Software Testing
Course's Code: CSE 453
Test Design Techniques: Decision Table based Testing
(Chapter 4)

Decision Table

- Specifications often contain business rules to define
  - functions of the system
  - conditions or decisions under which each function operates
- Individual conditions are simple, but the overall effects of these logical conditions can become quite complex
- As testers, we need to able to assure ourselves that every combinations of these conditions might occur has been tested
  - need to capture all decisions in a way that enables us to explore their combinations
  - Decision Table is the mechanism that is used to capture the logical decisions in a precise and compact way

Decision Table

- A decision table lists all the input conditions that can occur and all the actions that can arise from them
- The resulting decision tables are easy to understand, and can be validated by domain experts.
- Furthermore, testers can use decision tables for the systematic derivation of test cases,
  - in order to verify that the system under test correctly implements the required conditional logic.
- A decision table is structured into a table as rows
  - the conditions at the top of the table
  - possible actions at the bottom
  - business rules which involve some combinations of conditions to produce some combinations of actions are arranged across the top

Decision Table

- A decision table is structured into a table as rows
  - the conditions at the top of the table
  - possible actions at the bottom
  - each column represents a single business rule shows how input conditions are combined to produce actions

	Rule 1	Rule 2	Rule 3
Condition 1	T	F	T
Condition 2	T	T	T
Condition 3	T	dc	F
Action 1	Y	N	Y
Action 2	N	Y	Y

Decision Table

- Rule 1 requires all conditions to be true to generate action 1
- Rule 2 results in action 2 if condition 1 is false and condition 2 is true, but does not depends on condition 3
- Rule 3 requires conditions 1 and 2 to be true and condition 3 to be false
- Hyphen "dc" in decision table represents a "don't care" entry.

	Rule 1	Rule 2	Rule 3
Condition 1	T	F	T
Condition 2	T	T	T
Condition 3	T	dc	F
Action 1	Y	N	Y
Action 2	N	Y	Y

Example-Phone Subscriptions

- A Dutch phone company, lets users click various options and then determines a price per month.
- The price per month is determined by two conditions. The conditions are:
  - whether the subscription is for national, which is cheaper, or international, more expensive, that's on the first row
  - the second condition is whether the customer is willing to renew automatically, which would also be cheaper.
  - At the bottom in bold, we see the actual outcome or action, as determined by the conditions. In this case the outcomes are different monthly prices.

		Variants			
Conditions	International?	F	F	T	T
	Auto-renewal?	T	F	T	F
Action	**Price/month**	**10**	**15**	**30**	**32**

Example-Phone Subscriptions

- In this example, there are 4 rules
  - The first rule describes the cheapest subscription, 10 Euros per month, limited to national usage and with an obligation to automated renewal
  - The fourth column is the most expensive one, 32 Euros per month with usage across the world, and the possibility to cancel any moment.

		Variants			
Conditions	International?	F	F	T	T
	Auto-renewal?	T	F	T	F
Action	**Price/month**	**10**	**15**	**30**	**32**

Example-Phone Subscriptions

- As a slightly more complex example, consider an extra condition, shown in the third row.
  - If you as a potential buyer are a loyal customer already, you deserve a reduction.
  - Here, we assume a customer can either get loyalty reduction, or auto-renewal reduction, but not both.

	Rule 1	**Rule 2**	**Rule 3**	**Rule 4**	**Rule 5**	**Rule 6**
International?	F	F	F	T	T	T
Auto-renewal?	T	dc	F	T	dc	F
Loyal?	dc	T	F	dc	T	F
Price/month	10	10	15	30	30	32

Example-Phone Subscriptions

- The first column indicates that if we have auto-renewal already, T-value, whether the customer is loyal as well does not matter, DC-value.

- Likewise, if the customer is loyal, second column, picking auto-renewal makes no difference.

	Rule 1	**Rule 2**	**Rule 3**	**Rule 4**	**Rule 5**	**Rule 6**
International?	F	F	F	T	T	T
Auto-renewal?	T	dc	F	T	dc	F
Loyal?	dc	T	F	dc	T	F
Price/month	10	10	15	30	30	32

Example-Phone Subscriptions

- These don't care values are essentially an abbreviation for two separate columns, for the true and false case, which are identical except for the DC value.
- If we expand each DC-value, we get, in this table, 4 extra variants or columns.
- We can see that variants one and three are exactly the same, even though they were derived from expansions of different DC-cells, shown in orange.
- The table is in this case well designed, in the sense that these two variants share the same action, the reduced price is 10 Euros in both cases.

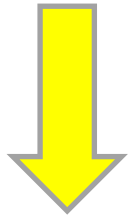
	Rule 1	**Rule 2**	**Rule 3**	**Rule 4**	**Rule 5**	**Rule 6**
International?	F	F	F	T	T	T
Auto-renewal?	T	dc	F	T	dc	F
Loyal?	dc	T	F	dc	T	F
Price/month	10	10	15	30	30	32

International?	F	F	F	F	F	T	T	T	T	T
Auto-renewal?	T	T	T	F	F	T	T	T	F	F
Loyal?	T	F	T	T	F	T	F	T	T	F
Price/month	**10**	**10**	**10**	**10**	**15**	**30**	**30**	**30**	**30**	**32**

Example-Phone Subscriptions

International?	F	F	F	F	F	T	T	T	T	T
Auto-renewal?	T	T	T	F	F	T	T	T	F	F
Loyal?	T	F	T	T	F	T	F	T	T	F
Price/month	**10**	**10**	**10**	**10**	**15**	**30**	**30**	**30**	**30**	**32**

- If we omit the duplicate columns we arrive at the simpler table shown here. With three conditions and 8 variants it shows the maximum number of variants.



Expanded and De-Duplicated

International?	F	F	F	F	T	T	T	T
Auto-renewal?	T	T	F	F	T	T	F	F
Loyal?	T	F	T	F	T	F	T	F
Price/month	**10**	**10**	**10**	**15**	**30**	**30**	**30**	**32**

Example-Phone Subscriptions

- In general, if we have N conditions, rows, this leads to 2^N possible variants, columns.
- The mobile plan example given here is relatively simple, with just three conditions.
- Decision tables in practice can have many more conditions. For example, the actual mobile plan has several more conditions, bandwidth limits, phone minutes, type of previous subscription, etc. This then easily leads to at least six conditions and 2^6 = 64 variants.

Larger Decision Tables

Decision tables can have many conditions

In general: *N* conditions: 2^*N* variants

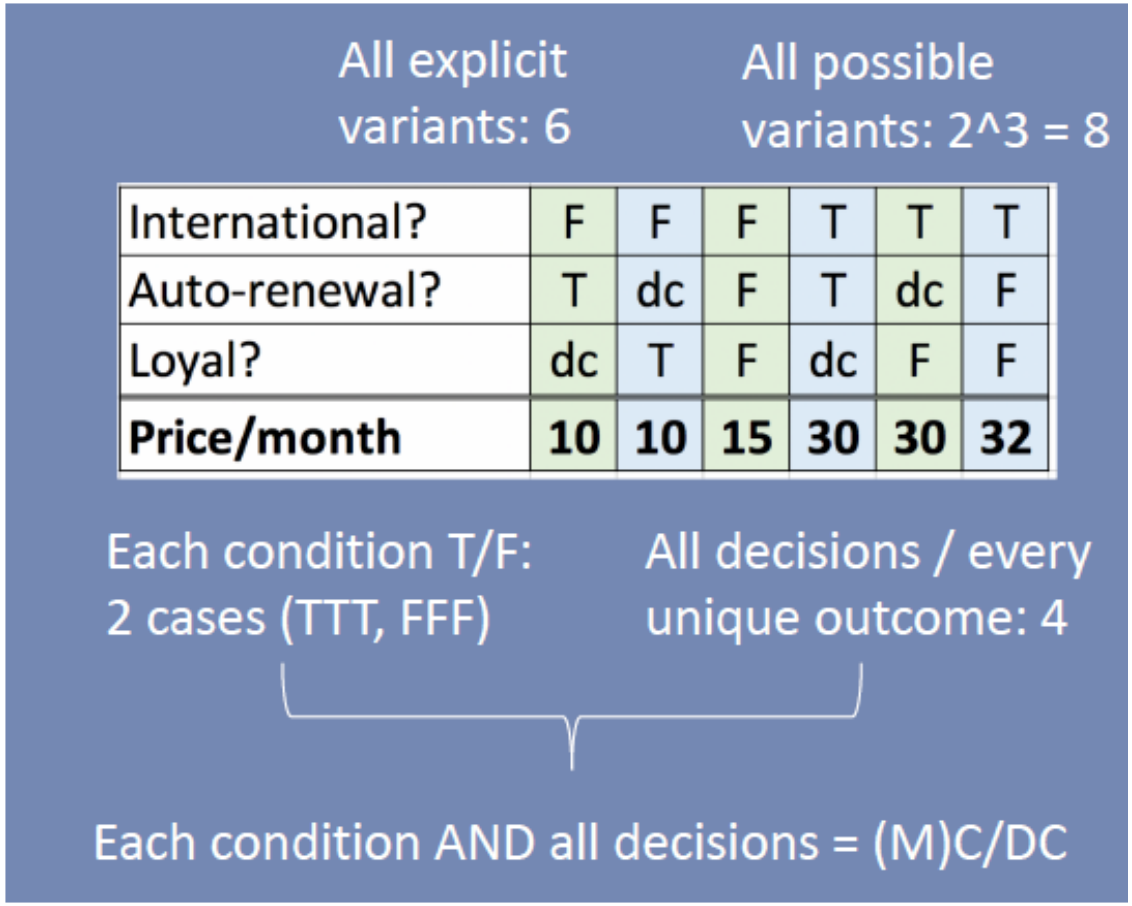
Omitted / non-specified variants?

Indicate what "default" behavior is.

Example-Phone Subscriptions: Testing Decision Table

- How to create test cases from a decision table?
  - Two ways
    - create one test case per variant (Column) listed in the table

    Or
    - MC/DC Coverage: Modified Condition / Decision coverage.



Example-Phone Subscriptions: Testing Decision Table

- MC/DC demands the following: Every condition should yield both true and false, Every outcome or action should be taken at least once, Every condition should be shown to individually determine the decision outcome,

MC/DC: Modified Condition / Decision Coverage

1. **Conditions:** Each condition should be once true, once false
2. **Decisions:** Each action should be taken at least once
3. **Modified:** Each condition should individually determine the outcome

For each condition require two test cases that *only* differ in outcome and *that* condition

Example-Phone Subscriptions: Testing Decision Table

Finding an "MC/DC Cover"

- Expand decision table
- Pick variants with unique outcome
- Combine with others so that they differ in one condition only

	v1	*v2*	*v3*	*v4*	*v5*	*v6*	*v7*	*v8*	
International?	F	F	F	F	T	T	T	T	
Auto-renewal?	T	T	F	F	T	T	F	F	
Loyal?	T	F	T	F	T	F	T	F	
Price/month	**10**	**10**	**10**	**15**	**30**	**30**	**30**	**32**	

Finding an "MC/DC Cover"

- Expand decision table
- Pick variants with unique outcome
- Combine with others so that they differ in one condition only

	v1	*v2*	*v3*	*v4*	*v5*	*v6*	*v7*	*v8*	*mc/dc*	*action*
International?	F	F	F	F	T	T	T	T	v4,v8	15 ,32
Auto-renewal?	T	T	F	F	T	T	F	F		
Loyal?	T	F	T	F	T	F	T	F		
Price/month	**10**	**10**	**10**	**15**	**30**	**30**	**30**	**32**		

Example-Phone Subscriptions: Testing Decision Table

Finding an "MC/DC Cover"

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- Pick variants with unique outcome
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	v1	*v2*	*v3*	*v4*	*v5*	*v6*	*v7*	*v8*	
International?	F	F	F	F	T	T	T	T	
Auto-renewal?	T	T	F	F	T	T	F	F	
Loyal?	T	F	T	F	T	F	T	F	
Price/month	**10**	**10**	**10**	**15**	**30**	**30**	**30**	**32**	

Finding an "MC/DC Cover"

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- Pick variants with unique outcome
- Combine with others so that they differ in one condition only

	v1	*v2*	*v3*	*v4*	*v5*	*v6*	*v7*	*v8*	*mc/dc*	*action*
International?	F	F	F	F	T	T	T	T	v4,v8	15 ,32
Auto-renewal?	T	T	F	F	T	T	F	F	v4,v2	10
Loyal?	T	F	T	F	T	F	T	F		
Price/month	**10**	**10**	**10**	**15**	**30**	**30**	**30**	**32**		

Example-Phone Subscriptions: Testing Decision Table

Finding an "MC/DC Cover"

- Expand decision table
- Pick variants with unique outcome
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	v1	*v2*	*v3*	*v4*	*v5*	*v6*	*v7*	*v8*
International?	F	F	F	F	T	T	T	T
Auto-renewal?	T	T	F	F	T	T	F	F
Loyal?	T	F	T	F	T	F	T	F
Price/month	**10**	**10**	**10**	**15**	**30**	**30**	**30**	**32**

Finding an "MC/DC Cover"

- Expand decision table
- Pick variants with unique outcome
- Combine with others so that they differ in one condition only

	v1	*v2*	*v3*	*v4*	*v5*	*v6*	*v7*	*v8*	*mc/dc*	*action*
International?	F	F	F	F	T	T	T	T	v4,v8	15 ,32
Auto-renewal?	T	T	F	F	T	T	F	F	v4,v2	10
Loyal?	T	F	T	F	T	F	T	F	v8,v7	30
Price/month	**10**	**10**	**10**	**15**	**30**	**30**	**30**	**32**		

- 4 Test Cases are: V2,V4,V8 and V7.

Example-Phone Subscriptions: Testing Decision Table

MC/DC: N+1 Test Cases

For a table with N conditions and yes/no actions, N+1 test cases suffice to obtain an MC/DC cover

Implementation of Decision Table based Testing

```java
@Test
void internationalExpensive() {
    PhonePlan plan = new PhonePlan();

    plan.setInternational(true);
    plan.setAutoRenewal(false);
    plan.setLoyal(false);

    assertThat(plan.pricePerMonth())
            .isEqualTo(32);
}
```

Junit Parameterized Tests

```java
@ParameterizedTest
@CsvSource({
        "true,  false, false, 32",
        "true,  false, true,  30",
        "false, false, false, 15",
        "false, true,  false, 10"
})
void testPlan(boolean inter,
              boolean renew,
              boolean loyal,
              int expected) {
    PhonePlan plan = new PhonePlan();

    plan.setInternational(inter);
    plan.setAutoRenewal(renew);
    plan.setLoyal(loyal);

    assertThat(plan.pricePerMonth())
            .isEqualTo(expected);

}
```

Example 2 - Decision Table based Testing

- A supermarket has a loyalty schema that is offered to all customers.
- Loyalty cardholders enjoy the benefits of either additional discounts on all purchases or the acquisition of loyalty points
- Loyalty points can be converted into vouchers for the supermarket or to equivalent points in schemas run by partners
- Customers without a loyalty card receive an additional discount only if they spend more that $100 on any one visit to the store
- otherwise only the special offers offered to all customers apply

Example 2 - Decision Table based Testing

		RULE 1	RULE 2	RULE 3	RULE 4	RULE 5
Conditions	Customer loyalty card?	T	T	T	F	F
	Special Offer selected?	T	F	F	T	F
	Spend>$100	dc	dc	dc	T	F
Actions	Additional Discount	F	F	T	T	F
	Loyalty Points-Voucher	F	T	F	F	F
	Loyalty Points-Equivalent Points	T	F	F	F	F
	Special offer applied	T	F	F	T	F

- 5 Test Cases are: Rule 1, Rule 2, Rule 3, Rule 4, Rule 5. (Without applying MC/DC)

Example 3 - Decision Table based Testing

- The triangle program accepts three integers, a, b, and c, as input
- These are taken to be the sides of a triangle
- The integers a, b, and c must satisfy the following conditions:

C1: a<b+c
C2: b<a+c
C3: c<a+b

- The output of the program may be: Equilateral, Isosceles, Scalene, Not-a-triangle and Impossible

Example 3- Decision Table based Testing

		R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11
Conditions	a<b+c?	F	T	T	T	T	T	T	T	T	T	T
	b<a+c?	-	F	T	T	T	T	T	T	T	T	T
	c<a+b?	-	-	F	T	T	T	T	T	T	T	T
	a=c?	-	-	-	T	T	T	F	T	F	F	F
	b=c?	-	-	-	T	T	F	T	F	T	F	F
	a=b?	-	-	-	T	F	T	T	F	F	T	F
Actions	Not a triangle	T	T	T								
	Scalene											T
	Isosceles								T	T	T	
	Equilateral				T							
	Impossible					T	T	T				

- 11 Test Cases are: R1-R11. (Without applying MC/DC)

Example 4- Decision Table Based Testing

- A mutual insurance company has decided to float its shares on the stock exchange and is offering its members rewards for their past custom at the time of flotation
- Anyone with a current policy will benefit provided it is a ‘with-profits’ policy and they have held it since 2001
- Those who meet these criteria can opt for either a cash payment or an allocation of shares in the new company
- Those who have held a qualifying policy for less than the required time will be eligible for a cash payment but not for shares.

Example 4- Decision Table Based Testing

		Rule 1	Rule 2	Rule 3	Rule 4
Conditions	Current policy holder	Y	Y	Y	N
	Policy holder since 2001	N	Y	N	dc
	‘With-profits’ policy	Y	Y	N	dc
Actions	Eligible for cash payment	Y	Y	N	N
	Eligible for share allocations	N	Y	N	N

- 4 Test Cases are: RULE1-RULE4