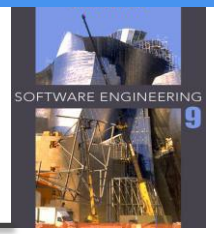
Sample Model



uc Manage Users

Use Case Diagram

Illustrates the Use Cases relating to Managing Users. Some of the use cases contain nested Sequence and Communication diagrams.
You can double-click these use cases to view the child diagrams

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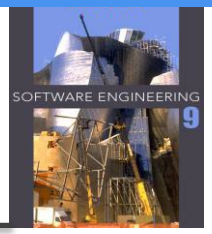
Existing and planned system models



- Models of the existing system are used during requirements engineering. They help clarify what the existing system does and can be used as a basis for discussing its strengths and weaknesses. These then lead to requirements for the new system.
- Models of the new system are used during system design to help explain the proposed requirements to other system stakeholders. Engineers use these models to discuss design proposals and to document the system for implementation.
- In a model-driven engineering process, it is possible to generate a complete or partial system implementation from the system model.

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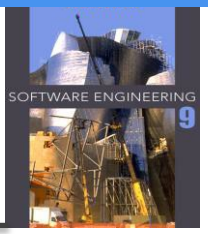
System perspectives

回种视角⇒4种model



- An external perspective, where you model the context or environment of the system.
- An interaction perspective, where you model the interactions between a system and its environment, or between the components of a system.
- A structural perspective, where you model the organization of a system or the structure of the data that is processed by the system.
- A behavioral perspective, where you model the dynamic behavior of the system and how it responds to events.

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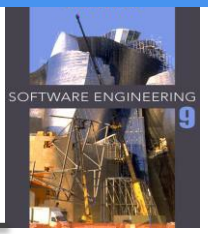
UML diagram types



- Activity diagrams, which show the activities involved in a process or in data processing .
- Use case diagrams, which show the interactions between a system and its environment.
- Sequence diagrams, which show interactions between actors and the system and between system components.
- Class diagrams, which show the object classes in the system and the associations between these classes.
- State machine diagrams, which show how the system reacts to internal and external events.

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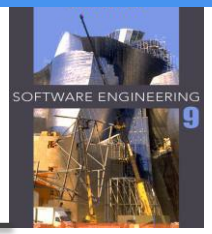
Use of graphical models



- As a means of facilitating discussion about an existing or proposed system
  - Incomplete and incorrect models are OK as their role is to support discussion.
- As a way of documenting an existing system
  - Models should be an accurate representation of the system but need not be complete.
- As a detailed system description that can be used to generate a system implementation
  - Models have to be both correct and complete.

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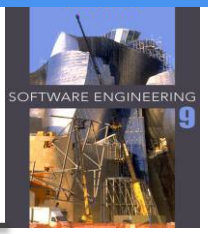
Question 1



Which perspective are you in when you are analysing and documenting: -

1. Relationship of the components in the requirement? → structural
2. Reaction of the componets in the requirement upon some input data? → behavioral
3. Users of the requirement? → external
4. Interaction between components in the requirement? → interaction

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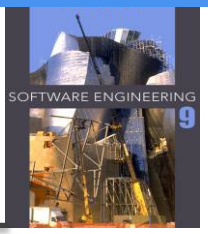
Context models



- 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.

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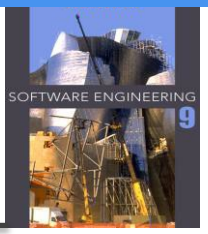
Context models



- System boundaries are established to define what is inside and what is outside the system.
  - They show other systems that are used or depend on the system being developed.
- The position of the system boundary has a profound effect on the system requirements.
- Defining a system boundary is a political judgment
  - There may be pressures to develop system boundaries that increase / decrease the influence or workload of different parts of an organization.

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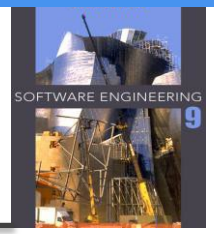
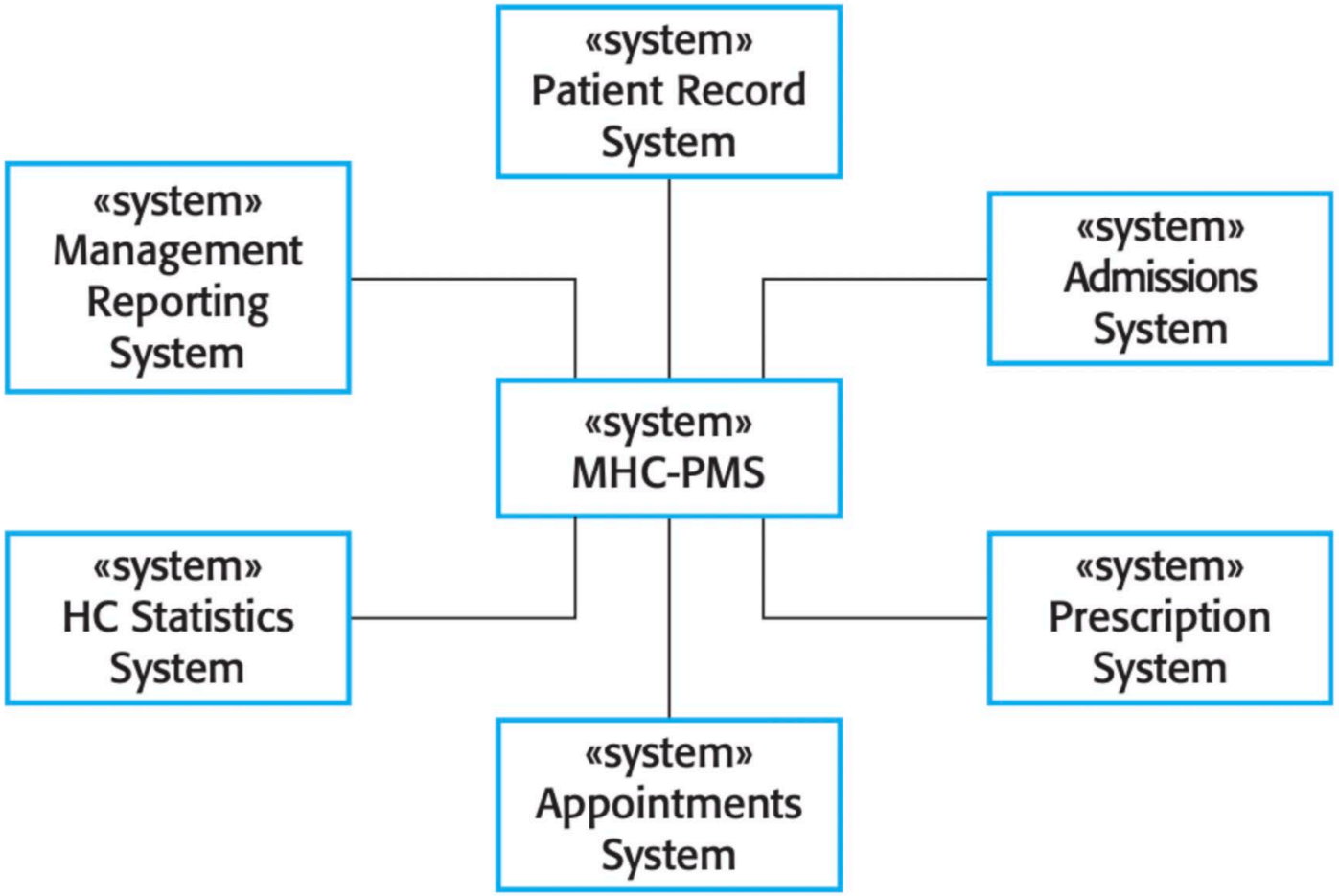
The context of the MHC-PMS





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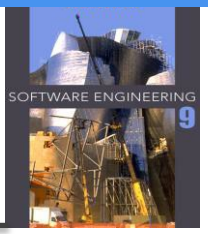
Context models



- Context models simply show the other systems in the environment, not how the system being developed is used in that environment. 只是显示环境中其他系统而不是该系统使用方式
- Used along with other models, such as business process models.
- UML activity diagrams may be used to define business process models.

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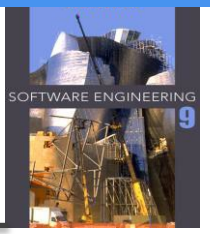
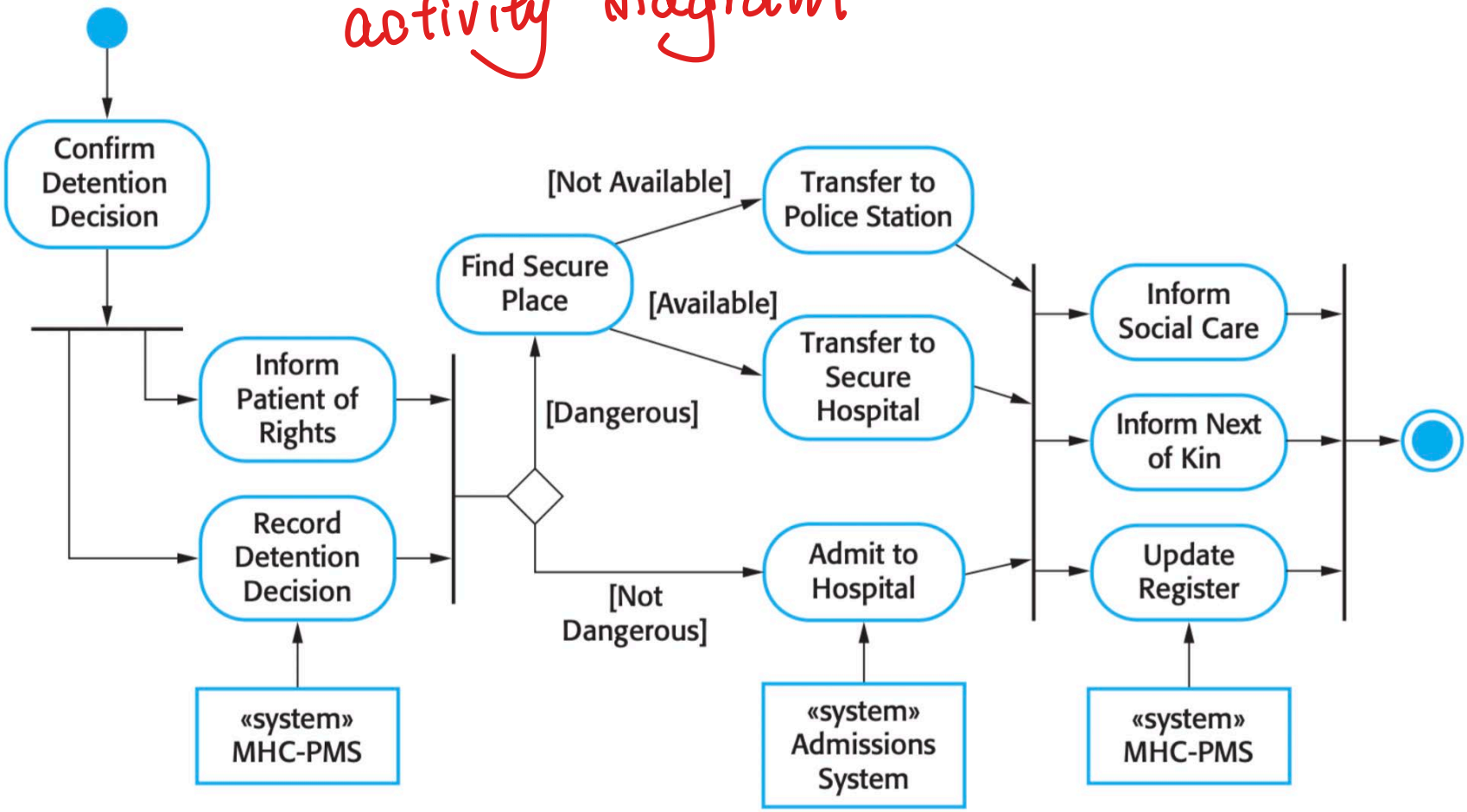
Process model of involuntary detention



activity diagram



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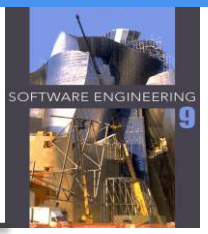
Interaction models



- Modeling user interaction is important as it helps to identify user requirements.
- Modeling system-to-system interaction highlights the communication problems that may arise.
- Modeling component interaction helps us understand if a proposed system structure is likely to deliver the required system performance and dependability.
- Use case diagrams and sequence diagrams may be used for interaction modeling.

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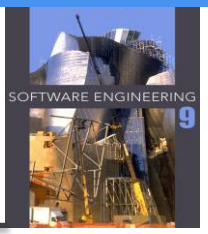
Use case diagram



- Use cases were developed originally to support requirements elicitation and now incorporated into the UML.
- **Each use case represents a discrete task that involves external interaction with a system.**

- Actors in a use case may be people or other systems.
- Represented diagramatically to provide an overview of the use case in a more detailed textual form.

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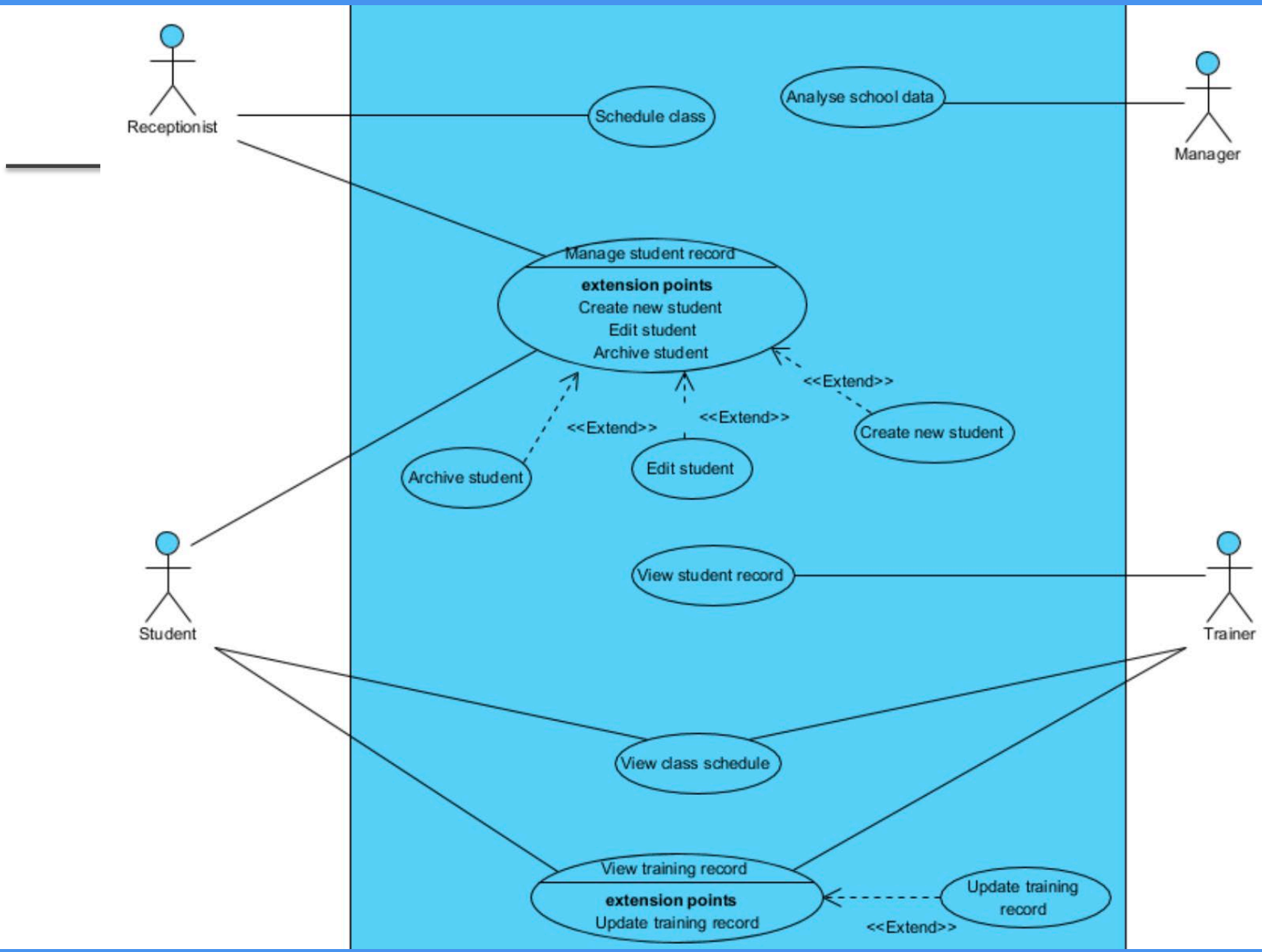

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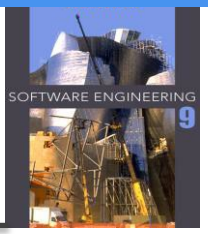
Tabular description of the 'Transfer data' use-case



MHC-PMS: Transfer data	
Actors	Medical receptionist, patient records system (PRS)
Description	A receptionist may transfer data from the MHC-PMS to a general patient record database that is maintained by a health authority. The information transferred may either be updated personal information (address, phone number, etc.) or a summary of the patient's diagnosis and treatment.
Data	Patient's personal information, treatment summary
Stimulus	User command issued by medical receptionist
Response	Confirmation that PRS has been updated
Comments	The receptionist must have appropriate security permissions to access the patient information and the PRS.

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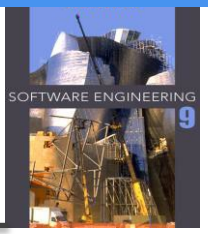
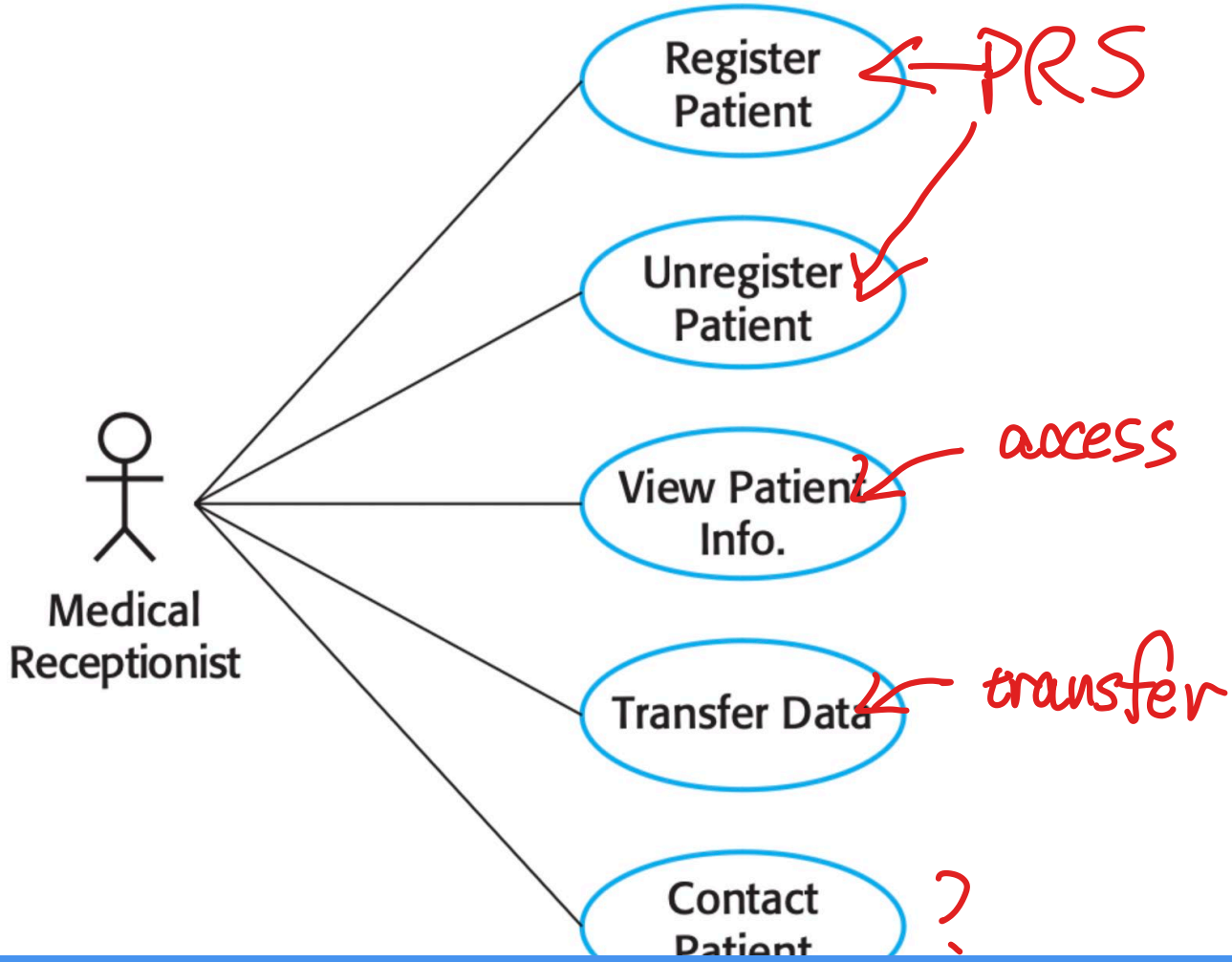
Use cases diagram in the MHC-PMS involving the role 'Medical Receptionist'





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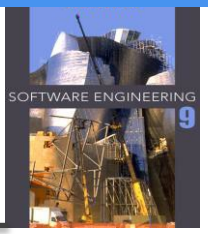
Whats Next?



- ✧ Checkout more details about Use Case diagram
- ✧ Try out one sample question
- ✧ Checkout the assignment 1 case study

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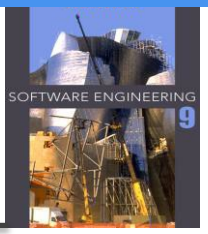
Sequence diagrams



- Sequence diagrams are part of the UML and are used to model the interactions between the actors and the objects within a system.
- A sequence diagram shows the sequence of interactions that take place during a particular use case.
- The objects and actors involved are listed along the top of the diagram, with a dotted line drawn vertically from these. 所涉及对象和actor列在图顶部垂直绘制虚线
- Interactions between objects are indicated by annotated arrows. 交互用带注释箭头表示

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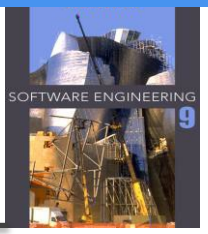
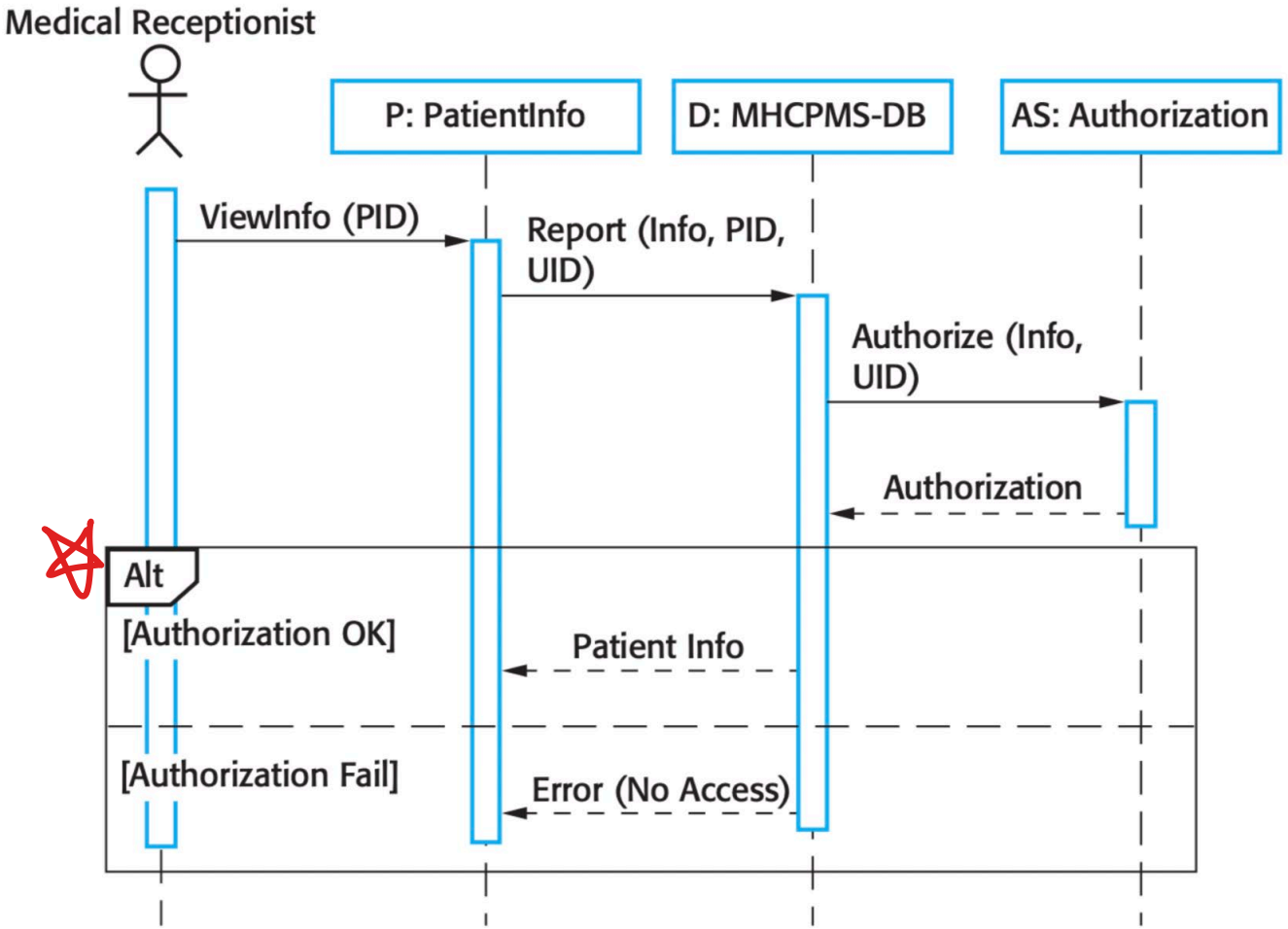
Sequence diagram for View patient information





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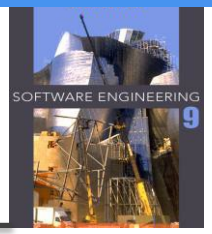

- ✧ Checkout more details about Sequence diagram
- ✧ Try out one sample question
- ✧ Checkout the assignment 1 case study

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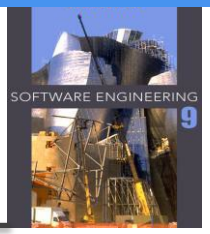
Structural models



- Structural models of software display the organization of a system in terms of the components that make up that system and their relationships.
- Structural models may be static models, which show the structure of the system design, or dynamic models, which show the organization of the system when it is executing.
- You create structural models of a system when you are discussing and designing the system architecture.

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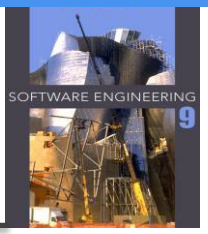
Class diagrams



- Class diagrams are used when developing an object-oriented system model to show the classes in a system and the associations between these classes.
- An object class can be thought of as a general definition of one kind of system object.
- An association is a link between classes that indicates that there is some relationship between these classes.
- When you are developing models during the early stages of the software engineering process, objects represent something in the real world, such as a patient, a prescription, doctor, etc.

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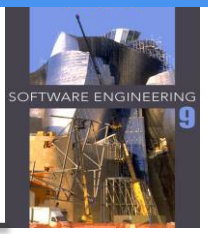
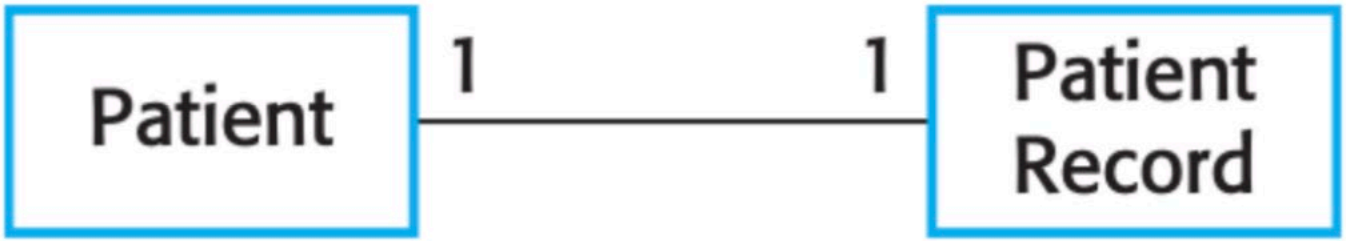
UML classes and association





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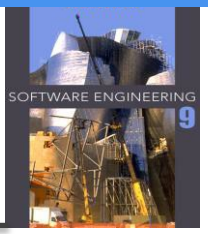
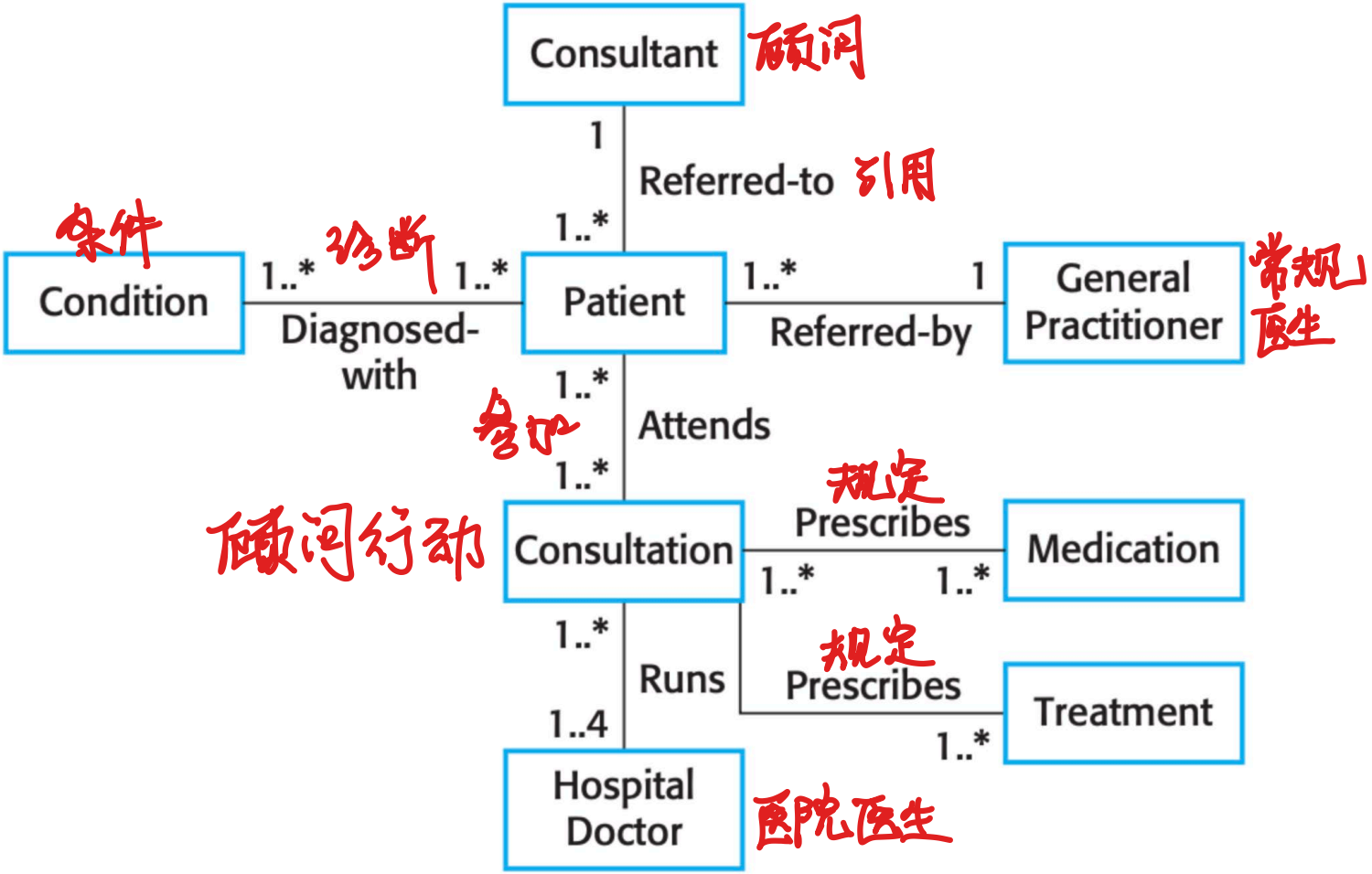
Classes and associations in the MHC-PMS





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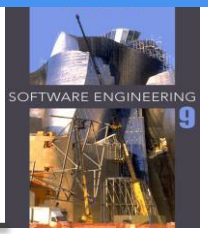
The Consultation class



Consultation
Doctors Date Time Clinic Reason Medication Prescribed Treatment Prescribed Voice Notes Transcript ...
New ( ) Prescribe ( ) RecordNotes ( ) Transcribe ( ) ...

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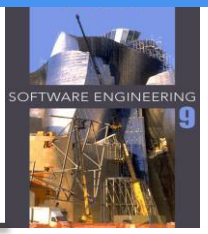
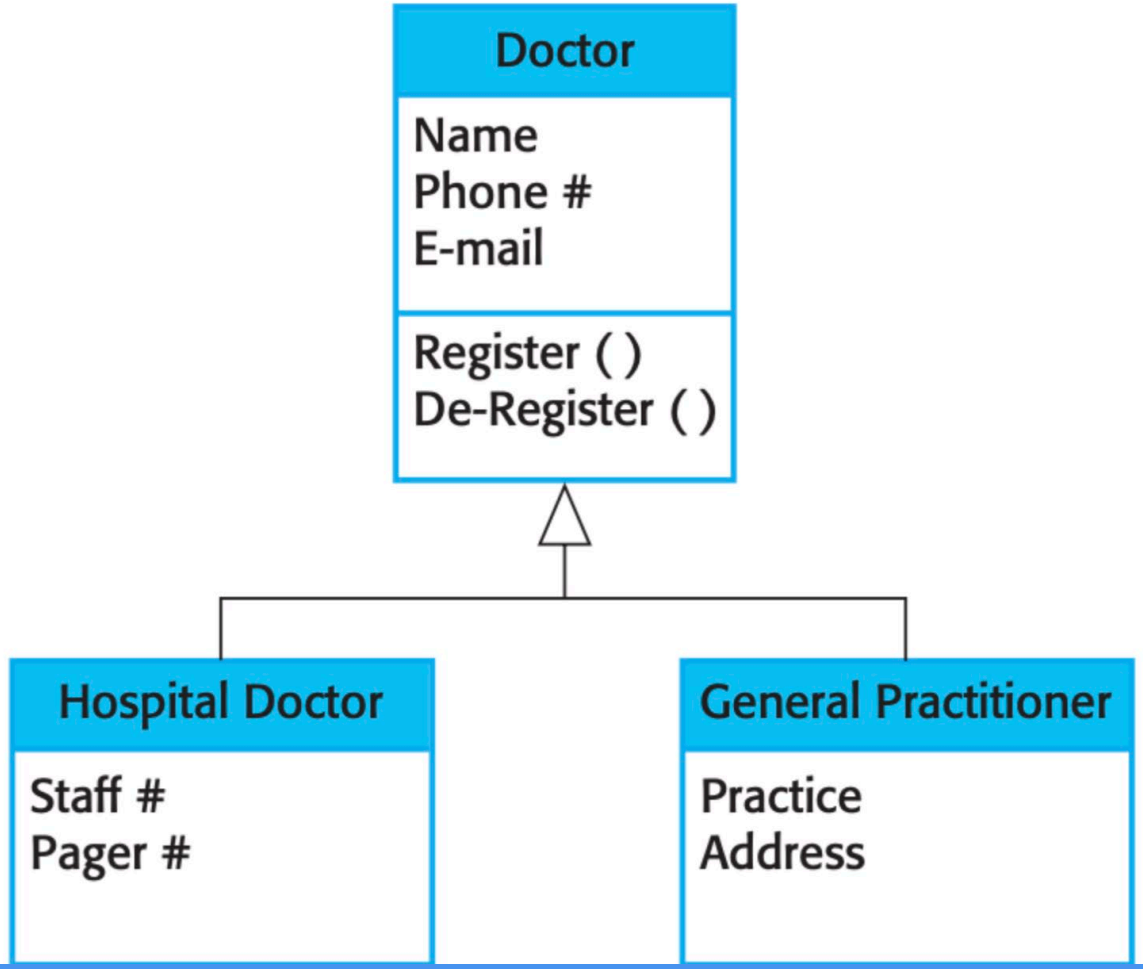
A generalization hierarchy with added detail





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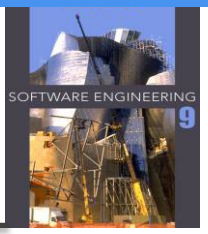
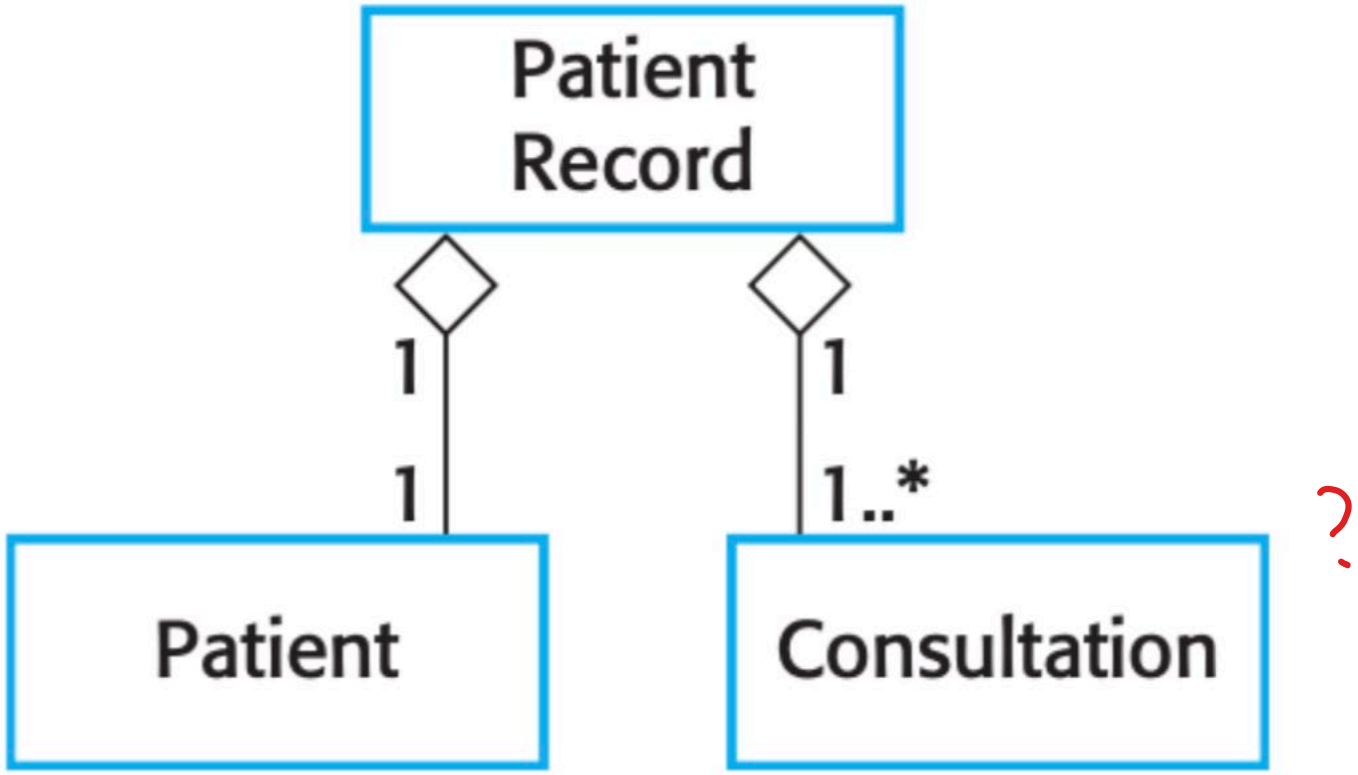
The aggregation association





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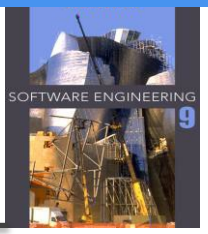
Behavioral models



- Behavioral models are models of the dynamic behavior of a system as it is executing. They show what happens or what is supposed to happen when a system responds to a stimulus from its environment.
- You can think of these stimuli as being of two types:
  - **Data** Some data arrives that has to be processed by the system.
  - **Events** Some event happens that triggers system processing. Events may have associated data, although this is not always the case.

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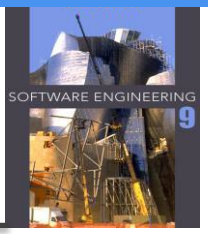
Data-driven modeling



- Many business systems are data-processing systems that are primarily driven by data. They are controlled by the data input to the system, with relatively little external event processing.
- Data-driven models show the sequence of actions involved in processing input data and generating an associated output.
- They are particularly useful during the analysis of requirements as they can be used to show end-to-end processing in a system.
- Activity diagram and sequence diagram are used in data-driven modeling

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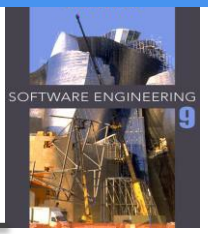
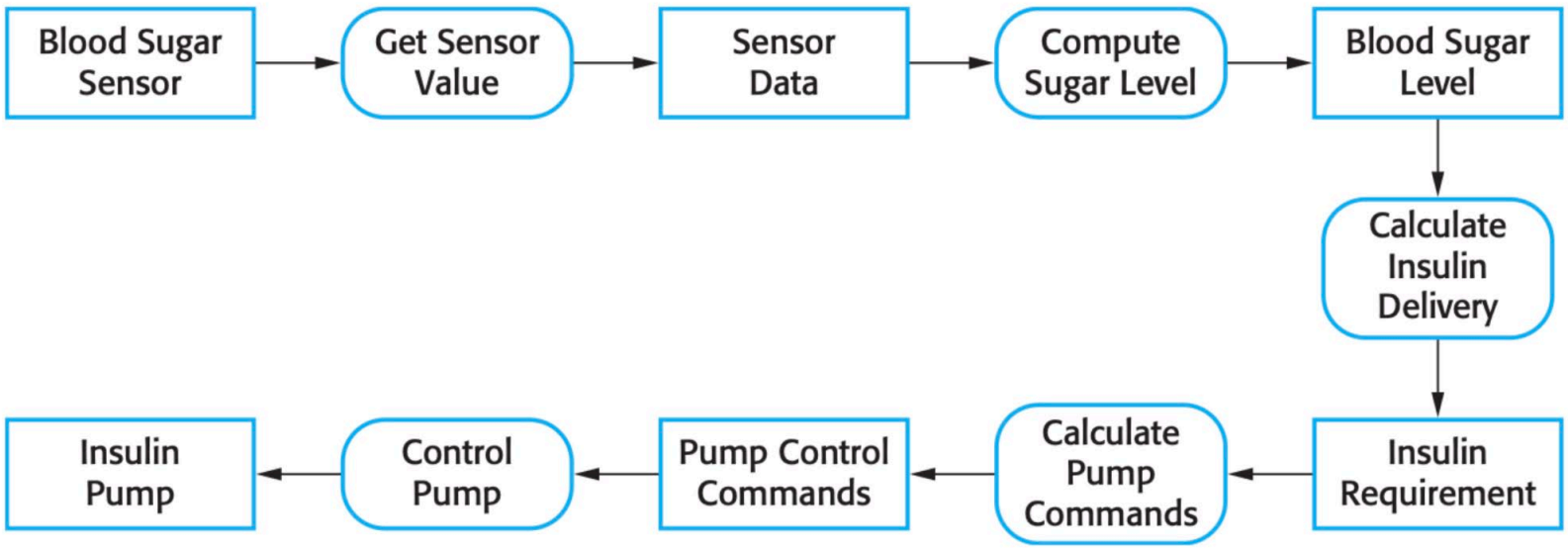
An activity diagram of the insulin pump's operation





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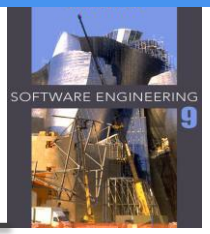
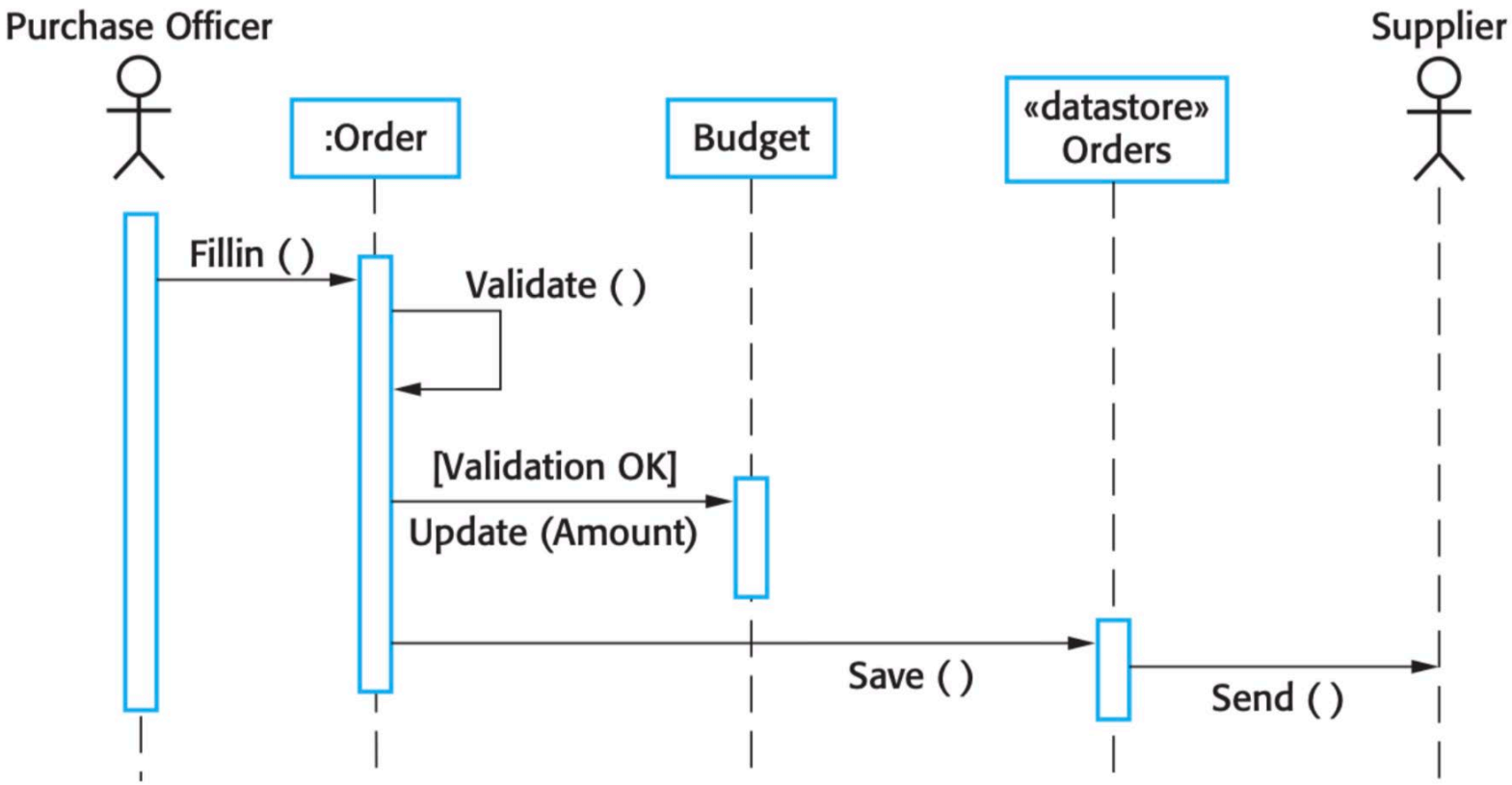
Sequence diagram of an order processing





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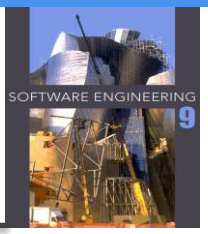
Event-driven modeling



- Real-time systems are often event-driven, with minimal data processing. For example, a landline phone switching system responds to events such as ‘receiver off hook’ by generating a dial tone.
- Event-driven modeling shows how a system responds to external and internal events.
- It is based on the assumption that a system has a finite number of states and that events (stimuli) may cause a transition from one state to another.

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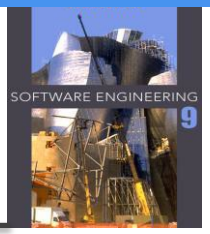
State machine diagram



- 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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State diagram of a microwave oven

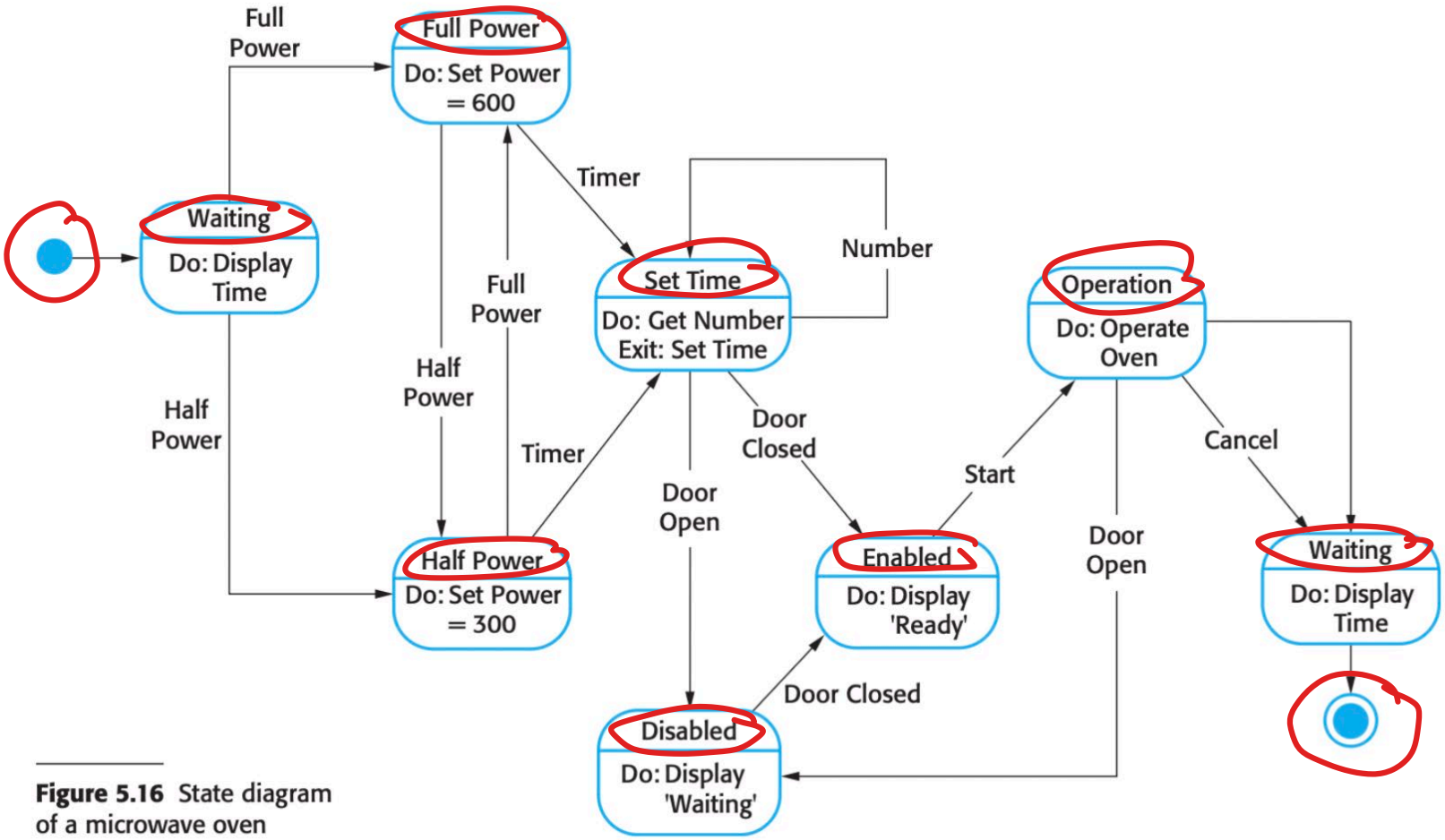

Figure 5.16 State diagram of a microwave oven

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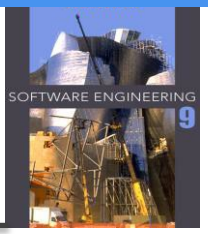
States and stimuli for the microwave oven (a)



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 five seconds. Oven light is on. Display shows ‘Cooking complete’ while buzzer is sounding.

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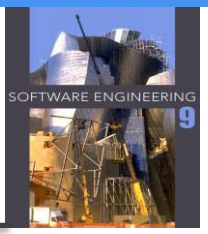
States and stimuli for the microwave oven (b)



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.

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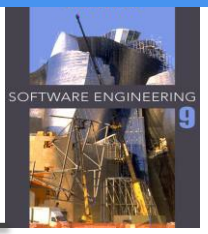
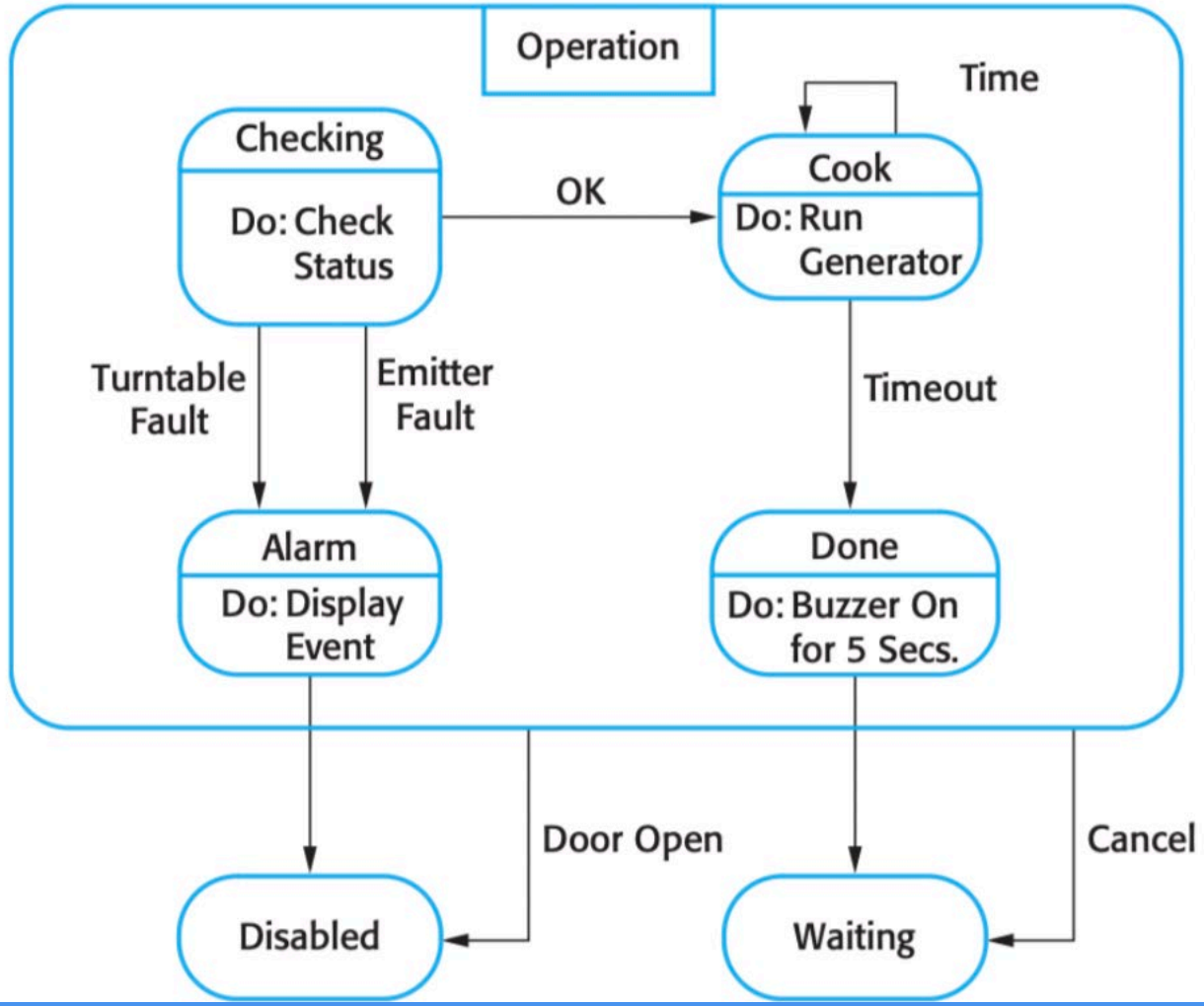
Microwave oven operation

内部细节





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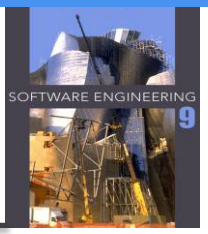
Key points



- A model is an abstract view of a system that ignores system details. Complementary system models can be developed to show the system's context, interactions, structure and behavior.
- Context models show how a system that is being modeled is positioned in an environment with other systems and processes.
- Use case diagrams and sequence diagrams are used to describe the interactions between users and systems in the system being designed. Use cases describe interactions between a system and external actors; sequence diagrams add more information to these by showing interactions between system objects.
- Structural models show the organization and architecture of a system. Class diagrams are used to define the static structure of classes in a system and their associations.

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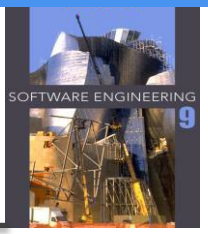
Key points



- Behavioral models are used to describe the dynamic behavior of an executing system. This behavior can be modeled from the perspective of the data processed by the system, or by the events that stimulate responses from a system.
- Activity diagrams / sequence diagrams may be used to model the processing of data, where each activity represents one process step.
- State diagrams are used to model a system's behavior in response to internal or external events.

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