MC/DC

- MC/DC is defined in DO-178B/ED-12B, -"Software Considerations in Airborne Systems and Equipment Certification", dated December 1, 1992.

- Definition of MC/DC:

(1) Every point of entry and exit in the program has been invoked at least once

(2) Every condition in a decision in the program has taken all possible outcomes at least once

(3) Every decision in the program has taken all possible outcomes at least once

(4) Each condition in a decision has been shown to independently affect that decision's outcome. A condition is shown to independently affect a decision's outcome by varying just that condition while holding fixed all other possible conditions

MC/DC

- MC/DC criteria is stronger than Condition/Decision

- 100% MC/DC will guarantee that each simple condition will not be masked by the other conditions.

- Consider the following decision: $x < 0$ OR $y < 0$
- If $x = -1$, then $x < 0$ is true and it will mask the condition $y < 0$, since no matter $y < 0$ is true or not, the whole decision will be evaluated to true.

- 100% MC/DC guarantees 100% C/D

Difference Between Coverage Criterias

Table 1. Types of Structural Coverage

Coverage Criteria	Statement Coverage	Decision Coverage	Condition Coverage	Condition/ Decision Coverage	MC/DC	Multiple Condition Coverage
Every point of entry and exit in the program has been invoked at least once		•	•	•	•	•
Every statement in the program has been invoked at least once	•					
Every decision in the program has taken all possible outcomes at least once		•		•	•	•
Every condition in a decision in the program has taken all possible outcomes at least once			•	•	•	•
Every condition in a decision has been shown to independently affect that decision's outcome					•	•[8]
Every combination of condition outcomes within a decision has been invoked at least once						•

Hayhurst, Kelly; Veerhusen, Dan; Chilenski, John; Rierson, Leanna (May 2001). "A Practical Tutorial on Modified Condition/ Decision Coverage". NASA.

MC/DC Example

• Considering the following code:

```
int isReadyToTakeOff(int a, int b, int c, int d)
{
  if(((a == 1) ||(b == 1)) && ((c == 1) || (d == 1)))
          return 1; else return 0;
}
```

$$T_1 = \begin{Bmatrix} t_1: < a = 0, b = 1, c = 1, d = 1 > \\ t_2: < a = 0, b = 0, c = 0, d = 1 > \\ t_3: < a = 1, b = 0, c = 0, d = 0 > \end{Bmatrix} \quad 100\%\ C/D$$

$$T_2 = \begin{Bmatrix} t_1: < a = 1, b = 0, c = 1, d = 0 > \\ t_2: < a = 1, b = 0, c = 0, d = 1 > \\ t_3: < a = 0, b = 1, c = 0, d = 1 > \\ t_4: < a = 1, b = 0, c = 0, d = 0 > \\ t_5: < a = 0, b = 0, c = 0, d = 1 > \end{Bmatrix} \quad 100\%\ MC/DC$$

MC/DC Example

$$T_2 = \begin{Bmatrix} t_1: < a = 1, b = 0, c = 1, d = 0 > \\ t_2: < a = 1, b = 0, c = 0, d = 1 > \\ t_3: < a = 0, b = 1, c = 0, d = 1 > \\ t_4: < a = 1, b = 0, c = 0, d = 0 > \\ t_5: < a = 0, b = 0, c = 0, d = 1 > \end{Bmatrix} \quad 100\%\ MC/DC$$

$t_2 + t_5$ shows the effect of $a = 1$;
- Values of b, c, d in t_2 and t_5 are same.
- when $a = 1$, t_2 → true;
- when $a = 0$, t_5 → false;

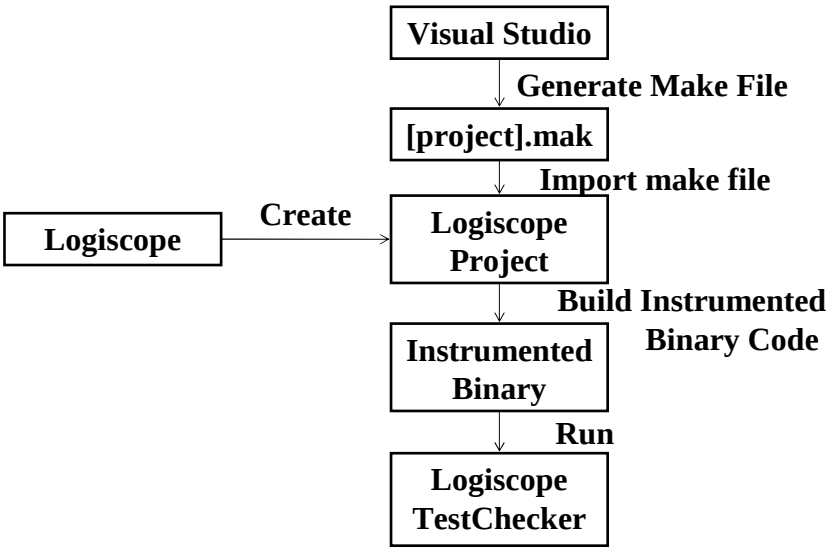
$t_3 + t_5$ shows the effect of $b = 1$;
- Values of a, c, d in t_3 and t_5 are same.
- when $b = 1$, t_3 → true;
- when $b = 0$, t_5 → false;

$t_1 + t_4$ shows the effect of $c = 1$;
- Values of a, b, d in t_1 and t_4 are same.
- when $c = 1$, t_1 → true;
- when $c = 0$, t_4 → false;

$t_2 + t_4$ shows the effect of $d = 1$;
- Values of a, b, c in t_2 and t_4 are same.
- when $d = 1$, t_2 → true;
- when $d = 0$, t_4 → false;

MCDC Demo
Using Logiscope TestChecker

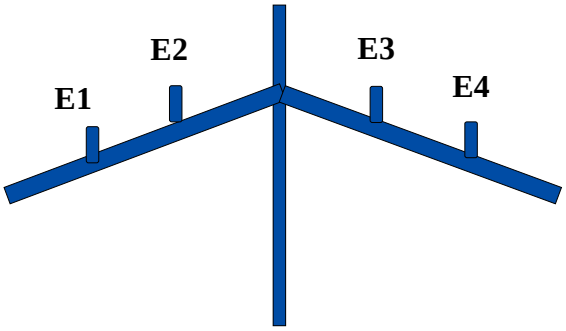
How Does Logiscope TestChecker Work?



Requirement

The self-check module will check the status of 4 engines of a airplane, then return if the airplane can take off.

•The airplane shall be able to take off with at least one of the engine1 and engine2 on, and at least one of the engine 3 and engine 4 on.



Source Code

```
int isReadyToTakeOff(int engine1, int engine2, int engine3, int engine4)
{
        if(((engine1 == 1) ||(engine2 == 1))
        && ((engine3 == 1) || (engine4 == 1)))
        {
                return 1;
        }
        else
        {
                return 0;
        }
}
```

Source Code

100% C/D coverage

Test cases	engine 1	engine 2	engine 3	engine 4	Result	Oracle
1	0	1	1	0	1	1
2	0	0	0	1	0	0
3	1	0	0	0	0	0

Requirement

The self-check module will check the status of 4 engines of a airplane, then return if airplane can take off.

- The airplane shall be able to take off with at least one of the engine1 and engine2 on, and at least one of the engine3 and engine4 on.

- New requirement:
- The airplane shall not be able to take off with engine3 off.

Source Code

Test cases	engine 1	engine 2	engine 3	engine 4	Result	Oracle
1	0	1	1	0	1	1
2	0	0	0	1	0	0
3	1	0	0	0	0	0

100% C/D

- Although these test cases achieved 100% C/D coverage, bug is not revealed, since with respect to all test cases, engine3 == 0 can not directly effect the decision's outcomes.
- In another word, with respect to all test cases, engine3 == 0 is masked by other conditions.

Source Code

Test cases	engine 1	engine 2	engine 3	engine 4	Result	Oracle
1	1	0	1	0	1	1
2	1	0	0	1	1	0
3	0	1	0	1	1	0
4	1	0	0	0	0	0
5	0	0	0	1	0	0

100% *MC/DC*

- Test cases t_2 and t_3 will reveal the bug.