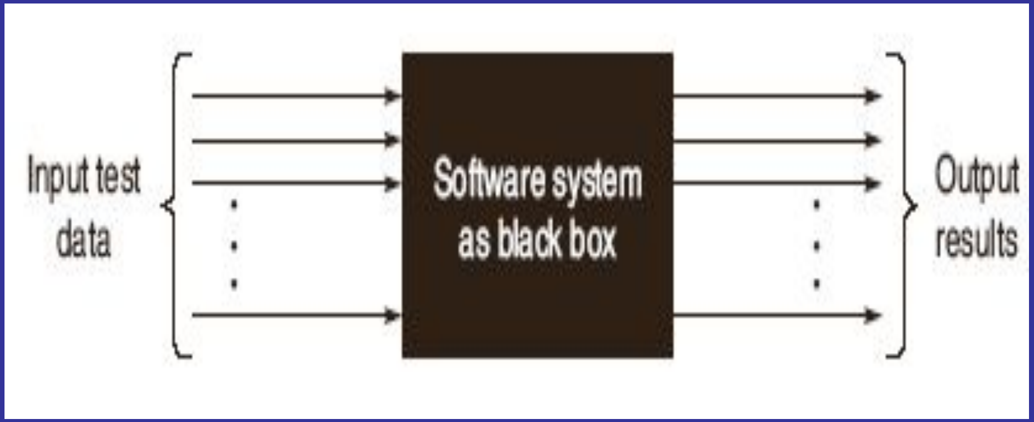
# Chapter 4
# Dynamic Testing: Black Box Testing Techniques

## Objectives

- Black box testing ignores the structural details of the software.
- Test case designing using black box techniques.
- Boundary value analysis method
- Equivalence class testing method
- State table based testing method
- Decision table based testing method
- Cause-effect graphing method

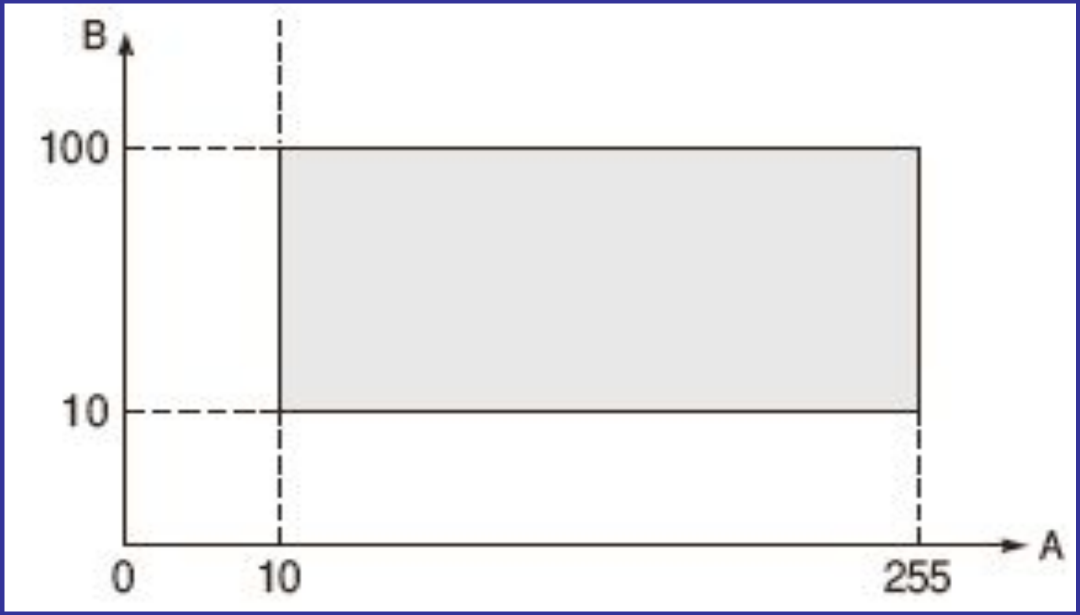
# Black Box Testing



# Black Box Testing

- To test the modules independently.
- To test the functional validity of the software
- Interface errors are detected.
- To test the system behavior and check its performance.
- To test the maximum load or stress on the system.
- Customer accepts the system within defined acceptable limits.

# Boundary Value Analysis (BVA)

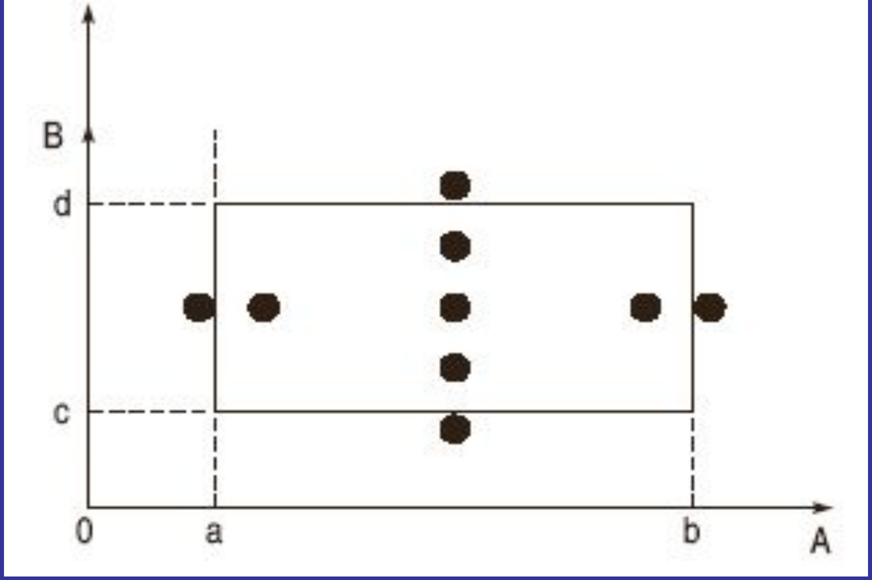


# Boundary Value Checking

- Test cases are designed by holding one variable at its extreme value and other variables at their nominal values in the input domain. The variable at its extreme value can be selected at:
  - Minimum value (Min)
  - Value just above the minimum value (Min+ )
  - Maximum value (Max)
  - Value just below the maximum value (Max-)

# Boundary Value Checking

- Anom, Bmin
- Anom, Bmin+
- Anom, Bmax
- Anom, Bmax-
- Amin, Bnom
- Amin+, Bnom
- Amax, Bnom
- Amax-, Bnom
- Anom, Bnom




- 4n+1 test cases can be designed with boundary value checking method.

# Robustness Testing Method

A value just greater than the Maximum value (Max+)

A value just less than Minimum value (Min-)

- When test cases are designed considering above points in addition to BVC, it is called Robustness testing.

- Amax+, Bnom
- Amin-, Bnom
- Anom, Bmax+
- Anom, Bmin-
-
- It can be generalized that for n input variables in a module, 6n+1 test cases are designed with Robustness testing.

# Worst Case Testing Method

- When more than one variable are in extreme values, i.e. when more than one variable are on the boundary. It is called Worst case testing method.
- It can be generalized that for n input variables in a module, $5^n$ test cases are designed with worst case testing.

| | |
|---|---|
| 10. $A_{min}$, $B_{min}$ | 11. $A_{min+}$, $B_{min}$ |
| 12. $A_{min}$, $B_{min+}$ | 13. $A_{min+}$, $B_{min+}$ |
| 14. $A_{max}$, $B_{min}$ | 15. $A_{max-}$, $B_{min}$ |
| 16. $A_{max}$, $B_{min+}$ | 17. $A_{max-}$, $B_{min+}$ |
| 18. $A_{min}$, $B_{max}$ | 19. $A_{min+}$, $B_{max}$ |
| 20. $A_{min}$, $B_{max-}$ | 21. $A_{min+}$, $B_{max-}$ |
| 22. $A_{max}$, $B_{max}$ | 23. $A_{max-}$, $B_{max}$ |
| 24. $A_{max}$, $B_{max-}$ | 25. $A_{max-}$, $B_{max-}$ |

# Example

- A program reads an integer number within the range [1,100] and determines whether the number is a prime number or not. Design all test cases for this program using BVC, Robust testing and worst-case testing methods.

- **1) Test cases using BVC**

| Test Case ID | Integer Variable | Expected Output |
|---|---|---|
| 1 | 1 | Not a prime number |
| 2 | 2 | Prime number |
| 3 | 100 | Not a prime number |
| 4 | 99 | Not a prime number |
| 5 | 53 | Prime number |

| |
|---|
| Min value = 1 |
| $Min^+$ value = 2 |
| Max value = 100 |
| $Max^-$ value = 99 |
| Nominal value = 50–55 |

# Example



- **Test Cases Using Robust Testing**

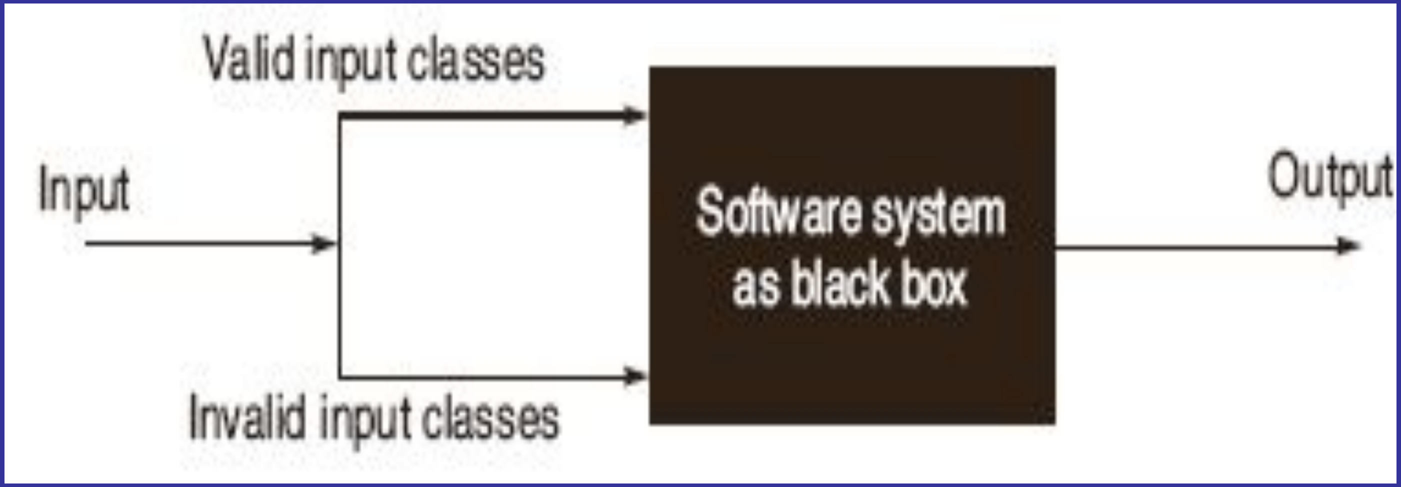
| Test Case ID | Integer Variable | Expected Output |
|---|---|---|
| 1 | 0 | Invalid input |
| 2 | 1 | Not a prime number |
| 3 | 2 | Prime number |
| 4 | 100 | Not a prime number |
| 5 | 99 | Not a prime number |
| 6 | 101 | Invalid input |
| 7 | 53 | Prime number |

| |
|---|
| Min value = 1 |
| $\text{Min}^{-}$ value = 0 |
| $\text{Min}^{+}$ value = 2 |
| Max value = 100 |
| $\text{Max}^{-}$ value = 99 |
| $\text{Max}^{+}$ value = 101 |
| Nominal value = 50–55 |

# BVC

- Problem Domain: "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: $1 \leq a \leq 200$
  C2: $1 \leq b \leq 200$
  C3: $1 \leq c \leq 200$
  C4: $a < b+c$
  C5: $b < a+c$
  C6: $c < a+b$
  The output of the program may be either of: Equilateral Triangle, Isosceles Triangle, Scalene or "Not a Traingle".

# Equivalence Class Testing



# Example

- A program reads three numbers A, B and C with range [1,50] and prints largest number. Design all test cases for this program using equivalence class testing technique.

I1 = {<A,B,C> : 1 ≤ A ≤ 50}

I2 = {<A,B,C> : 1 ≤ B ≤ 50}

I3 = {<A,B,C> : 1 ≤ C ≤ 50}

I4 = {<A,B,C> : A < 1}

I5 = {<A,B,C> : A > 50}

I6 = {<A,B,C> : B < 1}

I7 = {<A,B,C> : B > 50}

I8 = {<A,B,C> : C < 1}

I9 = {<A,B,C> : C > 50}

| Test case ID | A | B | C | Expected result | Classes covered by the test case |
|---|---|---|---|---|---|
| 1 | 13 | 25 | 36 | C is greatest | $I_1, I_2, I_3$ |
| 2 | 0 | 13 | 45 | Invalid input | $I_4$ |
| 3 | 51 | 34 | 17 | Invalid input | $I_5$ |
| 4 | 29 | 0 | 18 | Invalid input | $I_6$ |
| 5 | 36 | 53 | 32 | Invalid input | $I_7$ |
| 6 | 27 | 42 | 0 | Invalid input | $I_8$ |
| 7 | 33 | 21 | 51 | Invalid input | $I_9$ |

# Example

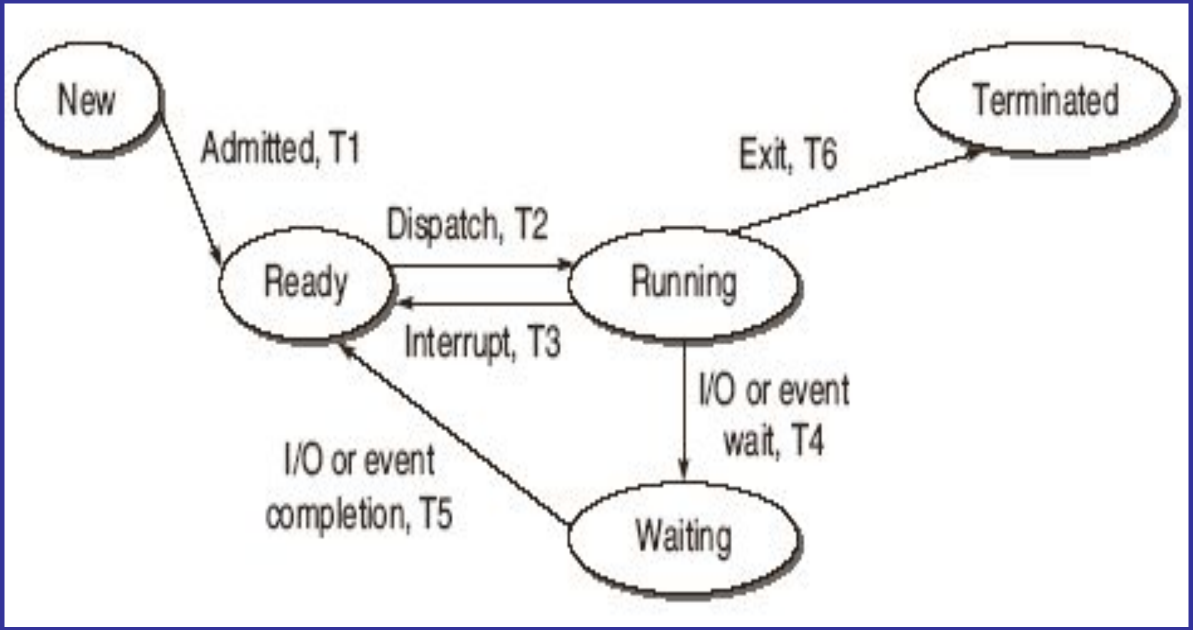
- $I1 = \{<A,B,C> : A > B,\ A > C\}$
- $I2 = \{<A,B,C> : B > A,\ B > C\}$
- $I3 = \{<A,B,C> : C > A,\ C > B\}$
- $I4 = \{<A,B,C> : A = B,\ A \neq C\}$
- $I5 = \{<A,B,C> : B = C,\ A \neq B\}$
- $I6 = \{<A,B,C> : A = C,\ C \neq B\}$
- $I7 = \{<A,B,C> : A = B = C\}$

| Test case ID | A | B | C | Expected Result | Classes Covered by the test case |
|---|---|---|---|---|---|
| 1 | 25 | 13 | 13 | A is greatest | $I_1, I_5$ |
| 2 | 25 | 40 | 25 | B is greatest | $I_2, I_6$ |
| 3 | 24 | 24 | 37 | C is greatest | $I_3, I_4$ |
| 4 | 25 | 25 | 25 | All three are equal | $I_7$ |

# State Table Based Testing

**Finite State Machine (FSM)**

**State Transition Diagrams or State Graph**



# State Table Based Testing

- ***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 |

# State Table Based Testing

| 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 | 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

ENTRY

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

# Decision Table Based Testing

**Example**

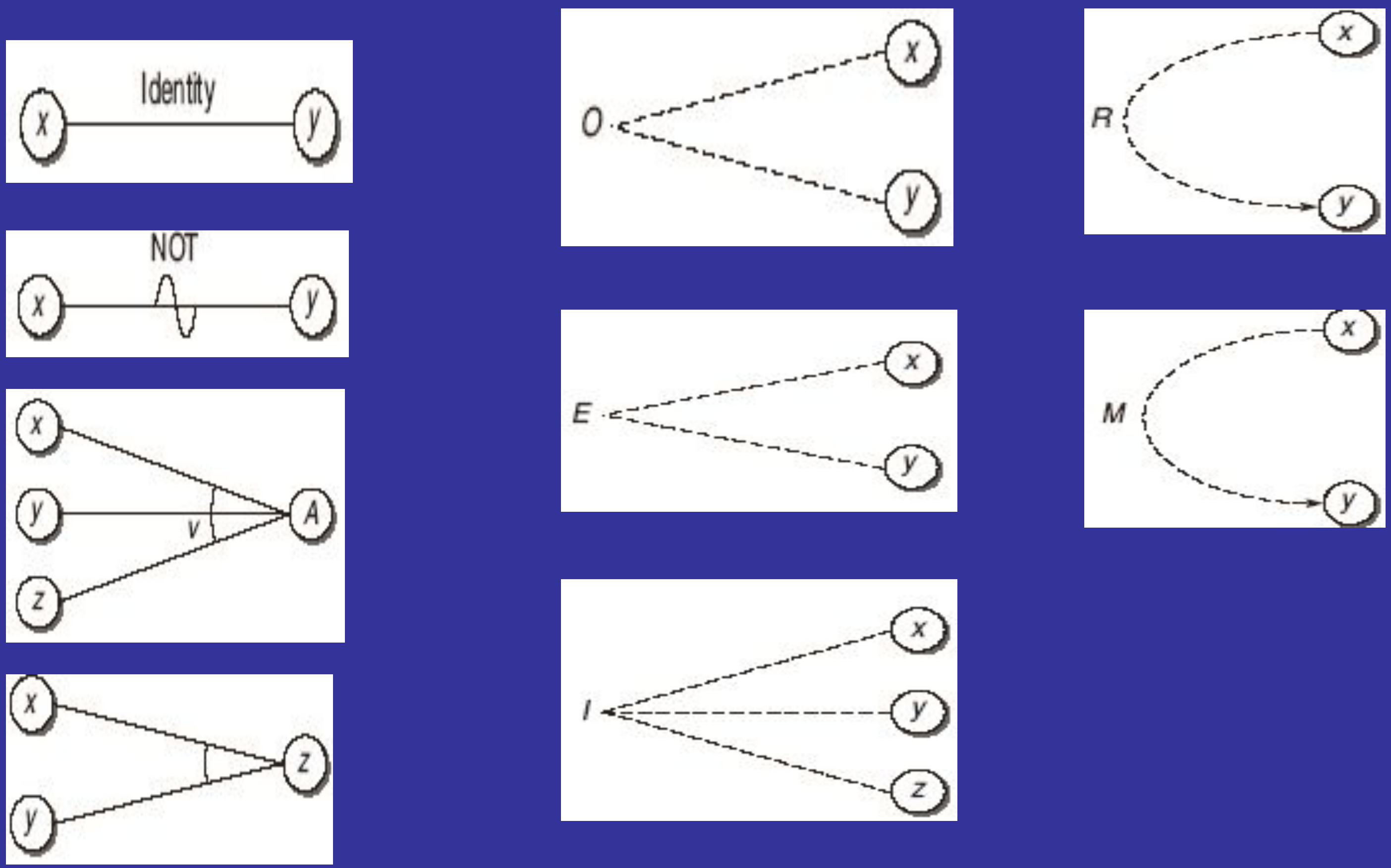
- A program calculates the total salary of an employee with the conditions that if the working hours are less than or equal to 48, then give normal salary. The hours over 48 on normal working days are calculated at the rate of 1.25 of the salary. However, on holidays or Sundays, the hours are calculated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

| | | ENTRY | | |
|---|---|---|---|---|
| | | Rule 1 | Rule 2 | Rule3 |
| 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 Based Testing

| 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 |

## Basic Notations for Cause-Effect Graph



# Cause-Effect Graphing based Testing

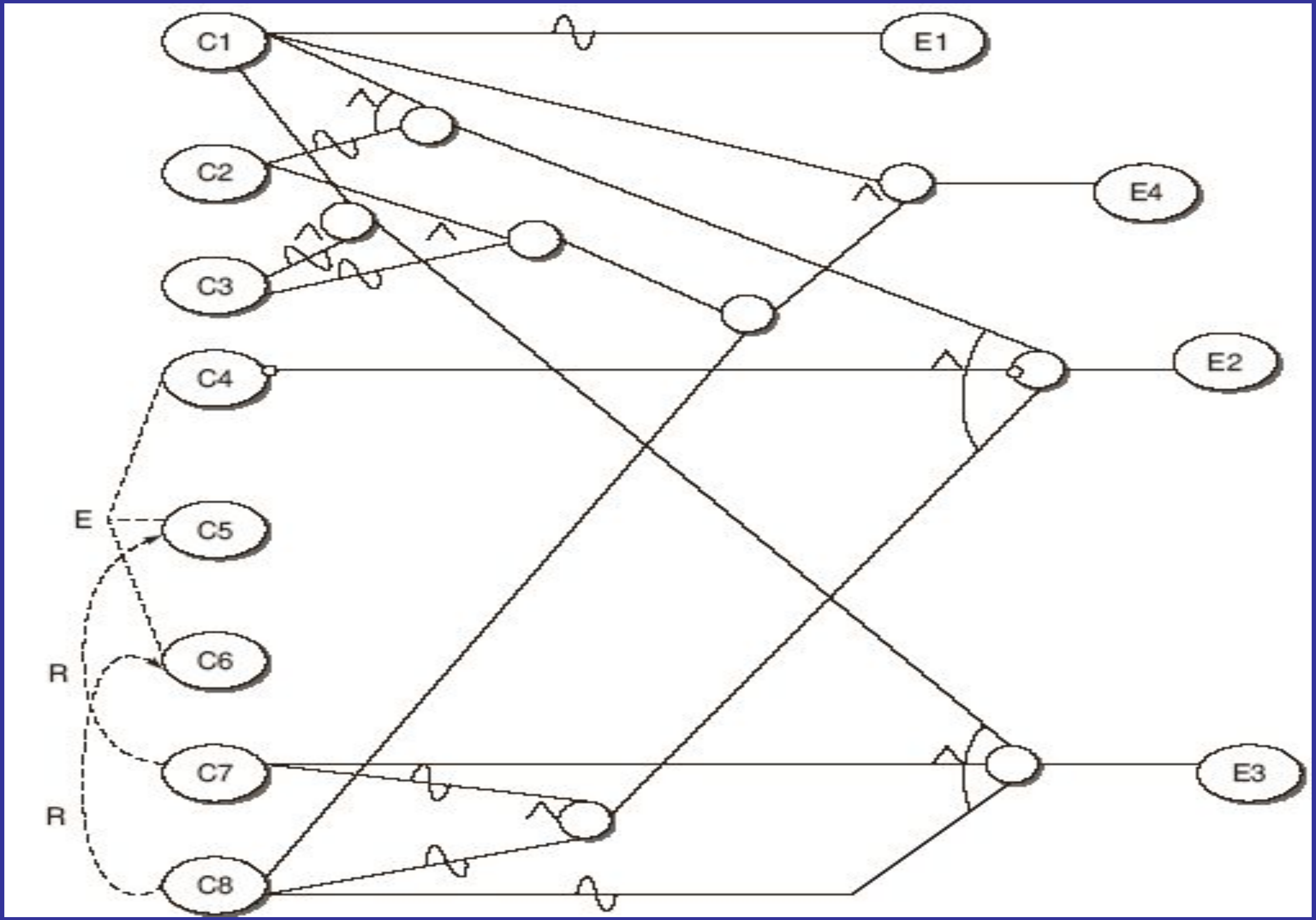
**Example**

- A program has been designed for the determination of nature of roots of a quadratic equation. Quadratic equation takes three input values from the range [0,100]. Design all test cases using Cause-Effect graphing technique.

# Cause-Effect Graphing based Testing

- C1: $a \neq 0$
- C2: $b = 0$
- C3: $c = 0$
- C4: $D > 0$ where D is $b2 - 4 * a * c$
- C5: $D < 0$
- C6: $D = 0$
- C7: $a = b = c$
- C8: $a = c = b/2$
- E1: Not a quadratic equation
- E2: Real Roots
- E3: Imaginary Roots
- E4: Equal Roots

# Cause-Effect Graphing based Testing



# Cause-Effect Graphing Based Testing

| | R1 | R2 | R3 | R4 | R5 | R6 | R7 |
|---|---|---|---|---|---|---|---|
| C1: a ≠ 0 | T | T | T | T | T | T | F |
| C2: b = 0 | F | I | I | T | F | F | I |
| C3: c = 0 | I | F | I | T | F | F | I |
| C4: D > 0 | T | F | F | F | F | F | I |
| C5: D < 0 | F | T | F | F | T | F | I |
| C6: D = 0 | F | F | T | T | F | T | I |
| C7: a = b = c | F | I | F | F | T | F | I |
| C8: a = c = b/2 | F | F | I | F | F | T | I |
| A1: Not a quadratic equation | | | | | | | X |
| A2: Real roots | X | | | | | | |
| A3: Imaginary roots | | X | | | X | | |
| A4: Equal roots | | | X | X | | X | |

| Test Case ID | a | b | c | Expected Output |
|---|---|---|---|---|
| 1 | 1 | 50 | 50 | Real roots |
| 2 | 100 | 50 | 50 | Imaginary roots |
| 3 | 1 | 6 | 9 | Equal |
| 4 | 100 | 0 | 0 | Equal |
| 5 | 99 | 99 | 99 | Imaginary |
| 6 | 50 | 100 | 50 | Equal |
| 7 | 0 | 50 | 30 | Not a quadratic equation |

# Error Guessing

- Error guessing is the method used when all other methods fail or it is the method for some special cases which need to be tested.
- It means error or bug can be guessed which do not fit in any of the earlier defined situations. So test cases are generated for these special cases.