CSCE 747 Software Testing and Quality Assurance

Lecture 04 –

Decision Tables Based Testing

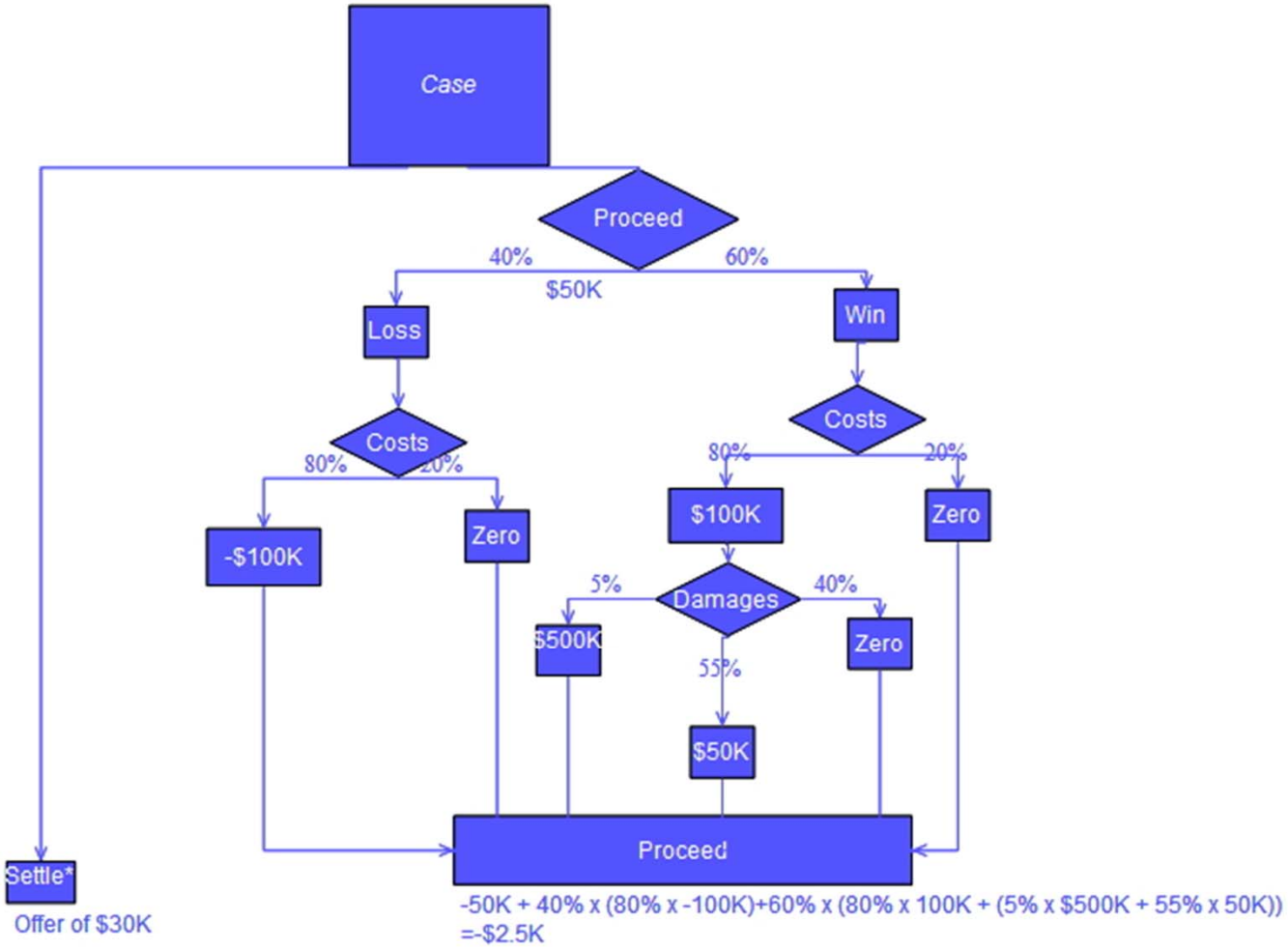
Last Time

- Equivalence Class Testing
- Revision Control Systems
- Git intro

Today

- Decision Table Based Testing
- Ch 7 pp 103-116
- Decision Trees
- Decision Tables for Business Logic
- Decision Tables for Testing

Decision Trees



- CSCE 510

http://en.wikipedia.org/wiki/Decision_tree

Decision Tables

Printer troubleshooter

		Rules							
		R1	R2						R8
Conditions	Printer does not print	Y	Y	Y	Y	N	N	N	N
	A red light is flashing	Y	Y	N	N	Y	Y	N	N
	Printer is unrecognized	Y	N	Y	N	Y	N	Y	N
Actions	Check the power cable			X					
	Check the printer-computer cable	X		X					
	Ensure printer software is installed	X		X		X		X	
	Check/replace ink	X	X			X	X		
	Check for paper jam		X		X				

 http://en.wikipedia.org/wiki/Decision_table

Decision Tables

- Decision tables have been used to represent and analyze complex logical relationships since the early 1960s.
- Ideal for describing situations in which a number of combinations of actions are taken under varying sets of conditions
- Capture "Business Logic"
  - **Capture = describe = document = display for stakeholders**

Decision Tables Support Completeness

- Decision table with boolean conditions like rotated truth table
  - Supports complete coverage of the logic
- Testing based on decision tables enforce logical rigor. "Completeness"
- Related methods are used:
  - cause–effect graphing (Elmendorf, 1973; Myers, 1979) and
  - the decision tableau method (Mosley, 1993).

Decision Table for Triangle Problem01

Table 7.1 Portions of a Decision Table

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	–
a1	X	X		X		
a2	X				X	
a3		X		X		
a4			X			X

don't care

Mapping

Decision Tables to Test Cases

- "To identify test cases with decision tables, we:

1. Interpret conditions as inputs and actions as outputs.
   - Sometimes conditions end up referring to equivalence classes of inputs, and
2. Actions refer to major functional processing portions of the item tested.
3. The rules are then interpreted as test cases.

- Because the decision table can mechanically be forced to be complete, we know we have a comprehensive set of test cases."

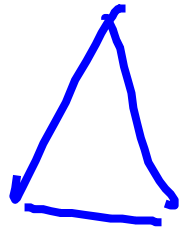


Table 7.2 Decision Table for the Triangle Problem

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			

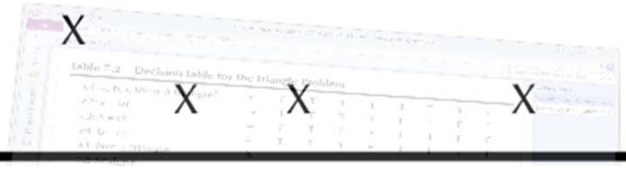
$2^6 = 64$

$a = b = c = 7$

32 16 8

Table 7.3 Refined Decision Table for the Triangle Problem

c1: a < b + c?	F	T	F	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			



NextDate Decision tables

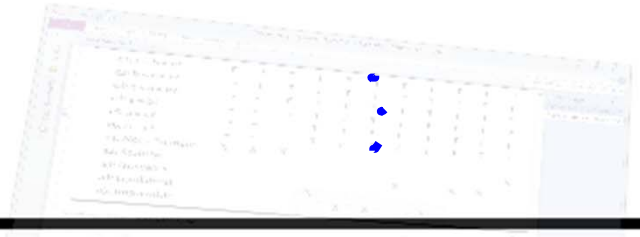
- What are meaningful decisions for NextDate?
  - Months
    - M1 ={ months that have 30 days}
    - M2 ={ months that have 31 days}
    - M3 ={February}
  - Days
    - D1 ( ), D2( ), D3( ), D4( )
  - Years Y1(2000), Y2(non-century-leap-year), Y3()
- So how big is the table?
  - 9 boolean tests → 2^{10}=1024
  - 3*4*3

When conditions refer to equivalence classes

- In NextDate
  - Consider equivalence class = sameLengthMonth

Table 7.4 Decision Table with Mutually Exclusive Conditions

Conditions	*R1*	*R2*	*R3*
c1: month in M1?	T	—	—
c2: month in M2?	—	T	—
c3: month in M3?	—	—	T
a1			
a2			
a3			



Triangle

Rule Counts

- **Rule Count – number of corresponding cases**

Table 7.5 Decision Table for Table 7.3 with Rule Counts

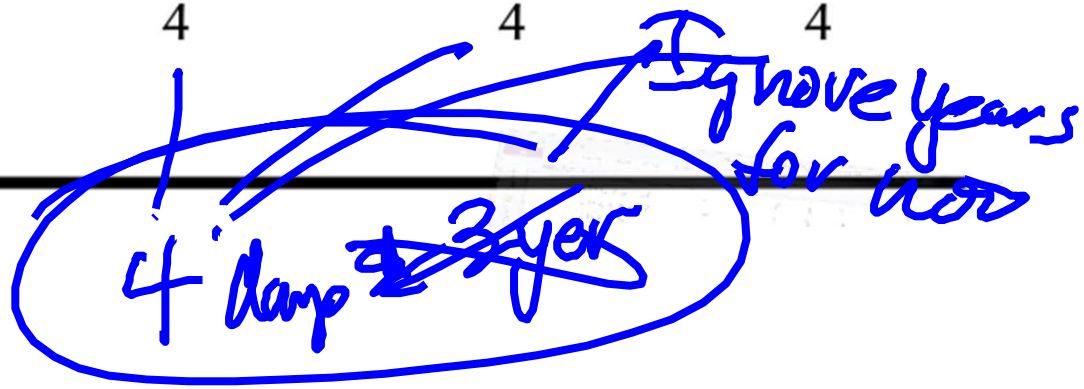
c1: a < b + c?	F	T	T	T	T	T	T	T	T	T	T
c2: b < a + c?	—	F	T	T	T	T	T	T	T	T	T
c3: c < a + b?	—	—	F	T	T	T	T	T	T	T	T
c4: a = b?	—	—	—	T	T	T	T	F	F	F	F
c5: a = c?	—	—	—	T	T	F	F	T	T	F	F
c6: b = c?	—	—	—	T	F	T	F	T	F	T	F
Rule count	32	16	8	1	1	1	1	1	1	1	1
a1: Not a Triangle	X	X	X								
a2: Scalene											X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

- **Note sum of counts = 64 for complete truth table**

Rule Counts for NextDate

Table 7.6 Rule Counts for a Decision Table with Mutually Exclusive Conditions

Conditions	*R1*	*R2*	*R3*
c1: month in M1	T	—	—
c2: month in M2	—	T	—
c3: month in M3	—	—	T
Rule count	4	4	4
a1			



- **Consider Equivalence Relation M X D**
  - **Eg. 2.3 = equivalence class M2 X D3**

M = M2
D = D1

2.3
M.D

Table 7.7 Expanded Version of Table 7.6

Conditions	*1.1*	*1.2*	*1.3*	*1.4*	*2.1*	*2.2*	*2.3*	*2.4*	*3.1*	*3.2*	*3.3*	*3.4*
c1: mo. in M1	T	T	T	T	T	T	F	F	T	T	F	F
c2: mo. in M2	T	T	F	F	T	T	T	T	T	F	T	F
c3: mo. in M3	T	F	T	F	T	F	T	F	T	T	T	T
Rule count	1	1	1	1	1	1	1	1	1	1	1	1
a1												

Impossible Rules

- **Impossible Rules – cases that cannot happen**

Table 7.8 Mutually Exclusive Conditions with Impossible Rules

	1.1	*1.2*	*1.3*	*1.4*	*2.3*	*2.4*	*3.4*	
c1: mo. in M1	T	T	T	T	F	F	F	F
c2: mo. in M2	T	T	F	F	T	T	F	F
c3: mo. in M3	T	F	T	F	T	F	T	F
Rule count	1	1	1	1	1	1	1	1
a1: Impossible	X	X	X		X			X

Redundancy in Decision Tables

Table 7.9 A Redundant Decision Table

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

- Here rules 4 and rule 9 are identical; redundant

Redundancy OK; but Inconsistency?

- Now consider rules 4 and 9

Table 7.10 An Inconsistent Decision Table

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	–

Test Cases for the Triangle Problem

- 11 test cases
  - 3 impossible
  - 3 not triangle
  - 1 equilateral
  - 1 scalene
  - 3 isosceles
- ? means invalid

Table 7.11 Test Cases from Table 7.3

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

one for each rule

NextDate Try1

- 8 boolean conditions → 2^8 =256 cases

Table 7.12 First Try Decision Table with 256 Rules

Conditions			
c1: month in M1?	T		
c2: month in M2?		T	
c3: month in M3?			T
c4: day in D1?			
c5: day in D2?			
c6: day in D3?			
c7: day in D4?			
c8: year in Y1?			
a1: impossible			
a2: next date			

Test Cases for NextDate

- Invalid actions
  - a1: Day invalid for this month
  - a2: Cannot happen in a non-leap year
  - a3: Compute the next date
- 3([months])*4([days])*3([year]) = 36 equiv classes
  - [x] = equivalence classes
  - <m,d,y> 36 equiv. classes on M x D x Y
  - 36 rules/test cases – reducing by combining rules with don't care cases yields 16 rules

NextDate 2nd Try

Table 7.13 Second Try Decision Table with 36 Rules

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

M3 = Feb
D2 = 29th!!! 24+6+2×3
Y2 = 2
non-century leap yr 24+6+6 = 36

	9	10	11	12	13	14	15	16
c1: month in	M3	M3	M3	M3	M3	M3	M3	M3
c2: day in	D1	D1	D1	D2	D2	D2	D3	D4
c3: year in	Y1	Y2	Y3	Y1	Y2	Y3	—	—
Rule count	1	1	1	1	1	1	3	3
Actions								
a1: impossible						X	X	X
a2: increment day		X						
a3: reset day	X		X	X	X			
a4: increment month	X		X	X	X			
a5: reset month								
a6: increment year								

But Problems Remain

- December problems in rule 8
- Feb 28 problems in 9, 11 and 12
- So new decomposition
  - M1 = {month : month has 30 days}
  - M2 = {month : month has 31 days except December}
  - M3 = {month : month is December}
  - M4 = {month : month is February}
  - D1 = {day : 1 ≤ day ≤ 27}
  - D2 = {day : day = 28}
  - D3 = {day : day = 29}
  - D4 = {day : day = 30}
  - D5 = {day : day = 31}
  - Y1 = {year : year is a leap year}
  - Y2 = {year : year is a common year}
  - note author eliminated Y3 to make tables smaller

4 x 5 x 2

Table 7.14 Decision Table for the NextDate Function

	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	—	—	—	—	—	—	—	—	—	—
Actions										
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										

	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	—	—
Actions												
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							

Compressing the Table

- Combining columns

not always is good idea! output Bussed

Table 7.15 Reduced Decision Table for the NextDate Function

	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	—	—	—	—	—
Actions					
a1: impossible			X		
a2: increment day	X			X	
a3: reset day		X			X
a4: increment month		X			X
a5: reset month					
a6: increment year					

- Table for 11-22 in text

NextDate Decision Table Test cases

Table 7.16 Decision Table Test Cases for NextDate

Case ID	*Month*	*Day*	*Year*	*Expected Output*
1–3	April	15	2001	April 16, 2001
4	April	30	2001	May 1, 2001
5	April	31	2001	Invalid Input Date
6–9	January	15	2001	January 16, 2001
10	January	31	2001	February 1, 2001
11–14	December	15	2001	December 16, 2001
15	December	31	2001	January 1, 2002
16	February	15	2001	February 16, 2001
17	February	28	2004	February 29, 2004
18	February	28	2001	March 1, 2001
19	February	29	2004	March 1, 2004
20	February	29	2001	Invalid Input Date
21, 22	February	30	2001	Invalid Input Date

Jorgensen, Paul C. Software Testing
A Craftsman Approach

Decision Table for Commission Problem

- Not well suited
- Very little decision logic
- Variables truly independent → no impossible cases as in NextDate
- 3 equivalence classes:
  - **Commission1, commission2, commission3**

Guidelines and Observations

1. Decision table approach appropriate for applications with
   - Prominent if-then-else logic
   - Logical relationships among input variables
   - Calculations involving subsets of inputs
2. Decision tables do not scale up well
3. Iteration helps. Start then refine.

Homework

1. Consider a NextMonth function
   - **NextMonth(Feb, 15, 2000) = (March, 15, 2000)**
   - **NextMonth(jan, 30, 2000) =? There are multiple correct answers here. Your answer here will affect #2.**
2. Develop a decision table for NextMonth function (not ignoring days)