STATE TABLE AND DECISION TABLE BASED TESTING

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STATE TABLE – BASED TESTING

- Tables are useful tools for representing and documenting many types of information relating to test case design.

- These are beneficial for applications which can be described using state transition diagrams and state tables.

Basic terms related to State Table

1. Finite State Machine (FSM)

- An FSM is a behavioral model whose outcome depends upon both the previous and current inputs.
- This model can be prepared for software structure or software behavior.
- It can be used as a tool for functional testing.

2. State Transition Diagrams or State Graph

- A system or its components may have a number of states depending on its *input and time*.
- States are represented by *nodes.*
- *With the help of nodes and transition links between nodes, a STD or SG can be prepared.*

State Graph

- A state graph is the pictorial representation of an FSM.
- Its purpose is to depict the states that a system or its components can assume.
- It shows the events or circumstances that cause or result from a change from one state to another.

State Graph cont …

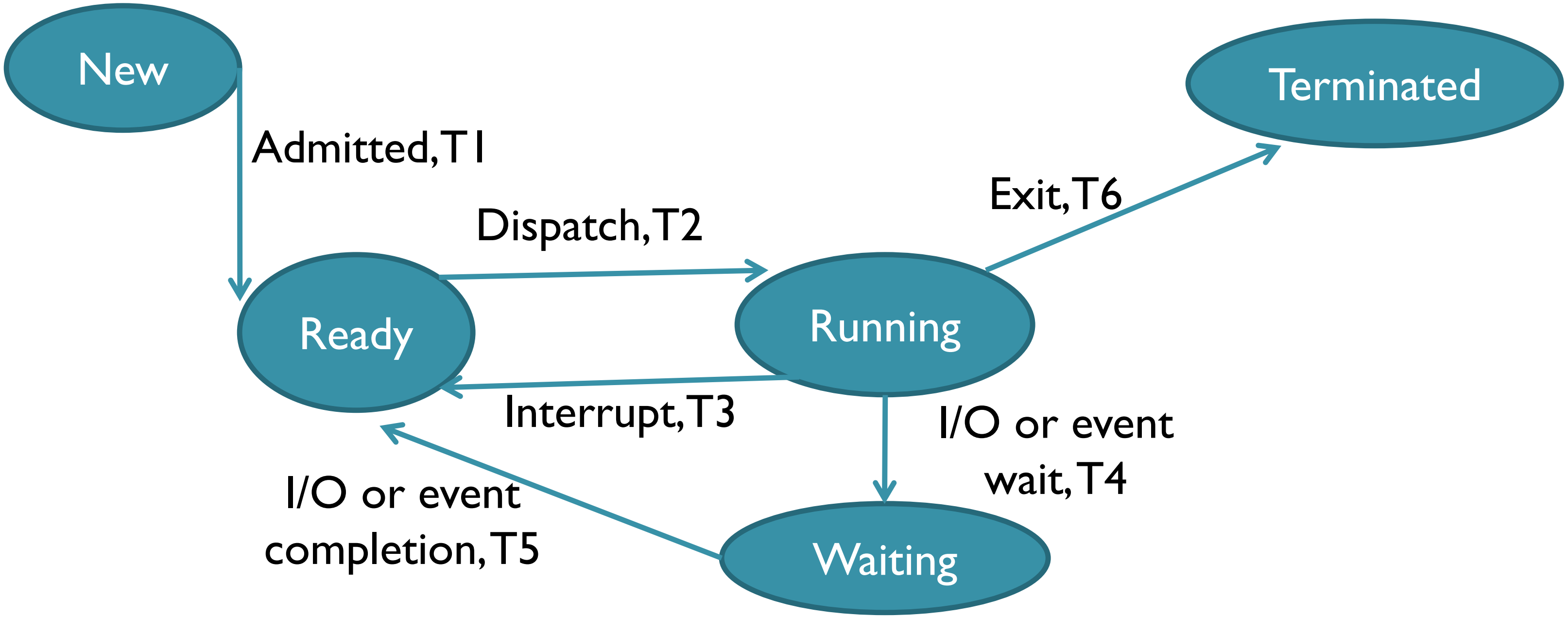
- Whatever is being modeled is subjected to inputs.
- As a result of these inputs, when one state is changed to another is called a *transition.*
- Transitions are represented by links that join the nodes.

Example

For example, a task in an O. S. can have its following states:

i. **New State :** When a task is newly created
ii. **Ready :** When the task is waiting in the ready queue for its turn.
iii. **Running :** When Instructions of the task are being executed by CPU.
iv. **Waiting :** When the task is waiting for an I/O event or reception of a signal
v. **Terminated :** The task has finished execution.

State Graph



- New State :When a task is newly created
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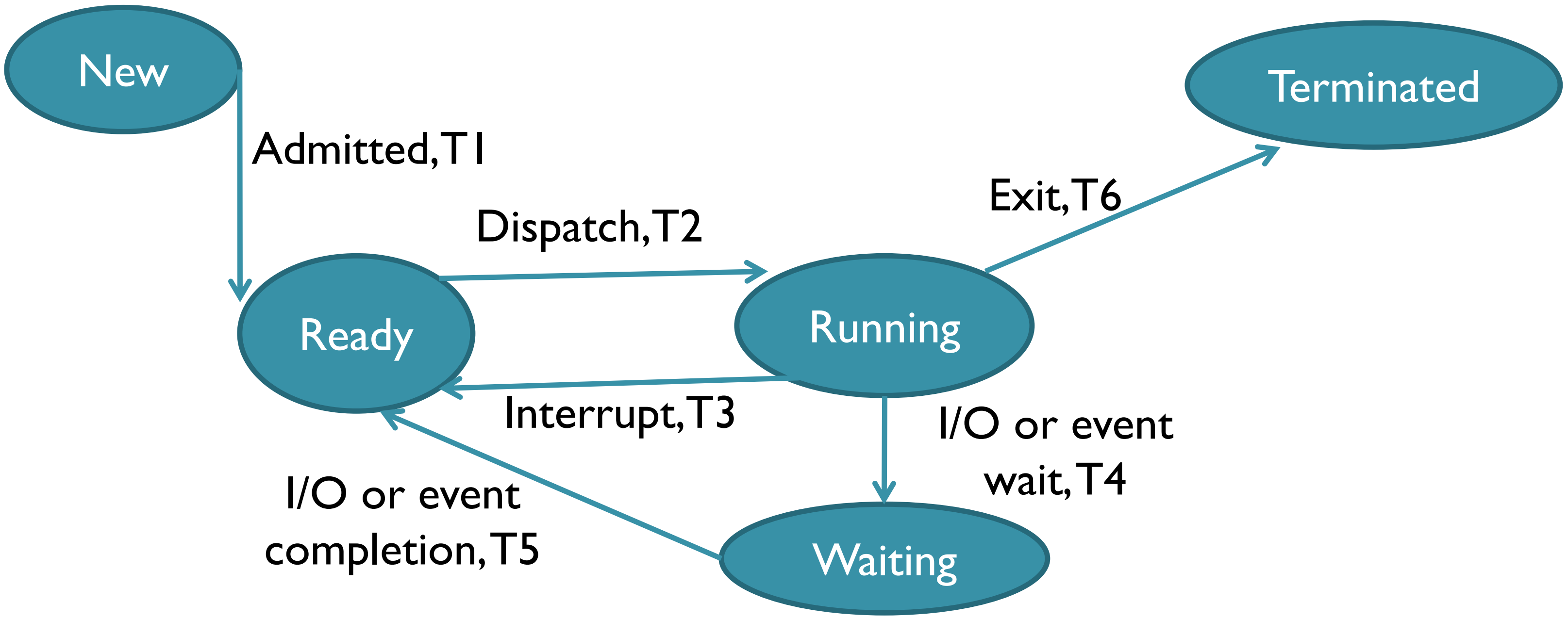


Each arrow link provides two types of Information :

1. **Transition events like admitted, dispatch, interrupt, etc.**
2. **The resulting output from a state like T1,T2,T3 etc.**

T0=Task is in new state and waiting for admission to ready queue.

T1= A new task admitted to ready queue

T2= A ready task has started running

T3= Running task has been interrupted

T4= Running task is waiting for I/O or event

T5= Wait period of waiting task is over

T6= Task has completed execution

3. State Table

State/input Event	**Admit**	**Dispatch**	**Interrupt**	**I/O or event Wait**	**I/O or event Wait Over**	**Exit**
New	**Ready/T1**	New / T0	New / T0	New / T0	New / T0	New / T0
Ready	Ready / T1	**Running /T2**	Ready / T1	Ready / T1	Ready / T1	Ready / T1
Running	Running /T2	Running /T2	**Ready / T3**	**Waiting/T4**	Running/ T2	**Terminated/ T6**
Waiting	Waiting/T4	Waiting/T4	Waiting/ T4	Waiting/T4	**Ready /T5**	Waiting/T4

- Each rows of the table corresponds to a state.
- Each column corresponds to an input condition
- The box at the intersection of a row and a column specifies the next state (transition) and the outputs, if any.

4. State Table-Based Testing

- After reviewing the basics, we can start functional testing with state tables.

Steps:

1. Identify the states

The number of states in a state graph is the number of states we choose to recognize or model.

Finding the number of states

- First, identify all the component factors of the state.
- Identify all the allowable values for each factor
- The number of states is the product of the number of allowable values of all the factors.

Steps cont …

2. **Prepare state transition diagram after understanding transitions between states**

- After having all the states, identify the inputs on each state and transitions between states and prepare the state graph.
- Every input state combination must have a specified transition.

Steps cont …

3. **Convert the state graph into the state table as discussed earlier**

4. **Analyze the state table for its completeness.**

Steps cont …

5. Develop the test cases from the state table, in a tabular form, with the following entries.

- **Test cases ID :** a unique identifier for each test case
- **Test Source :** a trace back to the corresponding cell in the state table.
- **Current state :** the initial condition to run the test
- **Event :** the input triggered by the user
- **Output :** the current value returned
- **Next State :** the new state achieved

Test Cases for the O.S. Example

Test case ID	Test Source	Input		Expected results	
		Current State	Event	Output	Next state
TC1	Cell 1	New	Admit	T1	Ready
TC2	Cell 2	New	Dispatch	T0	New
TC3	Cell 3	New	Interrupt	T0	New
TC4	Cell 4	New	I/O wait	T0	New
TC5	Cell 5	New	I/O wait over	T0	New
TC6	Cell 6	New	Exit	T0	New
TC7	Cell 7	Ready	Admit	T1	Ready
TC8	Cell 8	Ready	Dispatch	T2	Running
TC9	Cell 9	Ready	Interrupt	T1	Ready
TC10	Cell 10	Ready	I/O wait	T1	Ready
TC11	Cell 11	Ready	I/O wait over	T1	Ready
TC12	Cell 12	Ready	Exit	T1	Ready
TC13	Cell 13	Running	Admit	T2	Running
TC14	Cell 14	Running	Dispatch	T2	Running
TC15	Cell 15	Running	Interrupt	T3	Ready
TC16	Cell 16	Running	I/O wait	T4	Waiting
TC17	Cell 17	Running	I/O wait over	T2	Running
TC18	Cell 18	Running	Exit	T6	Terminated
TC19	Cell 19	Waiting	Admit	T4	Waiting
TC20	Cell 20	Waiting	Dispatch	T4	Waiting
TC21	Cell 21	Waiting	Interrupt	T4	Waiting
TC22	Cell 22	Waiting	I/O wait	T4	Waiting
TC23	Cell 23	Waiting	I/O wait over	T5	Ready
TC24	Cell 24	Waiting	Exit	T4	Waiting

Decision Table – Based Testing

- Boundary value analysis and equivalence class partitioning methods do not consider combinations of input conditions.
- There may be some critical behavior to be tested when some combinations of input conditions are considered.
- Decision table is another useful method to represent the information in a tabular method.
- Decision table has the specialty to consider complex combinations of input conditions and resulting actions.
- Decision tables obtain their power from logical expressions.
- Each operand or variable in a logical expression takes on the value, TRUE or FALSE

Formation of Decision Table

		Rule 1	Rule 2	Rule 3	Rule 4	…
Condition Stub	C1 C2 C3	True False True	True True True	False False True	I True I	
Action Stub	A1 A2 A3	X	X	X	X	

- **Condition stub** It is a list a list of input conditions for which the complex combination is made.

- **Action stub** It is a list of resulting action which will be performed if a combination of input condition is satisfied.

Condition entry

- It is a specific entry in the table corresponding to input conditions mentioned in the condition stub.
- When the condition entry takes only two values – TRUE or FALSE then it is called ***Limited Entry Decision Table.***
- When the condition entry takes several values , then it is called ***Extended Entry Decision Table.***

Action entry It is the entry in the table for the resulting action to be performed.

- List all actions that can be associated with a specific procedure.
- List all conditions during execution of the procedure.
- Associate specific sets of conditions with specific actions, eliminating impossible combinations and conditions; alternatively, develop every possible permutation of conditions.
- Define rules by indicating what action occurs for a set of conditions.

Test Case Design using Decision Table

- Interpret condition stubs as the inputs for the test case.
- Interpret action stubs as the expected output for the test case.
- Rule, which is the combination of input conditions, becomes the test case itself.
- If there are *k* rules over *n* binary conditions, there are at least *k* test cases and at the most 2^n test cases.

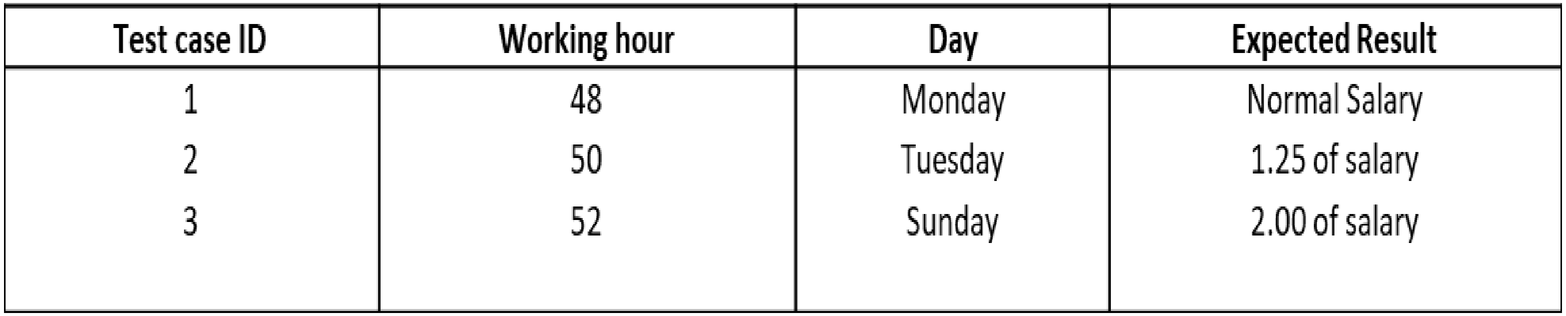
Example - 1

A program calculates the total salary of an employee with the conditions that if the working hours are less than or equal to 48, then give normal salary. The hours over 48 normal working days are calculated at the rate of 1.25 of the salary. However, on holidays or Sundays, the hours are calculated at the rate of 2.00 times of the salary. Design test cases using decision table testing.

Solution

		Entry		
		Rule 1	**Rule 2**	**Rule 3**
Condition Stub	C1: Working hours > 48	I	F	T
	C2: Holidays or Sundays	T	F	F
Action Stub	A1: Normal Salary		X	
	A2: 1.25 of salary			X
	A3: 2.00 of salary	X		

Decision Table



Test case ID	Working hour	Day	Expected Result
1	48	Monday	Normal Salary
2	50	Tuesday	1.25 of salary
3	52	Sunday	2.00 of salary

Expanding the Immaterial Cases in Decision Table

- These conditions means that the value of a particular condition in the specific rule does not make a difference whether it is TRUE or FALSE.
- Sometimes expanding the decision table to spell out don't-care conditions can reveal hidden problems.

Example - 1

Entry (Decision table)

		Rule 1	**Rule 2**	**Rule 3**
Condition Stub	C1: Working hours > 48	I	F	T
	C2: Holidays or Sundays	T	F	F
Action Stub	A1: Normal Salary		X	
	A2: 1.25 of salary			X
	A3: 2.00 of salary	X		

- The immaterial test case in rule 1 of the above table can be expanded by taking both T and F values of C1.

Entry (Expanded decision table)

		Rule 1-1	Rule 1-2	Rule 2	Rule 3
Condition Stub	C1: Working hours > 48	F	T	F	T
	C2: Holidays or Sundays	T	T	F	F
Action Stub	A1: Normal Salary			X	
	A2: 1.25 of salary				X
	A3: 2.00 of salary	X	X		

Entry (Expanded decision table)

Test case ID	Working hour	Day	Expected Result
1	48	Monday	Normal Salary
2	50	Tuesday	1.25 of salary
3	52	Sunday	2.00 of salary
4	30	Sunday	2.00 of salary

Example - 2

A wholesaler has three commodities to sell and has three types of customers. Discount is given as per the following procedure:

(a) For DGS & D orders, 10% discount is given irrespective of the value of the order.

(b) For orders of more than Rs 50,000, agents get a discount of 15% and the retailer gets a discount of 10%.

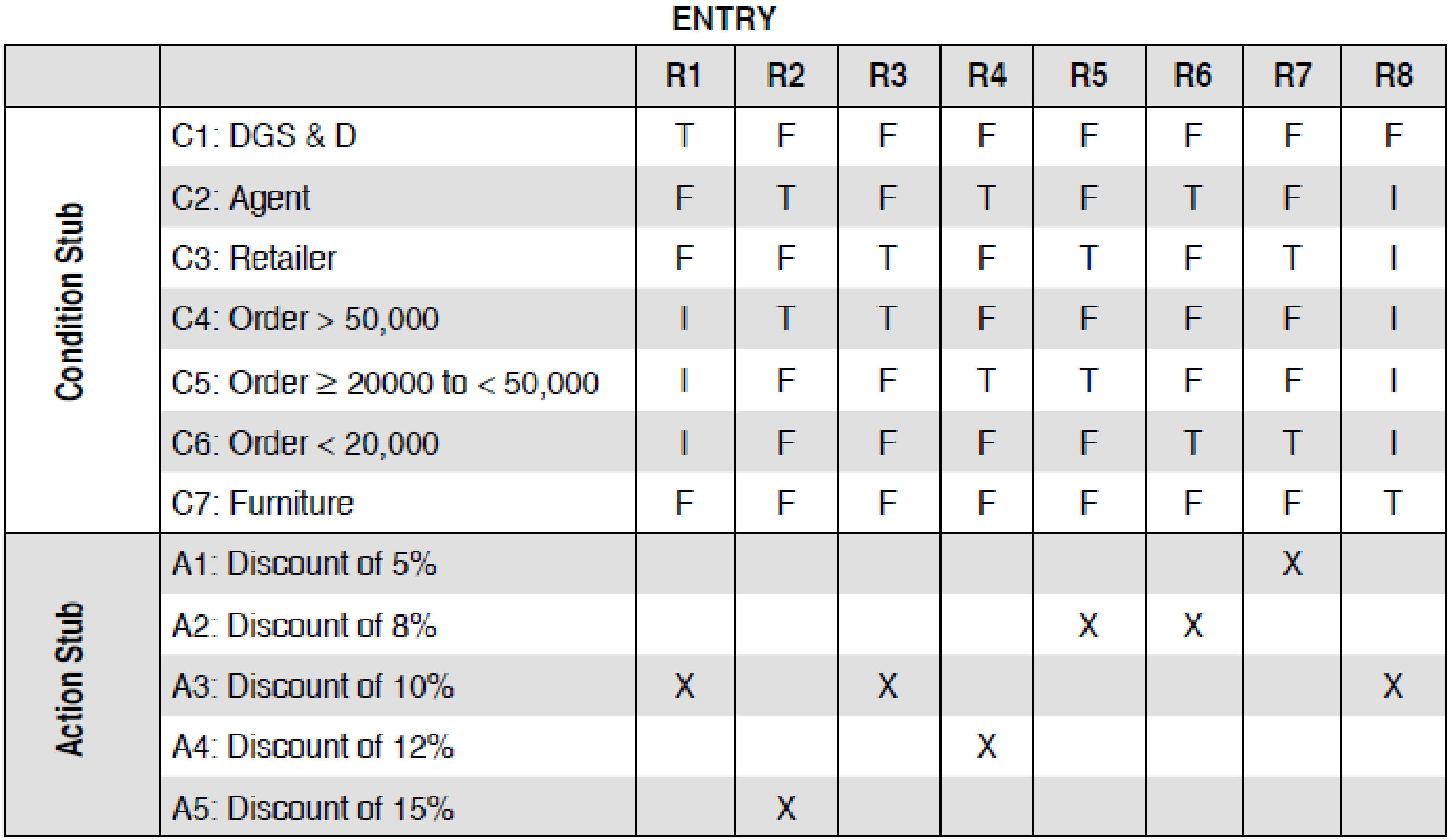
(c) For orders of Rs 20,000 or more and up to Rs 50,000, agents get 12% and the retailer gets 8% discount.

(d) For orders of less than Rs 20,000, agents get 8% and the retailer gets 5% discount.

The aforementioned rules do not apply to the furniture items wherein a flat rate of 10% discount s admissible to all customers irrespective of the value of the order.

Design the test cases for this system using decision table testing.

Decision Table for Example 2



		ENTRY							
		R1	R2	R3	R4	R5	R6	R7	R8
Condition Stub	C1: DGS & D	T	F	F	F	F	F	F	F
	C2: Agent	F	T	F	T	F	T	F	I
	C3: Retailer	F	F	T	F	T	F	T	I
	C4: Order > 50,000	I	T	T	F	F	F	F	I
	C5: Order ≥ 20000 to < 50,000	I	F	F	T	T	F	F	I
	C6: Order < 20,000	I	F	F	F	F	T	T	I
	C7: Furniture	F	F	F	F	F	F	F	T
Action Stub	A1: Discount of 5%							X	
	A2: Discount of 8%					X	X		
	A3: Discount of 10%	X		X					X
	A4: Discount of 12%				X				
	A5: Discount of 15%		X						

Test cases for Example - 2

Test Case Id	Type of Customer	Product Furniture?	Order value (Rs)	Expected Result
1	DGS & D	No	51,000	10% Discount
2	Agent	No	52,000	15% Discount
3	Retailer	No	53,000	10% Discount
4	Agent	No	23,000	12% Discount
5	Retailer	No	27,000	8% Discount
6	Agent	No	15,000	8% Discount
7	Retailer	No	18,000	5% Discount
8	Agent	Yes	34,000	10% Discount

Thank You