System Models

Xin Feng

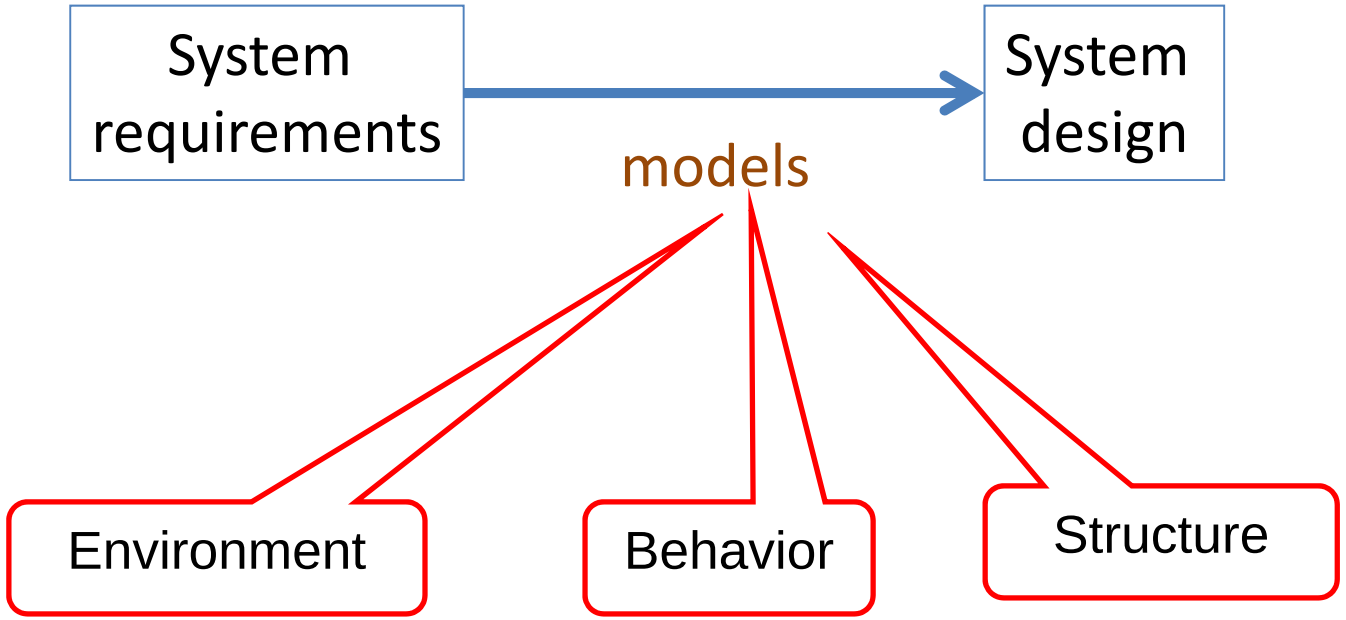
Outline

- System models
- Context model
- Use case diagram
- State transition diagram
- Data flow diagram

System Models

- System models are used to describe
  - the environment of the system
    - Context model
    - Use case diagram
  - the behavior flow of the system
    - State machine model
    - Data-flow model
  - the structure of a system
    - Data models
    - Object models

System Models

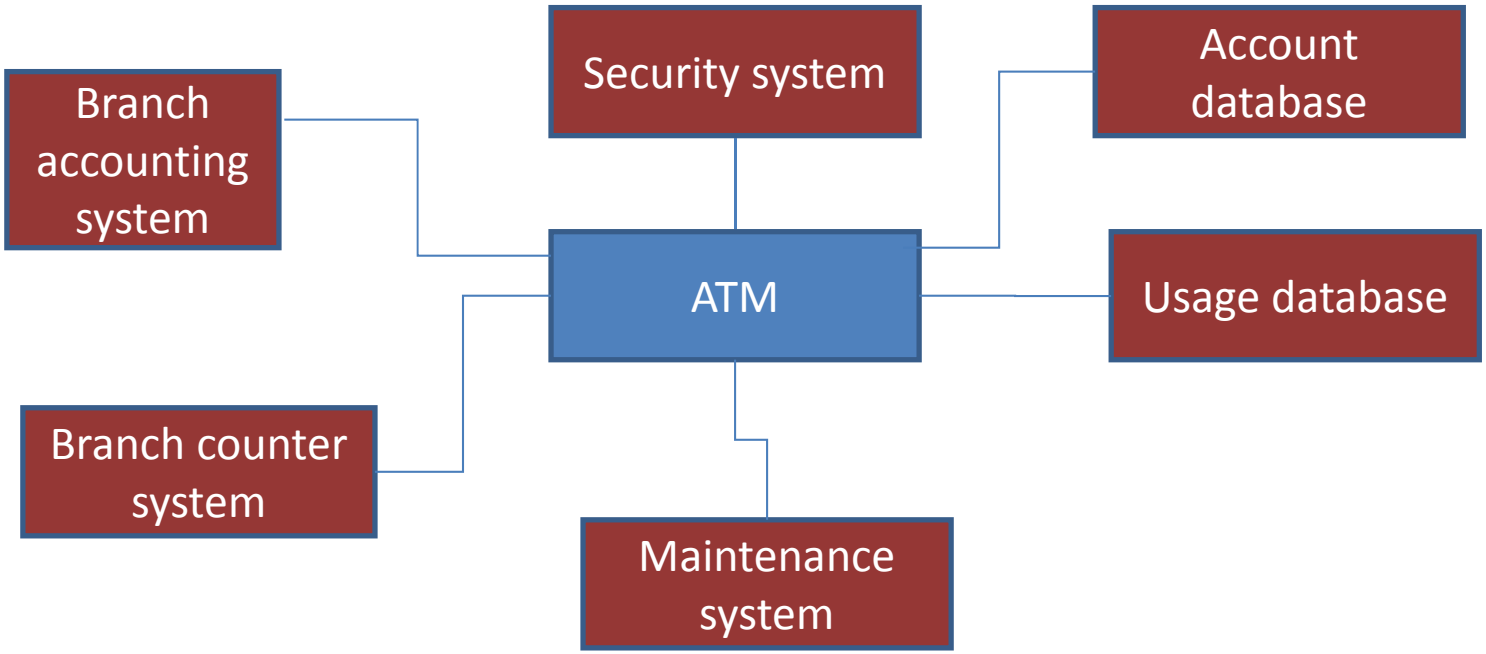


Different perspectives (in text or diagrams)

Context Models （上下文模型）

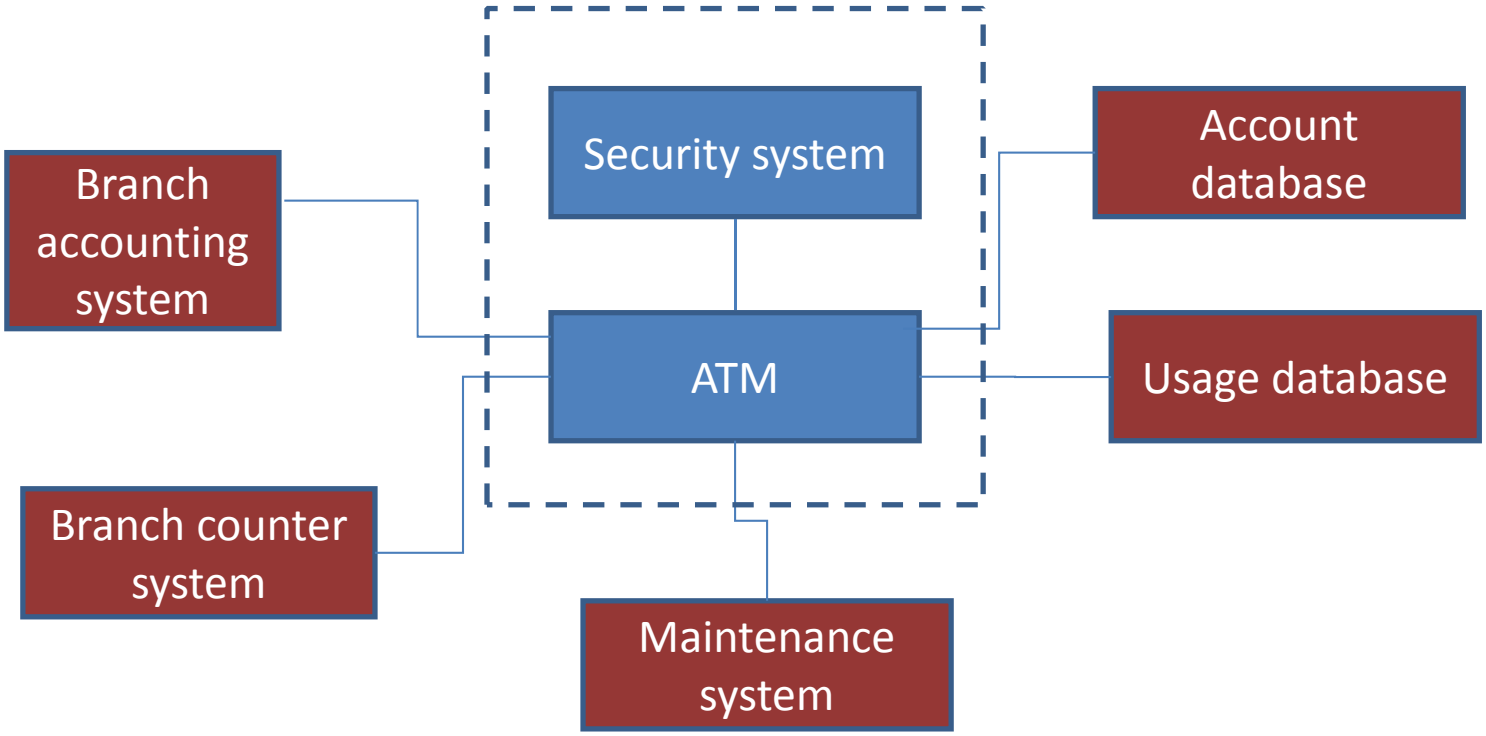
- Decide the boundaries (边界) or environment of the system
  - What are not included in but related with this system
- Many factors can affect the boundaries of the system
  - Technical factors
  - Non-technical factors

Context Models – Example 1



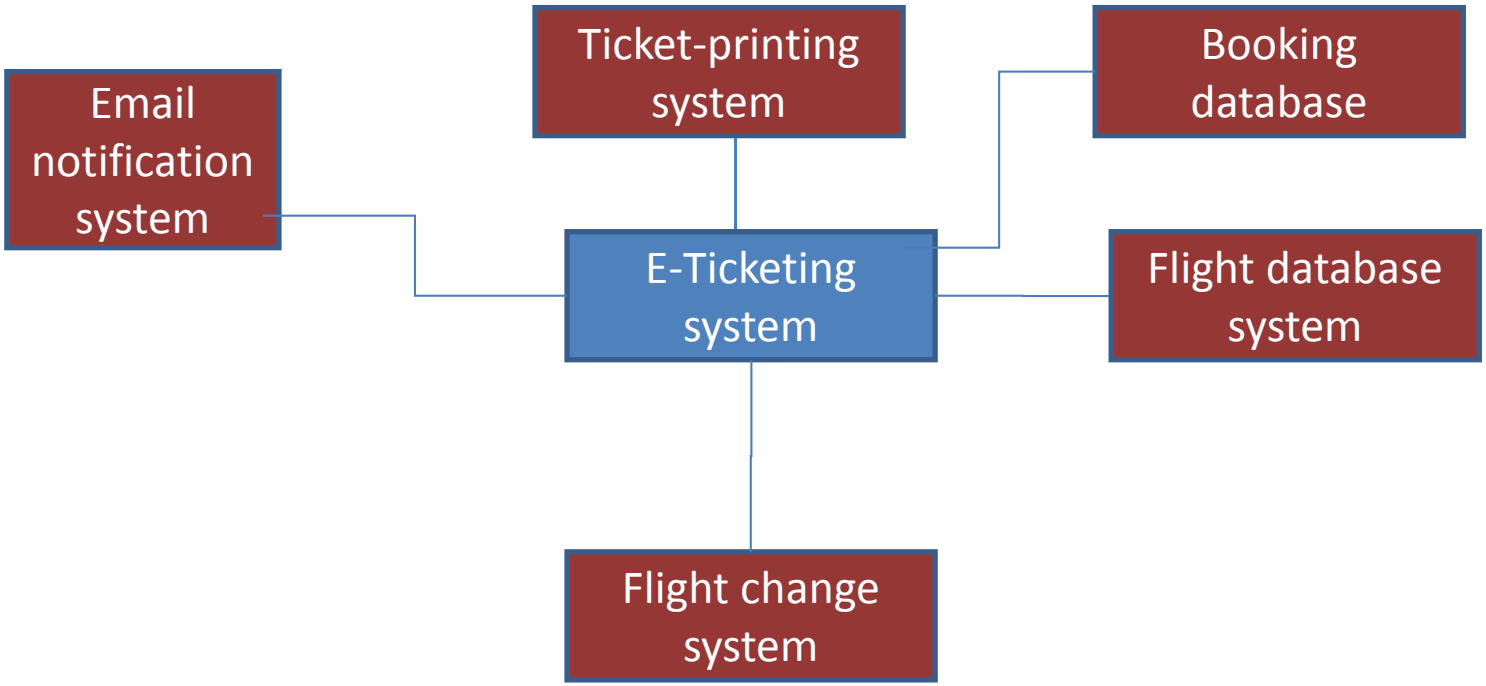
An ATM system

Context Models – Example 1



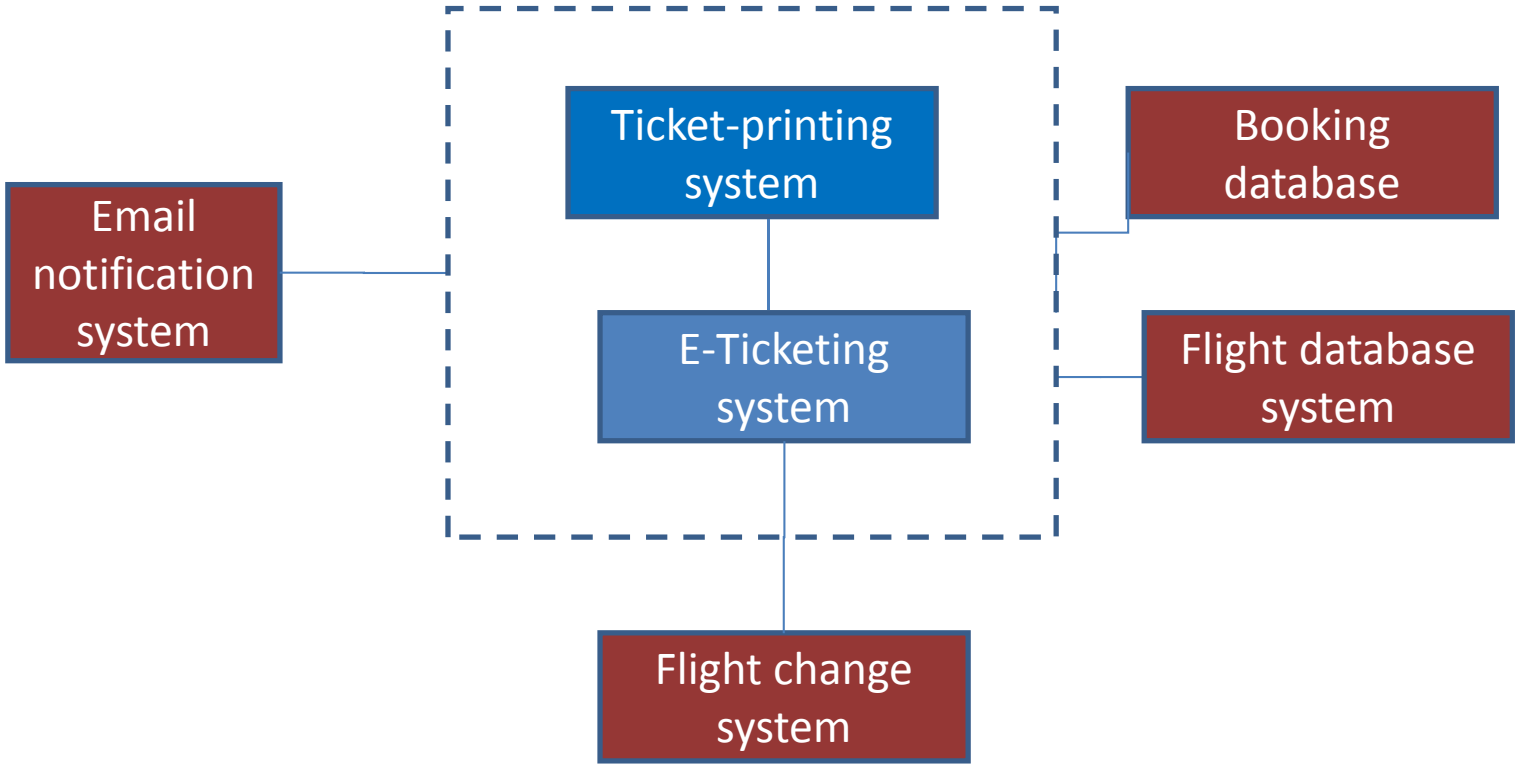
An ATM system

Context Models –Example 2



An E-Ticking System

Context Models –Example 2



An E-Ticking System

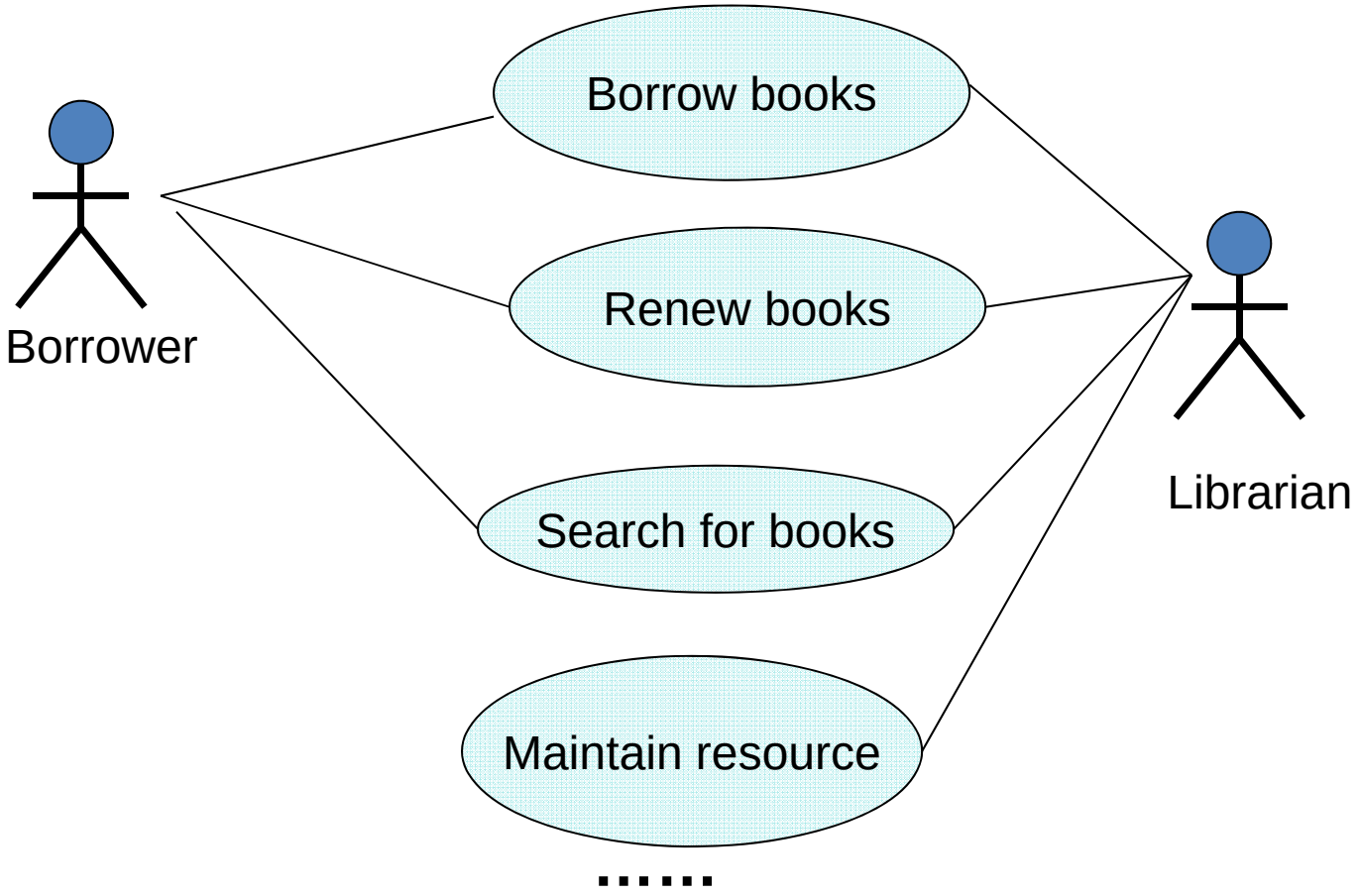
Use Case Diagrams

- Use case diagrams
  - Describe the systems' functionalities from a user's (or other systems') point of view in diagrams (Externally visible （看得见的） behavior of the system, system's functionality)
    - Actors
    - Use cases
  - First step in requirements specification

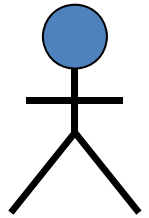
Use Case Diagrams

- A use case diagram contains
  - Actors
    - The role of the users that can play when interacting with the system
  - Use case
    - Tasks (transactions) that the system can perform when users use the system
- The actors and use cases must be determined (决定) by consulting （磋商）the client (客户)

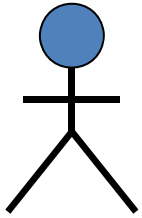
Use Case Diagrams - Library



Actors

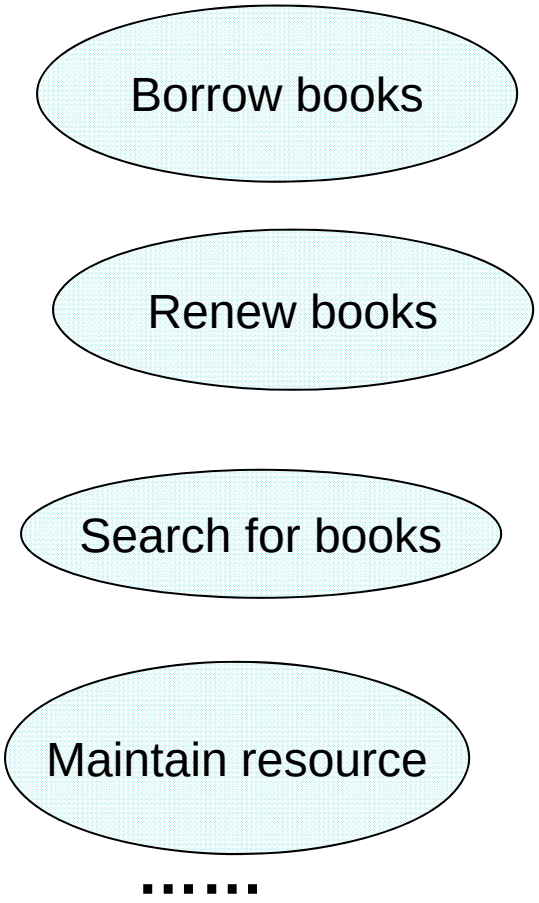


Borrower



Librarian (图书馆员)

Use Cases


Borrow books
Renew books
Search for books
Maintain resource
.....

Focus of Base Case

- Use case should focus on goal rather than process
- ATM

Withdraw money	Verify password
Deposit money	Login
Check balance	Select transaction
Transfer money	Quit

What can be the use cases???

Focus of Base Case

- Use case should focus on goal rather than process
- ATM

Goal	Process
Withdraw money	Verify password
Deposit money	Login
Check balance	Select transaction
Transfer money	Quit

Login: debate on this.

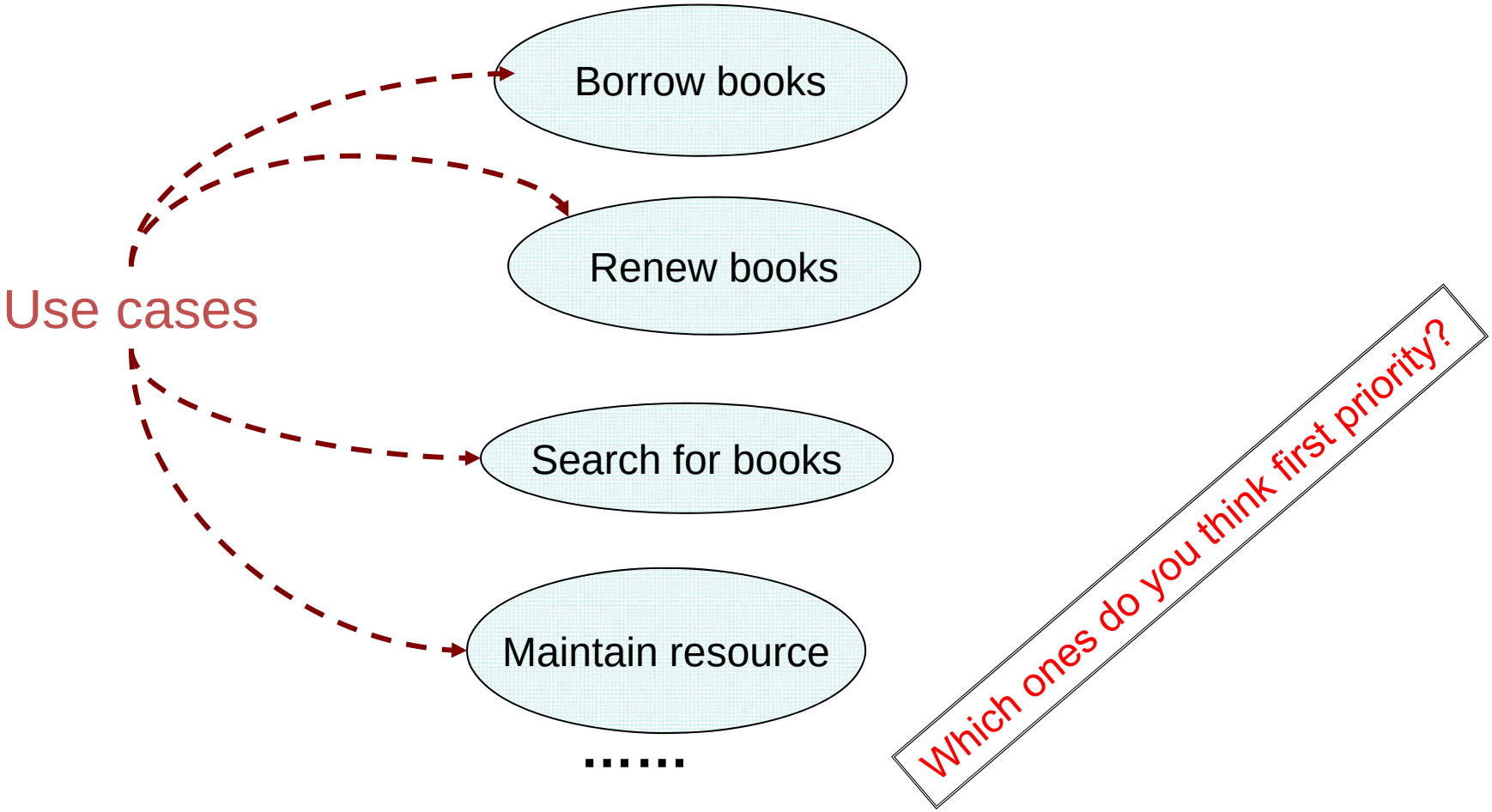
Good Use Cases

- Good use cases should be
  - Observable
  - the basic
- Examples in ATM machine
  - Withdraw, deposit, inquire are right use cases
  - Verify password is not a good use case

Prioritize Use Case

- Factors to consider
  - Support major business process
  - Architectural significance
  - Use of new technologies
  - Needs of substantial research efforts
  - Great improvement in efficiency

Prioritize Use Case



Use Case Scenario

- Scenario (情节)
  - A concrete (具体的) sequence of events.
  - Occurs during one particular execution path in a user case
  - For every use case, there is a scenario that can describe the possible interactions (交互作用) between the user and the system for this use case.

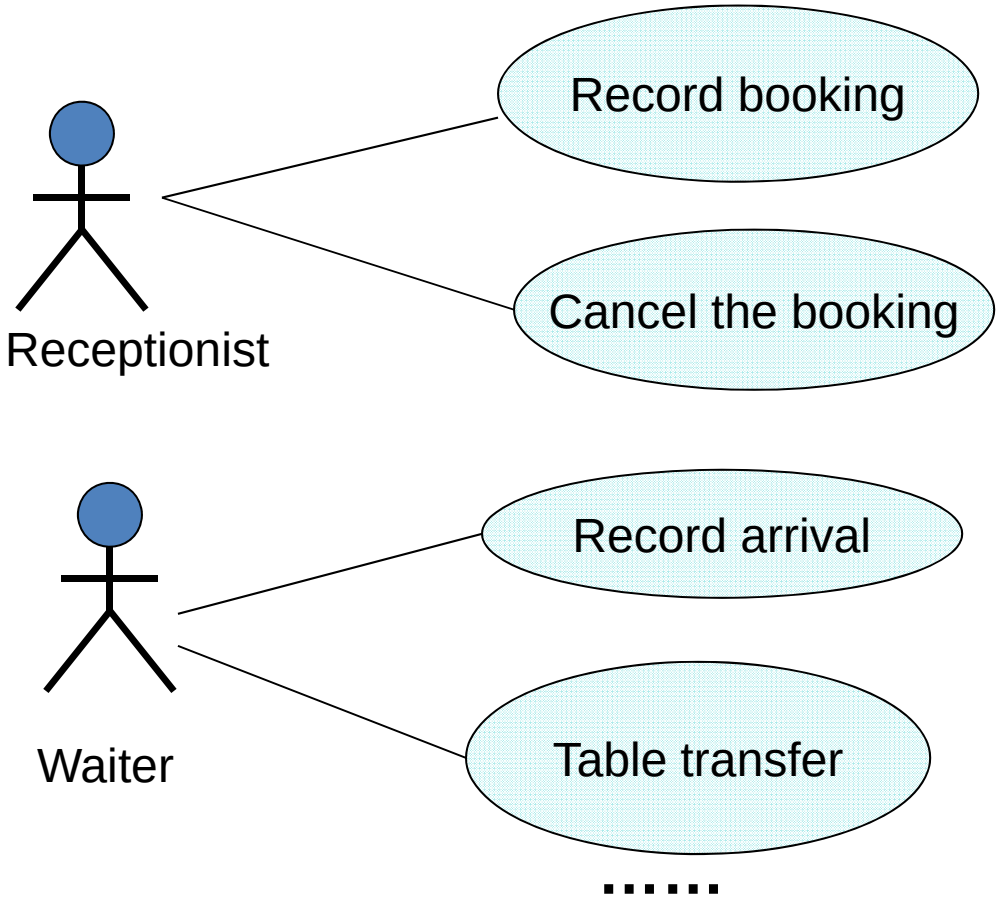
Use Case Scenario

- Basic scenario
  - Normal sequence (序列) of events
  - Achieve (实现) the main goal of the use case with no problem, no interruption
- Alternative (替代的) scenario
  - Something goes wrong
  - Main goal cannot be finished
  - Normal case cannot be finished

Example – Scenario for Books

- A basic scenario for “Search for Books” use case
  - The borrower activates the “catalogue”
  - The system displays the boxes for the keywords
  - The borrower enter the keywords
  - The system searches for the books and displays the book information
- An alternative scenario – Books not available
  - The borrower activates the “catalogue”
  - The system displays the boxes for the keywords
  - The borrower enter the keywords
  - No books are available and the use case ends

Another Example – Table Booking



Scenario for Record Booking

- A basic scenario for “Record booking” use case
  - The receptionists (接待员) enters the date requested by the customer
  - The system displays the bookings for the date
  - The table is available. The receptionist enters the customer’s name and phone number, number of customers and the tables
  - The system displays the new booking
- An alternative scenario – no table is available
  - The receptionists enters the date requested by the customer
  - The system displays the booking for that date
  - No table is available, use case terminates (结束)

Use Cases

- A use case can be described in a natural language text containing abstract information (Initial description) or refined details (concrete information)

An Initial Description

- A use case in initial description can be described in at least three parts
  - Name of the use case
  - Participating (参与) actors
  - Description

A Concrete Use Case

- A use case in concrete description can be described in more parts
  - Name of the use case
  - Use case ID
  - Participating (参与) actors
  - Entry (进入) conditions
  - Scenario
  - Priority
  - Exit （出口）conditions
  - Quality requirements
  - Source
  - …

Use Case Initial Description – Search Book Example

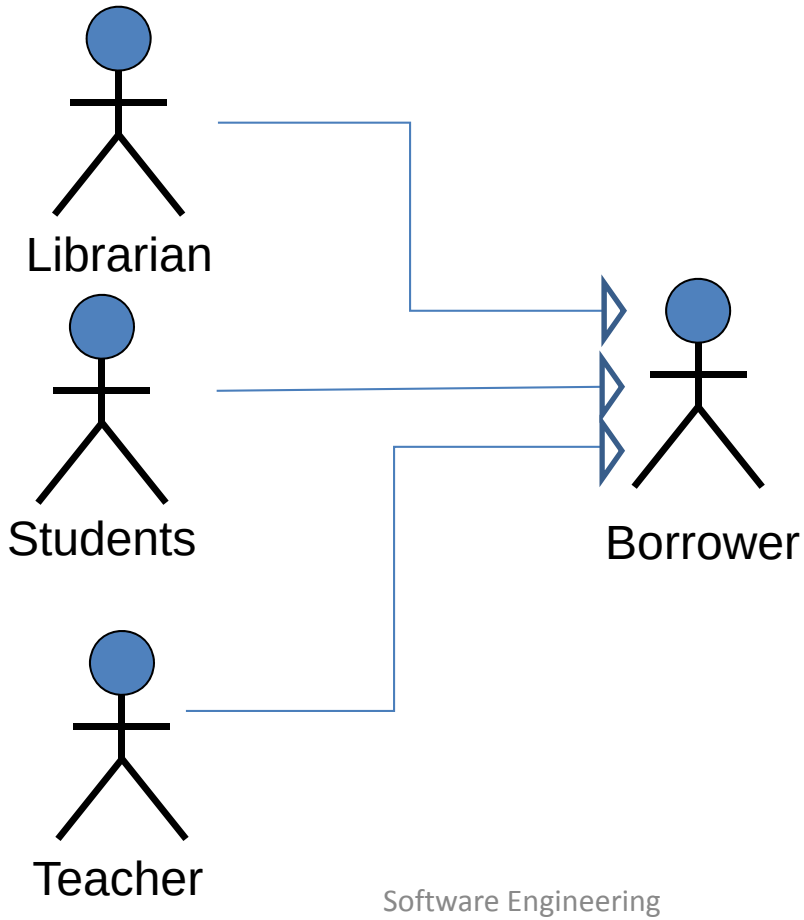
Use case name	Search for books
Use case ID	Library-001
Participating actors	Borrower, librarian
Description	The book in the library can be searched by inputting the keywords.

Use Case Concrete Description – Search Book Example

Use case name	Search for books
Use case ID	Library-001
Participating actors	Borrower, librarian
Scenario	1. The borrower activates the “catalogue” 2. The system displays the boxes for the keywords 3. The borrower enter the keywords 4. The system searches for the books and displays the book information
Entry conditions	The borrower has the right
Exit condition	NIL
Quality requirements	The search process should be finished in 1 seconds

Relationships in Use Case Diagrams

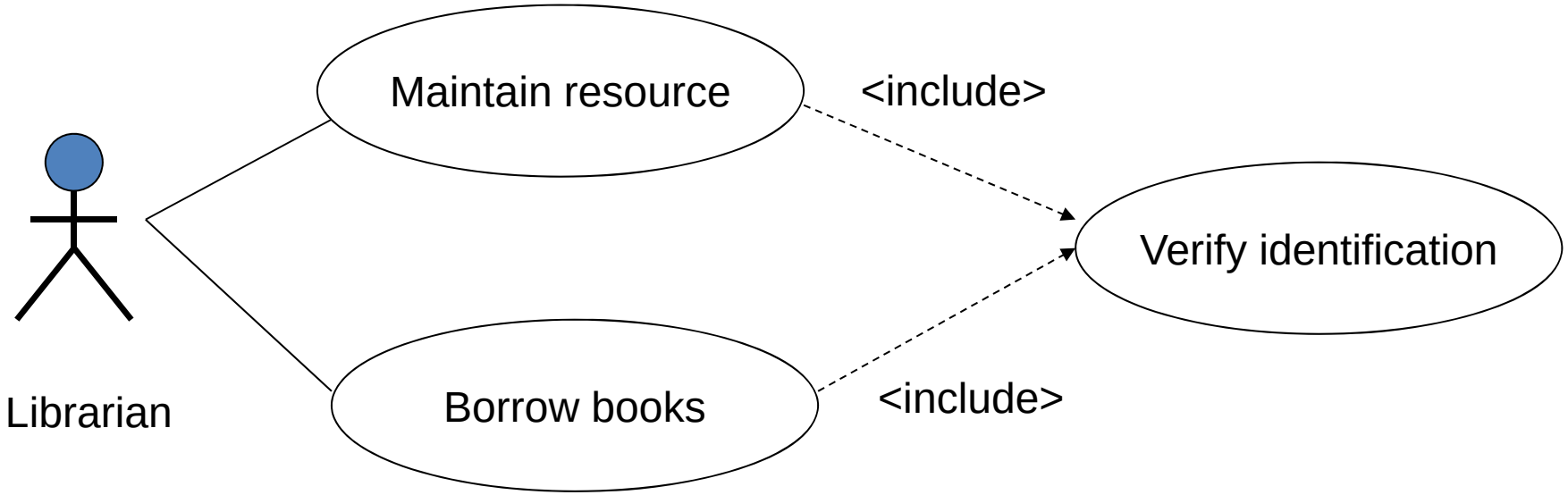
- Generalization of actors



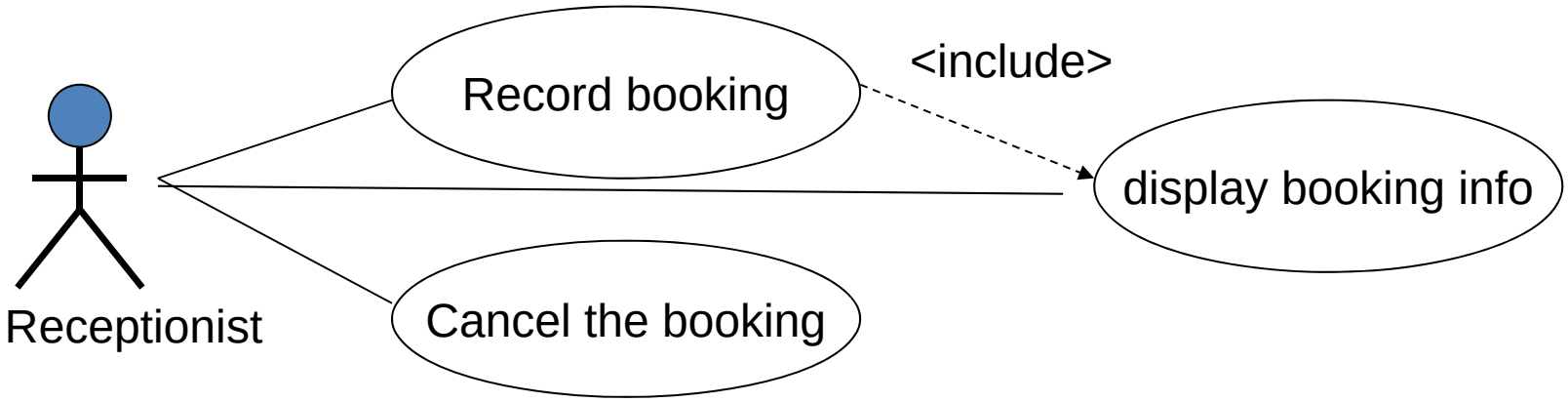
Relationships in Use Case Diagrams

- Relationships between use cases
  - Four relationships among the use cases in a use case diagram
  - Between actors and use cases
    - *"Communication"* relationships
  - Between use cases
    - *"Include"* relationships
    - *"Extend"* relationships
    - *"Inheritance"* relationships

Use Case Diagrams – *"Include"*



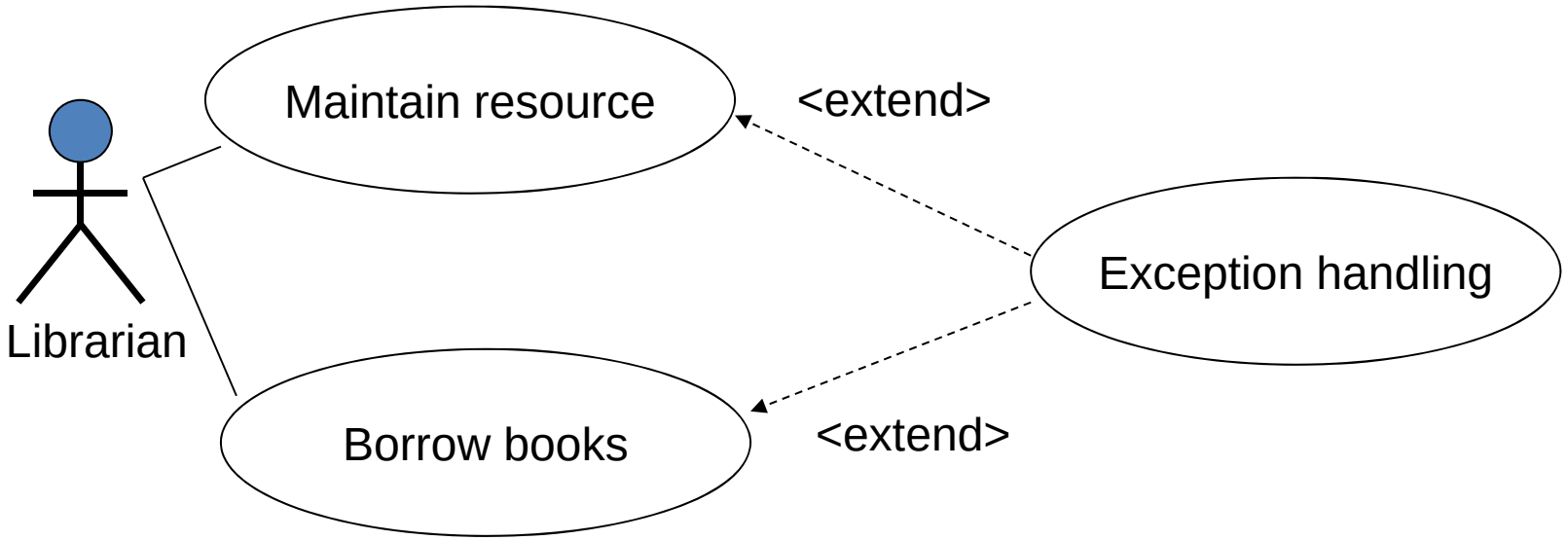
Use Case Diagrams – *"Include"*



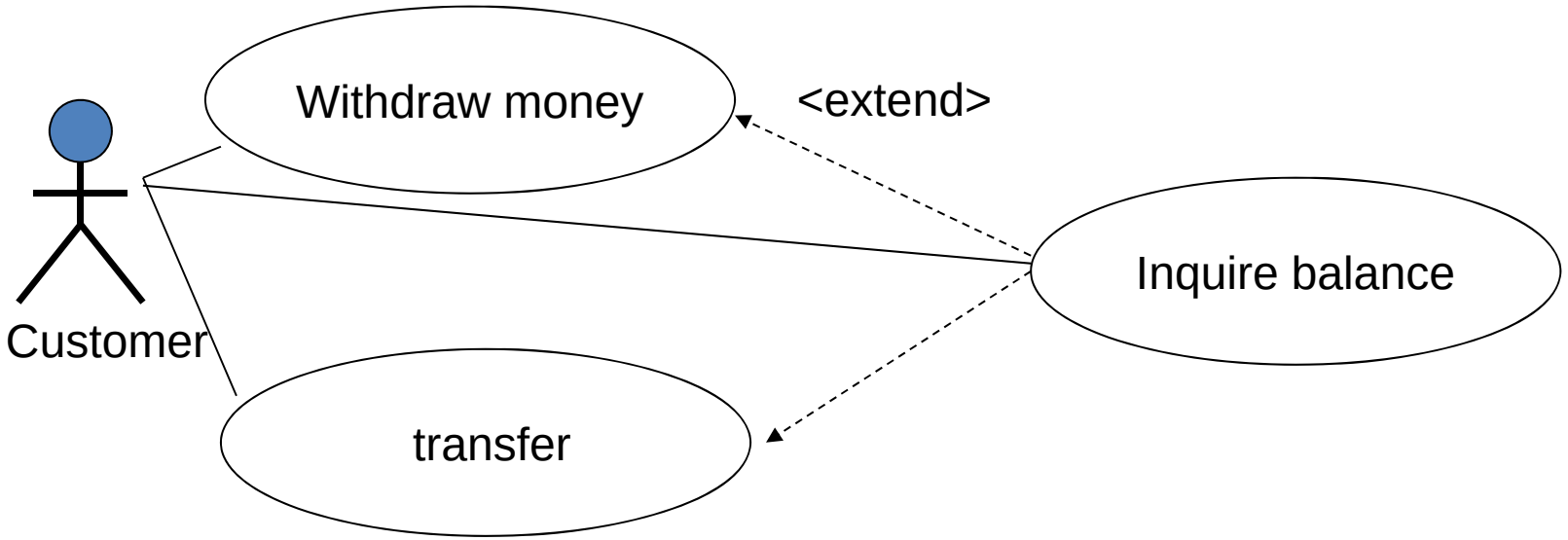
Use Case Diagrams – *"Include"*

- A basic scenario for "Record booking" use case
  - The receptionists enters the date requested by the customer
  - The system displays the bookings for the date (See scenario display booking info)
  - The table is available. The receptionist enters the customer's name and phone number, number of customers and the tables
  - The system displays the new booking
- A basic scenario for "Display booking info" use case
  - ……

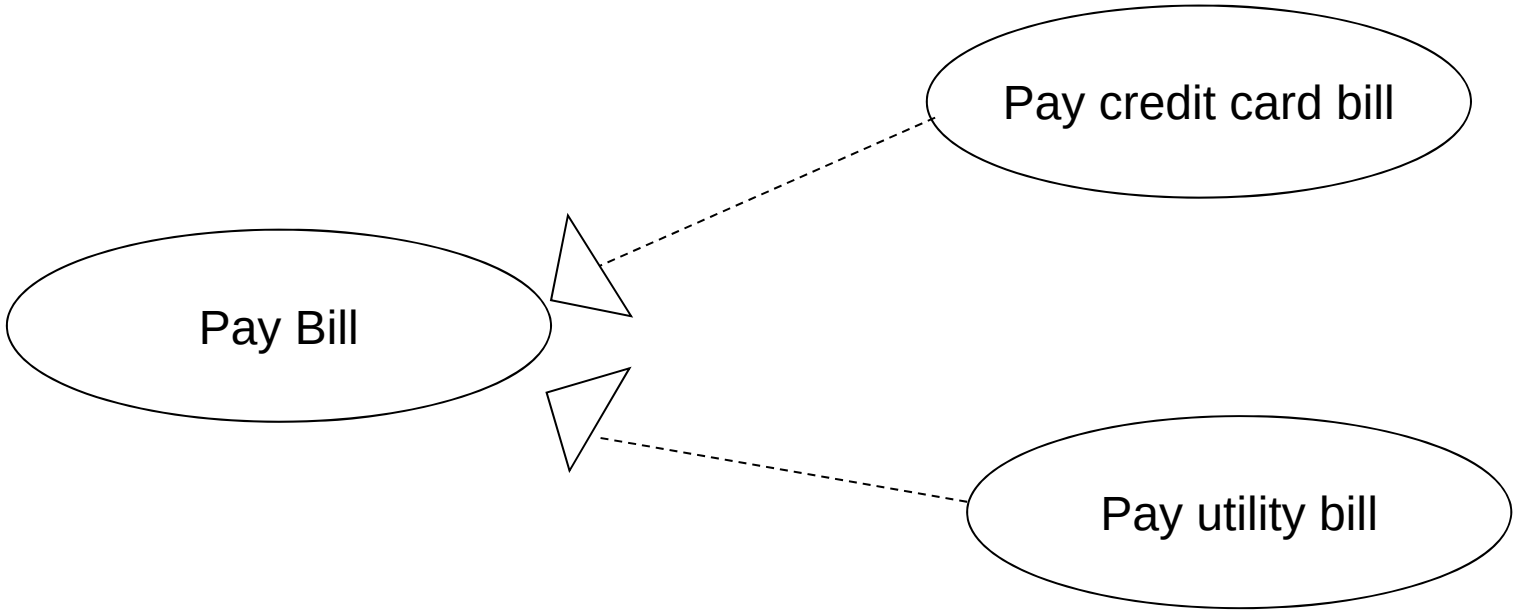
Use Case Diagrams – "*extend*"



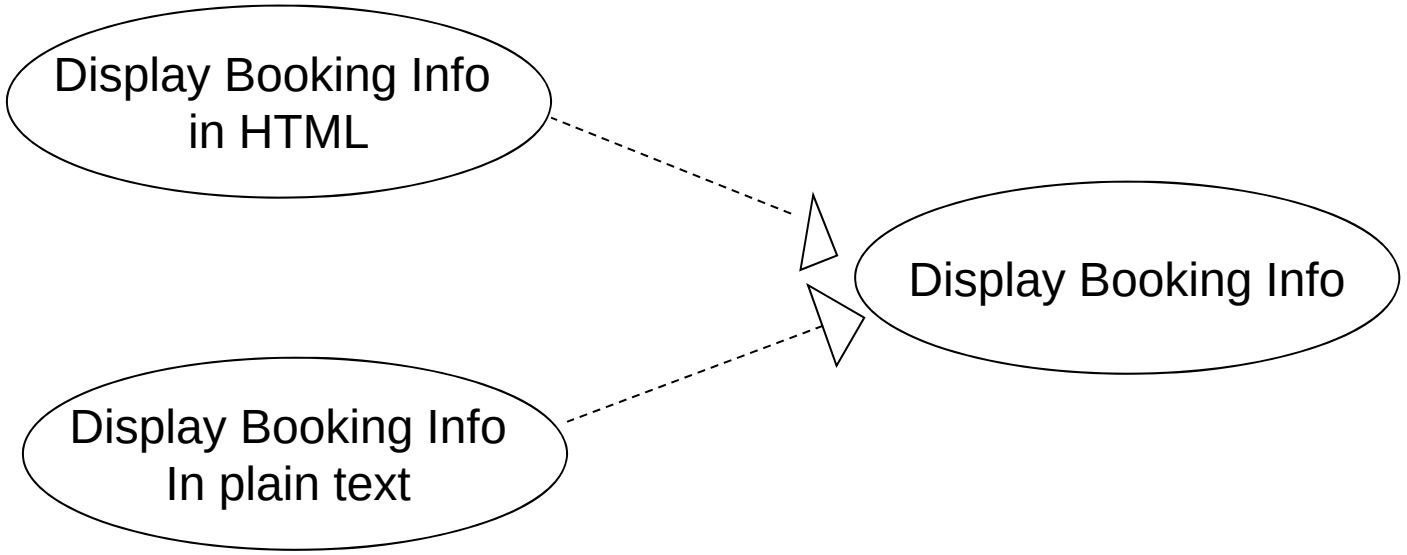
Use Case Diagrams – "*extend*"



Use Case Diagrams – *"inheritance"*



Use Case Diagrams – *"inheritance"*



Class Exercise

- Please draw the use case diagram and give the scenario for transfer between different currency from the following description
  - An online banking system can handle the transactions like inquire, time deposit and transfer. In the transfer transaction, the user can transfer between the same currency and different currencies. In the time deposit, the amount is transferred from a saving account to a time deposit account.

Behavior Models

- Describe overall function of the system
  - State machine model (Finite State Machine)
    - Event-driven （事件驱动）, e .g., embedded systems
  - Data flow model
    - Data-driven （数据驱动）, e.g. information systems

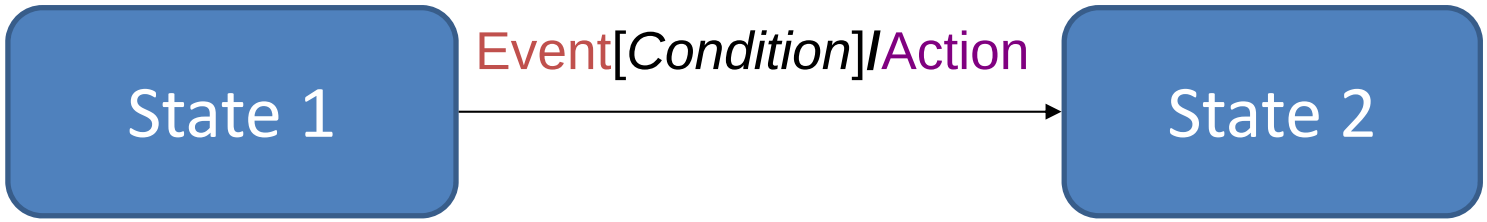
State Machine Model

- State transition (转换) diagrams (Finite State Machine) (有穷状态机) (FSM)
- Indicate how the system behaves as a consequence （结果） of external events

Elements in a State Machine Diagram

- State
  - a mode of behavior
  - last for a period
- Event
  - Causes the transition from a state to another state
- Action
  - The behavior that the system reacts to an event
- Condition
  - A condition for an action to an event
- Whether a behavior is a state or an event or an action depends on the real systems.

State, Event, Action, Condition



Event is necessary

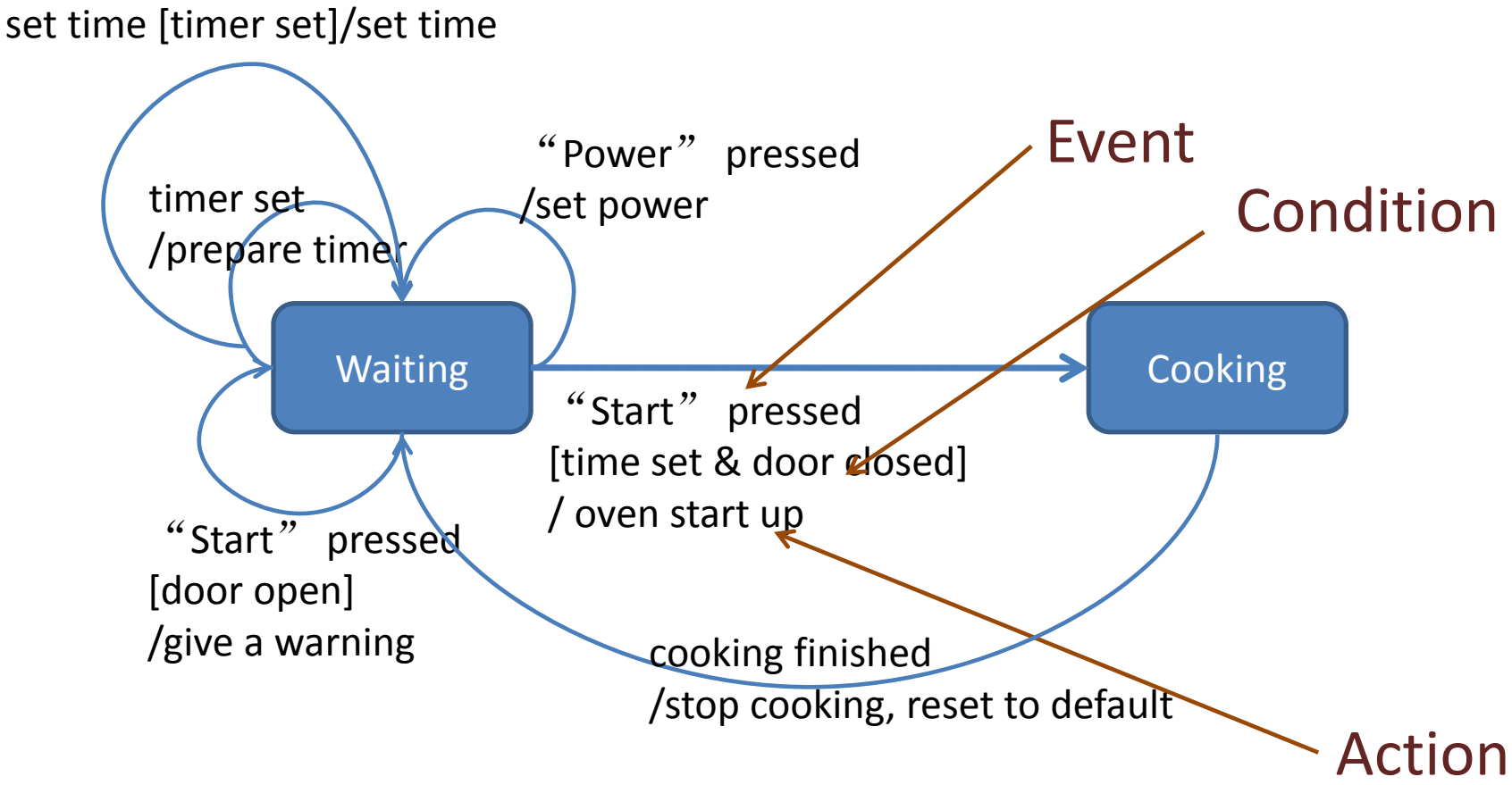
Condition and Action are optional

State Machine Model - Example

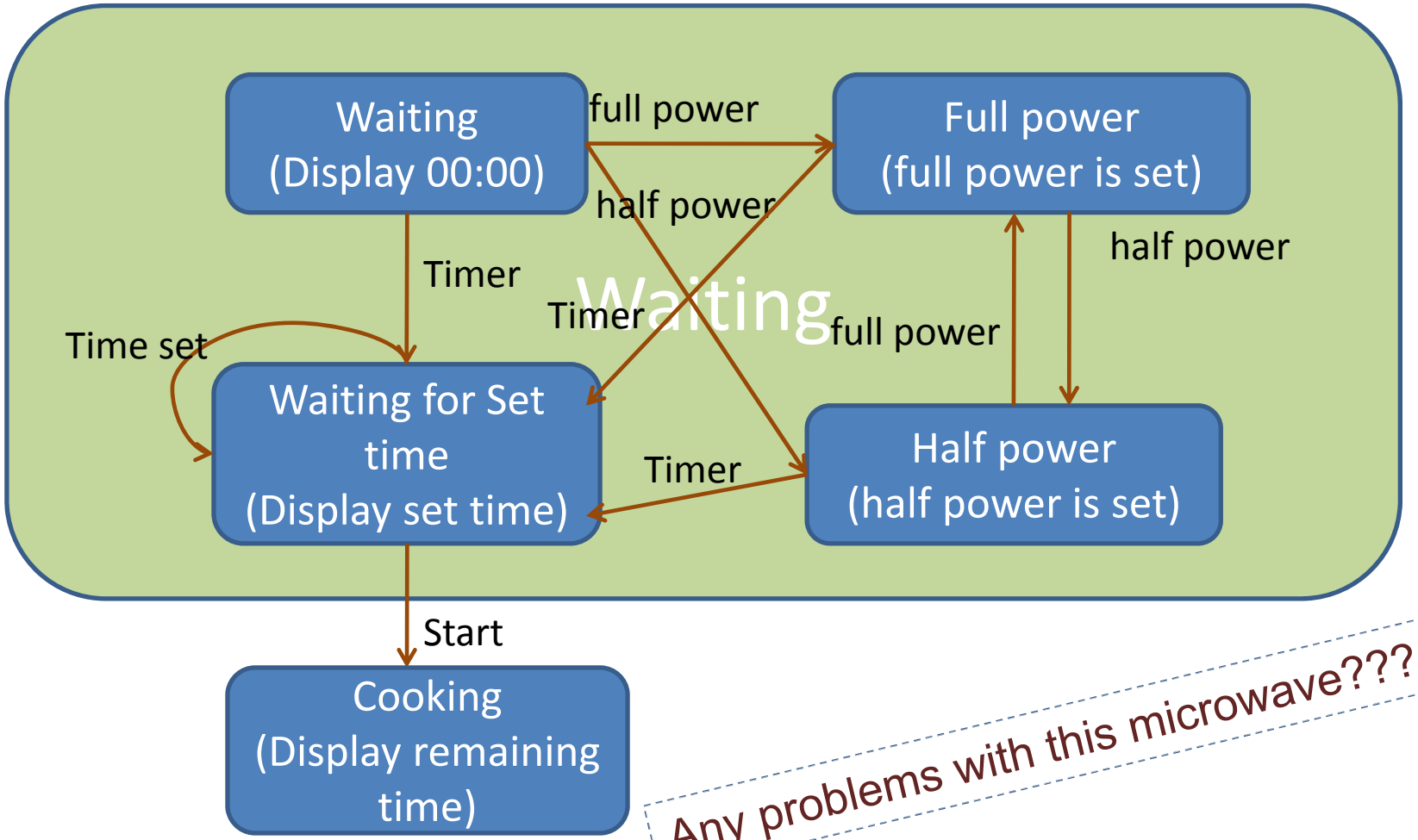
A microwave oven （微波炉）example

1. A microwave oven displays time 0:00 and full power when it is not used
2. There are two buttons for user to set the power: half power or full power （火力）
3. If the user presses the “timer” button, he can start to set time by continuing pressing the time buttons (10 secs, 1 min)
4. The user can press the “start” button to start cooking. If the door is closed, the cooking starts and then ends at the given time. If the door is open, display “close the door before cooking”.

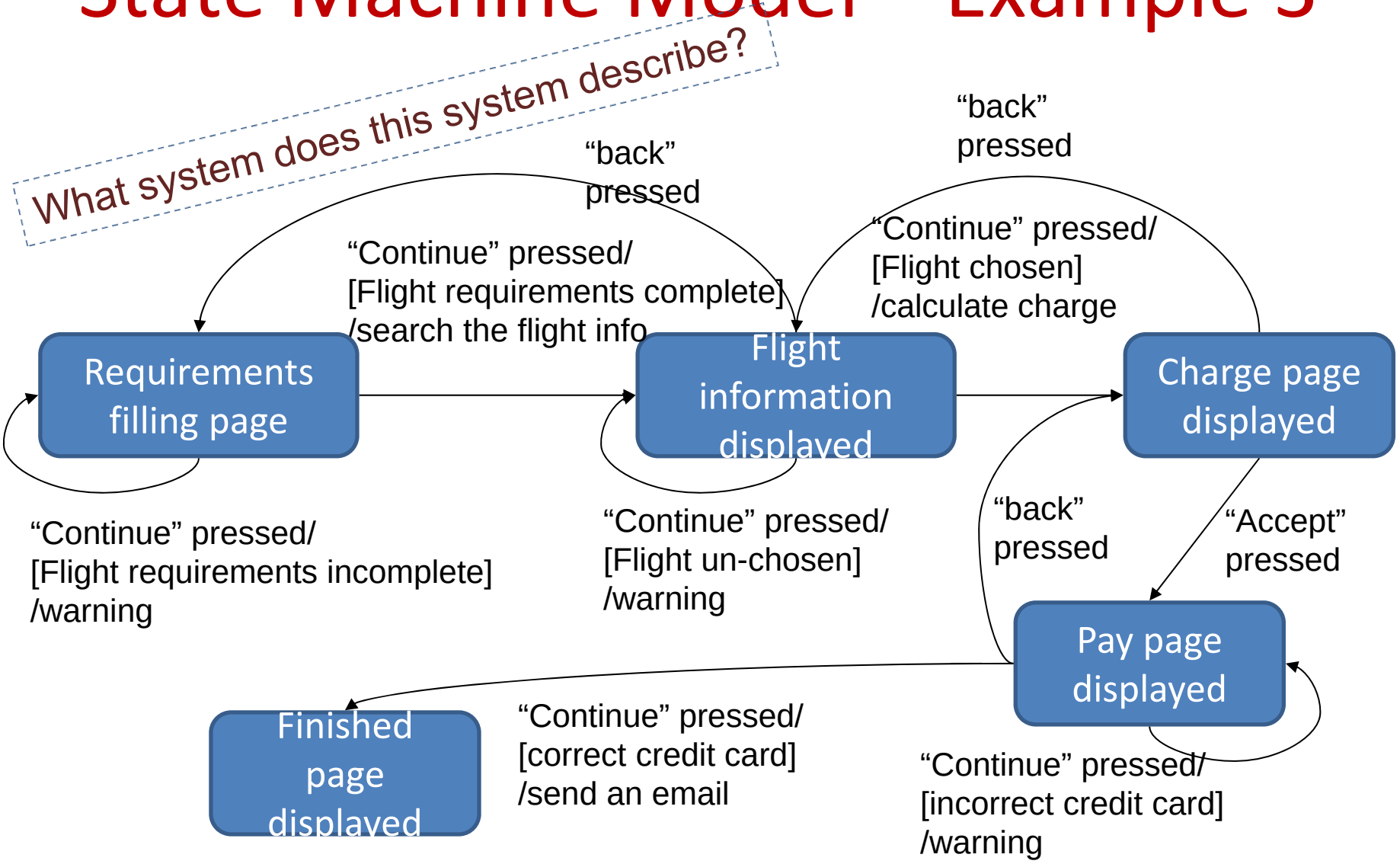
State Machine Model – Example 1



State Machine Model – Example 2



State Machine Model – Example 3



Class Exercises

- Draw a state transition diagram to describe Email system according to what teacher shows.

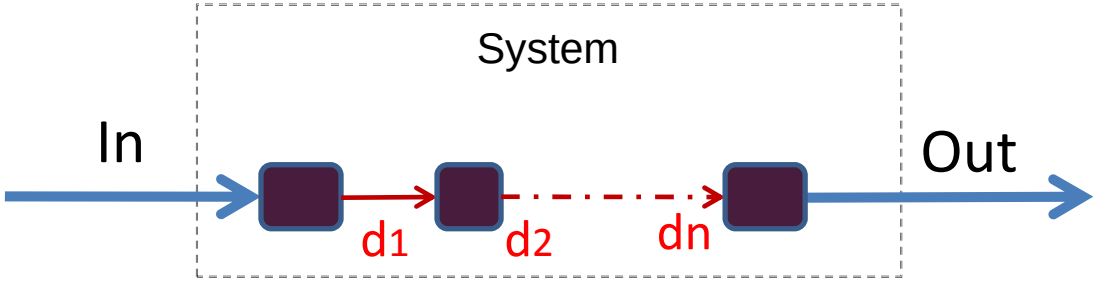
Data-Flow Model

- Provide an indication of how data are transformed （转换） as they move through the system
- Depict(描述) the functions that transform the data flow
- Help explain to the systems users how the system goes on (abstract)
- Help designers to design the system architectures （结构） (detailed).

Data-Flow Model

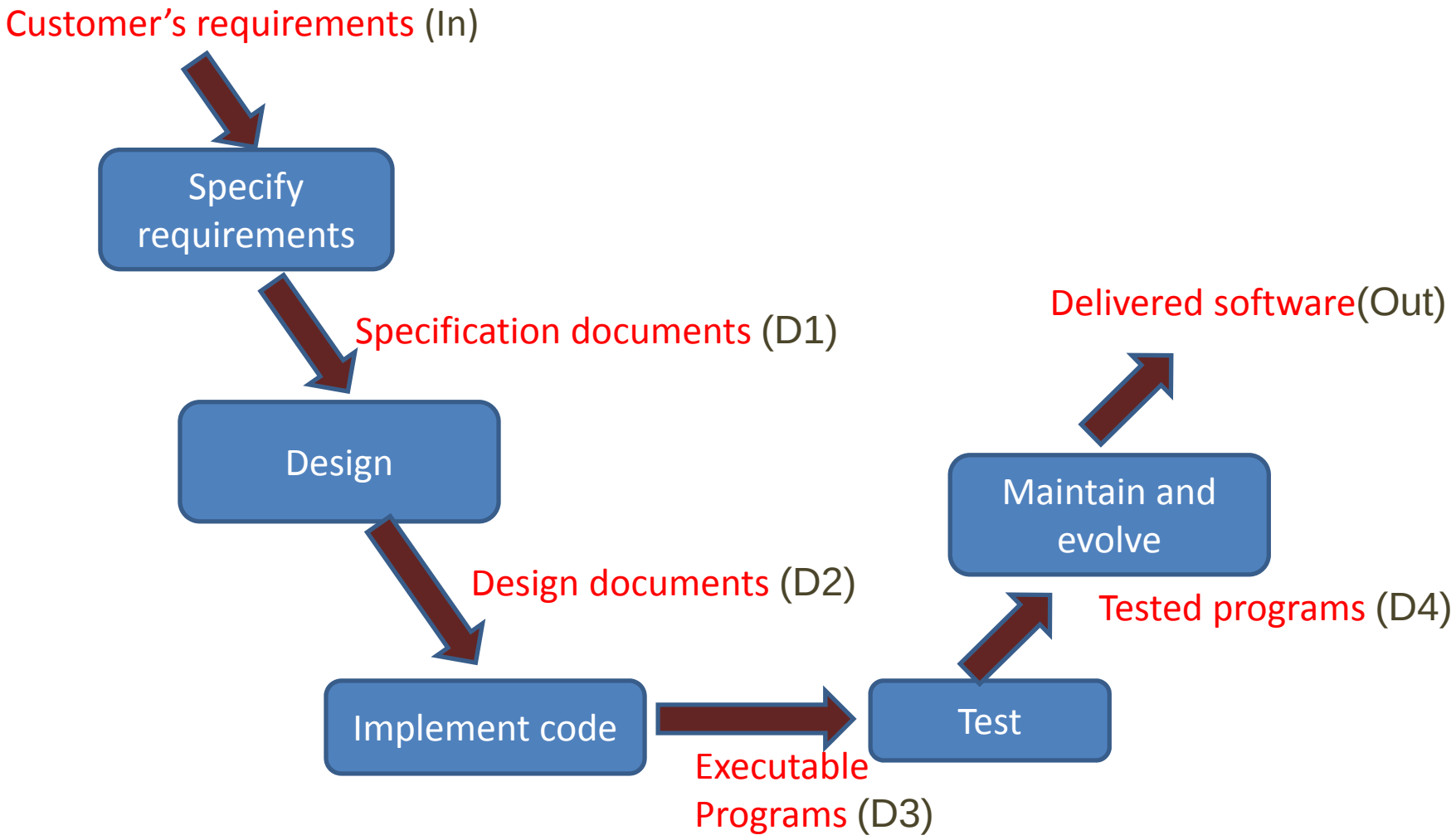
- Structured analysis method （结构化分析方法） (DeMarco 1978)
  - Data-flow diagrams (system analysis)
  - Structured modular design (system design)
- Widely used before the OO method

Data-Flow Model

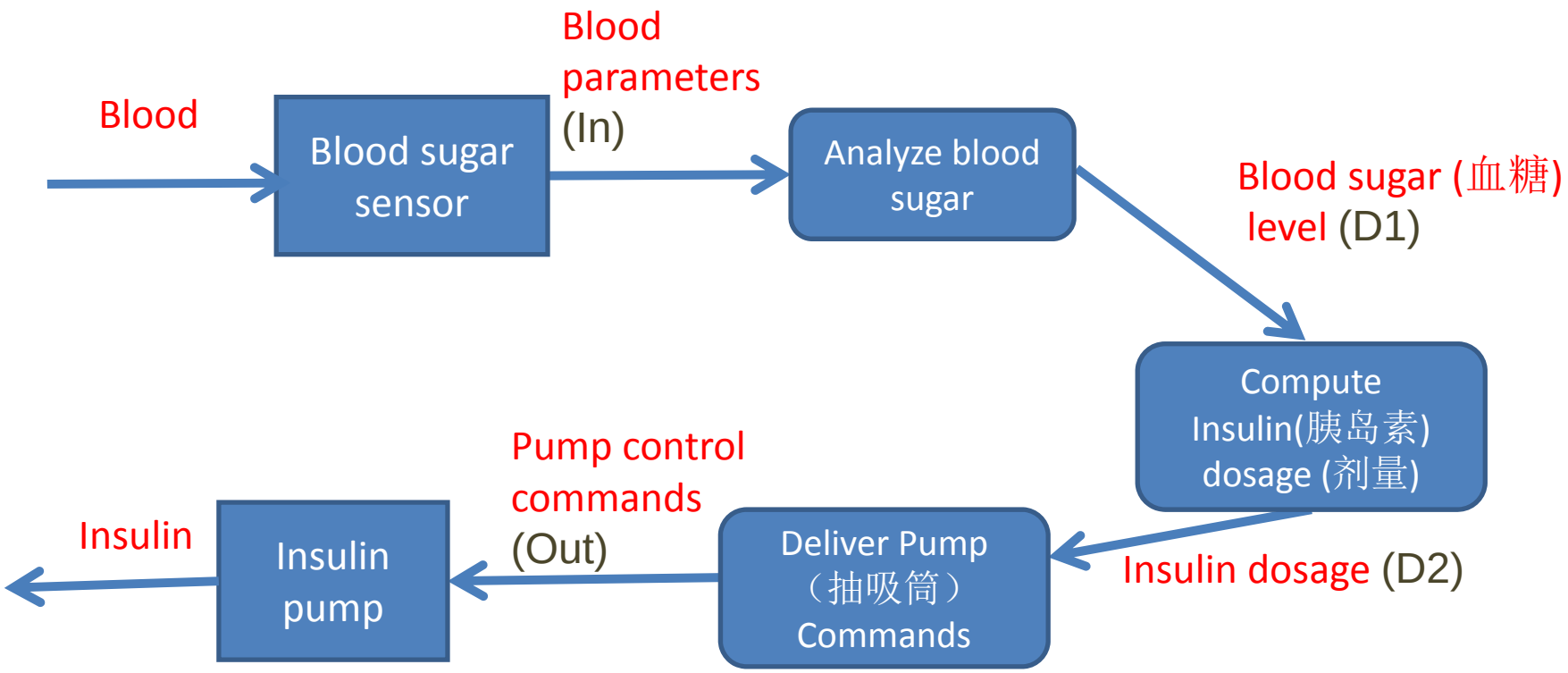


Data transformation(转换): In -> d1 -> d2 -> … -> dn -> Out

Data-Flow Model – Example 1

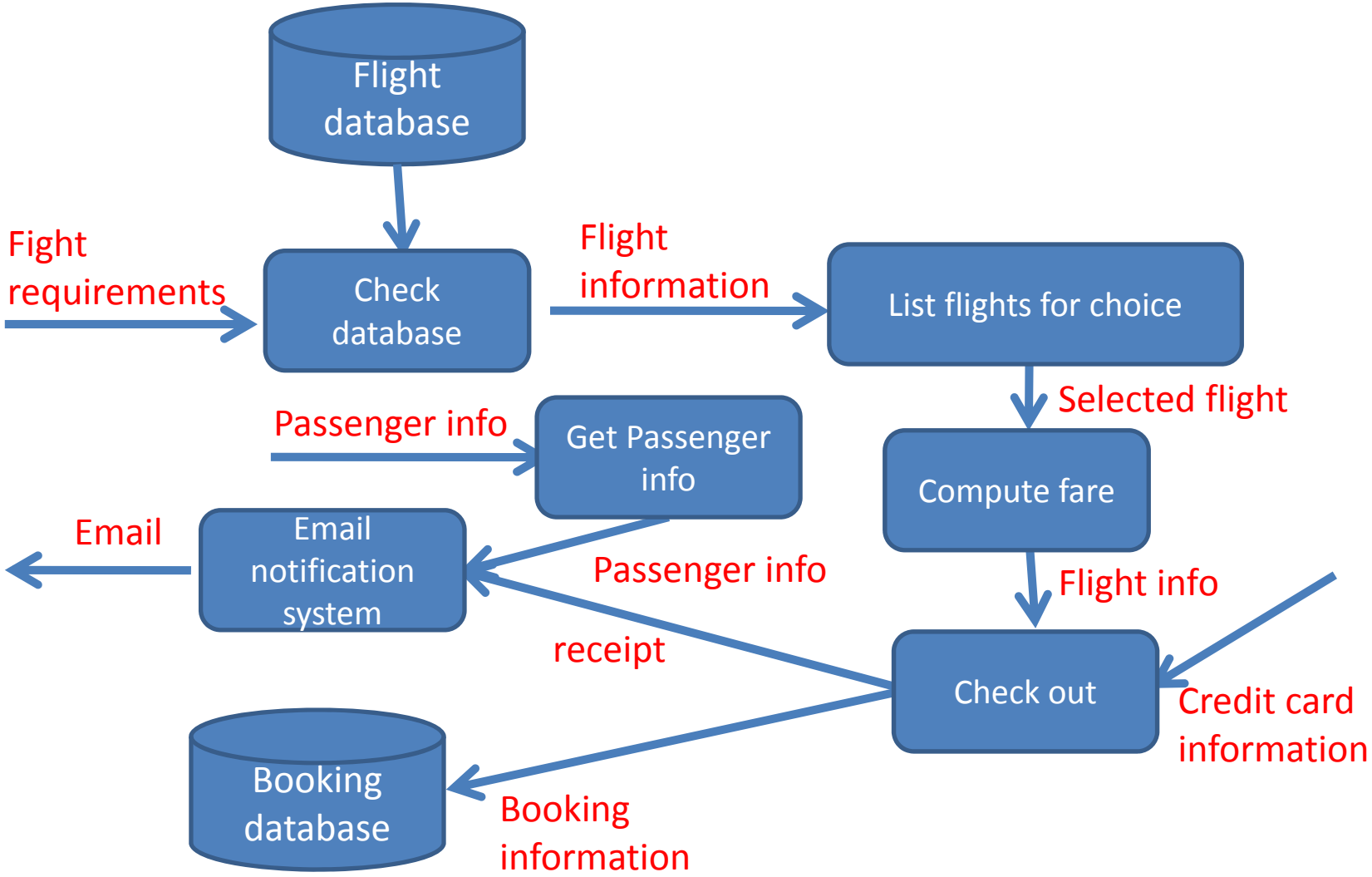


Data-Flow Model – Example 2



An insulin pump control system

Data-Flow Model – Example 3



An E-ticketing system

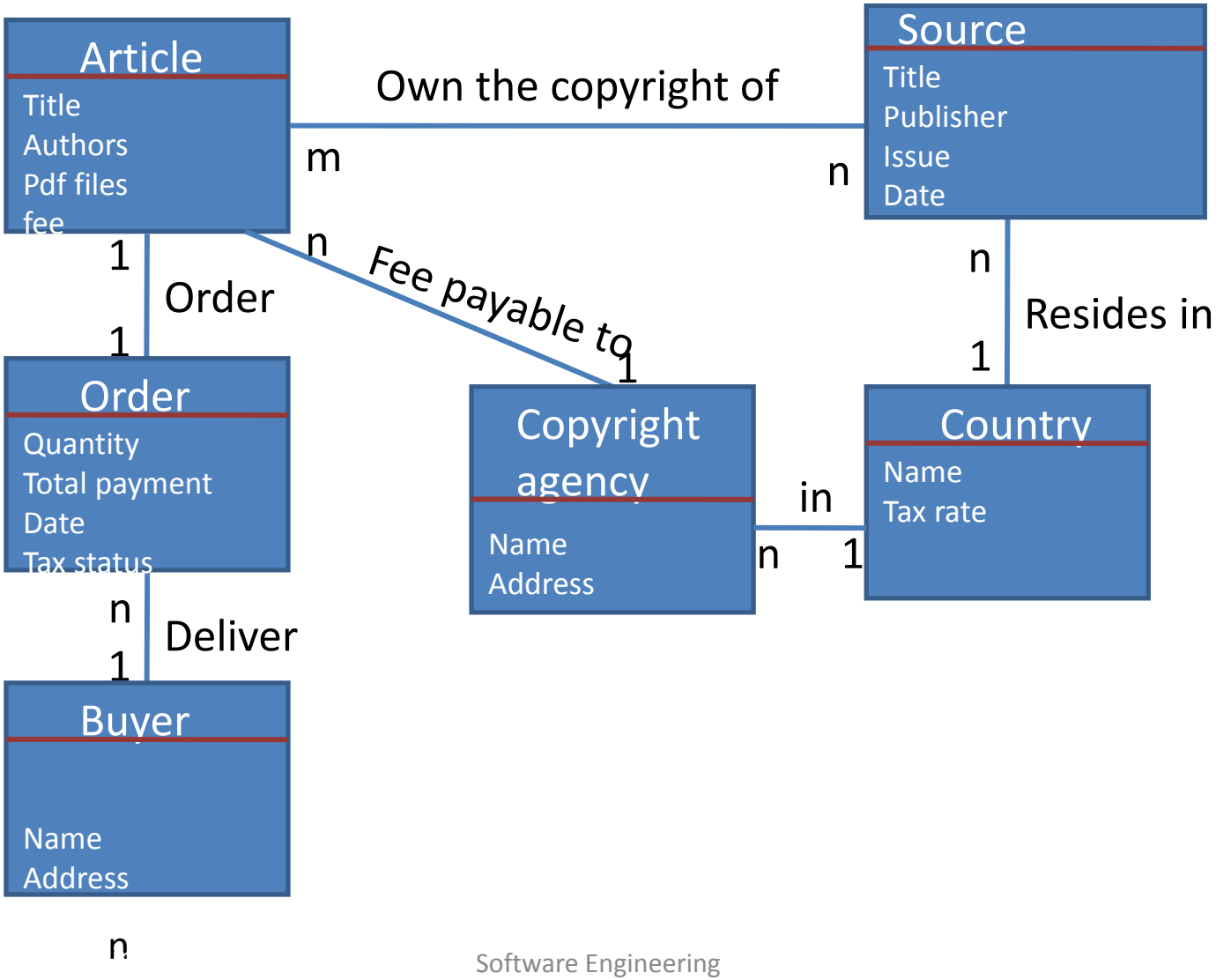
Data Model

- Data models are used a lot in the database systems
- Entity-Relation-Attribute models (ERA)
  - Peter Chen 1976
  - Semantic data model
  - Data dictionary

Notation

$m \geq 0$, $n \geq 0$, m, n cannot be 0 simultaneously

An Example – Copyright Fee Payment



Data Dictionary

Names	Description	Type	Date
Article	The published articles	Entity	21/2/2009
Author	Name of authors of the article	Attribute	21/2/2009
Buyer	The person who gives the order	Entity	21/2/2009
Address (Buyer)	Pay billing info.	Relation	21/2/2009
Free-payable-to	Relation between agency and article	Attribute	21/2/2009
…	…	…	…

Data Dictionary

- A data dictionary includes
  - All the names in the requirements
    - Entities
    - Relations
    - attributes
- Tool support
  - Automatically create, maintain and update dictionary

Assignment 3

- Question: Draw a data flow diagram and a state transition diagram to respectively for the following simplified Internet Purchasing system in JT
  1. JT provides an interface (initial page) for customer to enter goods name to search for. Then JT will display the goods list if any products can be found; otherwise, a warning information “no available goods” is given.
  2. The customer can choose a product in the list and then enter the product introduction page and read the information on this product. If the customer likes the product, he can either add the product into cart or purchase the product immediately. If he chooses to add to the cart, the cart page will be displayed with the selected product ticked while other goods (selected before) in cart unticked. If he choose to purchase the product immediately, the order confirmation page will be displayed.
  3. In the cart page, the customer can tick or untick the products. If the customer chooses to pay, the system will go to the order confirmation page.
  4. In the order confirmation page, the customer can choose to pay by Alipay or WeChat. Then the corresponding pay page will be displayed. After the customer types the password, the payment is made and an order information is produced and sent to customer center. The paying information will be sent to WeChat or Alipay according to the paying method.
  5. Then the system will go back to the initial page.
- Deadline: 11:55 pm 16 Mar 2019

Summary

- Several system models are introduced to specify software requirements
- Context diagram helps to identify the system's boundary
- Use case diagram illustrate the main features (goals) of the system
- State transition diagram dynamically illustrate the reactions of the system to the events
- Data flow diagram specifies the data flow between the transactions.