SOFTWARE TESTING

苏临之

sulinzhi029@mwu.edu.cn

Four Basic Techniques

- Static Black-Box Testing
- Dynamic Black-Box Testing
- Static White-Box Testing
- Dynamic White-Box Testing

Four Basic Techniques

- **Static Black-Box Testing**
- Dynamic Black-Box Testing
- Static White-Box Testing
- Dynamic White-Box Testing

Static Black-Box Testing

- High-Level Review of the Specification
  - Pretend to be the customer
  - Research existing standards and guidelines
  - Review and test similar software
- Low-Level Review of the Specification
  - Specification attributes
  - Specification terminology

Four Basic Techniques

- Static Black-Box Testing
- **Dynamic Black-Box Testing**
- Static White-Box Testing
- Dynamic White-Box Testing

DBBT Techniques

- Equivalence Partitioning
- Boundary Value Analysis
- Decision Table
- Cause-Effect Diagram
- Error Guessing

DBBT Techniques

- **Equivalence Partitioning**
- Boundary Value Analysis
- Decision Table
- Cause-Effect Diagram
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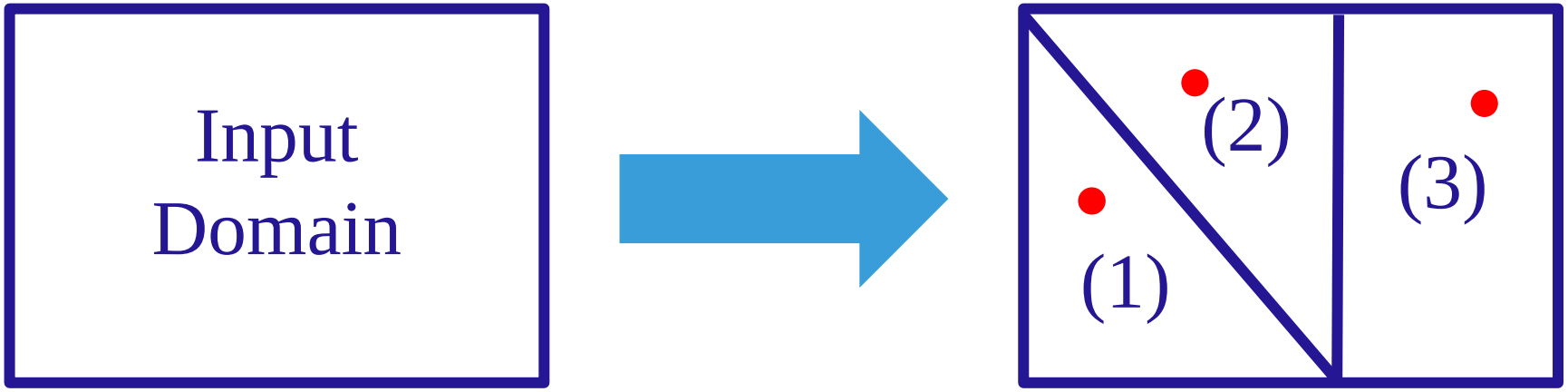
Equivalence Partitioning



Basic Principles

- Value Range: one VEC & two IECs
- Value Number: one VEC & two IECs
- Multiple Branching: one VEC for each branch value & one IEC
- "Must-Be": one VEC & one IEC
- If the elements are thought to be treated unequally for any reason, or if an EC is too general, then we should divide it into some smaller ECs.

Additional Principles

- If the condition contains the OR relationship, whether valid or invalid, we usually establish several dependent ECs; provided the relationship is AND, a further consideration is needed.
- "*n* numeric characters" indicates both "numerical digit equals *n*" and "must be numeric characters". By using the NOT operation, three IECs should be established.
- Multiple branches can also be expressed as "must be A, B or C".
- A special requirement for the numerical digit can be translated into the numerical value range.
- Sometimes the De Morgan's laws will facilitate the analysis.

Example 1

- **Description**

  某城市的电话号码由三部分组成。这三部分的名称和内容分别是:

  地区码：空白或3位数字;
  前　缀：非“0”或“1”开头的3位数;
  后　缀：4位数字。

- **The program accepts all the telephone numbers that conform to the terms above and rejects all that does not. Please design test cases by using the equivalence partitioning technique.**

Valid Equivalence Class

地区码 { ① 空白
② 3位数字

前缀 ③ 200~999之间的3位数

后缀 ④ 4位数字

Invalid Equivalence Class

地区码：⑤ 有非数字字符；⑥ 多于3位；⑦ 少于3位；

前缀：⑧ 有非数字字符；⑨ 多于3位；⑩ 少于3位；

⑪ 起始位是“0”；⑫ 起始位是“1”；

后缀：⑬ 有非数字字符；⑭ 多于4位；⑮ 少于4位；

Equivalence Class List

	有效等价类	无效等价类
地区码	空白 ① 3位数字 ②	有非数字字符 ⑤ 多于3位 ⑥ 少于3位 ⑦
前缀	200~999的3位数 ③	有非数字字符 ⑧ 多于3位 ⑨ 少于3位 ⑩ 起始位是“0” ⑪ 起始位是“1” ⑫
后缀	4位数字 ④	有非数字字符 ⑬ 多于4位 ⑭ 少于4位 ⑮

Legal Test Cases

测试用例	期望结果	覆盖范围
( ) 456-7890	输入有效	①③④
(029) 345-6789	输入有效	②③④

Illegal Test Cases

测试用例	期望结果	覆盖范围
(29z) 123-4567	输入无效	⑤
(29) 234-5678	输入无效	⑥
(0291) 345-6789	输入无效	⑦
(029) 34z-6789	输入无效	⑧
(029) 34-6789	输入无效	⑨
(029) 2345-6789	输入无效	⑩
(029) 045-6789	输入无效	⑪
(029) 145-6789	输入无效	⑫
(029) 345-678s	输入无效	⑬
(029) 345-678	输入无效	⑭
(029) 345-56789	输入无效	⑮

DBBT Techniques

- Equivalence Partitioning
- **Boundary Value Analysis**
- Decision Table
- Cause-Effect Diagram
- Error Guessing

Example 2

- **Description**

  Here is a function of two variables $F=(x+2)\times y$ where x and y are two integers. $x \in [10, 20]$ and $y \in [20,30]$. The software has guaranteed the integral inputs.

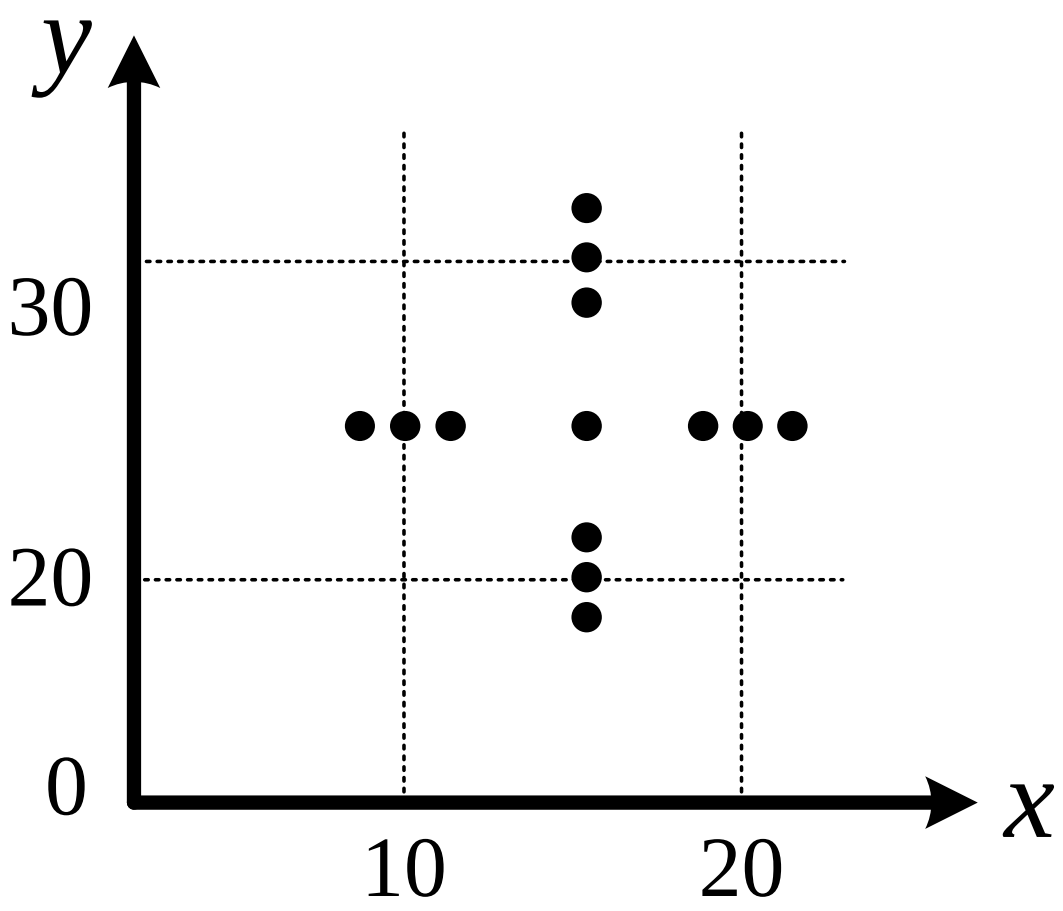
- **Please design test cases by using boundary value analysis. First give out the graphical analysis and then show the test case list.**

Equivalence Class List

	有效等价类	无效等价类
x	10至20的整数 ①	小于10的整数 ③ 大于20的整数 ④
y	20至30的整数 ②	小于20的整数 ⑤ 大于30的整数 ⑥

Analysis

序号	*x*	*y*	*F*
①	15	25	425
②	10	25	300
③	11	25	325
④	19	25	525
⑤	20	25	550
⑥	15	20	340
⑦	15	21	357
⑧	15	29	493
⑨	15	30	510
⑩	9	25	×
⑪	15	31	×
⑫	21	25	×
⑬	15	19	×



Limitations

- Boundary value analysis is the complement of the equivalence partitioning. But when it comes to the case where variables are limited by causalities or logical relationships (say $x + y \leq 50$), it will not be easy to use those techniques.
- To solve the problem, the decision table techniques can be employed. To facilitate generating some complicated decision tables, the cause-effect diagram will also be adopted.

DBBT Techniques

- Equivalence Partitioning
- Boundary Value Analysis
- **Decision Table**
- Cause-Effect Diagram
- Error Guessing

Decision Table

- A decision table is usually employed to describe the cases where **the input variables are logical concerned or the inputs and outputs are limited by causalities (输入变量之间存在逻辑关系或输入输出之间存在因果关系)**.
- A decision table consist of two parts. One is the input condition part and the other is the output action part. These two parts involves two kinds of stubs and their corresponding binary logical value.

Example 3

- **Description**
  - 某企业的报表处理系统要求用户输入处理报表的日期，日期限制在2003年1月至2008年12月，即系统只能对该段期间内的报表进行处理，如日期不在此范围内，则显示输入错误信息。输入信息要求：系统日期规定由表征年、月的6位数字字符组成，前4位代表年，后2位代表月。
- **Please design test cases to check the function for date input by using the decision table technique.**

Establishing the Condition Part

- The inputs involve three basic elements, which are called the **condition stubs (条件桩)**.

  C1: 6位数字字符；C2: 前4位范围2003~2008；
  C3: 后2位范围01~12。

- These three condition stubs can all value True or False logically. The corresponding values (T or F) are called condition terms. Here we have 3 condition stubs, so the combination number is $2^3=8$. By listing the 8 combinations can we establish the condition part in the decision table.

Establishing the Condition Part

- The inputs involve three basic elements, which are called the **condition stubs (条件桩)**.

C1: 6位数字字符；C2: 前4位范围2003~2008；
C3: 后2位范围01~12。

		1	2	3	4	5	6	7	8
条件部分	C1: 6位数字字符	T	T	T	T	F	F	F	F
	C2: 前4位范围2003~2008	T	T	F	F	T	T	F	F
	C3: 后2位范围01~12	T	F	T	F	T	F	T	F

Establishing the Action Part

- The outputs for condition combinations involve two possible results, i.e. the **action stubs (动作桩)**.

  A1: 对应报表信息；A2: 报错。

		1	2	3	4	5	6	7	8
条件部分	C1: 6位数字字符	T	T	T	T	F	F	F	F
	C2: 前4位范围2003~2008	T	T	F	F	T	T	F	F
	C3: 后2位范围01~12	T	F	T	F	T	F	T	F
动作部分	A1: 对应报表信息	√							
	A2: 报错		√	√	√	√	√	√	√

Merging the Arbitrary Terms

- It can be observed that if C1=F, the result must be A2 no matter how C2 and C3 vary. These arbitrary terms can be merged.

		1	2	3	4	5	6	7	8
条件部分	C1: 6位数字字符	T	T	T	T	F	F	F	F
	C2: 前4位范围2003~2008	T	T	F	F	T	T	F	F
	C3: 后2位范围01~12	T	F	T	F	T	F	T	F
动作部分	A1: 对应报表信息	√							
	A2: 报错		√	√	√	√	√	√	√

Merging the Arbitrary Terms

- After merging, there are actually only five combinations. Merging is one of the methods for simplifying the decision table.

		1	2	3	4	5
条件部分	C1: 6位数字字符	T	T	T	T	F
	C2: 前4位范围2003~2008	T	T	F	F	-
	C3: 后2位范围01~12	T	F	T	F	-
动作部分	A1: 对应报表信息	√				
	A2: 报错		√	√	√	√

Final Decision Table

- The final decision table is generated after the simplification step.

		1	2	3	4	5
条件部分	C1: 6位数字字符	T	T	T	T	F
	C2: 前4位范围2003~2008	T	T	F	F	-
	C3: 后2位范围01~12	T	F	T	F	-
动作部分	A1: 对应报表信息	√				
	A2: 报错		√	√	√	√

Designing Test Cases

- According to the five combinations of condition stubs, five corresponding test cases can be designed as follows.

1、200405
2、200400
3、200905
4、200900
5、2004May

Example 4

- **Description**
  - 程序从一个输入对话框中读取3个正整数值。这3个整数值代表了三角形三边的长度。程序显示提示信息，指出该三角形究竟是不等边三角形、等腰三角形还是等边三角形。
- **Please design test cases by using the decision table technique.**

Establishing the Condition Part

- Five condition stubs.

C1: 3个正整数；C2: 可以构成三角形；C3: 三边均不等；
C4: 三边仅两边相等；C5: 三边均相等。

Establishing the Condition Part

- It is quite easy to pre-estimate the result and thus recognize the arbitrary terms. So they can be merged in advance.

		1	2	3	4	5	6	7	8	9	10
条件部分	C1: 3个正整数	F	T	T	T	T	T	T	T	T	T
	C2: 可以构成三角形	-	F	T	T	T	T	T	T	T	T
	C3: 三边均不等	-	-	T	F	F	T	F	T	F	T
	C4: 三边仅两边相等	-	-	F	T	F	T	T	F	F	T
	C5: 三边均相等	-	-	F	F	T	F	T	T	F	T

Eliminating the Impossible Terms

- There is one and only one occurrence in terms of C3, C4 and C5. Hence, some combinations are impossible and should be eliminated.

		1	2	3	4	5	6	7	8	9	10
条件部分	C1: 3个正整数	F	T	T	T	T	T	T	T	T	T
	C2: 可以构成三角形	-	F	T	T	T	T	T	T	T	T
	C3: 三边均不等	-	-	T	F	F	T	F	T	F	T
	C4: 三边仅两边相等	-	-	F	T	F	T	T	F	F	T
	C5: 三边均相等	-	-	F	F	T	F	T	T	F	T

Eliminating the Impossible Terms

- Elimination of the impossible terms is another method for simplification.

		1	2	3	4	5
条件部分	C1: 3个正整数	F	T	T	T	T
	C2: 可以构成三角形	-	F	T	T	T
	C3: 三边均不等	-	-	T	F	F
	C4: 三边仅两边相等	-	-	F	T	F
	C5: 三边均相等	-	-	F	F	T

Establishing the Action Part

		1	2	3	4	5
条件部分	C1: 3个正整数	F	T	T	T	T
	C2: 可以构成三角形	-	F	T	T	T
	C3: 三边均不等	-	-	T	F	F
	C4: 三边仅两边相等	-	-	F	T	F
	C5: 三边均相等	-	-	F	F	T
动作部分	A1: 不是三角形		√			
	A2: 不等边三角形			√		
	A3: 等腰三角形				√	
	A4: 等边三角形					√
	A5: 报错	√				

Another Decision Table

- If we don't consider the illegal inputs, the following four condition stubs can be generated through analysis.

C1: 可构成三角形；C2: a=b；C3: a=c；C4: b=c。

		1	2	3	4	5	6	7	8	9
条件部分	C1:可构成三角形	F	T	T	T	T	T	T	T	T
	C2: a=b	-	F	F	F	F	T	T	T	T
	C3: a=c	-	F	F	T	T	F	F	T	T
	C4: b=c	-	F	T	F	T	F	T	F	T

Another Decision Table

- Three combinations are impossible (no corresponding result) and thus are eliminated.

		1	2	3	4	5	6	7	8	9
条件部分	C1:可构成三角形	F	T	T	T	T	T	T	T	T
	C2: a=b	-	F	F	F	F	T	T	T	T
	C3: a=c	-	F	F	T	T	F	F	T	T
	C4: b=c	-	F	T	F	T	F	T	F	T

Another Decision Table

- Three combinations are impossible (no corresponding result) and thus are eliminated.

		1	2	3	4	5	6
条件部分	C1:可构成三角形	F	T	T	T	T	T
	C2: a=b	-	F	F	F	T	T
	C3: a=c	-	F	F	T	F	T
	C4: b=c	-	F	T	F	F	T

Another Decision Table

- The final decision table is shown below.

		1	2	3	4	5	6
条件部分	C1:可构成三角形	F	T	T	T	T	T
	C2: a=b	-	F	F	F	T	T
	C3: a=c	-	F	F	T	F	T
	C4: b=c	-	F	T	F	F	T
动作部分	A1: 不是三角形	√					
	A2: 不等边三角形		√				
	A3: 等腰三角形			√	√	√	
	A4: 等边三角形						√

Some Refined Conditions

- Actually the conditions can be further refined.

C1: a∈**N***； C2: b∈**N*** ； C3: c∈**N*** ；
C4: a<b+c； C5: b<a+c； C6: c<a+b；
C7: a=b； C8: a=c； C9: b=c。

- Theoretically, there are 2^9=512 combinations. Please consider: how many actual combinations are there after simplification.

Procedure Summary

- 首先确定各个条件桩和动作桩；
- 对于可以预见的任意项加以合并，并对不可能并存的条件桩组合加以删除；
- 根据条件桩的组合和题目要求，画出对应输出了哪些动作桩。
- 检查判定表，根据最后的结果再次合并无关项；
- 根据判定表的条件桩组合给出测试用例，以检查结果是否和动作桩组合相一致。

Example 5

- **Description**
  - 订购单的检查软件测试。如果金额超过500元，又未过期，则发出批准单和提货单；如果金额超过500元，但过期了，则只发通知单；如果金额低于500元，则不论是否过期都发出批准单和提货单，在过期的情况下还需要发出通知单。
- **Please first consider the reason why it is appropriate to use the decision table technique. Then generate the original and simplified decision table.**

Establishing the Condition Part

- Two condition stubs.

C1:订单大于500元；C2: 订单未过期。

		1	2	3	4
条件部分	C1: 订单大于500元	T	T	F	F
	C2: 订单未过期	T	F	T	F

Establishing the Action Part

- Three action stubs.

A1: 发批准单；A2: 发提货单；A3: 发通知单。

		1	2	3	4
条件部分	C1: 订单大于500元	T	T	F	F
	C2: 订单未过期	T	F	T	F
动作部分	A1: 发批准单	√		√	√
	A2: 发提货单	√		√	√
	A3: 发通知单		√		√

Simplification

- Find the action term which shares the same results, and then check the corresponding condition stubs.

		1	2	3	4
条件部分	C1: 订单大于500元	T	T	F	F
	C2: 订单未过期	T	F	T	F
动作部分	A1: 发批准单	√		√	√
	A2: 发提货单	√		√	√
	A3: 发通知单		√		√

Final Simplified Decision Table

		1	2	3
条件部分	C1: 订单大于500元	-	T	F
	C2: 订单未过期	T	F	F
动作部分	A1: 发批准单	√		√
	A2: 发提货单	√		√
	A3: 发通知单		√	√

- Tip: if one can not recognize the arbitrary term(s) directly in advance, it is OK to list out the original decision table.

DBBT Techniques

- Equivalence Partitioning
- Boundary Value Analysis
- Decision Table
- **Cause-Effect Diagram**
- Error Guessing

Cause-Effect Diagram

- The cause-effect diagram (CED), or cause-and-effect diagram in some literature, is used to describe the test issue where multiple inputs are involved. At the same time, the CED is also able to point out the imperfection and ambiguousness in the specification.
- The CED is usually employed before the generation of the decision table. The process from a CED to a decision table can be achieved manually, but when it comes to some complicated issues, it is usually achieved by automatic tools.

Example 6

- **Description**
  - 程序的规格说明要求：输入的第1个字符必须是#或*，第2个字符必须是一个数字，此情况下进行对应文件的修改；如果第一个字符不是#或*，则给出报错信息X，如果第二个字符不是数字，则给出报错信息Y。
- **Please draw the cause-effect diagram and transfer it into a decision table. Then design the corresponding test cases.**

Causes and Effects

- Each single input is viewed as a **cause (原因)**, and each output is an **effect (结果)**.

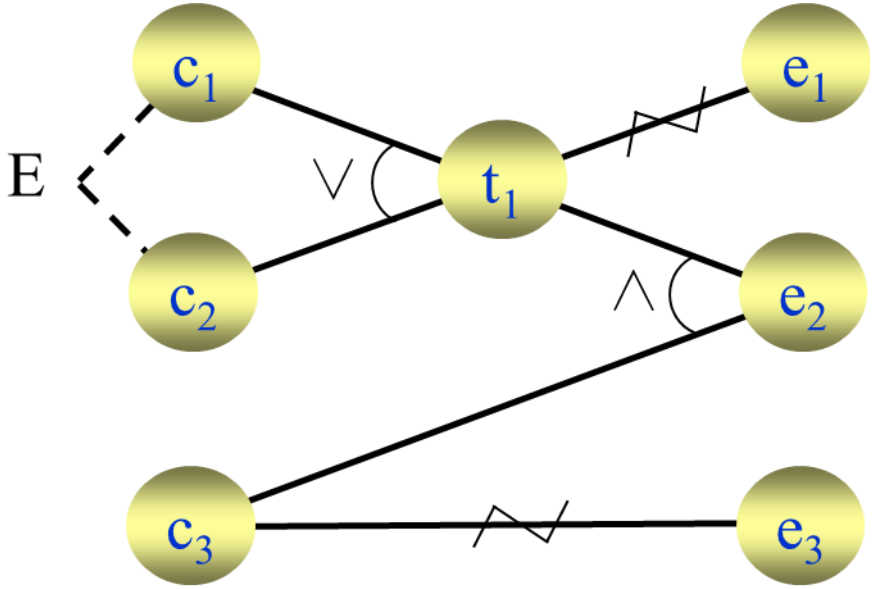
- 原因：
  c_1: 第1字符是#；
  c_2: 第1字符是*；
  c_3: 第2字符是数字。

- 结果：
  e_1: 报错信息X；
  e_2: 修改文件；
  e_3: 报错信息Y。

Basic Relationships and Constraints

- There are four basic relationships between the causes and the effects: **Equal (恒等关系)**, **Not (非关系)**, **Or (或关系)** & **And (与关系)**.
- There are five basic constraints among the causes or among the effects. For input causes, the four constraints are: **Exclusive (异约束, E)**, **Inclusive (或约束, I)**, **Only one (唯一约束, O)** & **Require (要求约束, R)**. For output effects, there is only one constraint: **Mask (强制约束/屏蔽约束, M)**.

Draw the CED



- According to the description as well as the basic relationships and constraints, the CED can be drawn as shown above.

Decision Table and Test Cases

		1	2	3	4	5	6
条件部分	c_1: 第1个字符是#	T	T	F	F	F	F
	c_2: 第1个字符是*	F	F	T	T	F	F
	c_3: 第2个字符是数字	T	F	T	F	T	F
动作部分	e_1: 报错信息X					√	√
	e_2: 修改文件	√		√			
	e_3: 报错信息Y		√		√		√
测试用例		#3	#A	*9	*b	T2	ZS

Homework-1

- **Description**

  某银行发放贷款原则如下：

  1、对于贷款未超过限额的客户，允许立即贷款。

  2、对于贷款超过限额的客户，若过去还款记录好且本次贷款在2万元以下，可作出贷款安排；否则拒绝贷款。

- **Please generate the decision table and simplify it (if necessary).**

Homework-2

- **Description**

  某国内快递公司寄包裹收费如下：若收件地点在偏远地区（如新疆、西藏等地），普通件每公斤2.5元，挂号件每公斤3.5元；若收件地点在非偏远地区，普通件每公斤2元，挂号件每公斤3元。上述两种情况中，若重量大于30公斤，超重部分每公斤加收0.5元。使用W表示重量，Q表示费用。

- **Please generate the decision table and simplify it (if necessary).**

THANK YOU!