SOFTWARE TESTING

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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
- Error Guessing

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**

  A café called Grace-Berry issues membership cards to attract guests, and the card number involves three parts. The card number must begin with the letters "GB" which stands for the name of the café. The middle part stands for the year one has applied for membership and consists of 4 numerical digits ranging from 2000 to 2022. The last 4 characters should be any numerical digits (i.e. 0000 ~ 9999). For example, a valid card number can be "GB20215678". The corresponding query system will accept the valid numbers and reject the invalid numbers.

- **Please establish the equivalence classes for the issue and the design the corresponding test cases.**

Example 1

	有效等价类	无效等价类
开头	GB ①	不是GB ④
中间	4位2000~2022数字字符 ②	有非数字字符 ⑤
		多于4位 ⑥
		少于4位 ⑦
		小于2000 ⑧
		大于2022 ⑨
末尾	4位数字字符 ③	有非数字字符 ⑩
		多于4位 ⑪
		少于4位 ⑫

Example 1

合法测试用例	覆盖等价类
GB20215678	①②③

Example 1

非法测试用例	覆盖等价类
AA20215678	④
GBabcd5678	⑤
GB202115678	⑥
GB2025678	⑦
GB19985678	⑧
GB20245678	⑨
GB2021abcd	⑩
GB202112345	⑪
GB2021123	⑫

DBBT Techniques

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

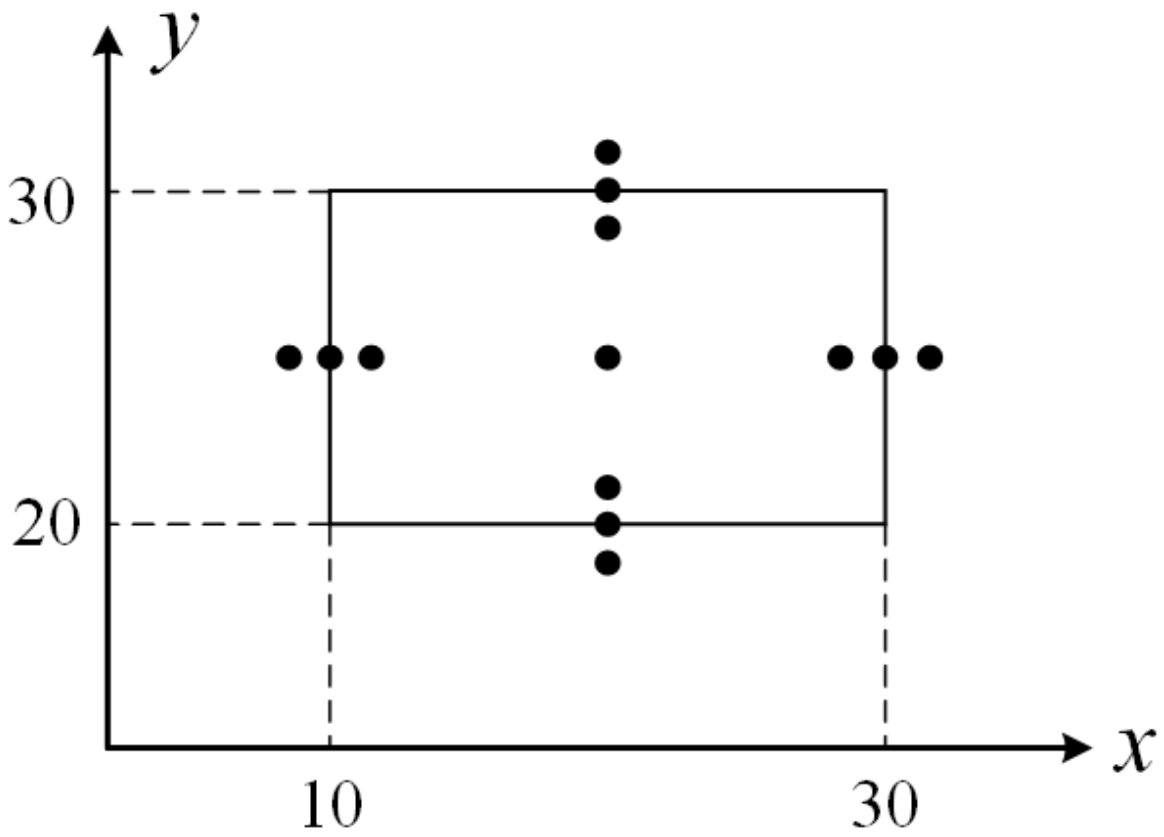
Example 2

- **Description**

  Here is a function $F = x + 2y$ with two integer variables x which varies from 10 to 30 and y which varies from 20 to 30. Draw the diagram of boundary value analysis and then give out the test cases by filling in the table below.

Test case number	x	y	F
.....	.....	.....	.....

Example 2



Example 2

Test Case Number	x	y	F
(1)	20	25	5
(2)	10	25	15
(3)	9	25	×
(4)	11	25	14
(5)	30	25	-5
(6)	29	25	-4
(7)	31	25	×
(8)	20	20	0
(9)	20	19	×
(10)	20	21	1
(11)	20	30	10
(12)	20	29	9
(13)	20	31	×

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 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			√	√

DBBT Techniques

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

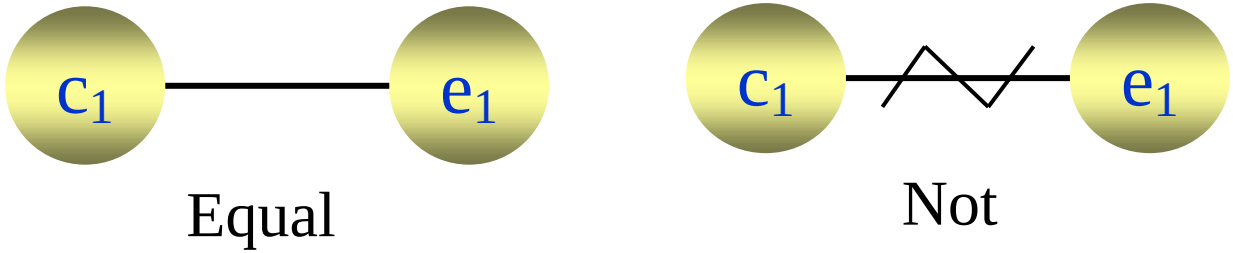
Cause-Effect Diagram

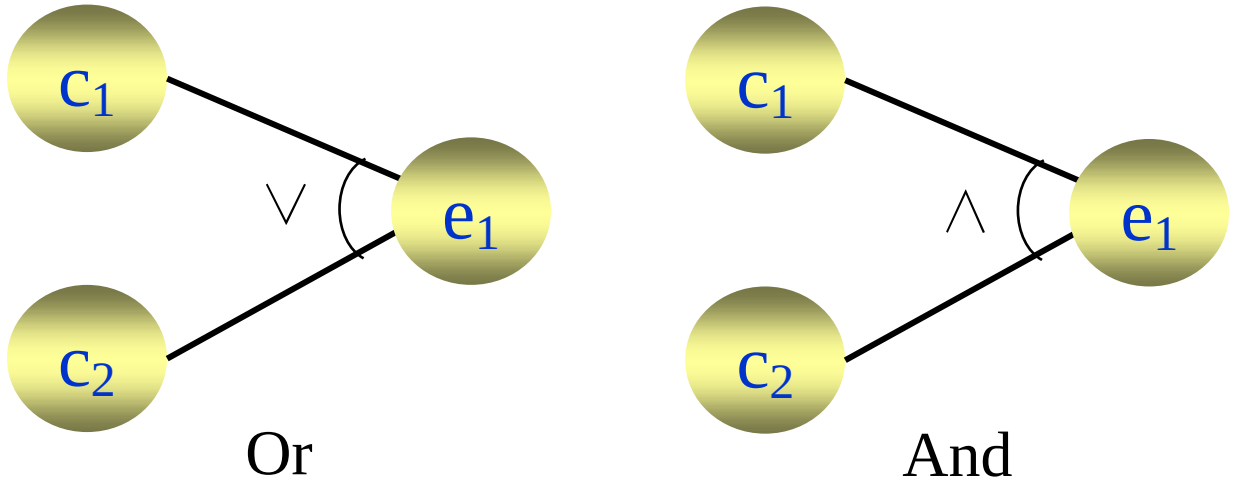
- The cause-effect diagram (CED), or cause-and-effect diagram in some literature, is used to describe the test issue where multiple inputs are involved. At the same time, the CED is also able to point out the imperfection and ambiguousness in the specification.
- Each single input is a **cause**, and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

Basic Relationships and Constraints

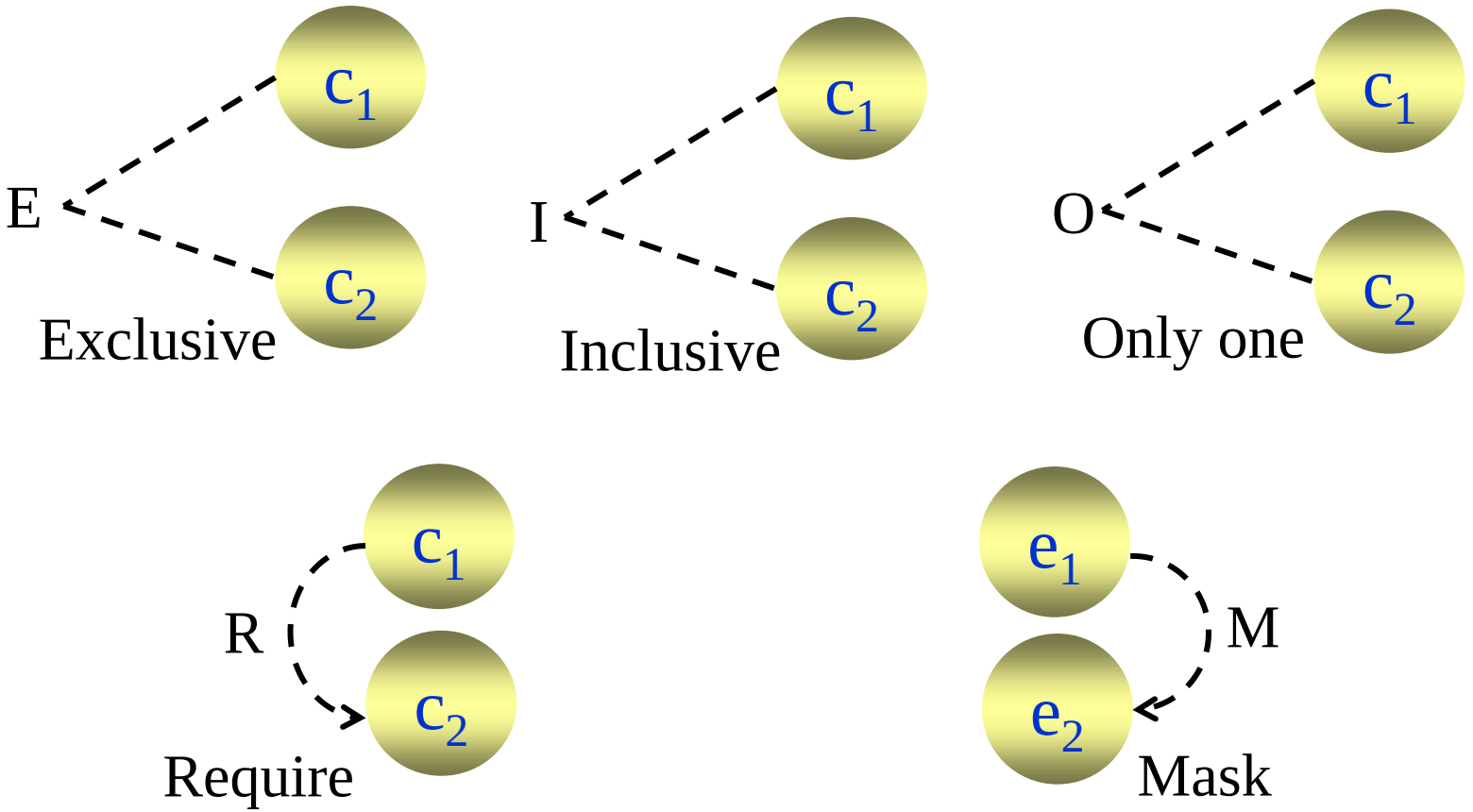
- There are four basic relationships between the causes and the effects: **Equal**, **Not**, **Or** & **And**.
- There are five basic constraints among the causes or among the effects. For input causes, the four constraints are: **Exclusive (E)**, **Inclusive (I)**, **Only one (O)** & **Require (R)**.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

Four Basic Relationships





Five Basic Constraints



Example 4

- **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

- 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：

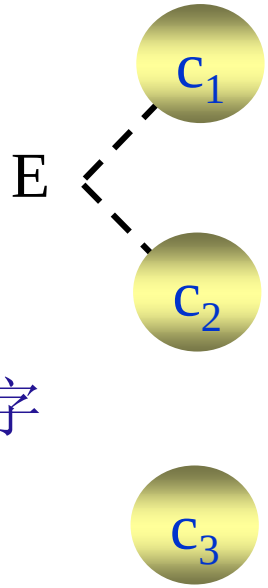
e_1: 报错信息X；
e_2: 修改文件；
e_3: 报错信息Y。

Analysis of Constraints for Causes

c_1: 第1字符是#

c_2: 第1字符是*

c_3: 第2字符是数字

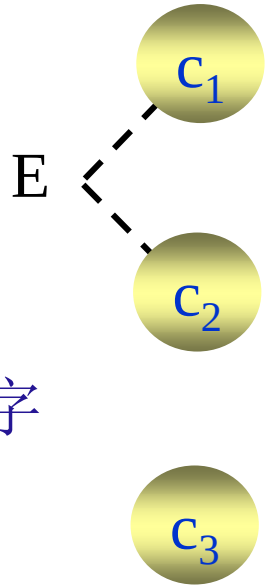


Causality Analysis

c_1: 第1字符是#

c_2: 第1字符是*

c_3: 第2字符是数字



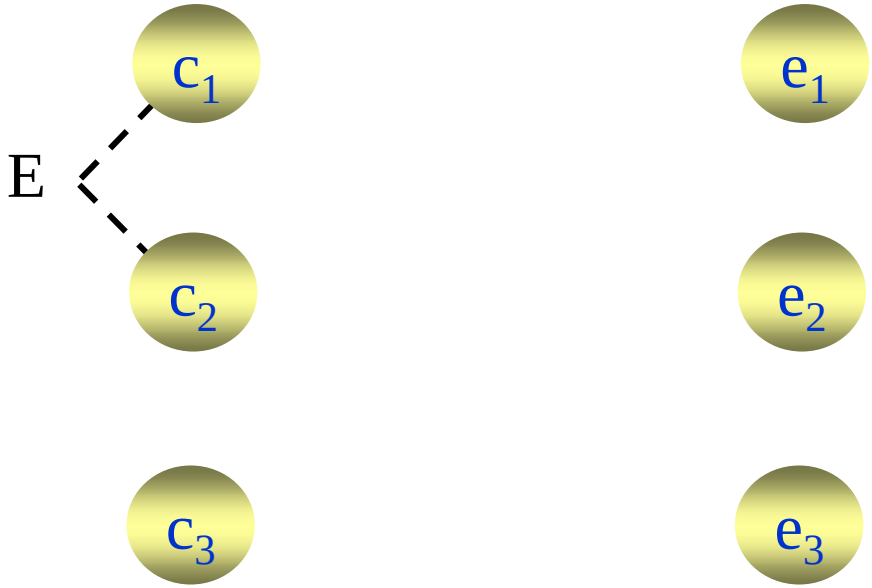
e_1: 报错信息X

e_2: 修改文件

e_3: 报错信息Y

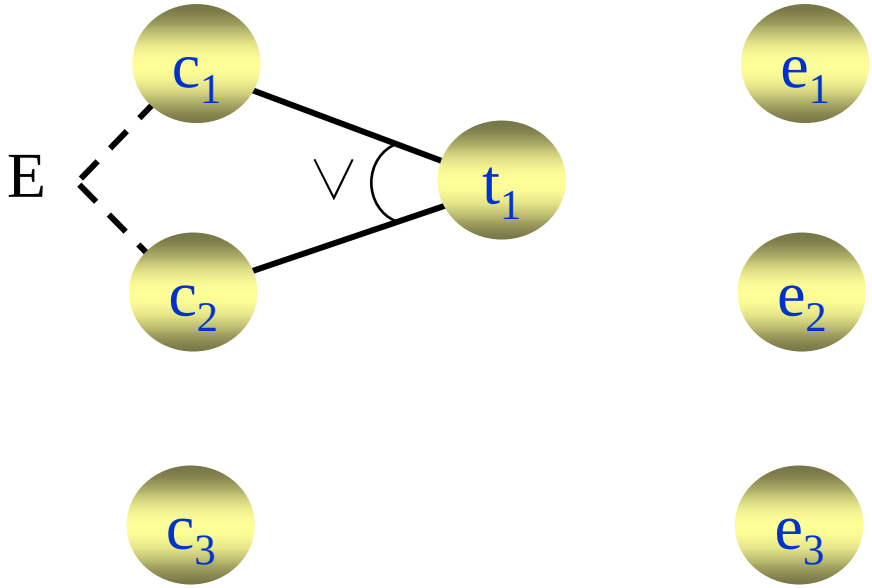
Establishing the Causality Equations

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



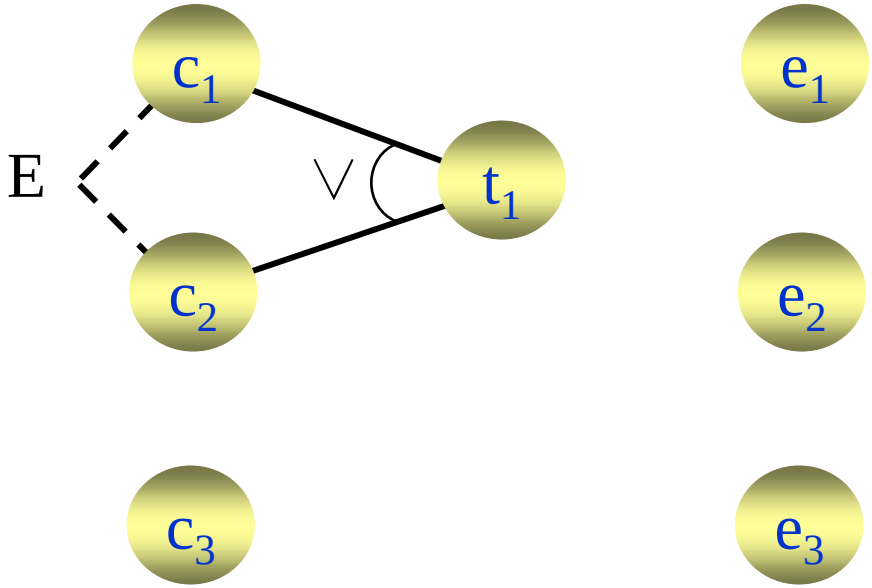
Intermediate Variables

- $t_1 = c_1 \vee c_2$.



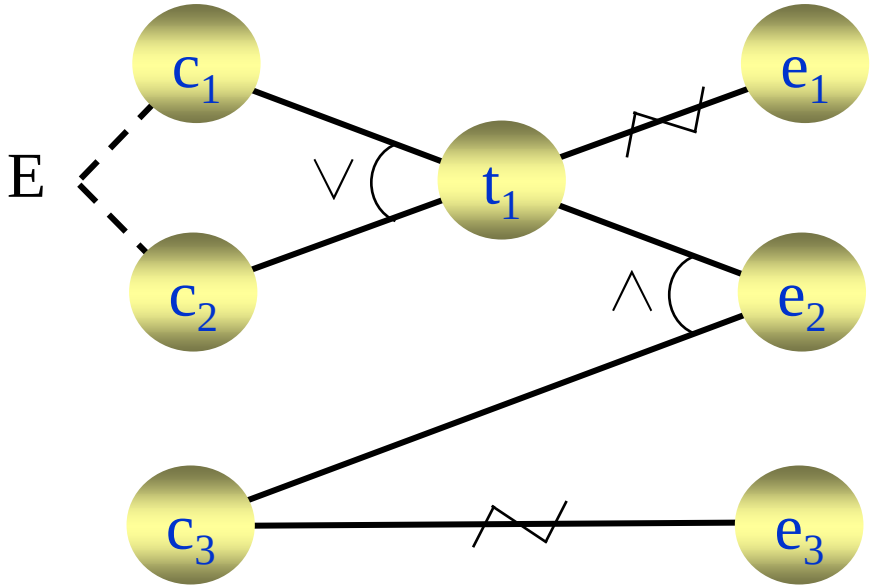
Equations with Intermediate Variables

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

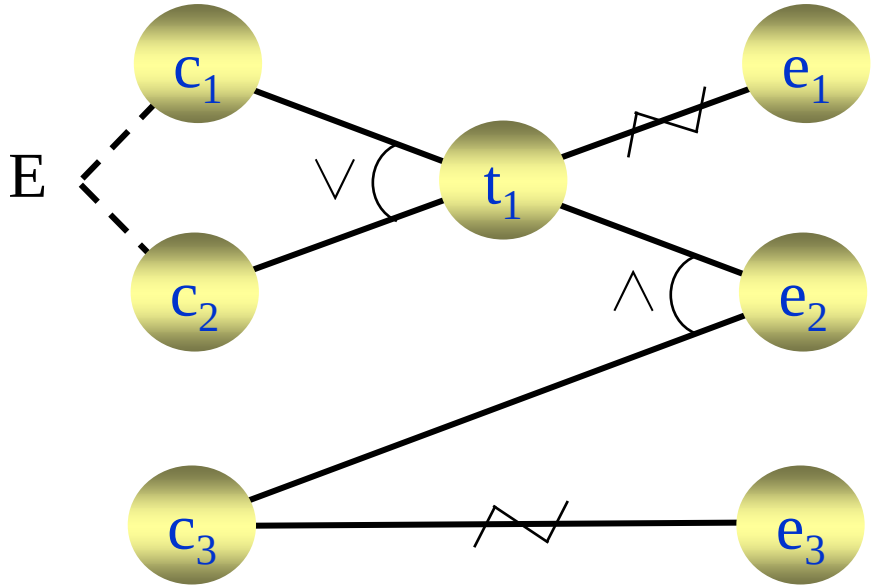


Equations with Intermediate Variables

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



Analysis of Constraints for Effects

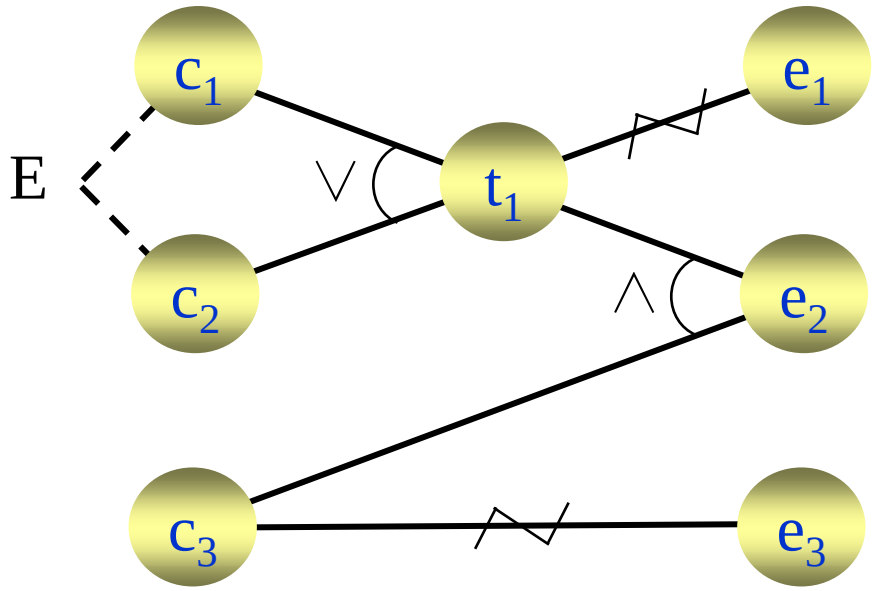


e_1: 报错信息X

e_2: 修改文件

e_3: 报错信息Y

Final CED



Transferring to the Decision Table

		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

		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

		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

Example 5

- **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

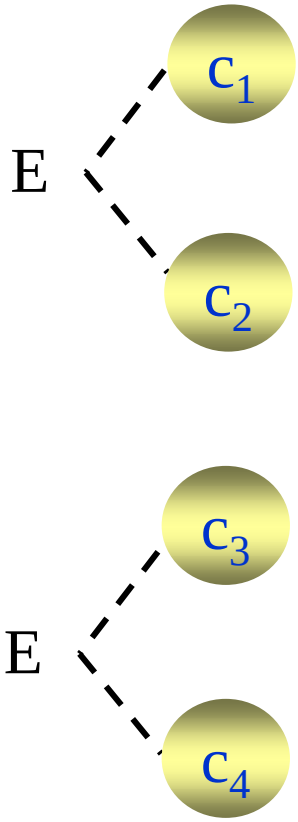
- 原因：

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

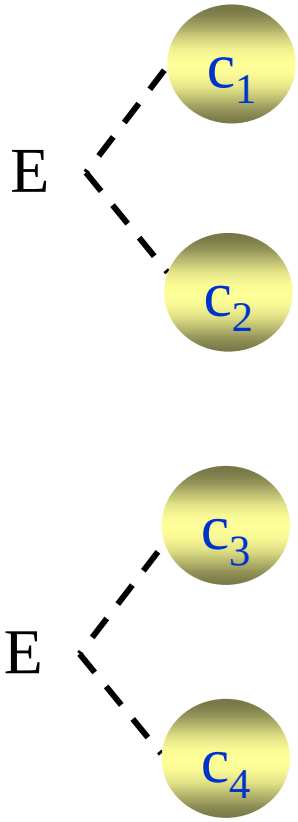
Analysis of Constraints for Causes



- 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



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

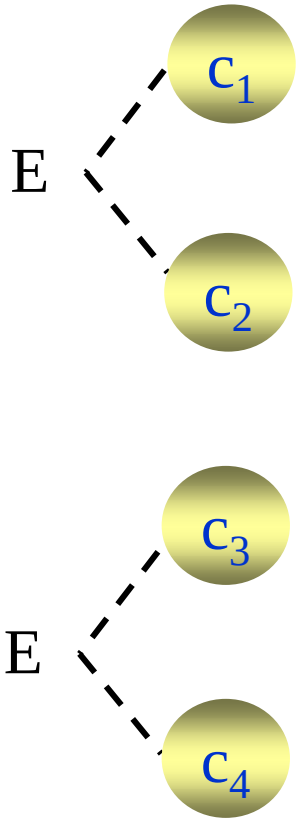
$e_2 = (c_1 \vee c_2) \wedge c_4$

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

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

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

Intermediate Variables



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

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

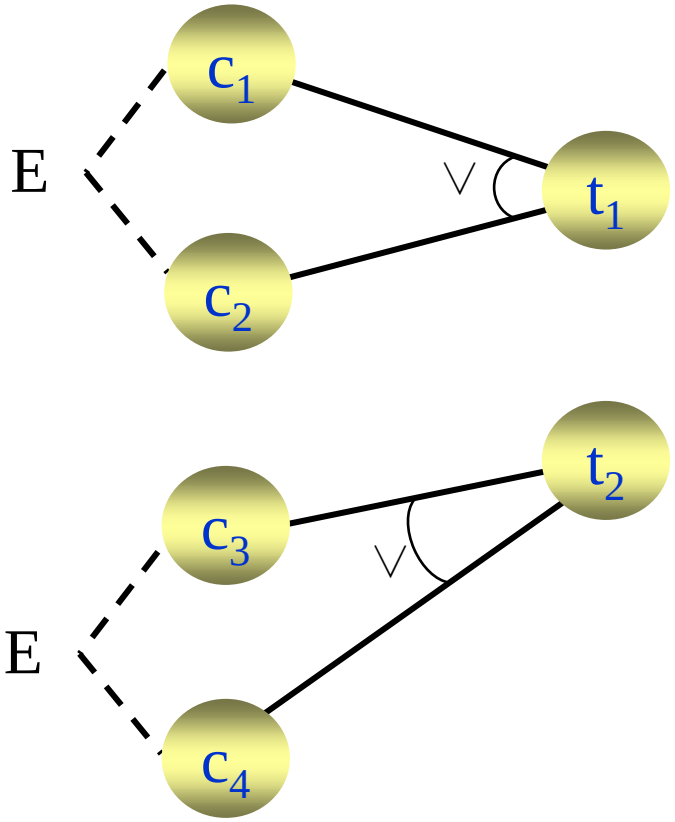
$e_3 = c_2 \wedge (c_3 \vee c_4) = c_2 \wedge t_2$

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

$t_1 = c_1 \vee c_2$

$t_2 = c_3 \vee c_4$

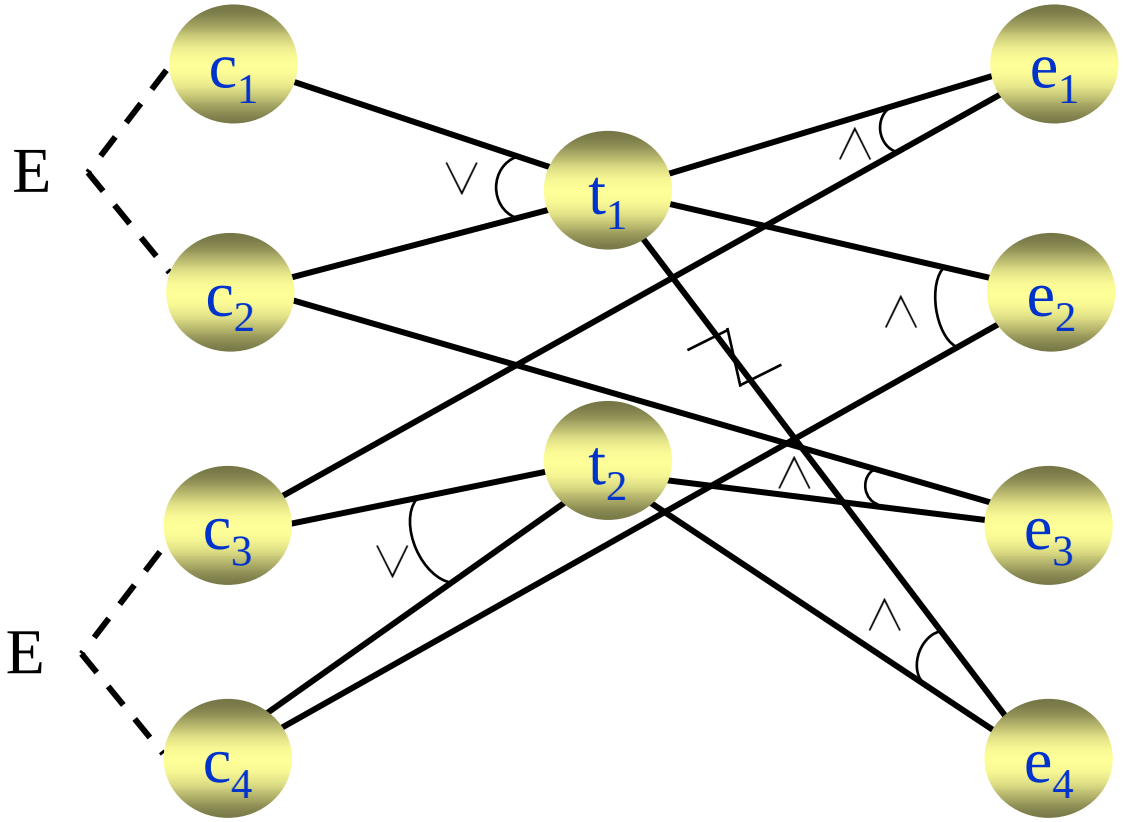
Intermediate Variables



$t_1 = c_1 \vee c_2$

$t_2 = c_3 \vee c_4$

Equations with Intermediate Variables



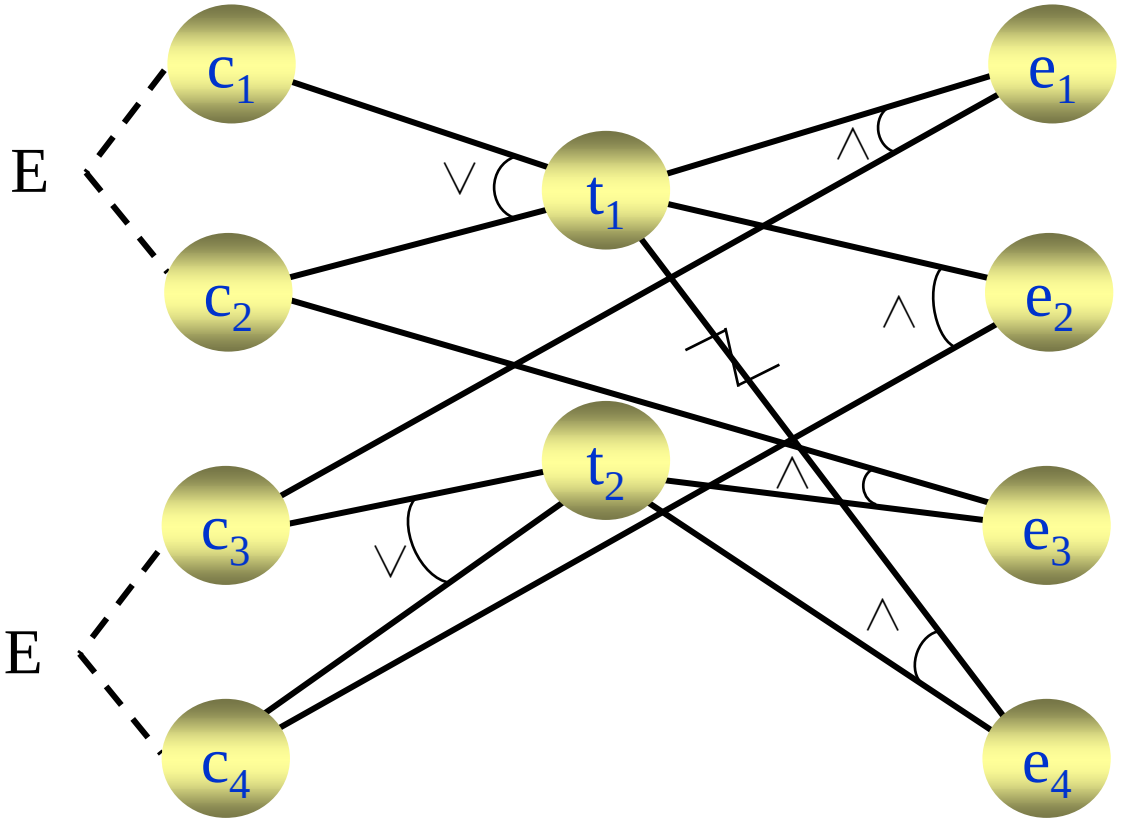
$e_1 = t_1 \wedge c_3$

$e_2 = t_1 \wedge c_4$

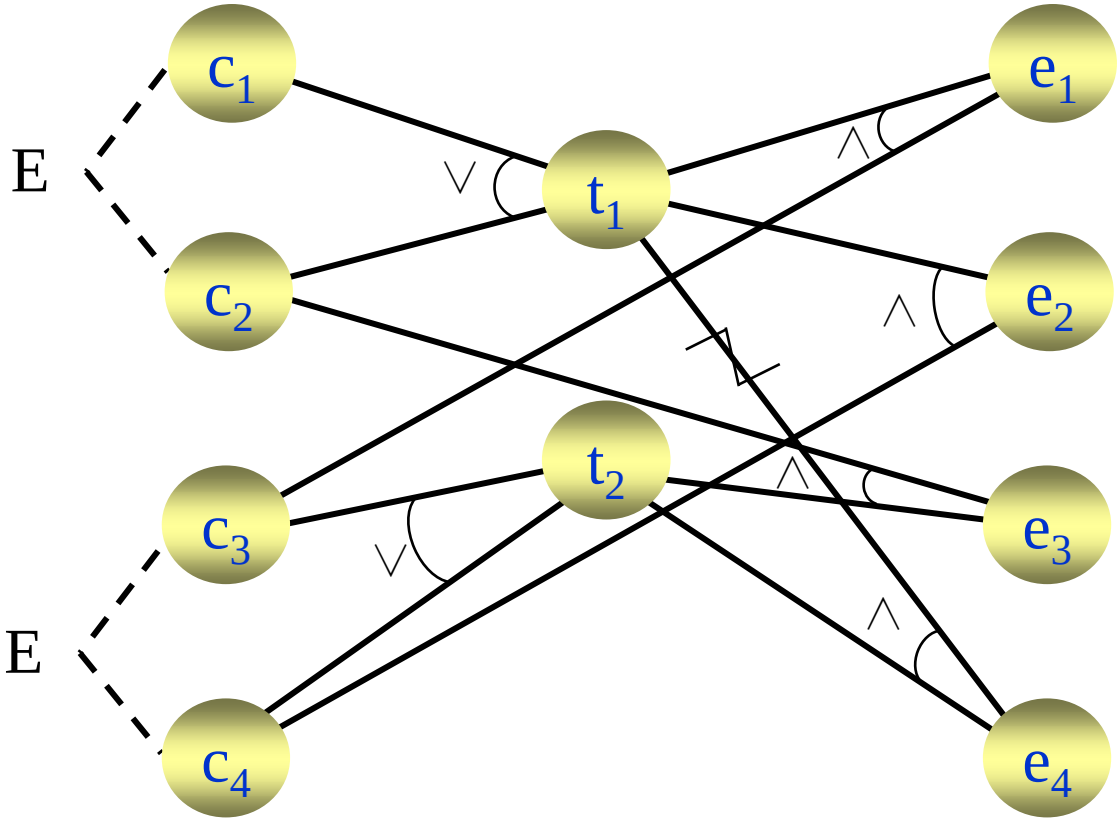
$e_3 = c_2 \wedge t_2$

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

Analysis of Constraints for Effects



Final CED



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.**

Causes and Effects

- Causes:

c_1: $N \leq 50000$
c_2: 顾客三个月无欠款
c_3: 顾客是20年以上老客户

- Effects:

e_1: $R=0$
e_2: $R=5\%$
e_3: $R=10\%$
e_4: $R=15\%$

Constraints among Causes

- Causes:

c_1: $N \leq 50000$
c_2: 顾客三个月无欠款
c_3: 顾客是20年以上老客户

- Actually, they are independent and there are no constraints.

Equations with Intermediate Variables

$e_1 = c_1$

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

$= \sim(t_1 \vee c_3) = \sim s_1$

$e_3 = (\sim c_1) \wedge (\sim c_2) \wedge c_3 = [\sim(c_1 \vee c_2)] \wedge c_3$

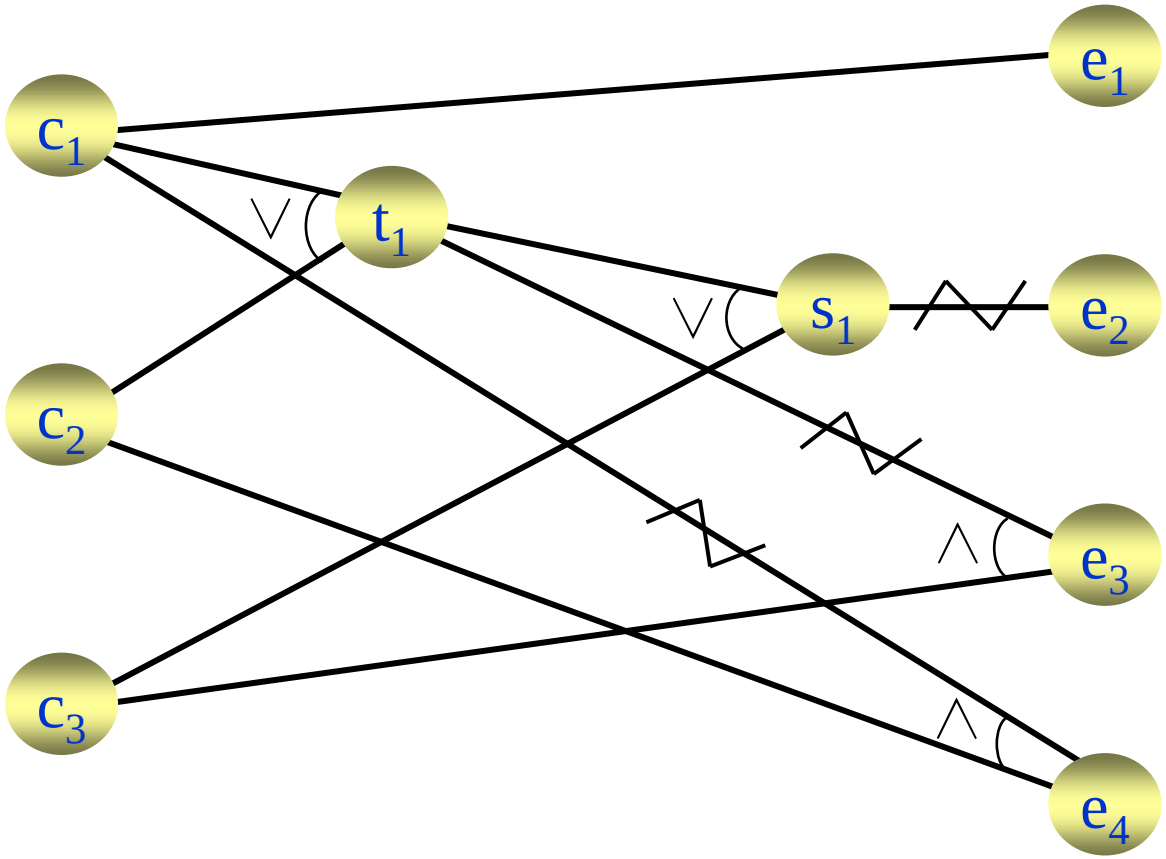
$= (\sim t_1) \wedge c_3$

$e_4 = (\sim c_1) \wedge c_2$

$t_1 = c_1 \vee c_2$

$s_1 = t_1 \vee c_3$

Drawing the CED



Transferring to a Decision Table

		1	2	3	4	5	6	7	8
条件部分	c_1	T	T	T	T	F	F	F	F
	c_2	T	T	F	F	T	T	F	F
	c_3	T	F	T	F	T	F	T	F
动作部分	e_1								
	e_2								
	e_3								
	e_4								

Transferring to a Decision Table

		1	2	3	4	5	6	7	8
条件部分	c_1	T	T	T	T	F	F	F	F
	c_2	T	T	F	F	T	T	F	F
	c_3	T	F	T	F	T	F	T	F
动作部分	e_1	√	√	√	√				
	e_2								√
	e_3							√	
	e_4					√	√		

Simplifying the Decision Table

		1	2	3	4	5	6	7	8
条件部分	c_1	T	T	T	T	F	F	F	F
	c_2	T	T	F	F	T	T	F	F
	c_3	T	F	T	F	T	F	T	F
动作部分	e_1	√	√	√	√				
	e_2								√
	e_3							√	
	e_4					√	√		

Final Decision Table

		1	2	3	4
条件部分	c_1	T	F	F	F
	c_2	-	T	F	F
	c_3	-	-	T	F
动作部分	e_1	√			
	e_2				√
	e_3			√	
	e_4		√		

Another Intermediate Variables

$e_1=c_1$

$e_2=(\sim c_1)\wedge(\sim c_2)\wedge(\sim c_3)$

$=\sim(c_1\vee c_2\vee c_3)=\sim t_1$

$e_3=(\sim c_1)\wedge(\sim c_2)\wedge c_3=[\sim(c_1\vee c_2)]\wedge c_3$

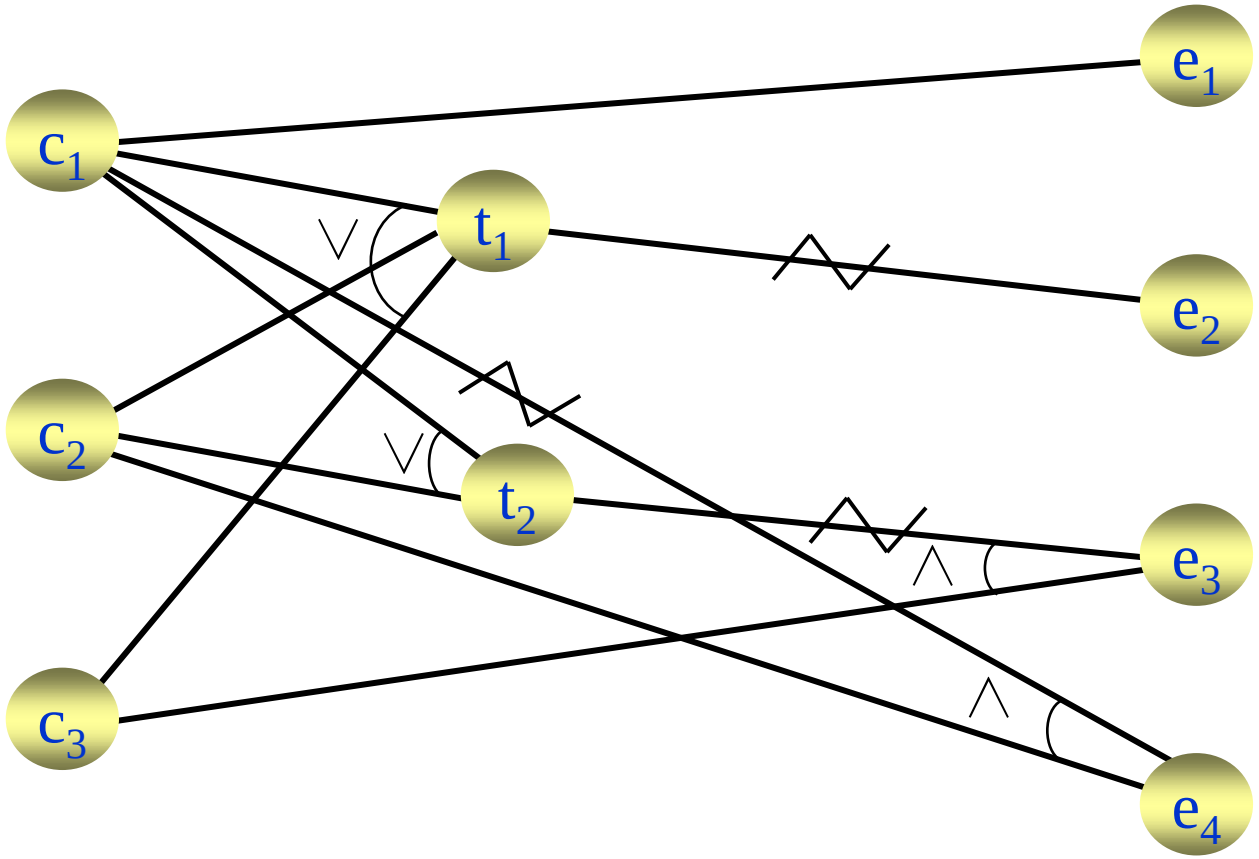
$=(\sim t_2)\wedge c_3$

$e_4=(\sim c_1)\wedge c_2$

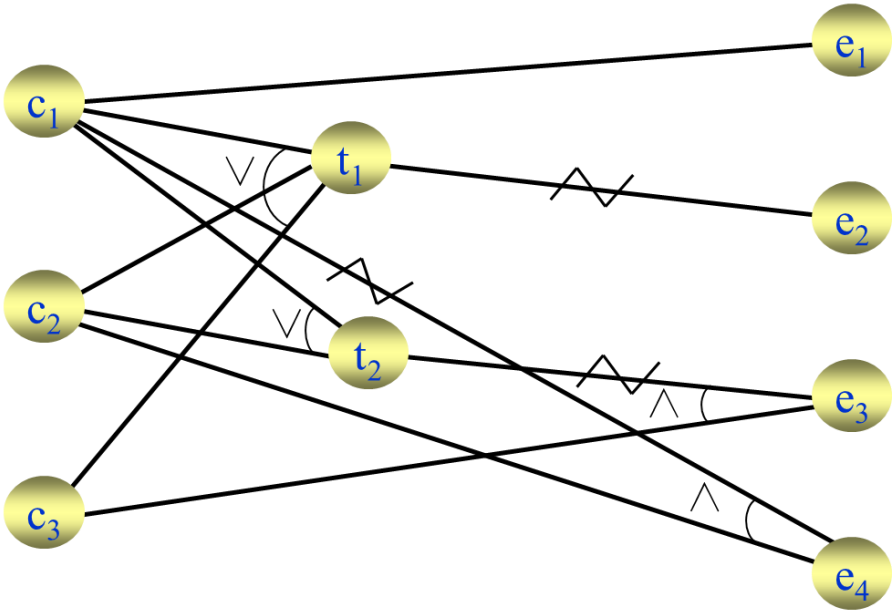
$t_1= c_1\vee c_2\vee c_3$

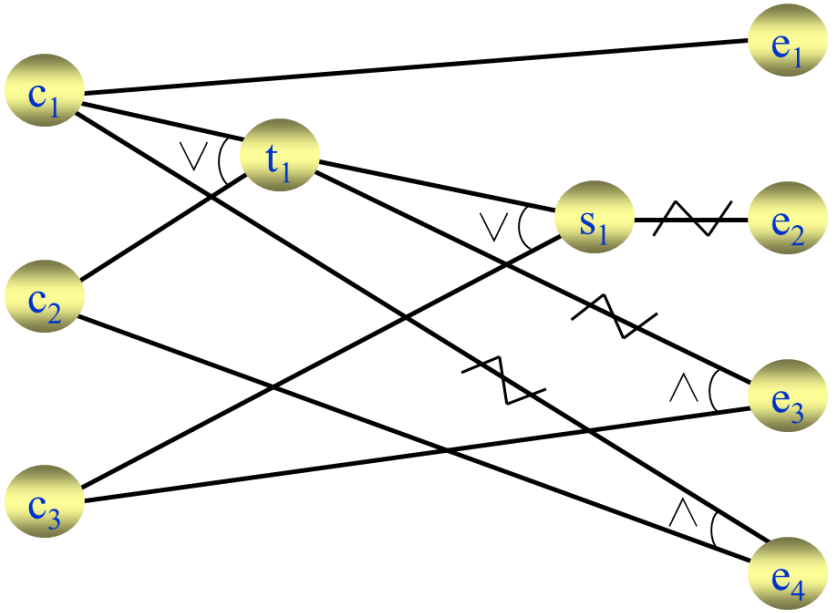
$t_2= c_1\vee c_2$

Another CED



Comparison





Example 7

- **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.**

Causes and Effects

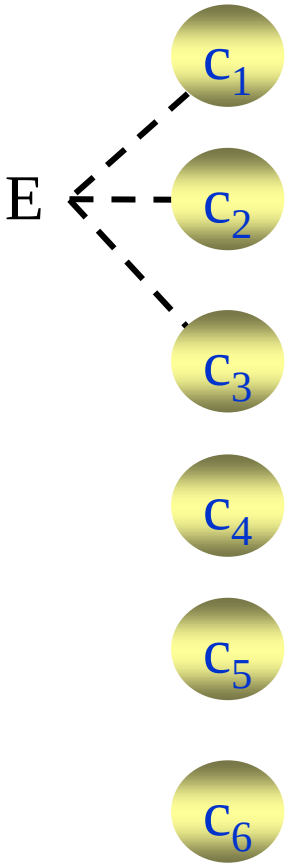
- 原因：

c_1: 输入学号；
c_2: 输入工号；
c_3: 输入序号；
c_4: 输入正确密码；
c_5: 输入验证码；
c_6: 安装控件。

- 结果：

e_1: 学生界面；
e_2: 教工界面；
e_3: 管理员界面；
e_4: “输入错误”；
e_5: “未安装控件”。

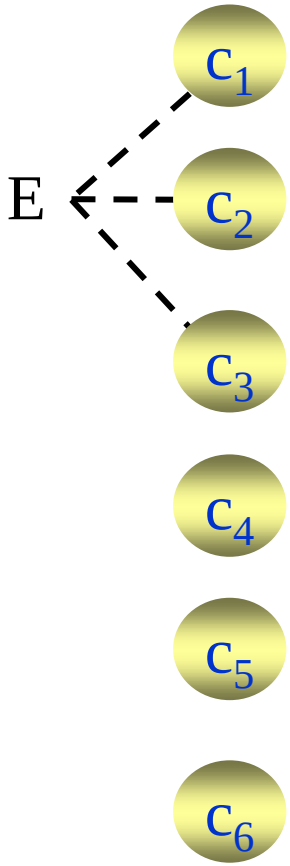
Constraints among Causes



- 原因：

c_1: 输入学号；
c_2: 输入工号；
c_3: 输入序号；
c_4: 输入正确密码；
c_5: 输入验证码；
c_6: 安装控件。

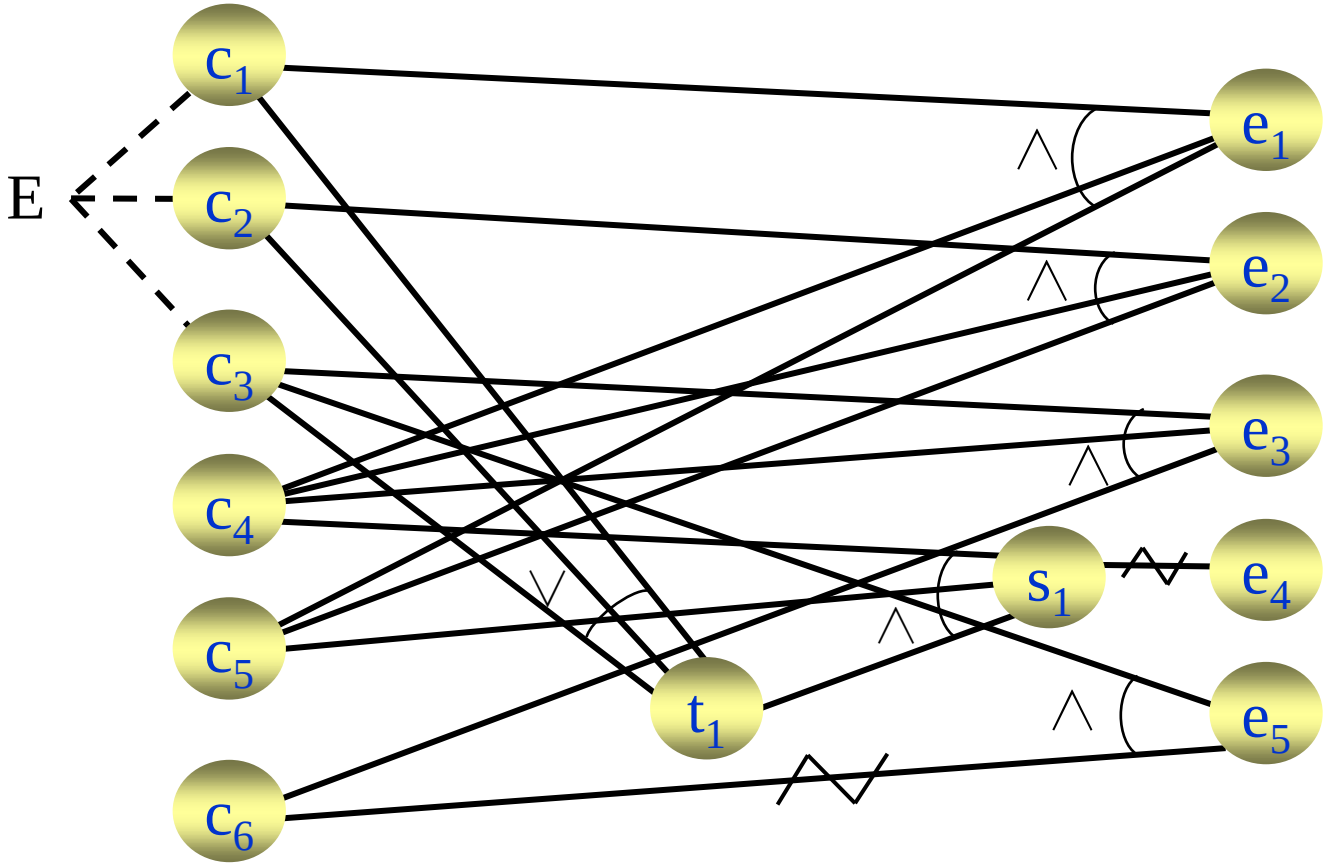
Equations with Intermediate Variables



$$e_1 = c_1 \wedge c_4 \wedge c_5$$
$$e_2 = c_2 \wedge c_4 \wedge c_5$$
$$e_3 = c_3 \wedge c_4 \wedge c_6$$
$$e_4 = [\sim(c_1 \vee c_2 \vee c_3)] \vee (\sim c_4) \vee (\sim c_5)$$
$$= \sim[(c_1 \vee c_2 \vee c_3) \wedge c_4 \wedge c_5]$$
$$= \sim(t_1 \wedge c_4 \wedge c_5) = \sim s_1$$
$$e_5 = c_3 \wedge (\sim c_6)$$

$$t_1 = c_1 \vee c_2 \vee c_3$$
$$s_1 = t_1 \wedge c_4 \wedge c_5$$

Drawing the CED



Limitations of the DBBT Techniques

- It is possible for the DBBT techniques to check whether there are bugs in software, whereas some specific kinds of bugs can not be detected (e.g. the bugs that are not actual errors).

```
MOV BX, 2000H
MOV AX, 1000H
NOP
MOV [BX], AX
```

Exercise-1

- **Description**
  - 某学校学生学号由3部分从前至后依次组成：入学年份、学院代码和学生编码。如果入学年份在1980年至1999年期间，只有年份后2位；如果入学年份在2000年至2016年期间，需是4位完整数字。学院代码为2位，必须是01、02、03或04。学生编码是范围在001~100的3位数字字符。现有学生管理系统软件来查询1980~2016级学生的成绩列表，如不符合上述输入规范则系统会报错。
- **Please design test cases by using the equivalence partitioning technique.**

Exercise-2

- **Description**
  - In February, 2020, COVID-2019 was raging all over the country, and Hubei Province was the most serious. A hospital in Xi'an decided to support Hubei Province at the crucial moment. Those who were under the age of 35 would go to Wuhan City if unmarried and go to Shiyan City if married. Those who were from the age of 35 and over would stay in the hospital for the intermediate grade and assist nucleic acid testing in the communities for the others.
- **Please list all the causes (c) and effects (e) and draw the cause-effect diagram for the issue.**

THANK YOU!