Chapter 7

Decision Table-Based Testing

Outline

- Decision table vocabulary
  - Limited Entry Decision Tables (LEDT)
  - Extended Entry Decision Tables (EEDT)
  - Mixed Entry Decision Tables (MEDT)
- Techniques
  - Redundant LEDTs
  - Inconsistent LEDTs
- Examples
- Guidelines
- Cause and Effect Graphs

Decision Table Based Testing

- Originally known as Cause and Effect Graphing
  - Done with a graphical technique that expressed AND-OR-NOT logic.
  - Causes and Effects were graphed like circuit components
  - Inputs to a circuit "caused" outputs (effects)
- Equivalent to forming a decision table in which:
  - inputs are conditions
  - outputs are actions
- Test every (possible) rule in the decision table.
- Recommended for logically complex situations.
- Excellent example of Model-Based Testing (MBT)

Decision Tables

- Represent complex conditional behavior.
- Support extensive analysis
  - Consistency
  - Completeness
  - Redundancy
  - Algebraic simplification
- Executable (and compilable)
- Two forms: Limited and Extended Entry.
- “Don't Care” condition entries require special attention.
- Dependencies usually yield impossible situations

Content of a Decision Table

- Conditions
  - binary in a Limited Entry Decision Table
  - finite set in an Extended Entry Decision Table
  - condition stub
  - condition entries
- Actions
  - also binary, either do or skip
  - the “impossible” action
- Rules
  - a rule consists of condition entries and action entries
  - a complete, non-redundant LEDT with n conditions has 2^n rules
  - logically impossible combinations of conditions are “impossible rules”, denoted by an entry in the impossible action

Example

Stub	*Rule 1*	*Rule 2*	*Rule 3*	*Rule 4*	*Rule 5*	*Rule 6*	*Rule 7*	*Rule 8*
c1	T	T	T	T	F	F	F	F
c2	T	T	F	F	T	T	F	F
c3	T	F	T	F	T	F	T	F
a1	X	X			X			
a2	X					X		
a3		X						
a4			X	X	X		X	X

Condition c3 has no effect on the actions of Rules 3 and 4. Similarly for Rules 7 and 8. They can be algebraically combined.

Example (continued)

Stub	*Rule 1*	*Rule 2*	*Rules 3, 4*	*Rule 5*	*Rule 6*	*Rules 7, 8*
c1	T	T	T	F	F	F
c2	T	T	F	T	T	F
c3	T	F	—	T	F	T
a1	X	X		X		—
a2	X				X	
a3		X				
a4			X	X		X

- The condition entries in rules 3 and 4, and rules 7 and 8 have the same actions. The "—" means ...
  - "Don't Care" (as in circuit analysis),
  - Irrelevant, or
  - not applicable, n/a

Example (continued)

Stub	*Rule 1*	*Rule 2*	*Rules 3, 4, 7, 8*	*Rule 5*	*Rule 6*
c1	T	T	—	F	F
c2	T	T	F	T	T
c3	T	F	—	T	F
a1	X	X		X	
a2	X				X
a3		X			
a4			X	X	

- One more algebraic simplification

Example (continued)

Stub	*Rule 1*	*Rule 2*	*Rules 3, 4, 7, 8*	*Rule 5*	*Rule 6*
c1	T	T	—	F	F
c2	T	T	F	T	T
c3	T	F	—	T	F
a1	X	X		X	
a2	X				X
a3		X			
a4			X	X	
count	1	1	4	1	1

- Rule counting
  - a rule with no don't care entries counts as 1
  - each don't care entry in a rule doubles the rule count
  - for a table with n limited entry conditions, the sum of the rule counts should be 2^n.

Problematic Decision Tables

- For LEDTs, simple rule counting helps identify decision tables that are ...
  - incomplete (rule count < 2^n) ,
  - redundant (rule count > 2^n) , or
  - inconsistent
    - (rule count > 2^n) AND
    - at least two rules have identical condition entries but different action entries.
- Redundancy and inconsistency are more likely with algebraically simplified tables that have been “maintained”.

A Redundant DT

conditions	*1 – 4*	*5*	*6*	*7*	*8*	*9*
c1	T	F	F	F	F	T
c2	—	T	T	F	F	F
c3	—	T	F	T	F	F
a1	X	X	X	—	—	X
a2	—	X	X	X	—	—
a3	X	—	X	X	X	X

- Rule 9 is redundant with Rules 1 – 4 (technically, with what was rule 4)
- But the action entries are identical (No harm, no foul?)

An Inconsistent DT

conditions	*1 – 4*	*5*	*6*	*7*	*8*	*9*
c1	T	F	F	F	F	T
c2	—	T	T	F	F	F
c3	—	T	F	T	F	F
a1	X	X	X	—	—	—
a2	—	X	X	X	—	X
a3	X	—	X	X	X	—

- Rule 9 is inconsistent with Rules 1 – 4 (technically, with what was rule 4)
  - condition portion is identical, BUT
  - action portion is different
- What happens when Rule 4 is executed? Rule 9?

Last Day of Month Decision Table

conditions	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*
c1. month in M1?	T	T	T	T	T	T	T	T	F	F	F	F	F	F	F	F
c2. month in M2?	T	T	T	T	F	F	F	F	T	T	T	T	F	F	F	F
c3. month in M3?	T	T	F	F	T	T	F	F	T	T	F	F	T	T	F	F
c4. leap year?	T	F	T	F	T	F	T	F	T	F	T	F	T	F	T	F
a1. last day = 30								x								
a2. last day = 31											x	x				
a3. last day = 28														x		
a4. last day = 29													x			
a5. impossible	x	x	x	x	x	x			x	x					x	x

- Rule pairs 1 and 2, 3 and 4, 5 and 6, 9 and 10 don't need c4, so they could be combined, BUT
- Impossible because c1, c2, and c3 are mutually exclusive.

Extended Entry Decision Tables

- When conditions are mutually exclusive, exactly one must be true.
- Extended entry decision tables typically (but not necessarily) have mutually exclusive conditions.
- The “extended” part is because a condition stub is an incomplete statement that is completed by the condition entry.
- (See the revised Last Day of Month EEDT)

Revised Last Day of Month DT

c1. month in	M1	M1	—	—	—	—
c2. month in	—	—	M2	M2	—	—
c3. month in	—	—	—	—	M3	M3
c4. leap year?	T	F	T	F	T	F
a1. last day = 30	x	x				
a2. last day = 31			x	x		
a3. last day = 28						x
a4. last day = 29					x	

- When conditions are mutually exclusive, exactly one must be true.
- This can be further simplified.

The "Emphatic False"

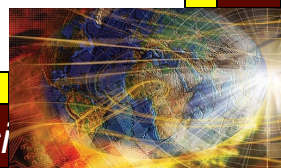
c1. month in	M1	—	—	—
c2. month in	—	M2	—	—
c3. month in	—	—	M3	M3
c4. leap year?	—	—	T	F
a1. last day = 30	x			
a2. last day = 31		x		
a3. last day = 28				x
a4. last day = 29			x	

- Maybe "—" should be replaced by "must be False"
- One writer suggested "F!" (before "!" meant "NOT")
- It is a Don't Care in c4.
- Technically, this is a Mixed Entry Decision Table, because it has both extended and limited entry conditions.

Triangle Program Decision Table

c1: a, b, c form a triangle?	F	T	T	T	T	T	T	T	T
c2: a = b?	—	T	T	T	T	F	F	F	F
c3: a = c?	—	T	T	F	F	T	T	F	F
c4: b = c?	—	T	F	T	F	T	F	T	F
a1: Not a triangle	X								
a2: Scalene									X
a3: Isosceles					X		X	X	
a4: Equilateral		X							
a5: Impossible			X	X		X			

Why are some rules impossible?



Expanding c1...

c1: a<b+c?	F	T	T	T	T	T	T	T	T	T	T
c2: b<a+c?	—	F	T	T	T	T	T	T	T	T	T
c3: c<a+b?	—	—	F	T	T	T	T	T	T	T	T
c4: a = b?	—	—	—	T	T	T	T	F	F	F	F
c5: a = c?	—	—	—	T	T	F	F	T	T	F	F
c6: b = c?	—	—	—	T	F	T	F	T	F	T	F
a1: Not a triangle	x	x	x								
a2: Scalene											x
a3: Isosceles						x			x	x	
a4: Equilateral				x							
a5: Impossible					x	x		x			

- Is this a complete decision table?
  How many test cases does this imply?

Rule Counting

c1: a<b+c?	F	T	T	T	T	T	T	T	T	T	T
c2: b<a+c?	—	F	T	T	T	T	T	T	T	T	T
c3: c<a+b?	—	—	F	T	T	T	T	T	T	T	T
c4: a = b?	—	—	—	T	T	T	T	F	F	F	F
c5: a = c?	—	—	—	T	T	F	F	T	T	F	F
c6: b = c?	—	—	—	T	F	T	F	T	F	T	F
Rule count	32	16	8	1	1	1	1	1	1	1	1
a1: Not a triangle	x	x	x								
a2: Scalene											x
a3: Isosceles						x			x	x	
a4: Equilateral				x							
a5: Impossible					x	x		x			

Corresponding Test Cases

Case ID	*a*	*b*	*c*	*Expected Output*
DT1	4	1	2	Not a Triangle
DT2	1	4	2	Not a Triangle
DT3	1	2	4	Not a Triangle
DT4	5	5	5	Equilateral
DT5	?	?	?	Impossible
DT6	?	?	?	Impossible
DT7	2	2	3	Isosceles
DT8	?	?	?	Impossible
DT9	2	3	2	Isosceles
DT10	3	2	2	Isosceles
DT11	3	4	5	Scalene

NextDate Decision Table (first half)

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
c1: month in	M1	M1	M1	M1	M1	M2	M2	M2	M2	M2
c2: day in	D1	D2	D3	D4	D5	D1	D2	D3	D4	D5
c3: year in	—	—	—	—	—	—	—	—	—	—
a1: impossible					X					
a2: increment day	X	X	X			X	X	X	X	
a3: reset day				X						X
a4: increment month				X						X
a5: reset month										
a6: increment year										

NextDate Decision Table (first half reduced)

	1–3	*4*	*5*	*6–9*	*10*
c1: month in	M1	M1	M1	M2	M2
c2: day in	D1, D2, D3	D4	D5	D1, D2, D3, D4	D5
c3: year in	—	—	—	—	—
a1: impossible			X		
a2: increment day	X			X	
a3: reset day		X			X
a4: increment month		X			X
a5: reset month					
a6: increment year					

NextDate Decision Table (second half)

	11	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*
c1: month in	M3	M3	M3	M3	M3	M4	M4	M4	M4	M4	M4	M4
c2: day in	D1	D2	D3	D4	D5	D1	D2	D2	D3	D3	D4	D5
c3: year in	—	—	—	—	—	—	Y1	Y2	Y1	Y2	—	—
a1: impossible										X	X	X
a2: increment day	X	X	X	X		X	X					
a3: reset day					X			X	X			
a4: increment month								X	X			
a5: reset month					X							
a6: increment year					X							

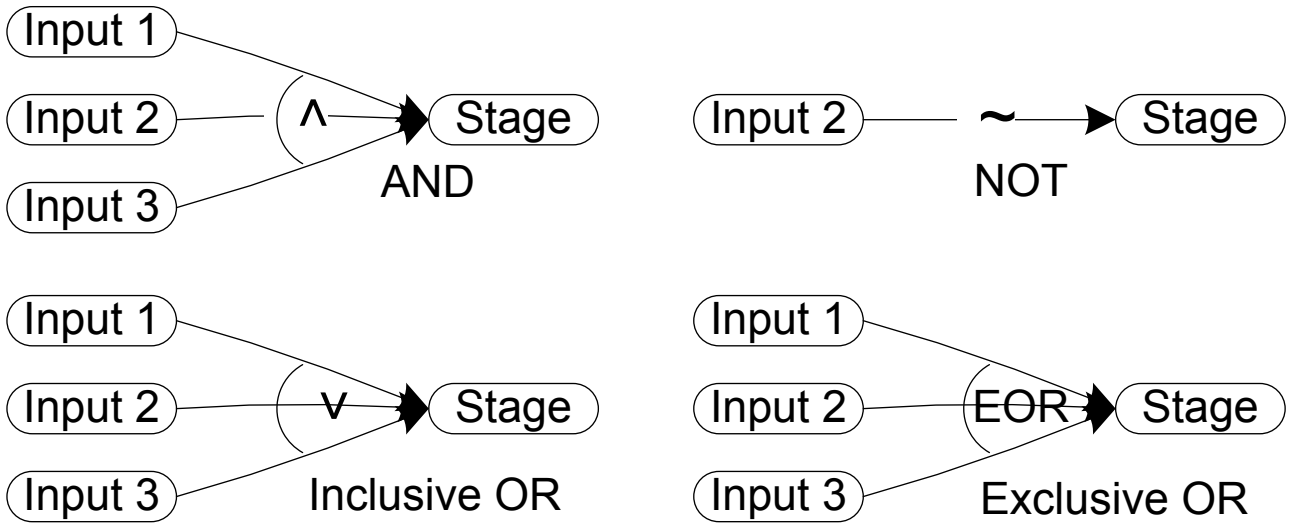
NextDate Decision Table (second half reduced)

	11–14	*15*	*16*	*17*	*18*	*19*	20	*21, 22*
c1: month in	M3	M3	M4	M4	M4	M4	M4	M4
c2: day in	D1, D2, D3, D4	D5	D1	D2	D2	D3	D3	D4, D5
c3: year in	—	—	—	Y1	Y2	Y1	Y2	—
a1: impossible							X	X
a2: increment day	X			X				
a3: reset day		X	X		X	X		
a4: increment month					X	X		
a5: reset month			X					
a6: increment year			X					

NextDate Test Cases

Test Case	*Rule(s)*	*Month*	*Day*	*Year*	*Expected Output*
1	1– 3	4	15	2001	4/16/2001
2	4	4	30	2001	5/1/2001
3	5	4	31	2001	Invalid Input Date
4	6–9	1	15	2001	1/16/2001
5	10	1	31	2001	2/1/2001
6	11–14	12	15	2001	12/16/2001
7	15	12	31	2001	1/1/2002
8	16	2	15	2001	2/16/2001
9	17	2	28	2004	2/29/2004
10	18	2	28	2001	3/1/2001
11	19	2	29	2004	3/1/2004
12	20	2	29	2001	Invalid Input Date
13	21, 22	2	30	2001	Invalid Input Date

Cause and Effect Graphs (basic gates)



Cause and Effect Graph for the Commission Problem