State Modelling: statcharts and state machines

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Based on materials developed by Marlon Dumas

状态建模：statcharts

和状态机

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Notation	Purpose
Class diagrams	Domain & application modeling ✓
Use case diagrams/use cases	User-system interaction modeling ✓
Sequence diagrams	User-system & system-system interaction modeling ✓
Statecharts	Object behavior modeling ✓
Petri nets	Concurrent systems & process modeling
Decision trees & DMN	Decision modeling

符号目的	
类图 领域和应用程序建模	☑ ☑
用例图/用途 案例	用户-系统交互建模
序列图 用户-系统和系统-系统	交互建模 ☑ ☑
状态图对象行为建模	
Petri 网并发系统和流程	造型
决策树和 DMN 决策建模	

State machine diagrams

State machine diagram is a UML diagram used

to model the dynamic nature of a system == to capture object beahaviour

Source: https://www.visual-paradigm.com/guide/uml-unified-modeling-language/what-is-state-machine-diagram/

状态机图

状态机图是使用的**UML**图

模拟系统的动态本质 **==** 捕获对象行为

Source: https://www.visual-paradigm.com/guide/uml-unified-modeling-language/what-is-state-machine-diagram/

Capturing object behaviour

- **STEP I: select / determine the object**
- **STEP II: think of all events that can take place and affect the [state of an] object**
- **STEP 3: derive the states of the object**

捕捉对象行为

- **STEPI**：选择/确定对象

- 第二步：考虑所有可能发生并影响对象[状态]的事件

Ø 第三步：导出对象的状态

What the state is?

"A state is an abstraction of the attribute values and links of an object.

Sets of values are grouped together into a state according to properties that affect the gross behavior of the object."

Typically the state of an object changes in response to stimuli ("events")

Michel, R. B., & Rumbaugh, J. R. (2005). Object-oriented modeling and design with UML. Boston: Pearson Education

状态是什么？

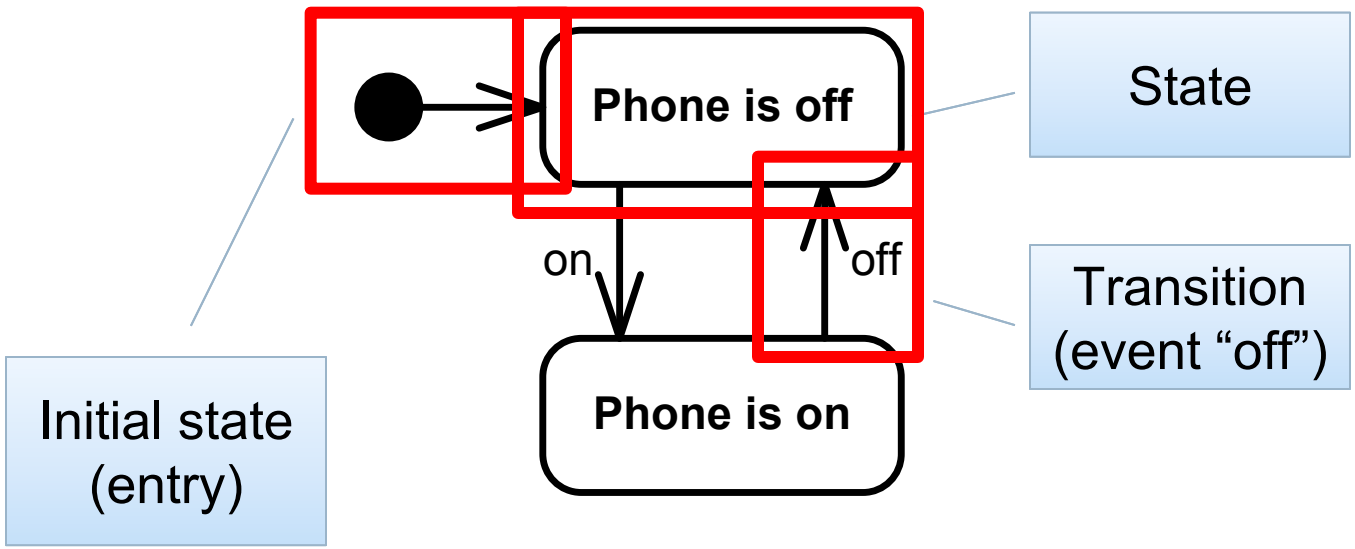
“ 状态是对象的属性值和链接的抽象。

根据影响对象总体行为的属性，将值集组合在一起形成一种状态。”

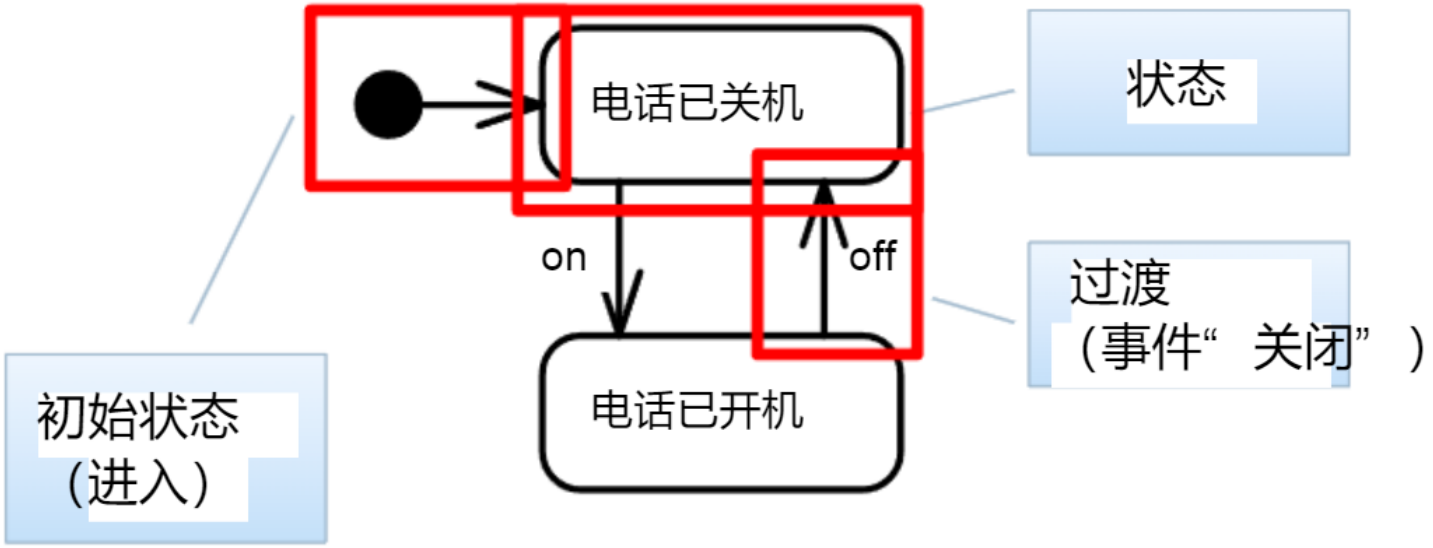
通常，对象的状态会响应刺激（“ 事件”）而发生变化

米歇尔，R.B. 和朗博，J.R. (2005)。使用 UML 进行面向对象建模和设计。波士顿：培生教育

State Machine (Automaton)



状态机（自动机）



Capturing object behaviour

Let's think about Scholarship application

- **STEP I: select / determine the object**
- **STEP II: think of all events that can take place and affect the [state of an] object**
- **STEP 3: derive the states of the object**

捕捉对象行为

让我们考虑一下奖学金申请

- 第 **I** 步：选择/确定对象
- 第 **II** 步：考虑可能发生并影响对象[状态]的所有事件
- 第 **3** 步：导出对象的状态

Capturing object behaviour

- **STEP I: select / determine the object**
- **STEP II: think of all events that can take place and affect the [state of an] object**
- **STEP 3: derive the states of the object**

Scholarship application

捕捉对象行为

- 第 **I** 步：选择/确定对象 ➢ 第 **II** 步：考虑可能发生并影响对象[状态]的所有事件
- 第 **3** 步：导出对象的状态

奖学金申请

目的!

Capturing object behaviour

- **STEP I: select / determine the object**
- **STEP II: think of all events that can take place and affect the [state of an] object**
- **STEP 3: derive the states of the object**

  - **Scholarship application:**
    - **A student creates the application**
    - **The student can withdraw it**
    - **Or the student can submit it**
      - **It can still be withdrawn!**
    - **A secretary can cancel it because of eligibility rules**
    - **A committee accepts or rejects it**
      - **If accepted the student can still withdraw it?!**
    - **If accepted, the accounting department disburses it**

捕捉对象行为

- 第 I 步：选择/确定对象 ➢ 第 II 步：考虑可能发生并影响对象[状态]的所有事件
- 第 3 步：导出对象的状态

- 奖学金申请：
  - 学生创建应用程序
  - 学生可以撤回
  - 或者学生可以提交
    - 还是可以撤的！
  - 由于资格规则，秘书可以取消它
  - 委员会接受或拒绝
    - 如果被录取了，学生还可以撤回吗？！
  - 如果被接受，会计部门将予以支付

Capturing object behaviour

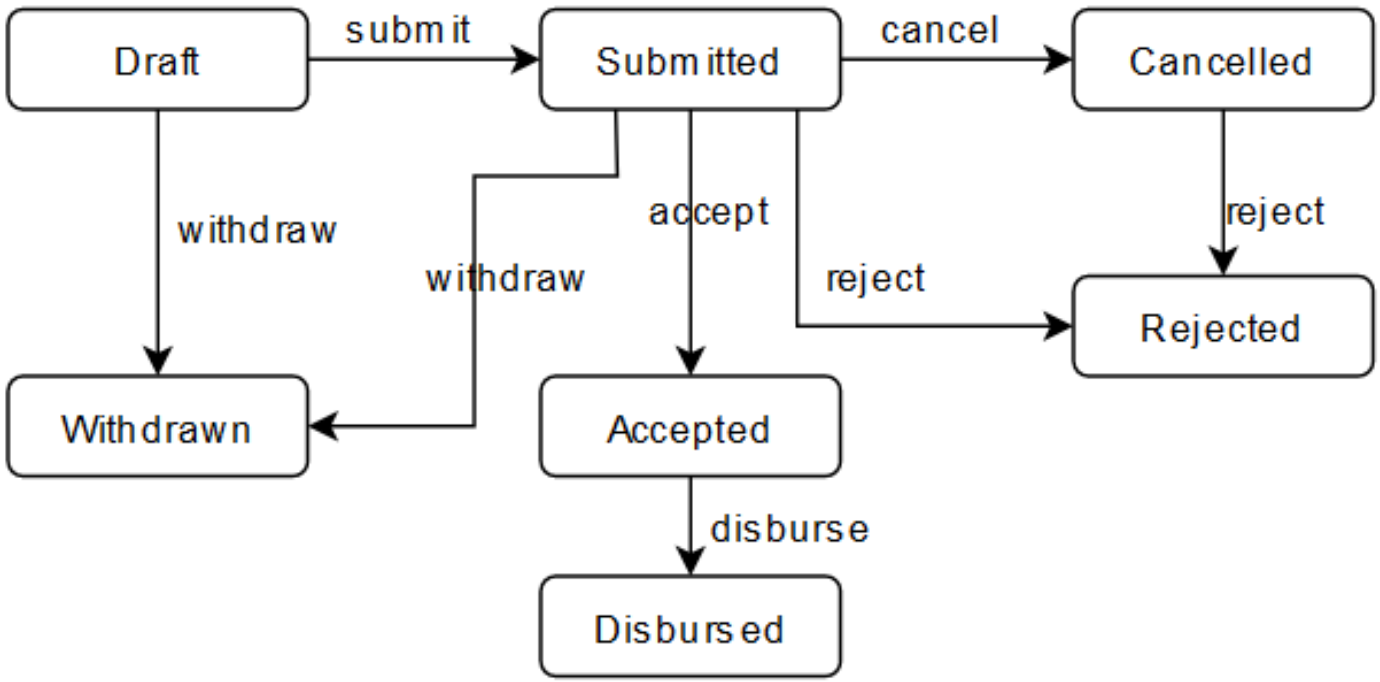
- **STEP I: select / determine the object**
- **STEP II: think of all events that can take place and affect the [state of an] object**
- **STEP 3: derive the states of the object**

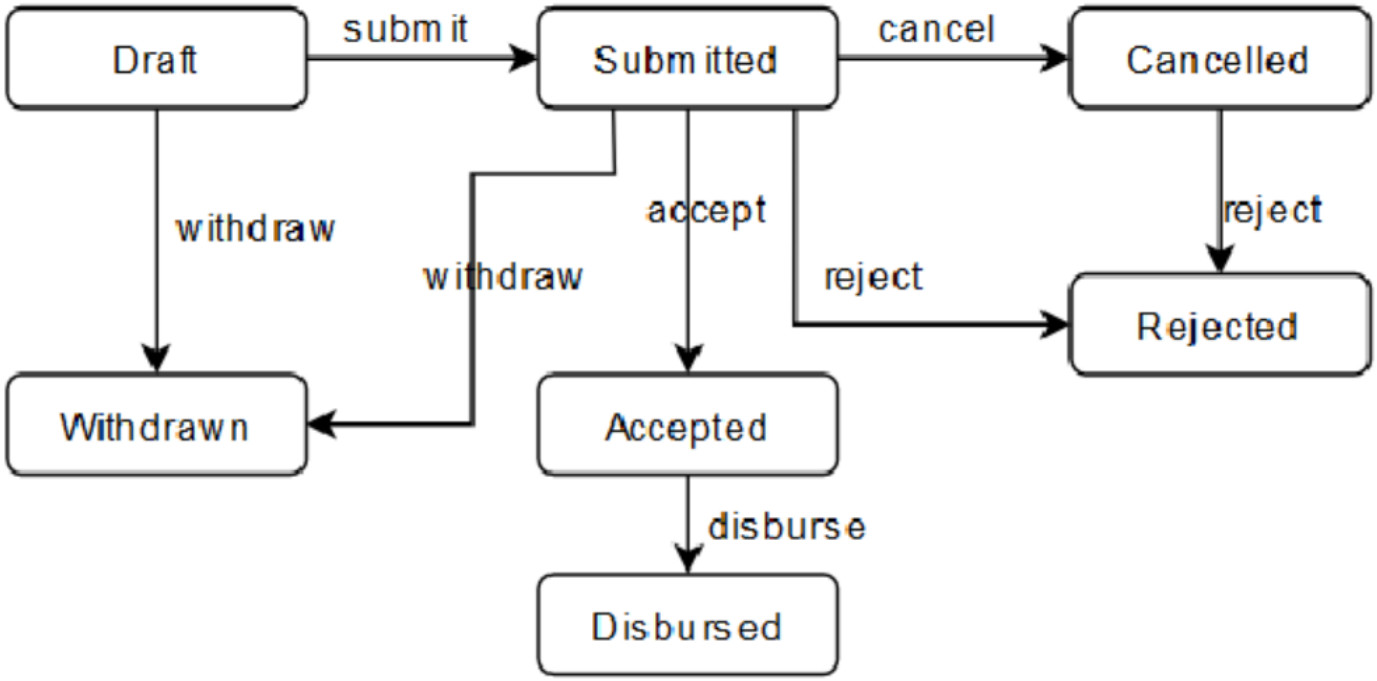
  - **Scholarship application:**
    - **A student creates the application (draft)**
    - **The student can withdraw it (withdrawn)**
    - **Or the student can submit it**
      - **It can still be withdrawn!**
    - **A secretary can cancel it because of eligibility rules (cancelled)**
    - **A committee accepts or rejects it (accepted or rejected)**
      - **If accepted the student can still withdraw it?!**
    - **If accepted, the accounting department disburses it (disbursed)**

捕捉对象行为

- 第 I 步：选择/确定对象 ➢ 第 II 步：考虑可能发生并影响对象[状态]的所有事件
- 第 3 步：导出对象的状态

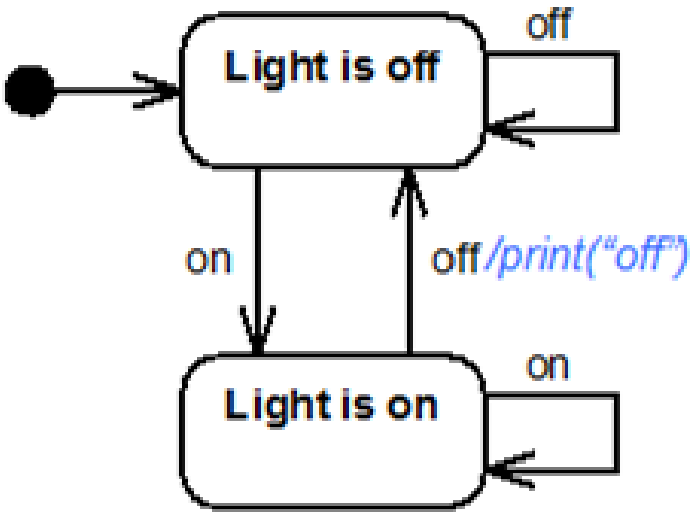
- 奖学金申请：
  - 学生创建申请（草稿）
  - 学生可以撤回（**withdrawal**）
  - 或者学生可以提交
    - 还是可以撤的！
  - 由于资格规则，秘书可以取消（已取消）
  - 委员会接受或拒绝（接受或拒绝）
    - 如果被录取了，学生还可以撤回吗？！
  - 如果接受，会计部门支付（**disbursed**）


Draft
submit
Submitted
cancel
Cancelled
withdraw
withdraw
accept
reject
reject
Rejected
Withdrawn
Accepted
disburse
Disbursed

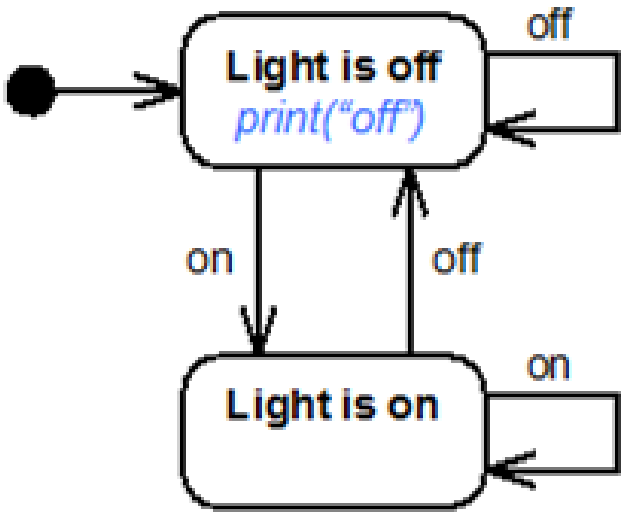

Draft
submit
Submitted
cancel
Cancelled
withdraw
withdraw
accept
reject
reject
Rejected
Withdrawn
Accepted
disburse
Disbursed

Action on the State Machine

- State changes can induce side-effect actions



Mealy automaton

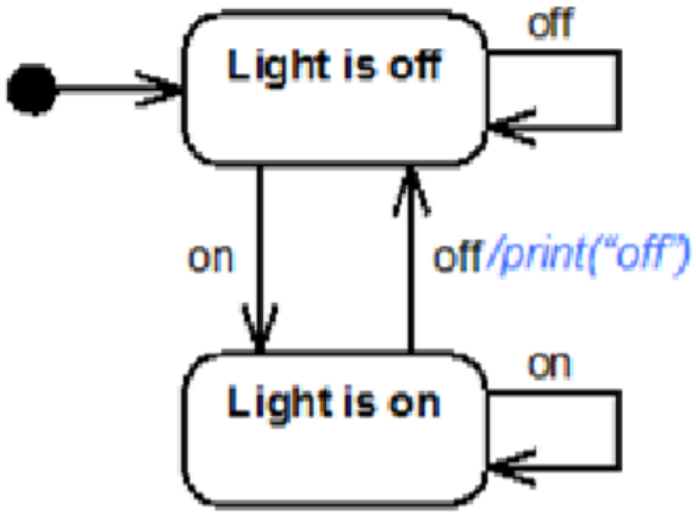


Moore automaton

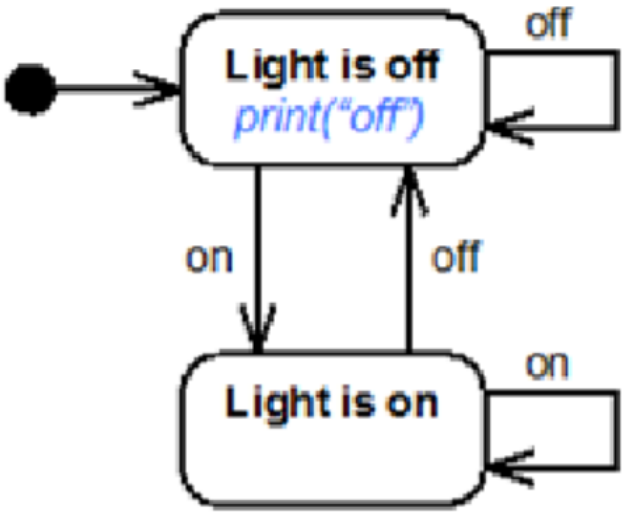
- ***Which one is correct? Which one should we prefer?***

状态机上的操作

- State changes can induce side-effect actions



Mealy automaton

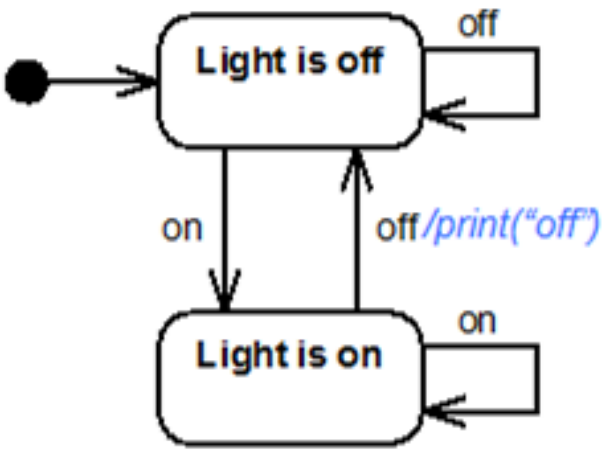


Moore automaton

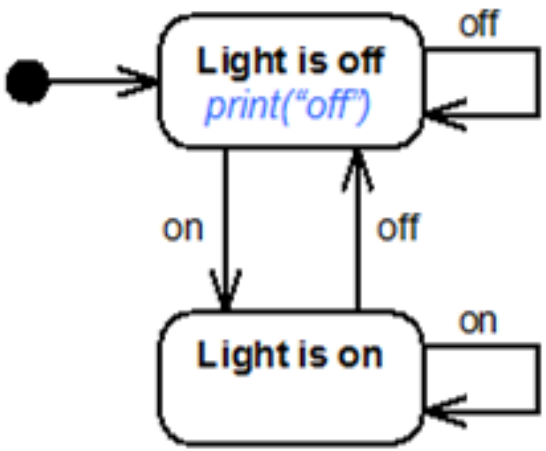
- 哪一个是正确的？我们应该选择哪一个？

Action on the State Machine

- State changes can induce side-effect actions



Mealy automaton

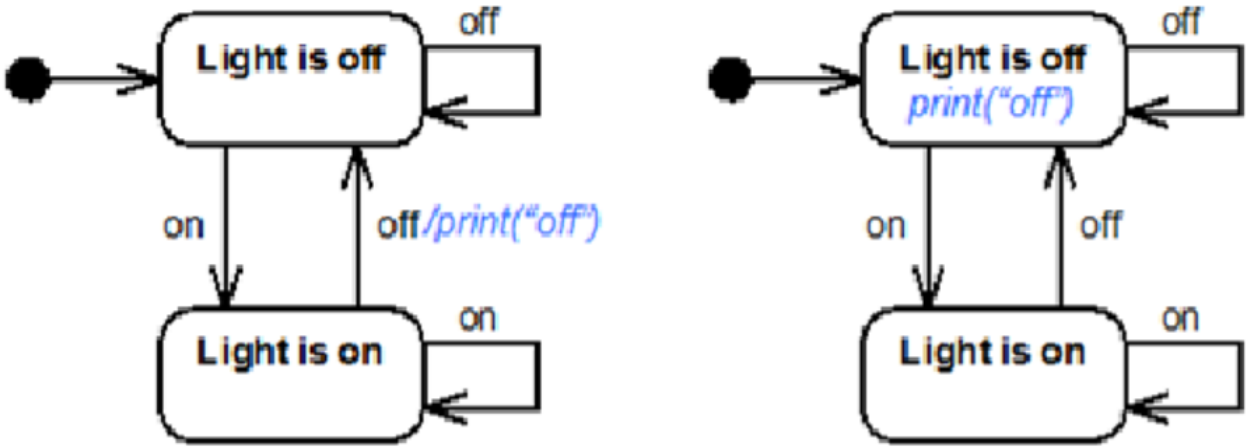


Moore automaton

- ***Both are correct!***
- ***Which one should we prefer? Why?***

状态机上的操作

- State changes can induce side-effect actions



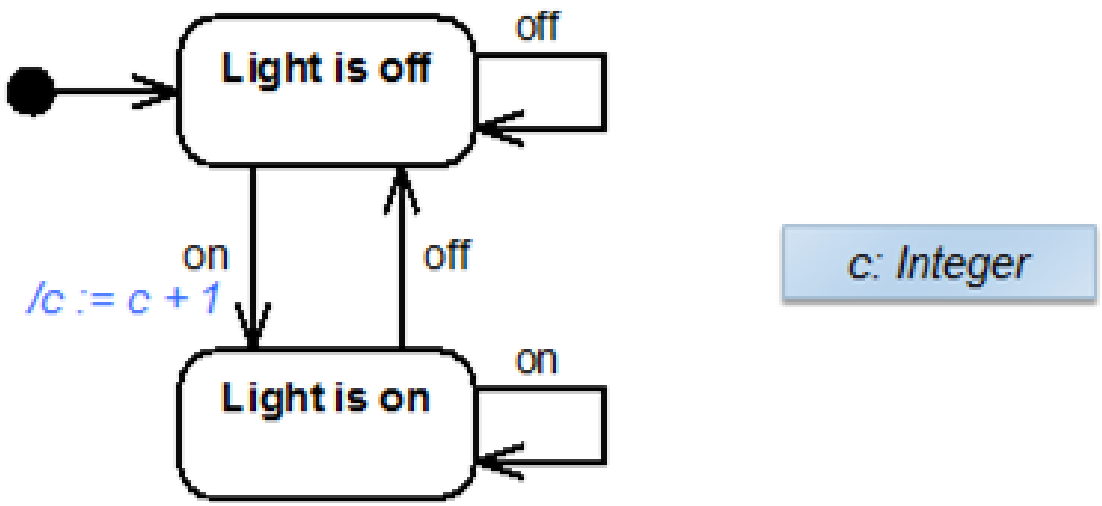
Mealy automaton

Moore automaton

- 两者都是正确的！
- 我们应该选择哪一个？为什么？

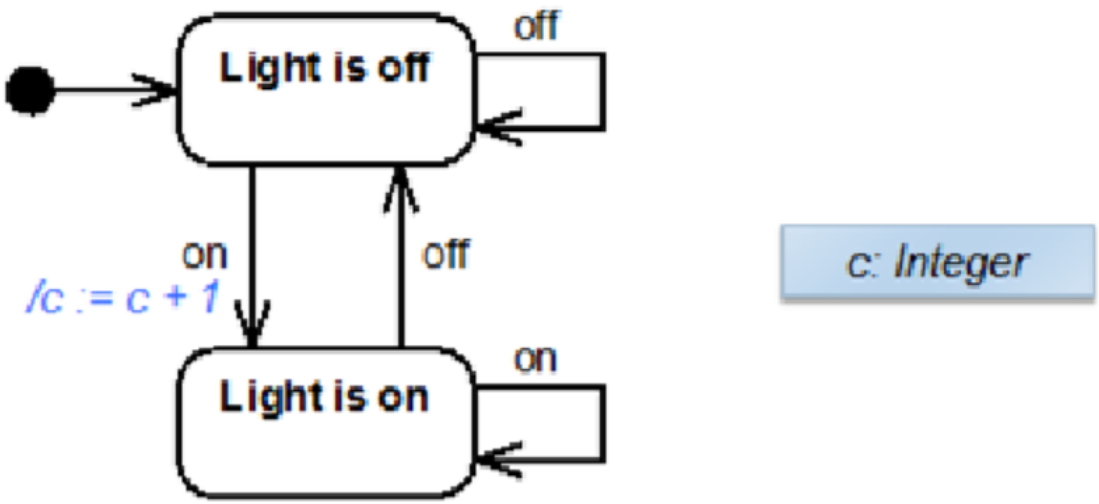
Extended State Machines

- State machine with variables

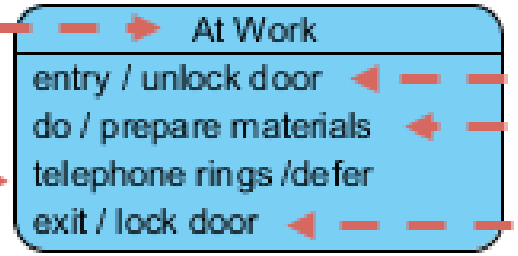


扩展状态机

- State machine with variables



State notation



State Name
Name of state

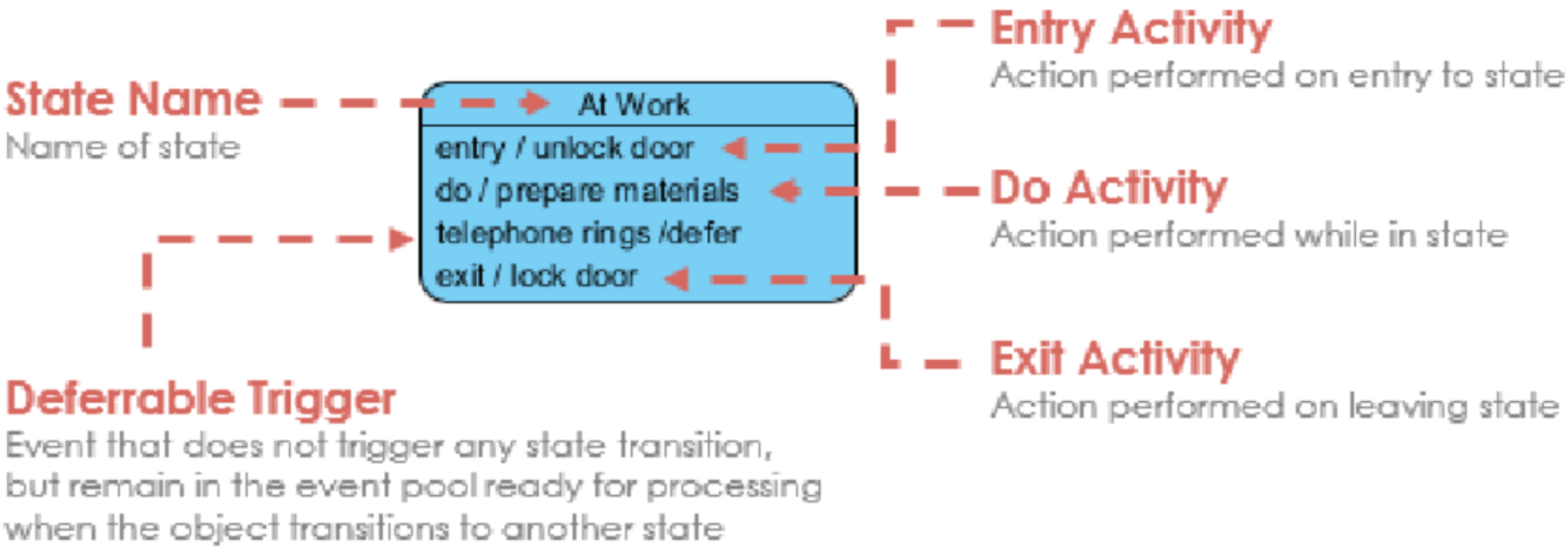
Entry Activity
Action performed on entry to state

Do Activity
Action performed while in state

Exit Activity
Action performed on leaving state

Deferrable Trigger
Event that does not trigger any state transition, but remain in the event pool ready for processing when the object transitions to another state

状态符号


State Name
Name of state
At Work
entry / unlock door
do / prepare materials
telephone rings /defer
exit / lock door
Entry Activity
Action performed on entry to state
Do Activity
Action performed while in state
Exit Activity
Action performed on leaving state
Deferrable Trigger
Event that does not trigger any state transition, but remain in the event pool ready for processing when the object transitions to another state

Example I

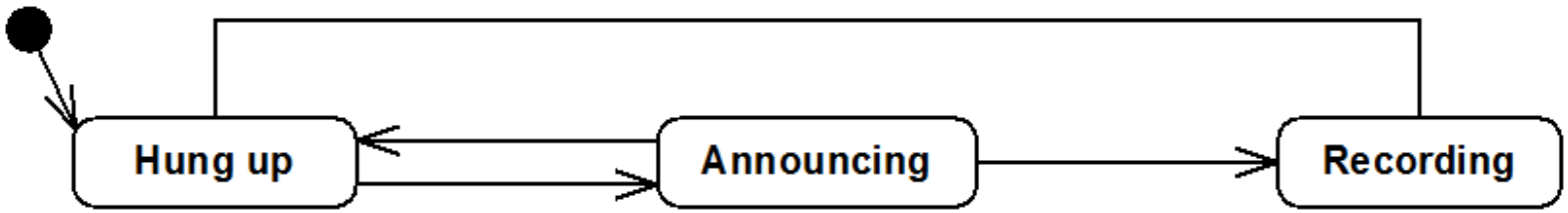
Let's think about Scholarship application

实施例一

让我们考虑一下奖学金申请

Example 2

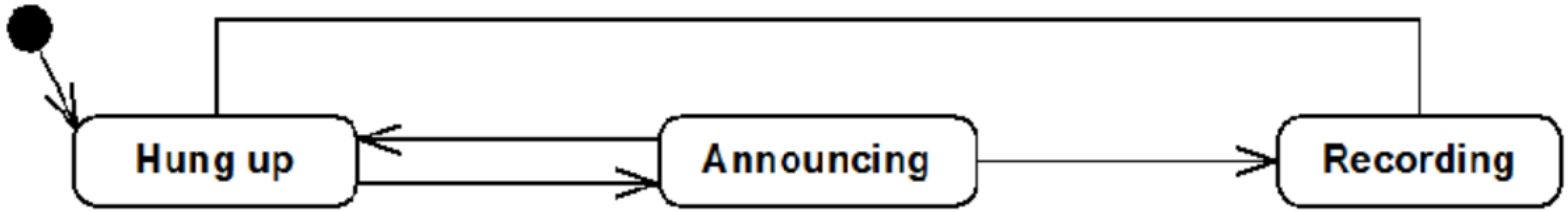
- Consider the state machine of an answering machine
  - Add the following events and actions: Call detected, Answer call, Play announcement, Record message, Caller hangs up, Announcement complete



- ***Revise the state machine so that the machine answer after five rings***

实施例2

- Consider the state machine of an answering machine
  - Add the following events and actions: Call detected, Answer call, Play announcement, Record message, Caller hangs up, Announcement complete



- 修改状态机，使机器在响铃五次后应答

Statecharts

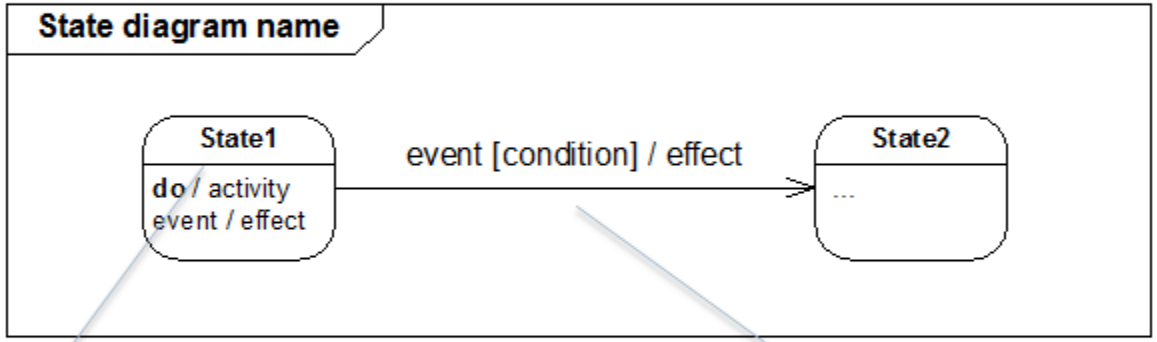
- **The statecharts notation extend state machines with:**
  - **Various types of events and conditions**
  - **State hierarchy (statecharts inside statecharts)**
  - **Concurrency**
  - **Other "cool" features we'll see…**
- **Part of UML**
- **Heavily used in SysML** (a general-purpose graphical modeling language for specifying, analyzing, designing, and verifying **complex systems**)

状态图

- 状态图符号通过以下方式扩展状态机：
  - 各种类型的事件和条件
  - 状态层次结构（状态图中的状态图）
  - 并发性
  - 我们将会看到其他“ 酷” 功能……
- 统一建模语言的一部分
- 大量用于 SysML 目的图形建模语言，用于指定、分析、设计和验证复杂系统）

Statecharts: The basics

A state model consists of one or more state diagrams

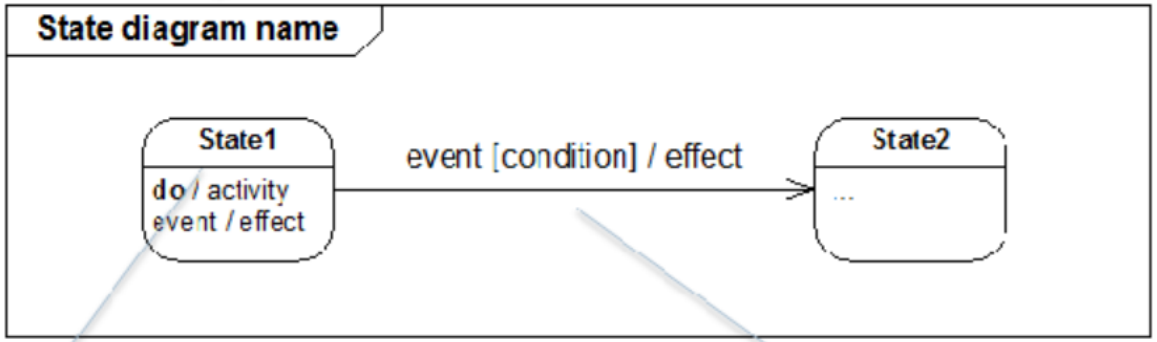


State

Transition

状态图：基础知识

A state model consists of one or more state diagrams

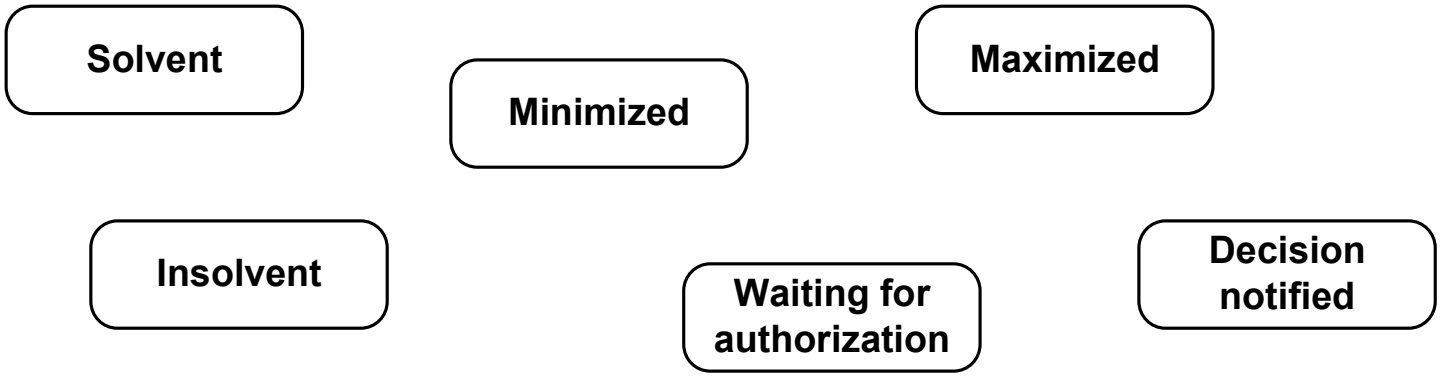


State

Transition

States

- A state is an abstraction of attribute values and links of a particular object
  - An object has a finite number of possible states
  - It can only be in one state at a time



状态

- 状态是特定对象的属性值和链接的抽象
  - 一个对象有有限数量的可能状态
  - 一次只能处于一种状态

溶剂

最小化

最大化

资不抵债

等待
授权

通知决定

Events

- An event is a "stimulus" that can trigger a state change of an object

- Kinds of events
  - Call event
  - Signal event
  - Change event
  - Time event

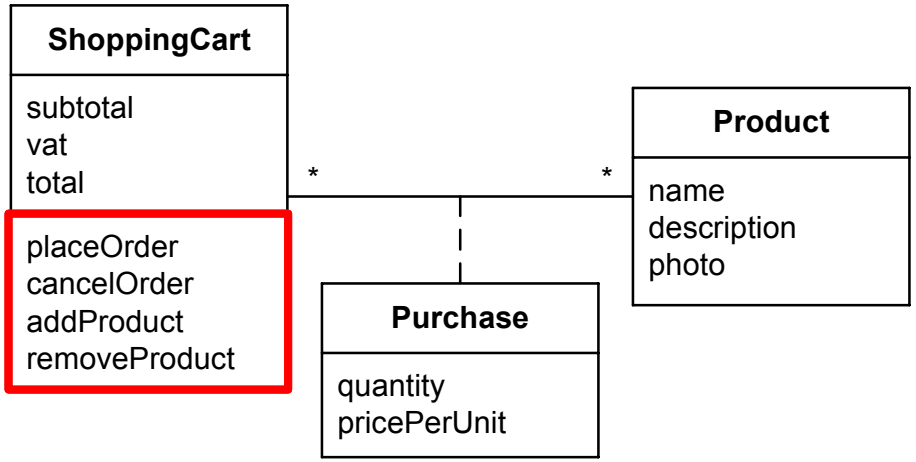
活动

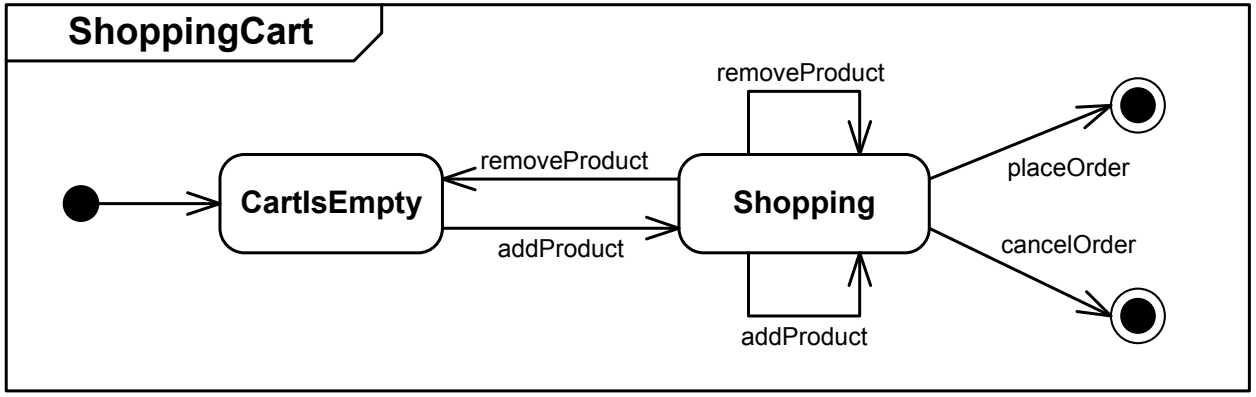
- 事件是可以触发状态变化的“ 刺激”一个物体的

- 活动种类
  - 通话事件
  - 信号事件
  - 变更事件
  - 时间事件

1. Call events

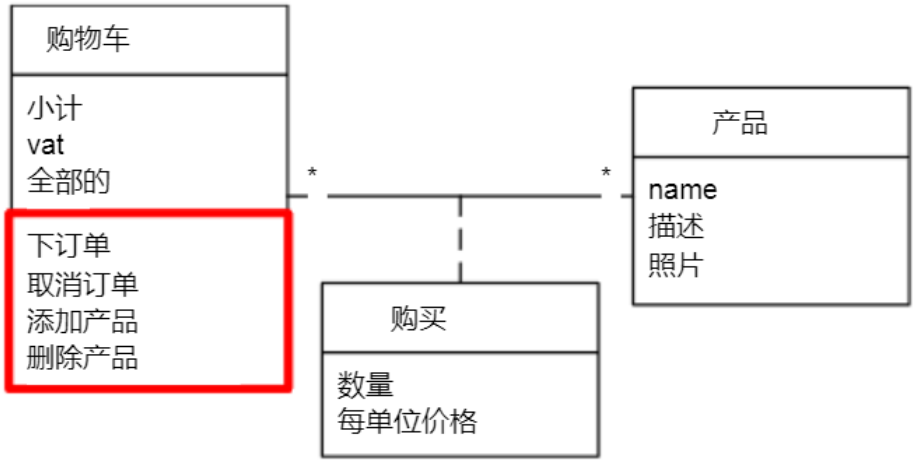
- A call event represents the reception of a request to invoke a specific operation

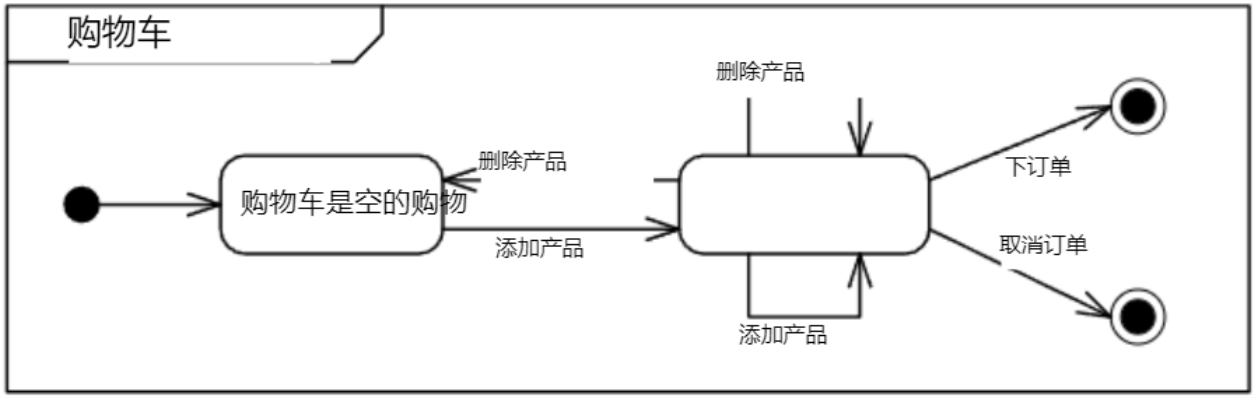




1. 调用事件21

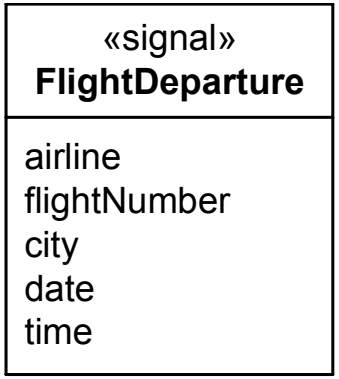
- 呼叫事件代表接待一个请求调用具体操作

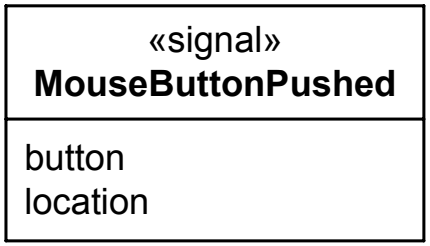


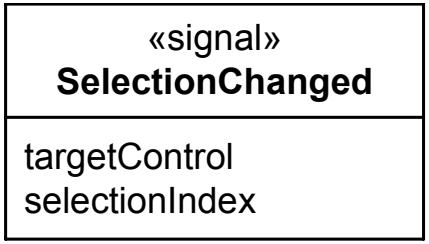


2. Signal Event

- A signal is an explicit one-way transmission of information from one object to another
  - A signal event is asynchronous
  - A call event is a two-way synchronous communication
- Signal events can be specified as UML classes

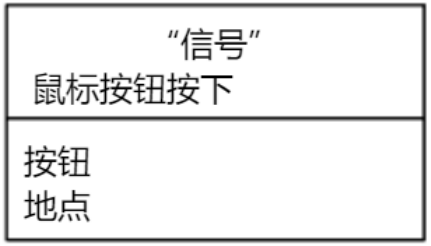


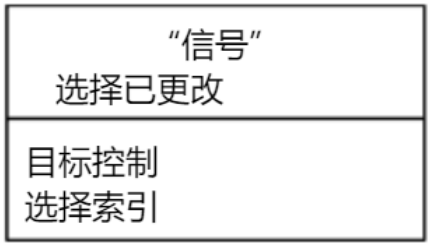




2.信号事件22

- 信号是从一个对象到另一个对象的显式单向信息传输
  - 信号事件是异步的 调用事件是双向同步通信
- 信号事件可以指定为 UML 类





3. Change events

- A change event is an event that is caused by the satisfaction of a boolean expression
  - UML specifies that the expression is continually tested
  - An implementation would not continuously check the expression, but at least often

Examples:

- when (room temperature < heating set point)
- when (room temperature > cooling set point)
- when (battery power < lower limit)
- when (tire pressure < minimum pressure)

3. 变更事件 23

- 更改事件是由布尔表达式的满足引起的事件
  - UML 指定持续测试表达式 实现不会持续检查表达式，但至少经常检查

例子：

- 当（室温 < 加热设定点）
- 当（室温>冷却设定点）
- 当（电池电量<下限）
- 当（轮胎气压 < 最低气压）

4. Time event

- A time event is an event that is caused by the occurrence of an absolute time or the elapse of a time interval

Examples absolute time:

- at (January 1, 2010)
- at (20:00)

Examples time interval:

- after (10 seconds)
- after (10 days)

4.时间事件24

- 时间事件是由于绝对时间的发生或时间间隔的流逝而引起的事件

绝对时间示例：

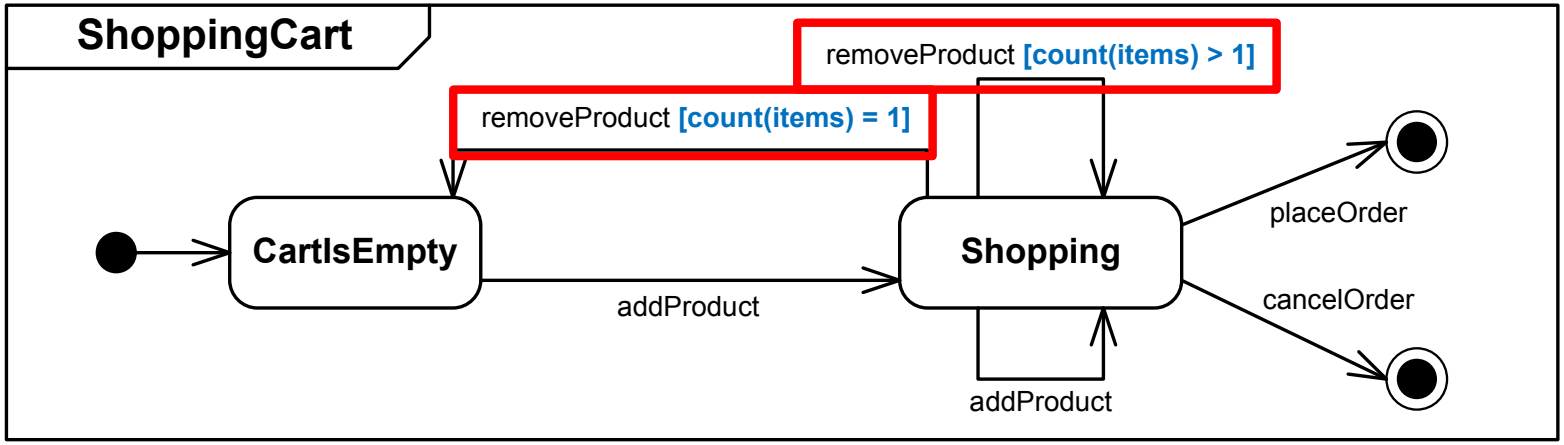
- 于（2010 年 1 月 1 日）
- 于 (20:00)

时间间隔示例：

- 之后（10 秒）
- 之后（10天）

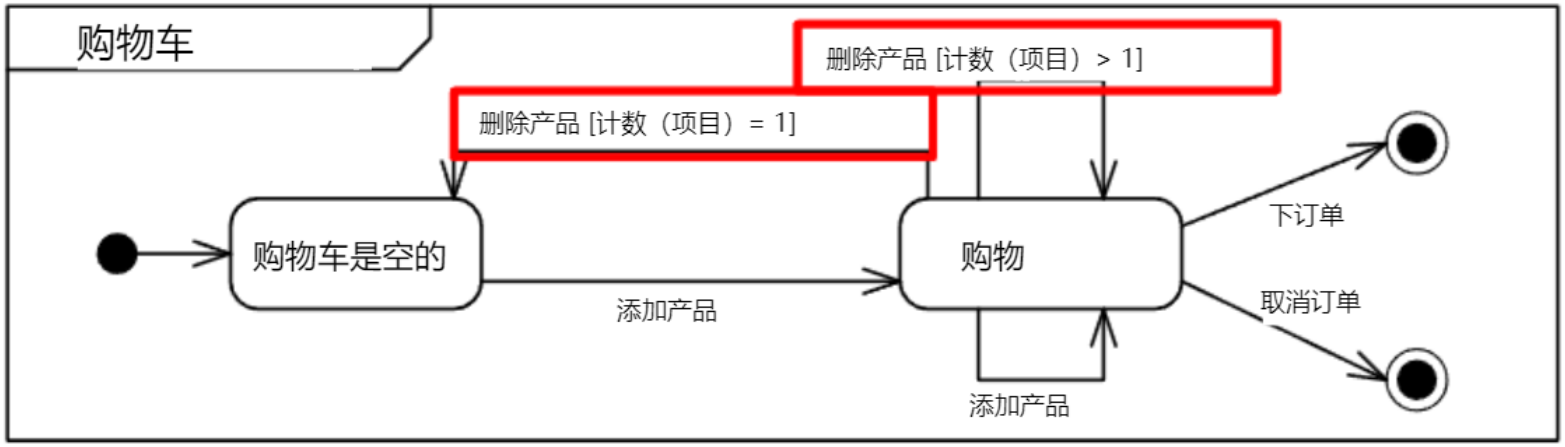
Guard conditions

- A transition is the change from one state to another
  - E.g. A phone line transitions from "Ringing" state to "Connected" when somebody picks the phone up
- A boolean expression can be used to add constraints in the firing of a transition
  - Interesting when more than one transition can be selected at a given time



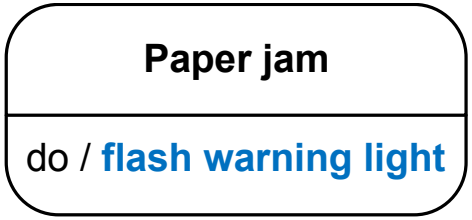
守卫条件

- 转换是从一种状态到另一种状态的变化
  - 例如。当有人拿起电话时，电话线从“响铃”状态转换为“已连接”状态
- 布尔表达式可用于在转换的触发中添加约束
  - 当在给定时间可以选择多个转换时会很有趣



Transition effects and do-activities

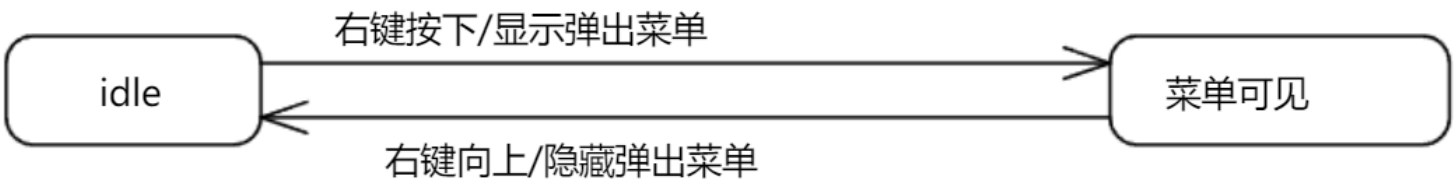
- Mealy automata actions correspond to UML statecharts' transition effects
  - A transition effect can be an assignment or the call to an operation



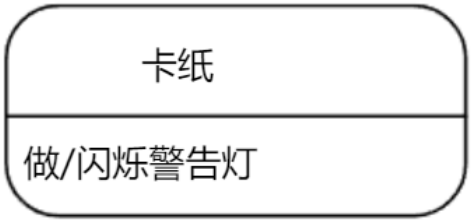
- UML statecharts can also specify actions attached to state nodes (as for Moore automata)
  - A "do-activity" is an activity that should execute continuously for an extended time

过渡效果和活动

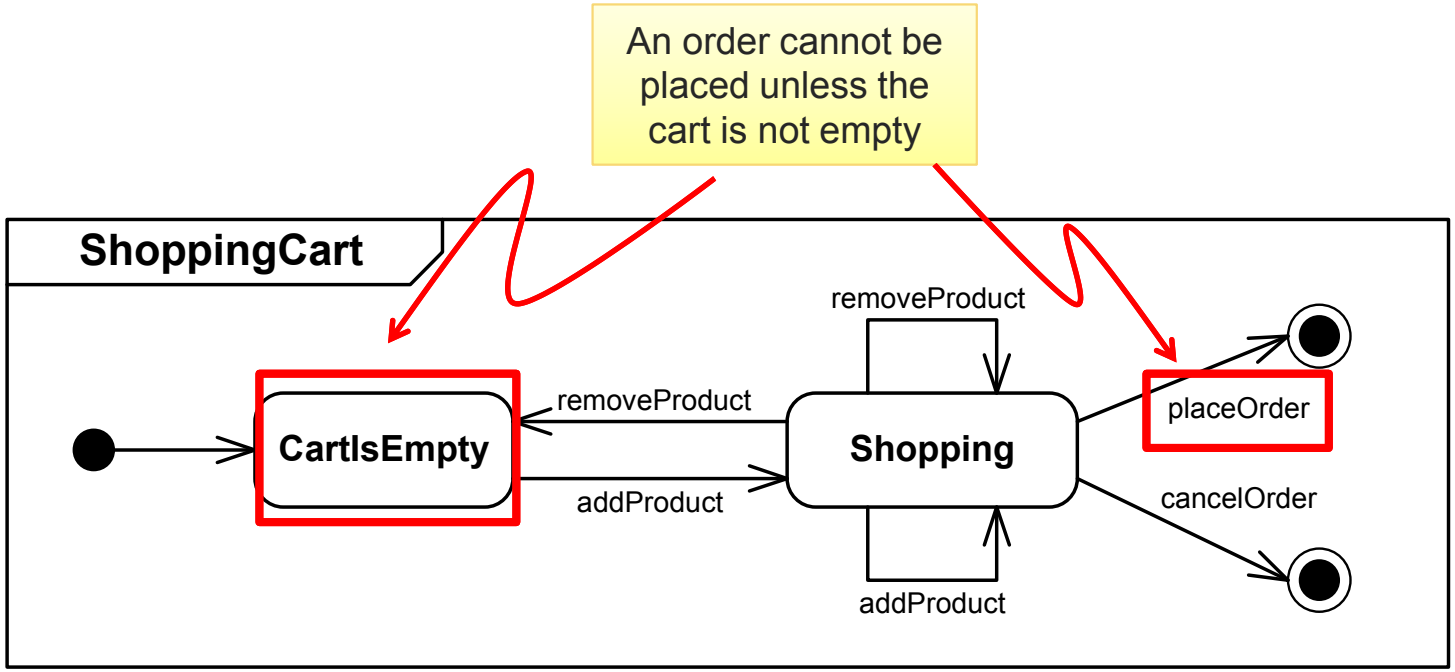
- Mealy 自动机动作对应于 UML 状态图的转换效果
  - 过渡效果可以是赋值或对操作的调用



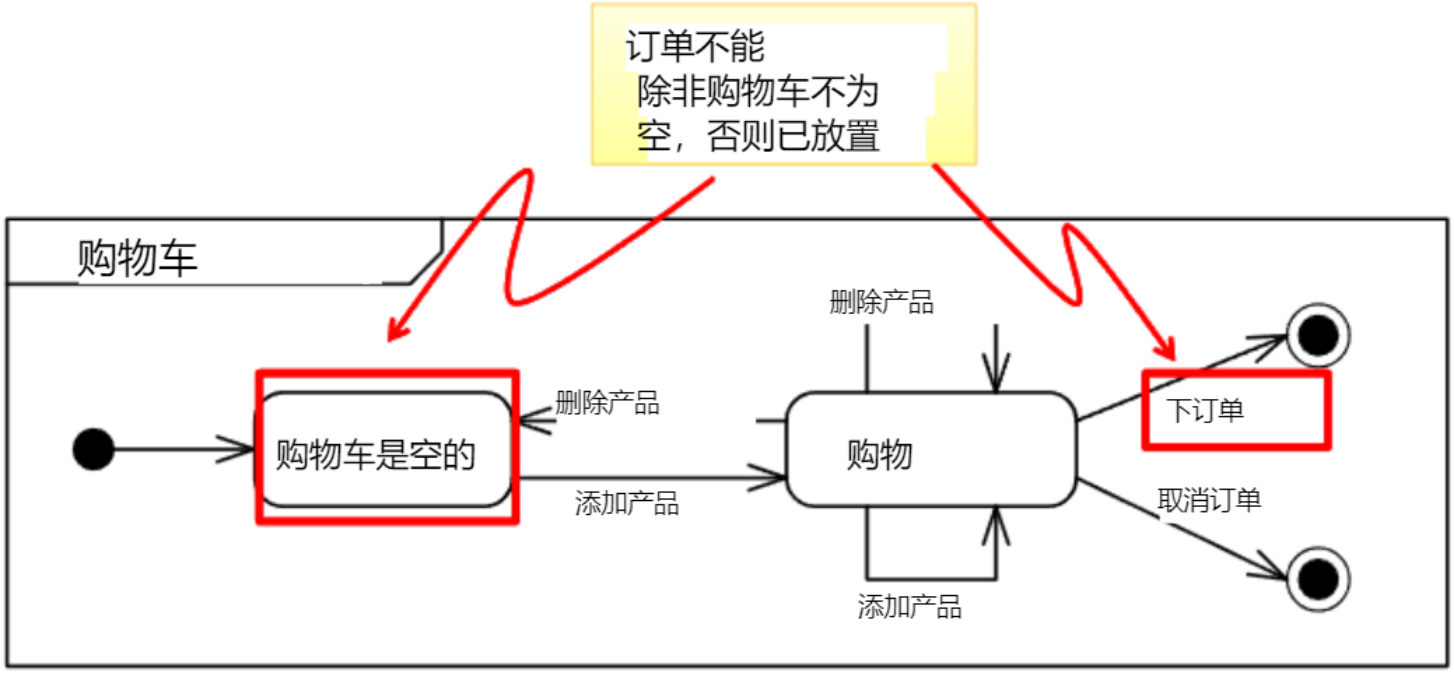
- UML 状态图还可以指定附加到状态节点的操作（对于摩尔自动机）
  - “do-activity”是一项活动应长时间连续执行



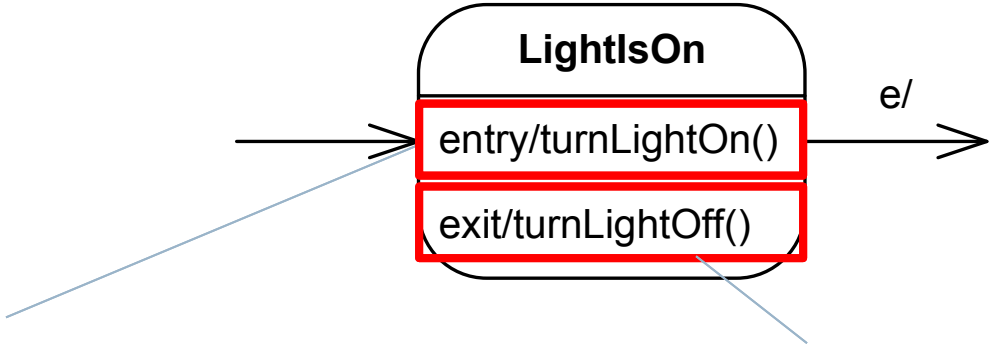
Exercise 3: complete this statechart



练习 3：完成此状态图


订单不能
除非购物车不为
空，否则已放置
购物车
删除产品
删除产品
购物车是空的
购物
下订单
添加产品
取消订单
添加产品

Entry/Exit Activities



An entry activity is performed whenever the state is entered

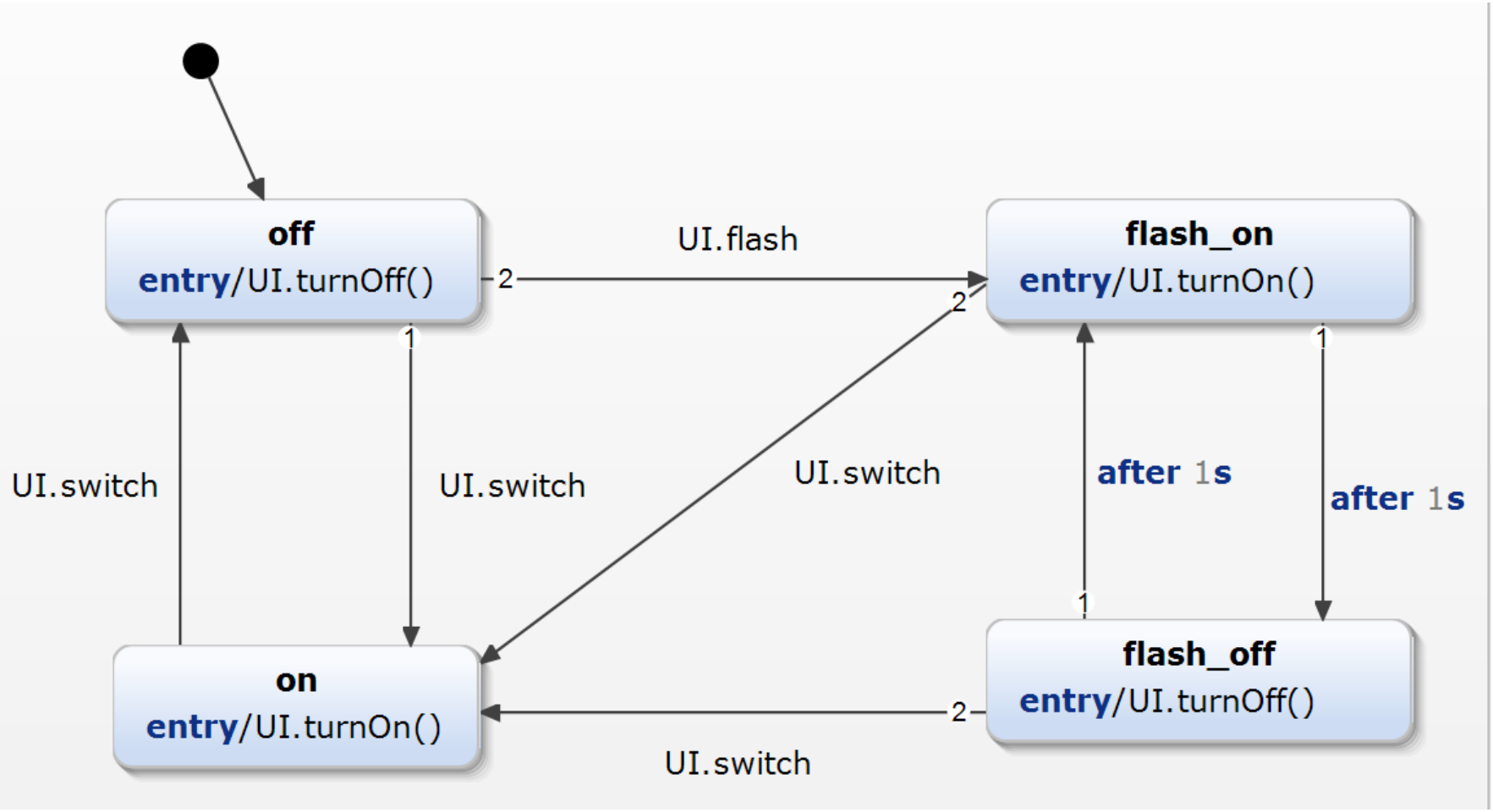
Whenever the state is exited, by any outgoing transition, the exit activity is performed first

出入境活动

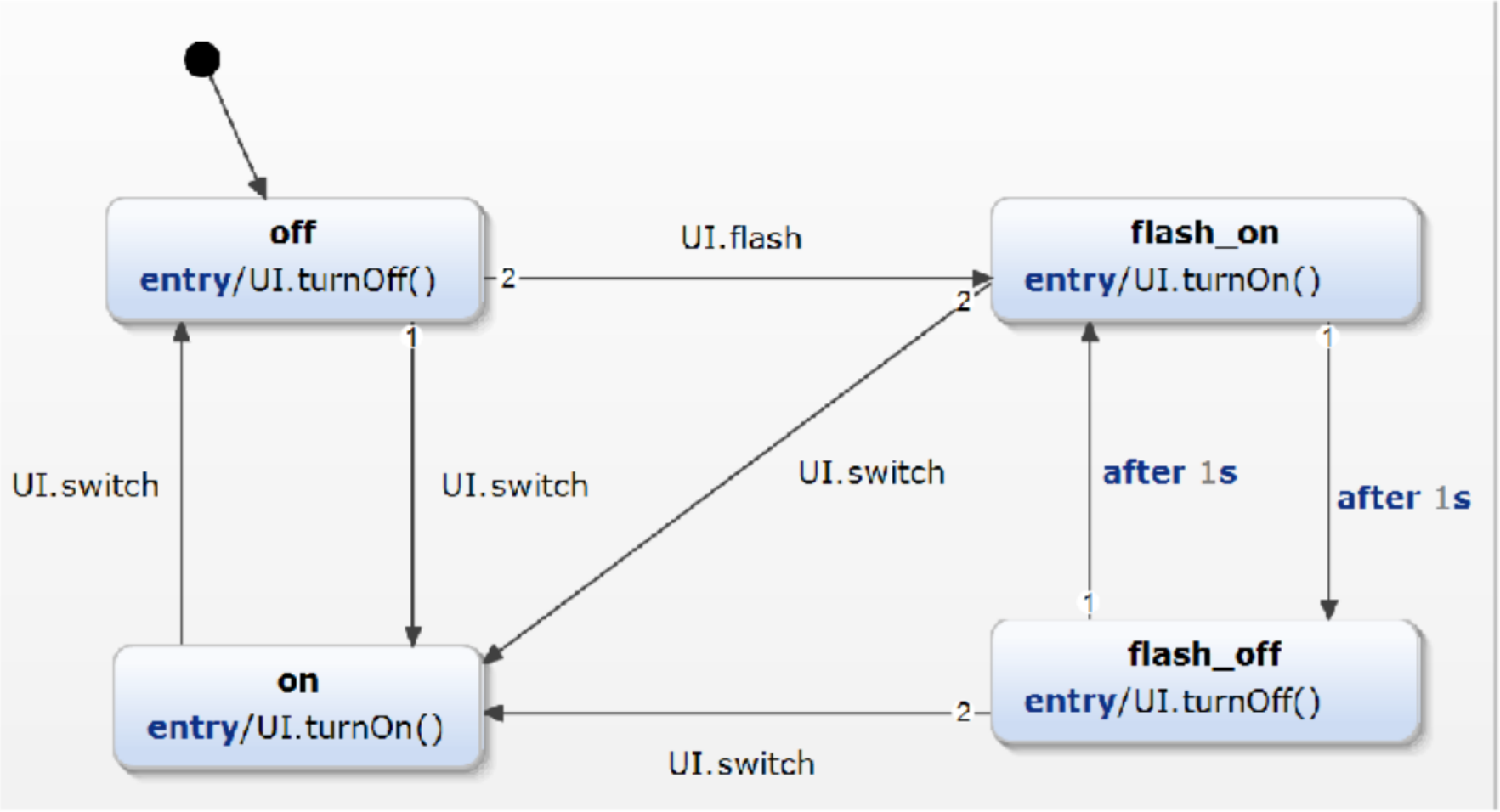
一个条目活动是
每当执行
进入状态

每当状态是
退出，通过任何传出转换，
退出活动是
首先执行

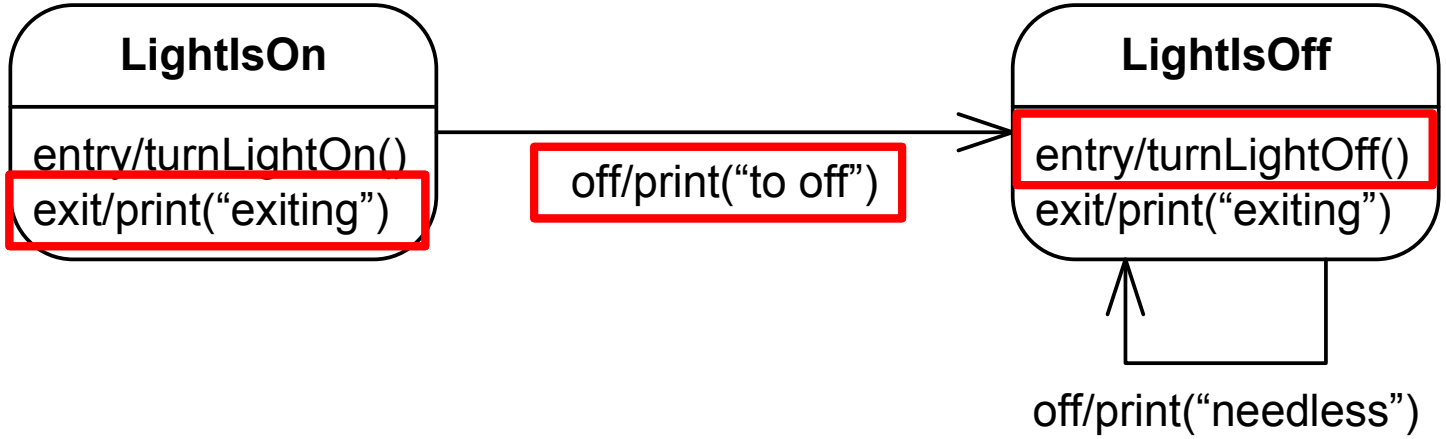
Example: Flashing Light Bulb (to be developed in the practice session)



示例：闪烁灯泡（将在练习中开发）



Order of activities



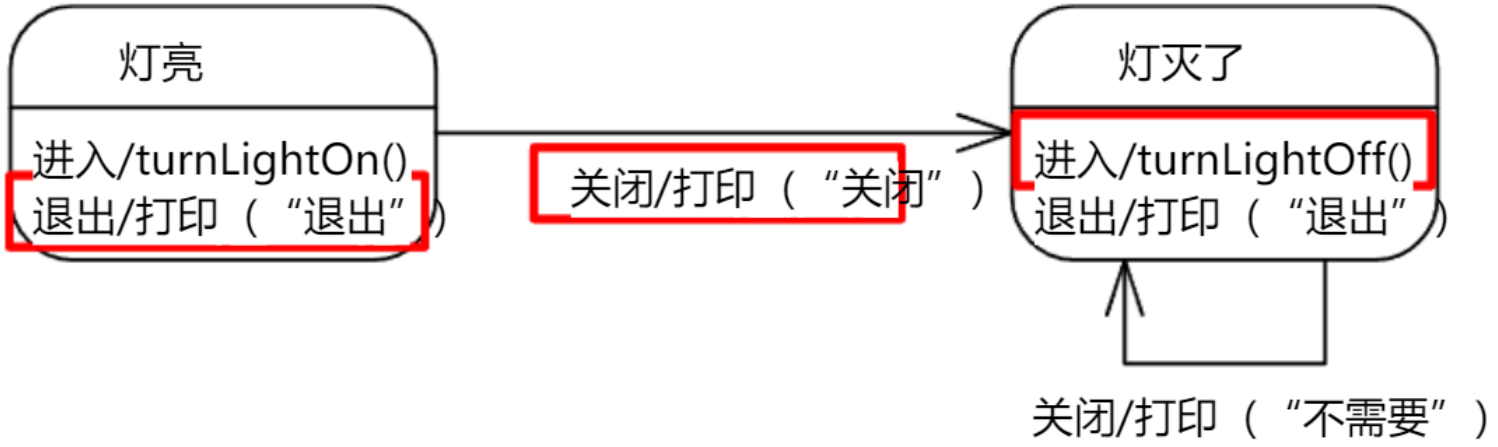
After first "off" event

- print("exiting")
- print("to off")
- turnLightOff()

After second "off" event

- print("exiting")
- print("needless")
- turnLightOff()

活动顺序



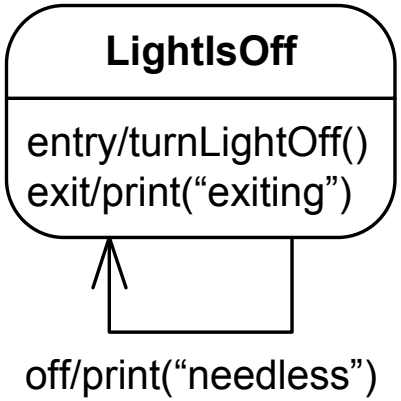
第一次“关闭”事件后

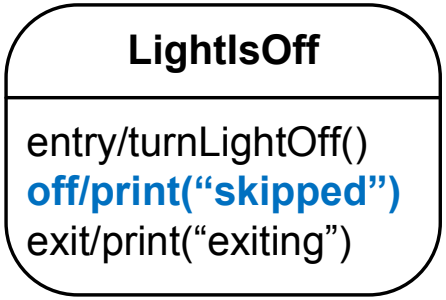
- 打印（“退出”）
- print(“关闭”)
- 关闭灯光()

第二次“关闭”事件后

- 打印（“退出”）
- 打印（“不需要”）
- 关闭灯光()

Event handling and self-loops





In this case "off" event is handled bypassing both the entry and exit activities

- print("skipped")

事件处理和自循环

在这种情况下，“关闭”事件是处理绕过两者
入口和出口
活动

- 打印（“跳过”）