SOFTWARE TESTING

苏临之

sulinzhi029@nwu.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

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
- Error Guessing

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
- 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**.
- 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 1

- **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 **condition stubs**.

		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 **action stubs**.

		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

		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		√	√	√	√	√	√	√

Final 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		√	√	√	√

Example 2

- **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

		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

		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

		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 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		√	√

Procedure

- 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，以查看结果是否和动作桩组合相一致。

Example 3

- **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).**

Establishing the Condition Part

C1: 贷款未超过限额；C2: 过去还款记好；
C3: 本次贷款在2万元以内。

		1	2	3	4	5	6	7	8
条件部分	C1: 贷款未超过限额	T	T	T	T	F	F	F	F
	C2: 过去还款记录好	T	T	F	F	T	T	F	F
	C3: 本次贷款在2万以内	T	F	T	F	T	F	T	F

Establishing the Action Part

A1: 立即贷款；A2: 做出贷款安排；A3: 拒绝贷款。

		1	2	3	4	5	6	7	8
条件部分	C1: 贷款未超过限额	T	T	T	T	F	F	F	F
	C2: 过去还款记录好	T	T	F	F	T	T	F	F
	C3: 本次贷款在2万以内	T	F	T	F	T	F	T	F
动作部分	A1: 立即贷款	√	√	√	√				
	A2: 做出贷款安排					√			
	A3: 拒绝贷款						√	√	√

Simplification

		1	2	3	4	5	6	7	8
条件部分	C1: 贷款未超过限额	T	T	T	T	F	F	F	F
	C2: 过去还款记录好	T	T	F	F	T	T	F	F
	C3: 本次贷款在2万以内	T	F	T	F	T	F	T	F
动作部分	A1: 立即贷款	√	√	√	√				
	A2: 做出贷款安排					√			
	A3: 拒绝贷款						√	√	√

Final Simplified Decision Table

		1	2	3	4
条件部分	C1: 贷款未超过限额	T	F	F	F
	C2: 过去还款记录好	-	T	T	F
	C3: 本次贷款在2万以内	-	T	F	-
动作部分	A1: 立即贷款	√			
	A2: 做出贷款安排		√		
	A3: 拒绝贷款			√	√

Example 4

- **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).**

Condition and Action Stubs

- Condition Stubs:

C1: 普通件；C2: W≤30；C3: 非偏远地区。

- Action Stubs:

A1: Q=2W； A2: Q=3W； A3: Q=2.5W； A4: Q=3.5W；
A5: Q=2×30+ (W-30)×2.5； A6: Q=3×30+(W-30)×3.5；
A7: Q=2.5×30+ (W-30)×3； A8: Q=3.5×30+(W-30)×4；

Final Decision Table

		1	2	3	4	5	6	7	8
条件部分	C1: 普通件	T	F	T	F	T	F	T	F
	C2: W≤30	T	T	T	T	F	F	F	F
	C3:非偏远地区	T	T	F	F	T	T	F	F
动作部分	A1: Q = 2×W	√							
	A2: Q = 3×W		√						
	A3: Q = 2.5×W			√					
	A4: Q = 3.5×W				√				
	A5: Q = 2×30+(W-30)×2.5					√			
	A6: Q = 3×30+(W-30)×3.5						√		
	A7: Q = 2.5×30+(W-30)×3							√	
	A8: Q = 3.5×30+(W-30)×4								√

DBBT Techniques

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

Cause-Effect Diagram

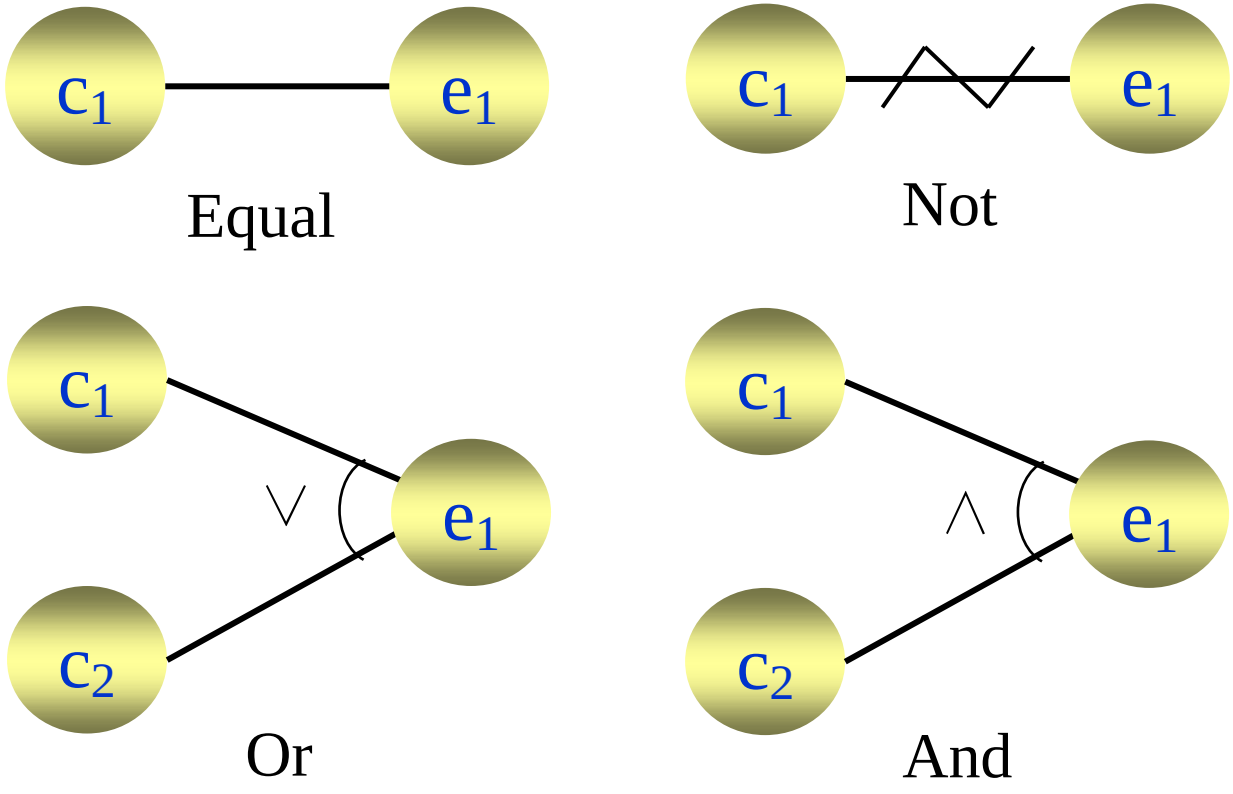
- The cause-effect diagram (CED), is used to describe the test issue where multiple inputs are involved. At the same time, the CED is also able to point out the imperfection and ambiguousness in the specification.
- Each single input is a **cause**, and each single output is an **effect**. They are shown as follows.

Basic Relationships and Constraints

- There are four basic relationships between the causes and the effects: **Equal**, **Not**, **Or** & **And**.
- There are five basic constraints among the causes or among the effects. For input causes, the four constraints are: **Exclusive (E)**, **Inclusive (I)**, **Only one (O)** & **Require (R)**. For output effects, there is only one constraint: **Mask (M)**.

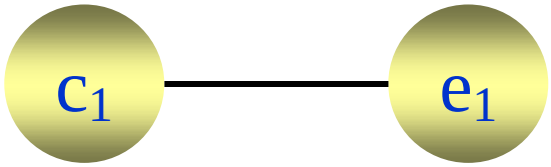
Four Basic Relationships

- The four basic relationships are depicted in solid lines.



Equal

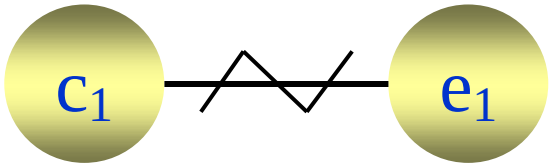
- If the cause c_1 occurs, then the effect e_1 must occur, and vice versa. This is called the Equal relationship. Mathematically, if c_1=1, then e_1=1; if c_1=0, then e_1=0. It can be also represented as e_1=c_1 for short.



Equal

Not

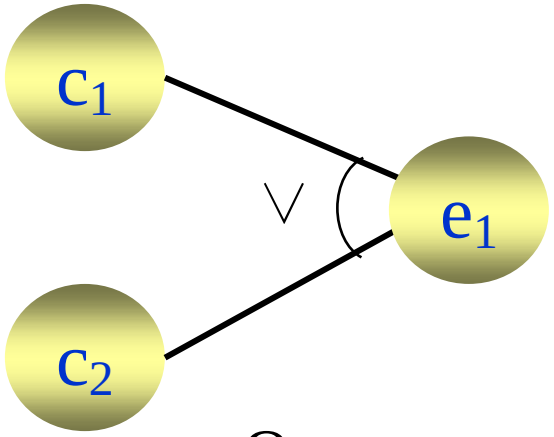
- If the cause c_1 occurs, then the effect e_1 won't occur, and vice versa. This is called the Not relationship. Mathematically, if c_1=1, then e_1=0; if c_1=0, then e_1=1, i.e. e_1=~c_1.



Not

Or

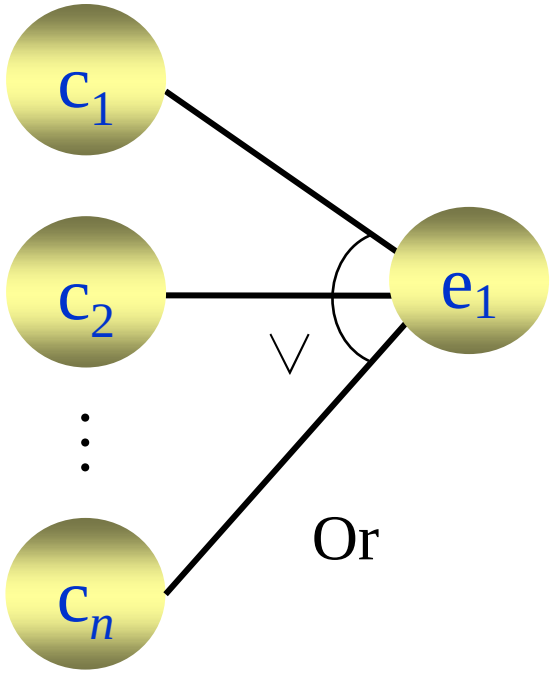
- The effect e_1 will occur provided one of the causes c_1 and c_2 occurs. Mathematically, if $c_1=1$ or $c_2=1$, then $e_1=1$; if $c_1=0$ and $c_2=0$, then $e_1=0$. This is the Or relationship represented as $e_1=c_1 \vee c_2$.



Or

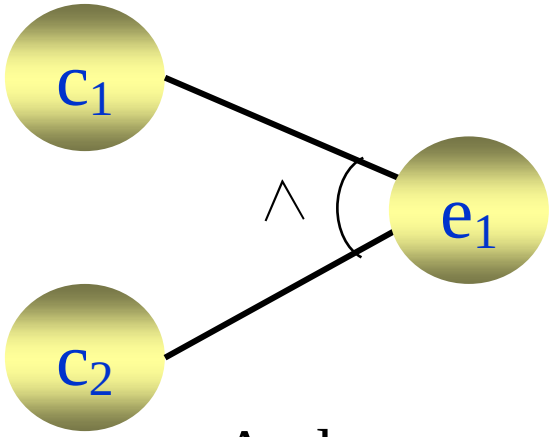
Or

- It also applies to multiple causes as $e_1 = c_1 \vee c_2 \vee \ldots \vee c_n$.
- The arc line here can **never** be omitted.



And

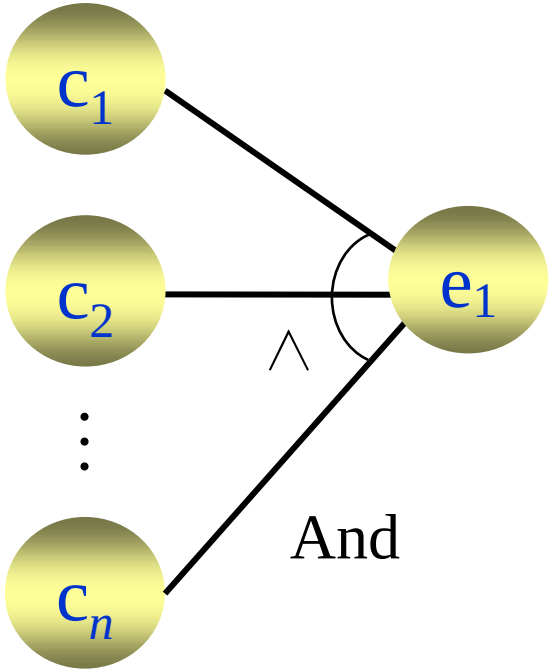
- The effect e_1 won't occur provided one of the causes c_1 and c_2 doesn't occur. Mathematically, if $c_1=0$ or $c_2=0$, then $e_1=0$; if $c_1=1$ and $c_2=1$, then $e_1=1$. This is the Or relationship represented as $e_1=c_1 \wedge c_2$.



And

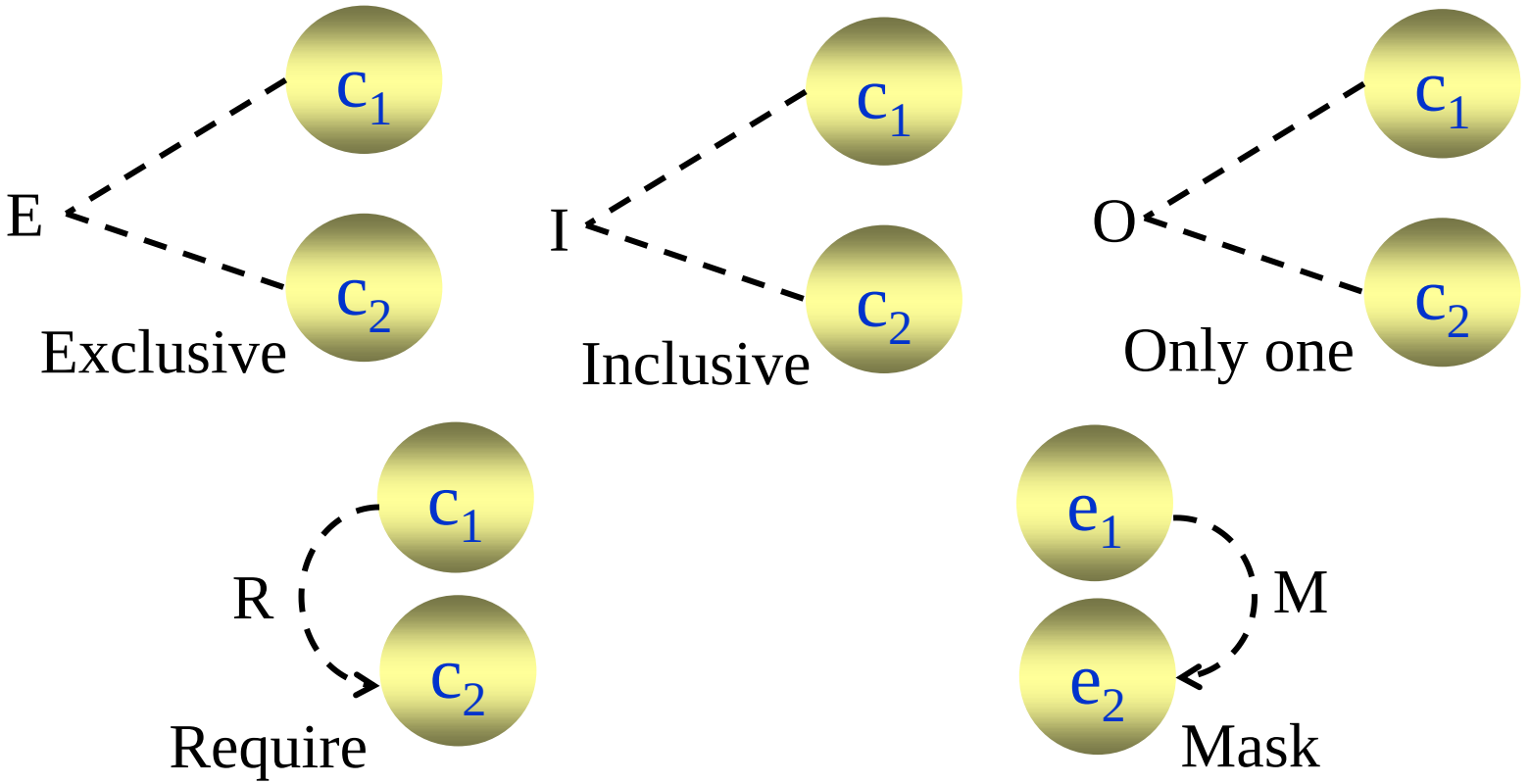
And

- It also applies to multiple causes as $e_1 = c_1 \wedge c_2 \wedge \ldots \wedge c_n$.
- The arc line here can **never** be omitted.



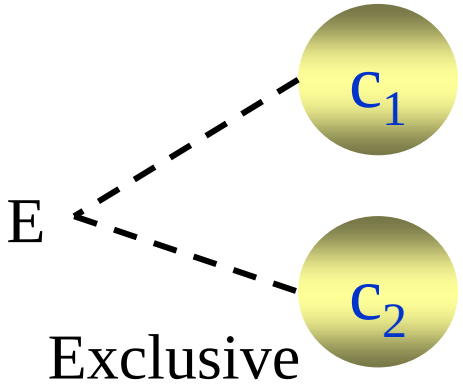
Five Basic Constraints

- The five basic constraints are depicted in dashed lines.



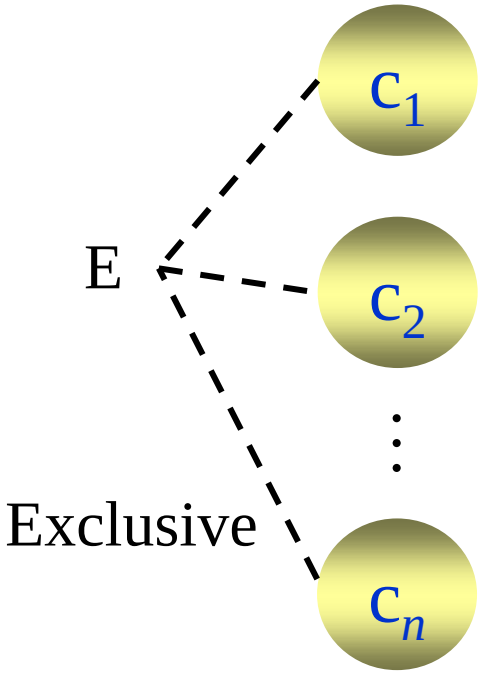
Exclusive

- The causes c_1 and c_2 will occur one **at most**, i.e. they are Exclusive. Mathematically, the situation where c_1=1 and c_2=1 won't happen.



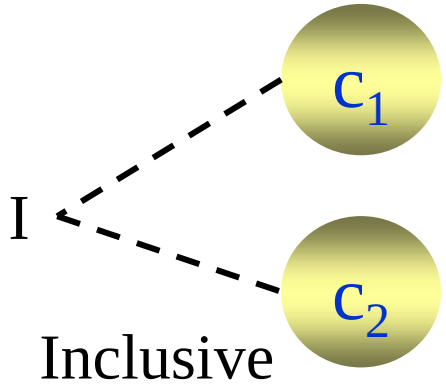
Exclusive

- For multiple causes $c_1, c_2, \ldots, c_n$, to be exclusive means that there exists one cause valuing 1 among at most. **(One at most)**



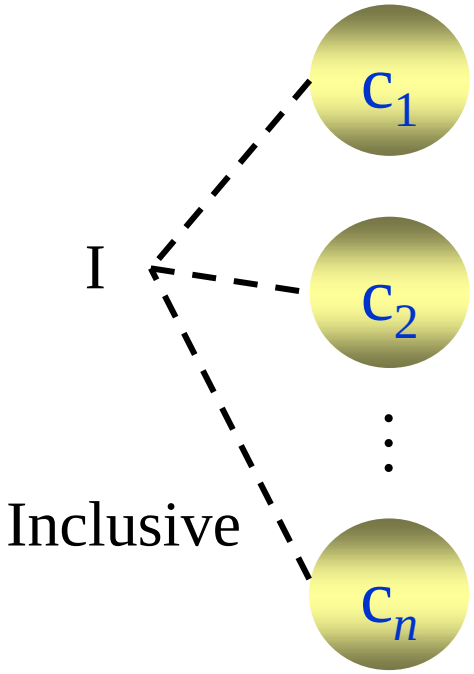
Inclusive

- The causes c_1 and c_2 will occur one **at least**, i.e. they are Inclusive. Mathematically, the situation where $c_1=0$ and $c_2=0$ won't happen.



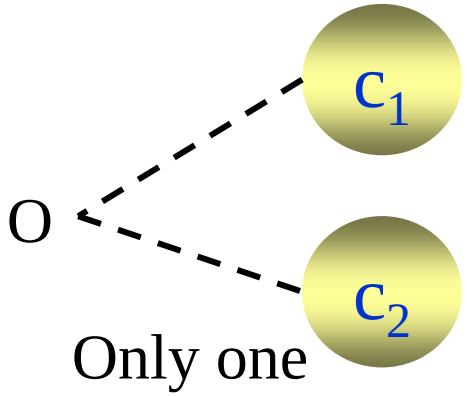
Inclusive

- For multiple causes $c_1, c_2, \ldots, c_n$, to be inclusive means that there exists one cause valuing 1 among at least. **(One at least)**



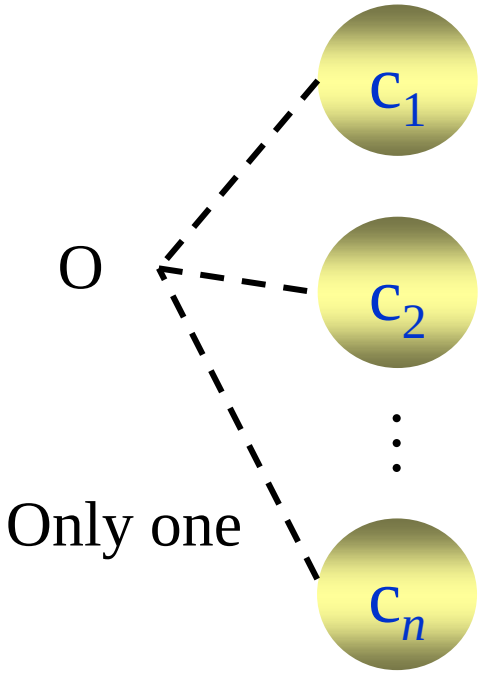
Only One

- The causes c_1 and c_2 will must occur one and only one (just Only One), i.e. there are only two situations: c_1=1 and c_2=0; c_1=0 and c_2=1.



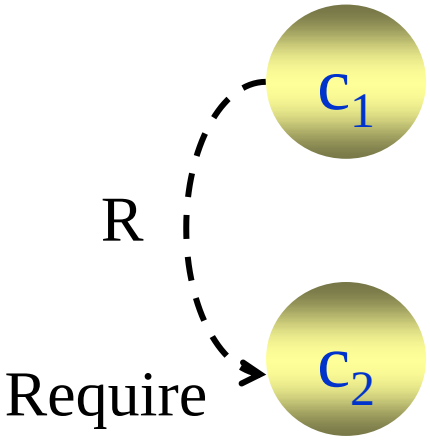
Only One

- For multiple causes $c_1, c_2, \ldots, c_n$, there exist just only one cause valuing 1 among.



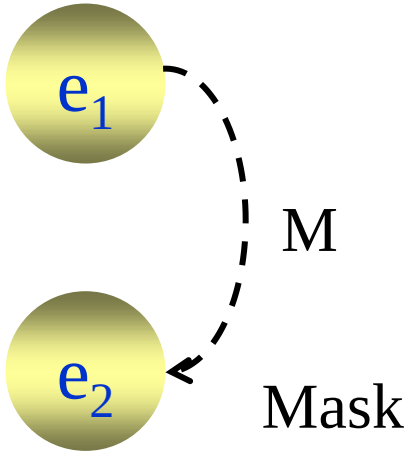
Require

- If c_1 occurs, c_2 also occurs inevitably, i.e. the occurrence of c_1 requires the occurrence of c_2. Mathematically, it is expressed as $c_1=1 \rightarrow c_2=1$.



Mask

- If e_1 is generated, then e_2 won't occur inevitably, i.e. the generation of e_1 shields (masks) the occurrence of e_2. Mathematically, it is expressed as $e_1=1 \rightarrow e_2=0$.



Example 5

- **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

- By analyzing the conditions in the issue, we have the following causes and effects.

- 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。

Analysis of Constraints for Causes

- Upon listing the causes, we can see that c_1 and c_2 are exclusive and that c_3 is independent without constraints.

c_1: 第1字符是#

c_2: 第1字符是*

c_3: 第2字符是数字

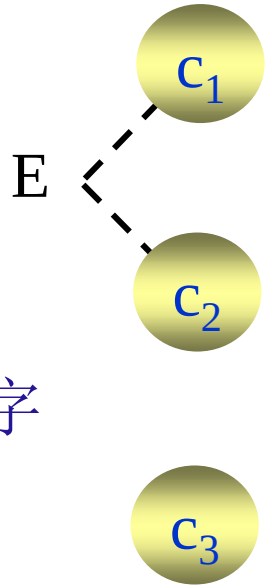
Analysis of Constraints for Causes

- Upon listing the causes, we can see that c_1 and c_2 are exclusive and that c_3 is independent without constraints.

c_1: 第1字符是#

c_2: 第1字符是*

c_3: 第2字符是数字



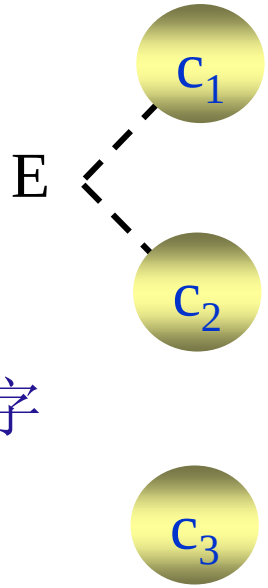
Causality Analysis

- The cause to generate e_1 is $(\sim c_1) \wedge (\sim c_2)$, i.e. $\sim(c_1 \vee c_2)$; for e_2, it is $(c_1 \vee c_2) \wedge c_3$, and for e_3, it is $\sim c_3$.

c_1: 第1字符是#

c_2: 第1字符是*

c_3: 第2字符是数字



e_1: 报错信息X

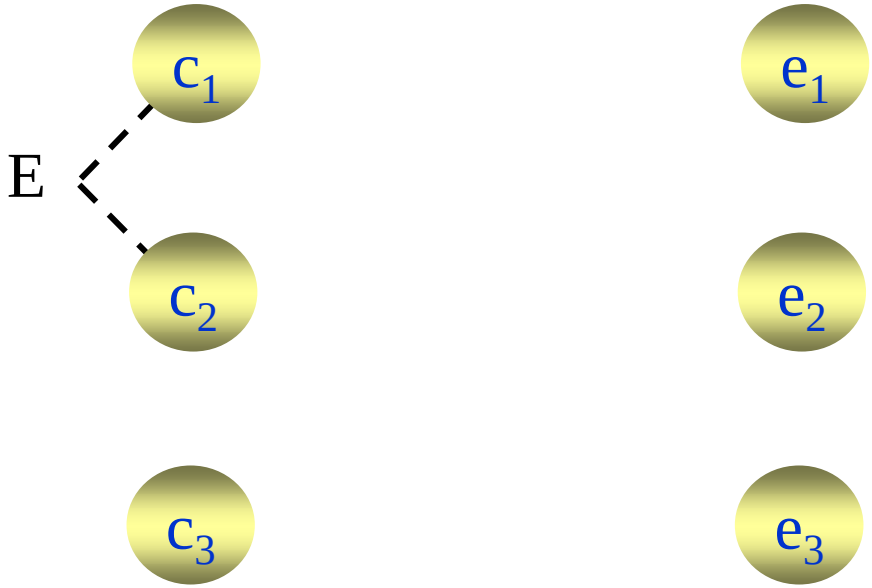
e_2: 修改文件

e_3: 报错信息Y

Establishing the Causality Equations

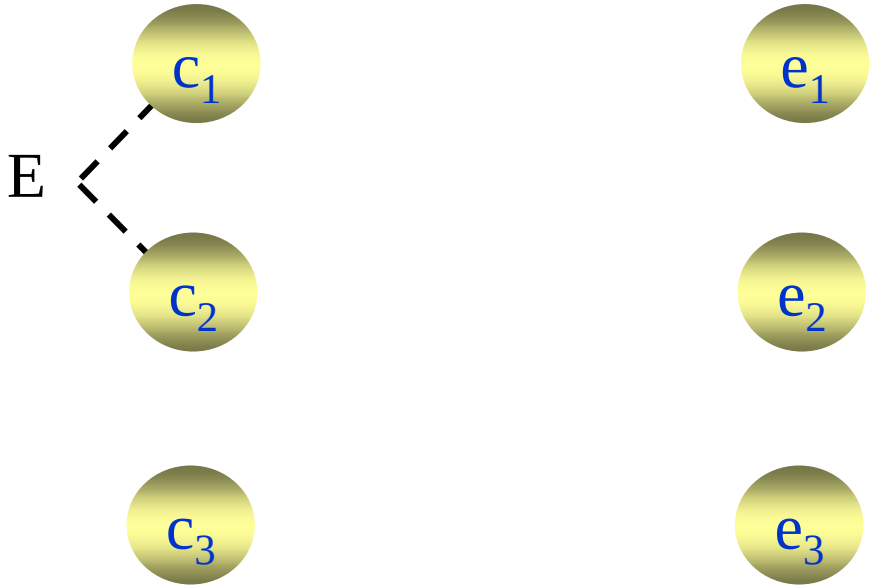
- According to the analysis, we list the three equations:

$e_1 = \sim(c_1 \vee c_2)$; $e_2 = (c_1 \vee c_2) \wedge c_3$; $e_3 = \sim c_3$



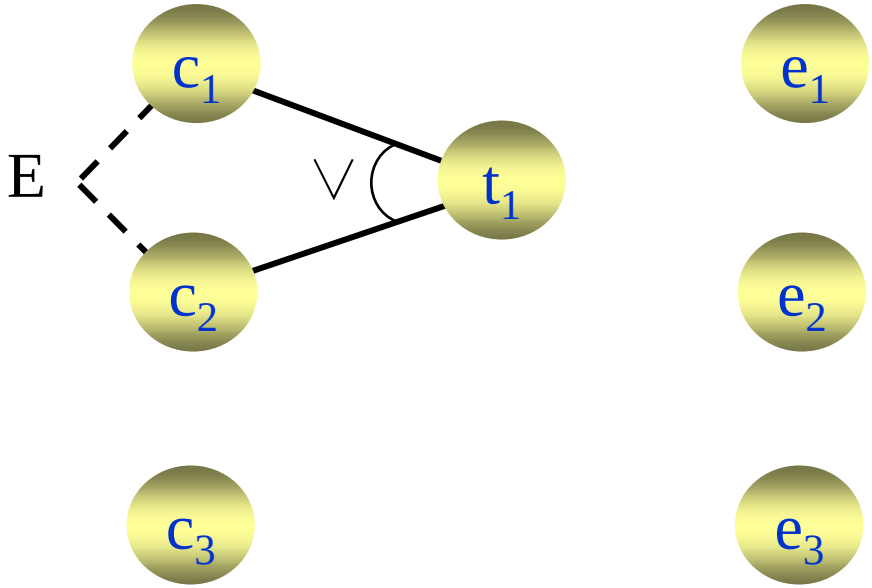
Intermediate Variables

- The terms $\sim(c_1 \vee c_2)$ and $(c_1 \vee c_2) \wedge c_3$ are complex, and we should turn to an intermediate variable. Here we use t_1 to represent $c_1 \vee c_2$, i.e. $t_1 = c_1 \vee c_2$.



Intermediate Variables

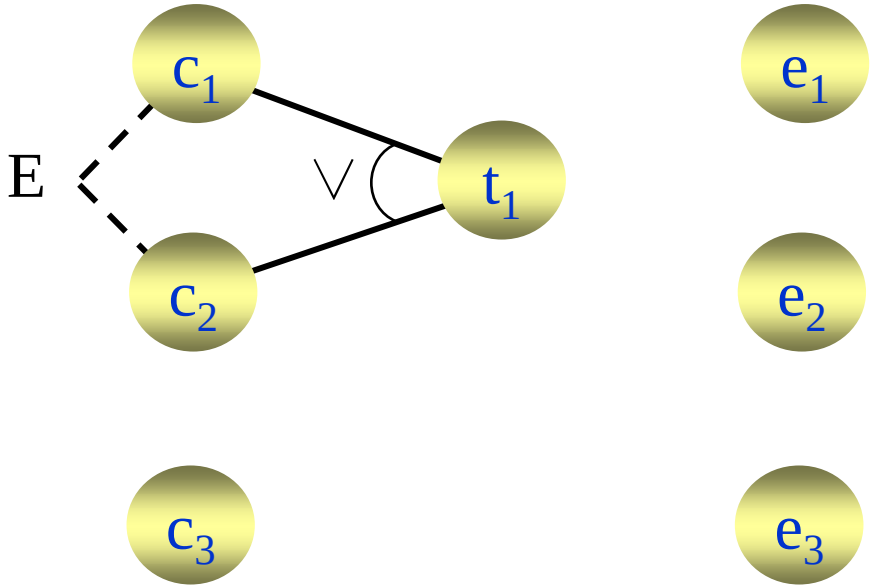
- The terms $\sim(c_1 \vee c_2)$ and $(c_1 \vee c_2) \wedge c_3$ are complex, and we should turn to an intermediate variable. Here we use t_1 to represent $c_1 \vee c_2$, i.e. $t_1 = c_1 \vee c_2$.



Equations with Intermediate Variables

- Since $t_1 = c_1 \vee c_2$, we have:

$e_1 = \sim(c_1 \vee c_2) = \sim t_1$; $e_2 = (c_1 \vee c_2) \wedge c_3 = t_1 \wedge c_3$; $e_3 = \sim c_3$.

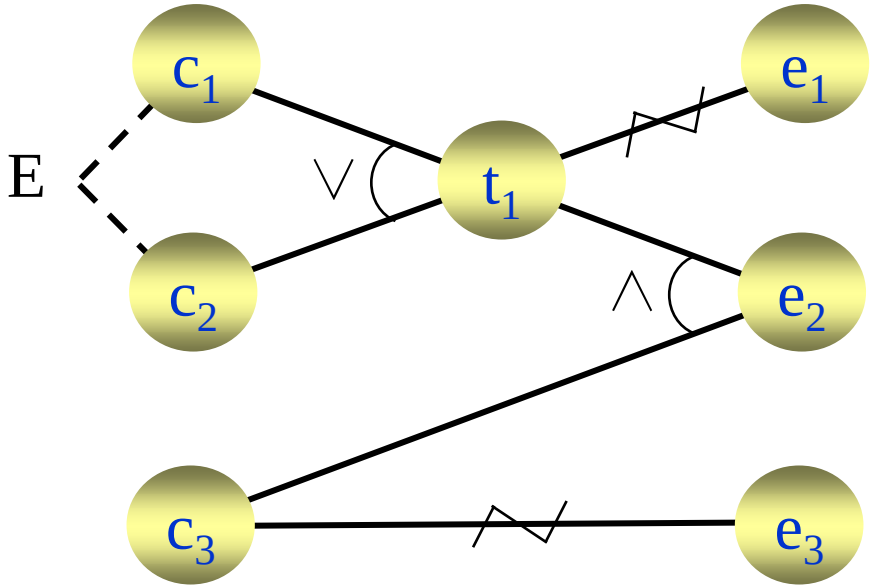


Equations with Intermediate Variables

- Since $t_1 = c_1 \vee c_2$, we have:

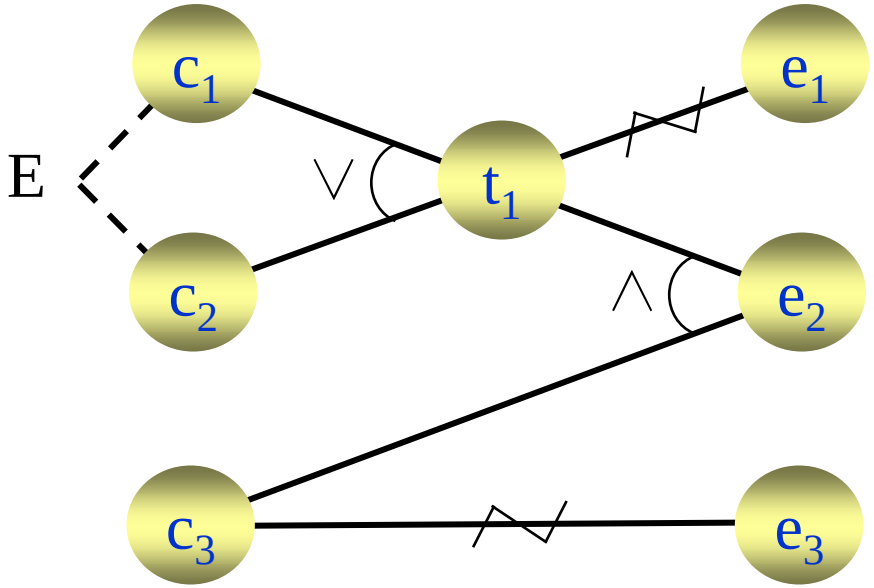
$e_1 = \sim(c_1 \vee c_2) = \sim t_1$; $e_2 = (c_1 \vee c_2) \wedge c_3 = t_1 \wedge c_3$; $e_3 = \sim c_3$.

- Then draw the rest part of the CED.



Analysis of Constraints for Effects

- No M constraints are needed.



e_1: 报错信息X

e_2: 修改文件

e_3: 报错信息Y

Transferring to the Decision Table

- Let each cause be a condition stub and each effect be an action stub.

		1	2	3	4	5	6	7	8
条件部分	c_1: 第1个字符是#	T	T	T	T	F	F	F	F
	c_2: 第1个字符是*	T	T	F	F	T	T	F	F
	c_3: 第2个字符是数字	T	F	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								

Transferring to the Decision Table

- Since c_1 and c_2 are exclusive, and can't value T at the same time, so we eliminate the corresponding terms.

		1	2	3	4	5	6	7	8
条件部分	c_1: 第1个字符是#	T	T	T	T	F	F	F	F
	c_2: 第1个字符是*	T	T	F	F	T	T	F	F
	c_3: 第2个字符是数字	T	F	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								

Transferring to the Decision Table

- Since c_1 and c_2 are exclusive, and can't value T at the same time, so we eliminate the corresponding terms.

		1	2	3	4	5	6	7	8
条件部分	c_1: 第1个字符是#	T	T	T	T	F	F	F	F
	c_2: 第1个字符是*	T	T	F	F	T	T	F	F
	c_3: 第2个字符是数字	T	F	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								

Transferring to the Decision Table

- Assign values for the condition combinations and get the action part. Eliminate the terms that violate Mask.

		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		√		√		√

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

Test Cases

测试用例编号	输入数据	预期输出
1	#3	修改文件
2	#A	报错信息Y
3	*9	修改文件
4	*b	报错信息Y
5	T2	报错信息X
6	ZS	报错信息X和Y

Procedure

1、列出作输入条件的原因和作输出条件的结果；
2、通过语义分析原因之间的约束，标于图上；
3、分析每一个结果由哪些原因组合构成的；
4、通过因果分析构建出恒等关系；
5、构建中间变量，使一次传播中仅一种基本关系；
6、完成因果图绘制，并分析结果间的约束；
7、转换为判定表；
8、划掉不满足诸约束的组合；
9、根据判定表给出相应的测试用例。

Procedure

1、因果列举；
2、原因约束；
3、因果分析；
4、恒等构建；
5、中间构建；
6、结果约束；
7、转判定表；
8、弃违约项；
9、测试用例。

Example 6

- **Description**
  - 某饮料售货机的橙汁和啤酒均售价5元钱。若投入5元纸币，然后按“橙汁”或“啤酒”按钮，则会出来相应的饮料；若投入10元纸币，然后按“橙汁”或“啤酒”按钮，不仅会出来相应的饮料，同时还会退回5元钱。如果不投币直接按下任一按钮，则会出现错误提示音。设机器一次只能接受一张5元或10元纸币（仅一个投币口），硬件设计使得无法同时按下两个按钮，也不能使得同一个按钮在一次购买中按两次。
- **Please draw the cause-effect diagram for the issue.**

Causes and Effects

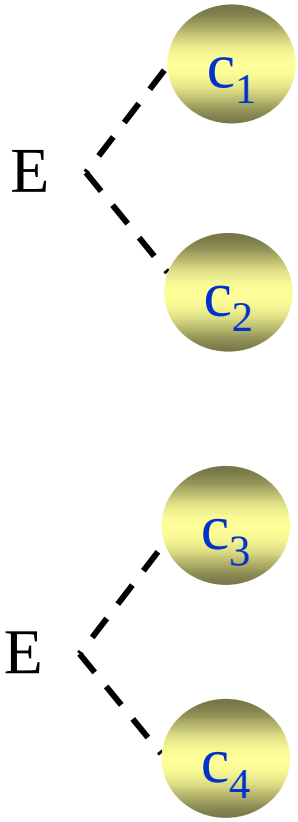
- 原因：

c_1: 投入5元
c_2: 投入10元
c_3: 按下“橙汁”
c_4: 按下“啤酒”

- 结果：

e_1: 出来橙汁
e_2: 出来啤酒
e_3: 退回5元
e_4: 错误提示音

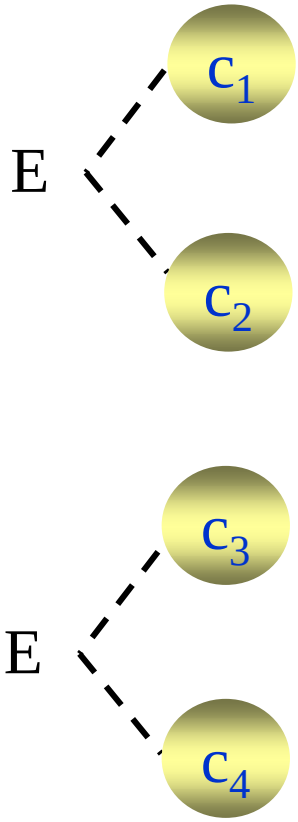
Analysis of Constraints for Causes



- 原因：

c_1: 投入5元
c_2: 投入10元
c_3: 按下“橙汁”
c_4: 按下“啤酒”

Establishing the Causality Equations



$e_1 = (c_1 \vee c_2) \wedge c_3$

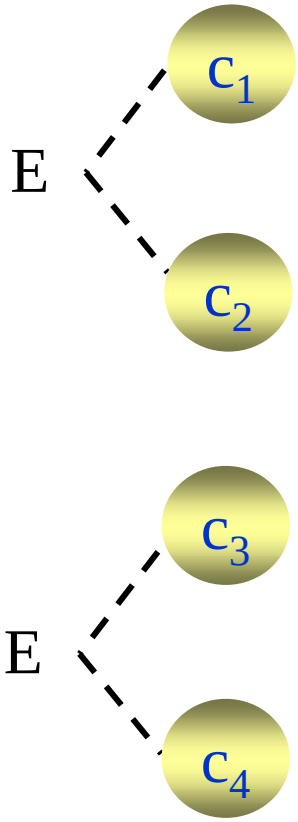
$e_2 = (c_1 \vee c_2) \wedge c_4$

$e_3 = c_2 \wedge (c_3 \vee c_4)$

$e_4 = ((\sim c_1) \wedge (\sim c_2)) \wedge (c_3 \vee c_4)$

$= (\sim(c_1 \vee c_2)) \wedge (c_3 \vee c_4)$

Intermediate Variables



$e_1 = (c_1 \vee c_2) \wedge c_3 = t_1 \wedge c_3$

$e_2 = (c_1 \vee c_2) \wedge c_4 = t_1 \wedge c_4$

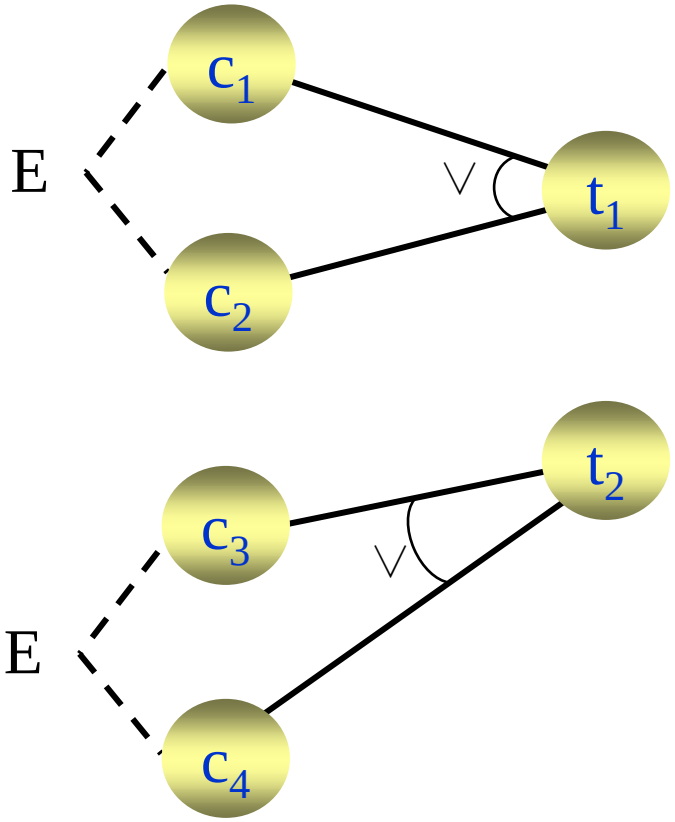
$e_3 = c_2 \wedge (c_3 \vee c_4) = c_2 \wedge t_2$

$e_4 = (\sim(c_1 \vee c_2)) \wedge (c_3 \vee c_4) = (\sim t_1) \wedge t_2$

$t_1 = c_1 \vee c_2$

$t_2 = c_3 \vee c_4$

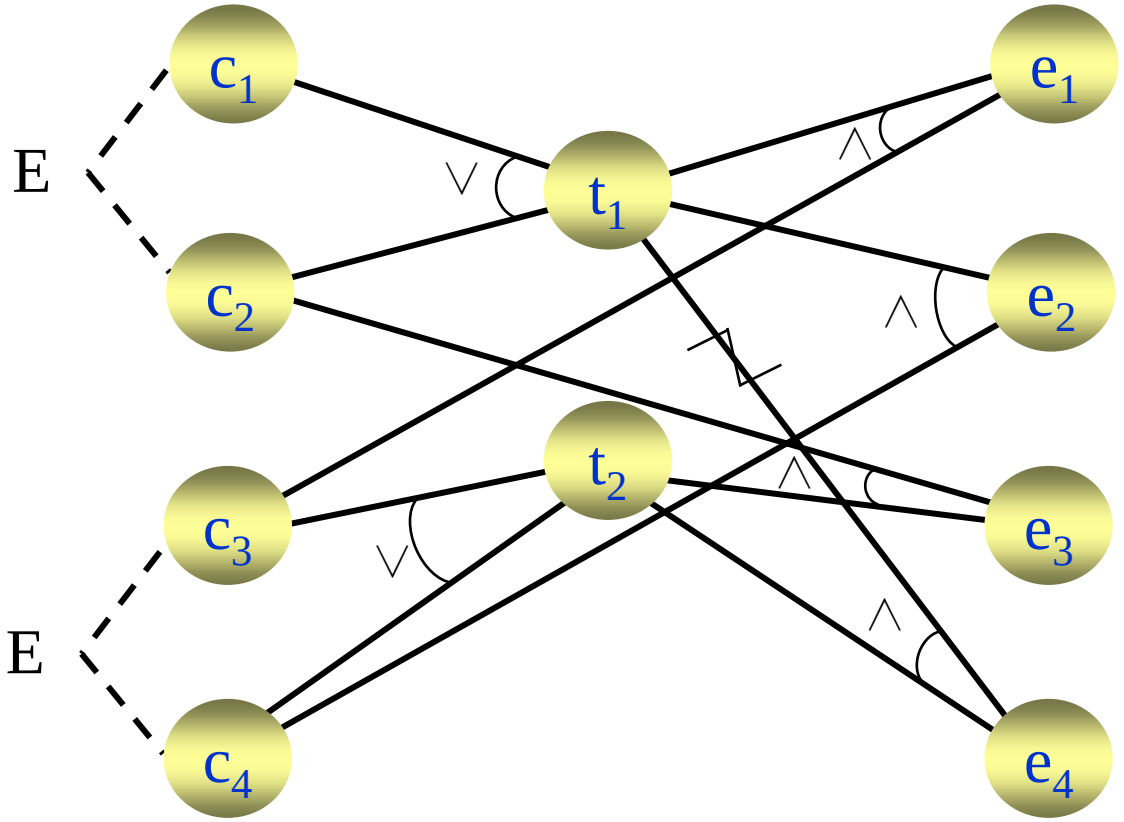
Intermediate Variables



$t_1 = c_1 \vee c_2$

$t_2 = c_3 \vee c_4$

Equations with Intermediate Variables



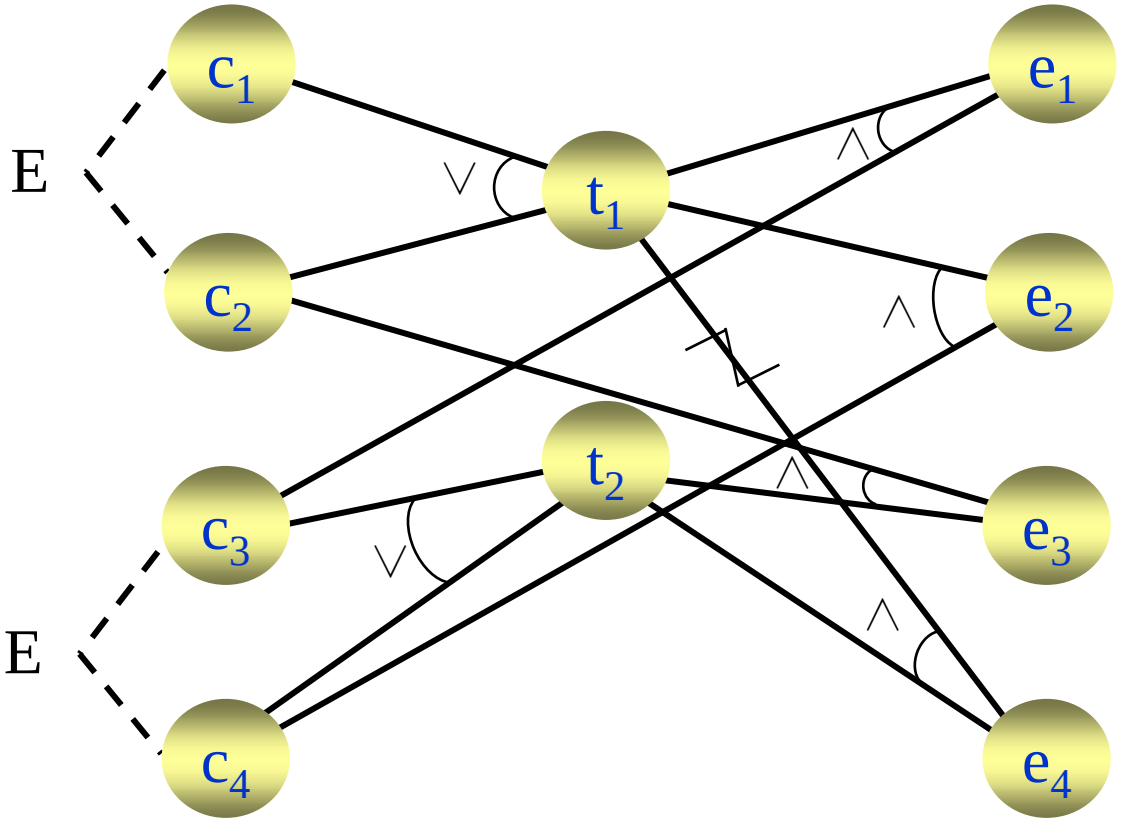
$e_1 = t_1 \wedge c_3$

$e_2 = t_1 \wedge c_4$

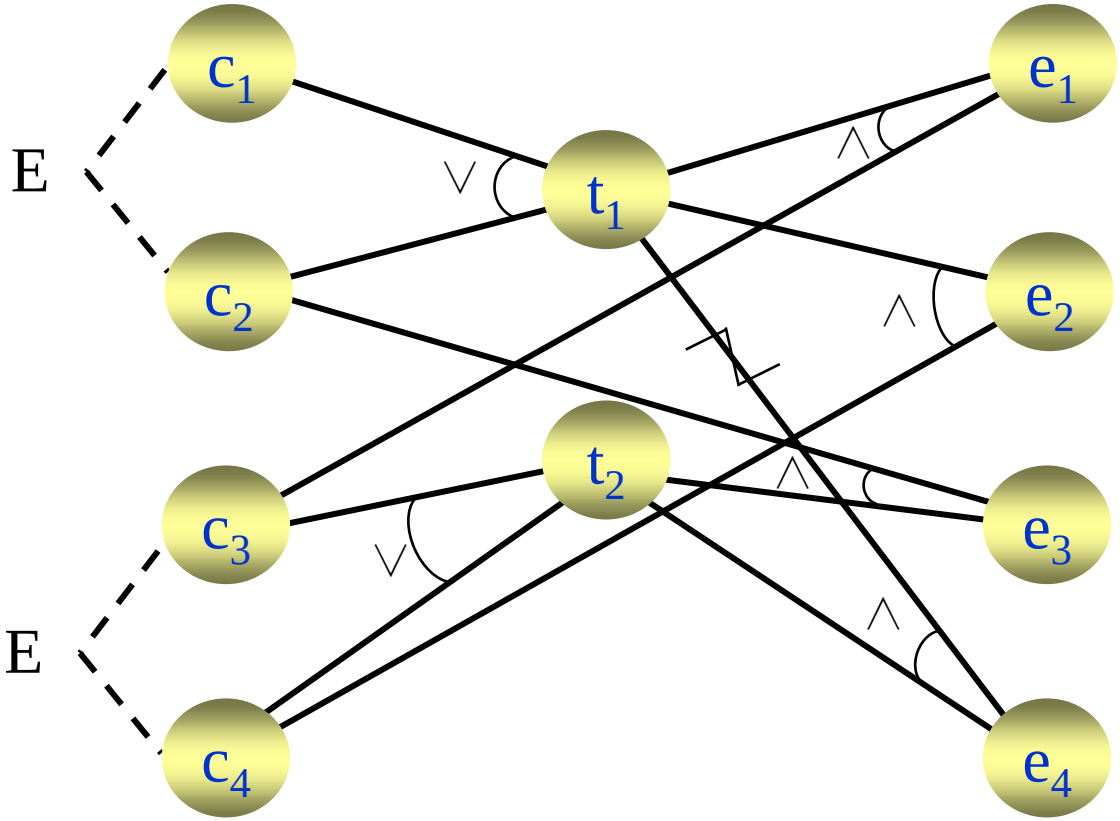
$e_3 = c_2 \wedge t_2$

$e_4 = (\sim t_1) \wedge t_2$

Analysis of Constraints for Effects



Final CED



DBBT Techniques

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

Error Guessing

- Error guessing is a informal process relying on instinct.
- 错误猜想的基本思想
  - 列举出可能犯的错误或错误易发情况的清单，然后依据清单来编写测试用例。
  - 在阅读规格说明时联系程序员可能做的假设来确定测试用例，如忽略了规格说明中的某些内容。
- 例：测试一个排序程序，可能猜测出错的情况
  - 输入列表为空
  - 输入列表仅包含一项
  - 输入列表所有条目的值都相同
  - 输入列表已经是有序的

Strategies in DBBT

- 以上的每种方法都能提供一组有用的测试用例，但是都不能单独提供一个完整的测试用例集合，可以应用以下策略得到较好的测试结果：
  1. 如果规格说明中输入条件有明显的逻辑关系以及与结果的因果关系，应该首先用判定表、因果图分析
  2. 应该为了输入和输出确定有效和无效的等价类，在必要时对上面确认的测试用例进行补充
  3. 在任何情况下都应该使边界值分析参与其中，而且是对输入和输出边界进行的分析，用以产生一系列补充的测试用例
  4. 使用错误猜测和其他技术增加更多的测试用例

Homework-1

- **Description**
  - 某公司的销售折扣计算软件算法如下：

  1、当顾客的交易额$N \leq 50000$元，则折扣率$R=0$；

  2、当顾客的交易额$N>50000$元时，假若该客户最近三个月无欠款，则折扣率$R=15\%$，否则看该客户是否为20年以上老客户，是则折扣率$R=10\%$，不是则折扣率$R=5\%$。
- **Please draw the cause-effect diagram for the issue, then transfer it into a simplified decision table.**

Homework-2

- **Description**
  - 某校网络系统用户由三部分组成：学生、教工和网络管理员。学生、教工登录系统需输入学生学号或教工工号、正确的密码和正确的验证码，然后跳转至学生界面或者教工界面；管理员需要输入管理序号和密码，且需要电脑预先安装安全控件才能登陆至管理员界面。如果输入的学号（或工号或序号）、密码或验证码错误，则提示“输入错误”；如果管理员电脑没有安装控件，不论密码是否正确都会提示“未安装控件”。
- **Please draw the cause-effect diagram for the issue.**

THANK YOU!