Session 7

Black-Box Testing (1)

-- Boundary Value Analysis

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Objectives

- In this Session, you will learn
  - **Introduction of Black-Box Testing**
  - **Boundary Value Analysis**
  - **Equivalence Partitioning**
  - **Decision Table**
  - **Cause-Effect Graph**

4.1 Introduction of Black-Box Testing

- With black-box testing, the tester views the program as a black-box and is completely unconcerned with the internal structure of the program or system.
- The tester focuses on testing the program's functionality against the specification.
- Behavioral, functional, closed-box, input-output …

4.1 Introduction of Black-Box Testing

- Why we need Black-box testing?
  - Specific knowledge of the application's code /internal structure and programming knowledge in general is not required.
  - The tester only know the "legal" inputs and what the expected outputs should be.
  - The tester is aware of what the software is supposed to do but is not aware of how it does it.

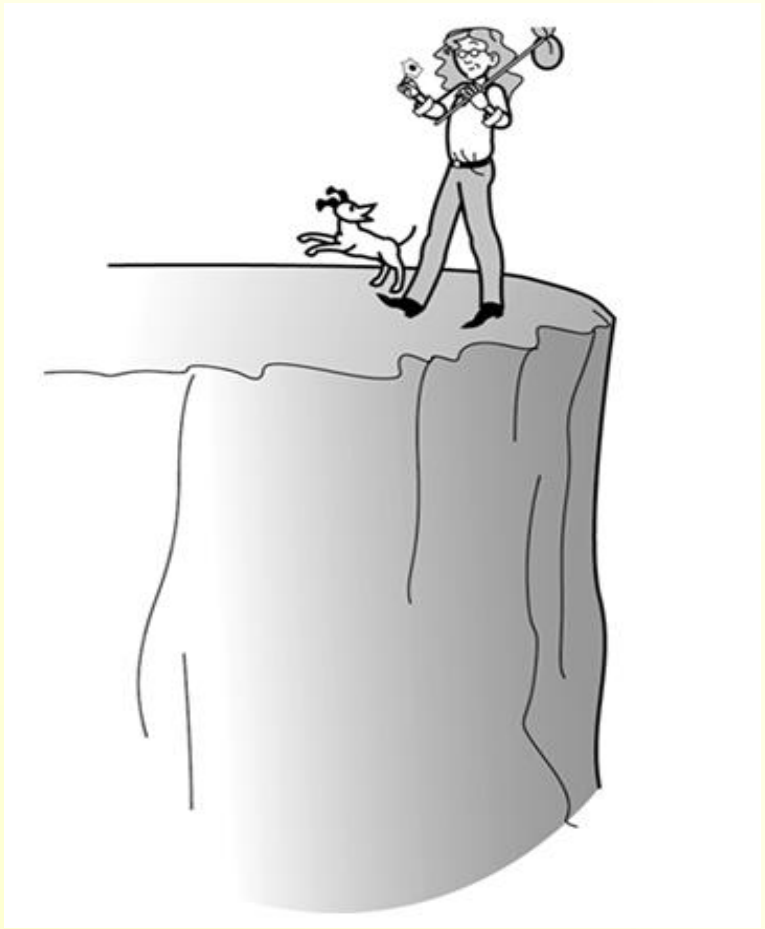
	White-box Testing	Black-box Testing
Tester visibility	have visibility to the code and write test cases based upon the code	have no visibility to the code and write test cases based on possible inputs and outputs for functionality documented in specifications and /or requirements
A failed test case reveals	a problem (a fault)	a symptom of a problem (a failure)
Controlled?	Yes – the test case helps to identify the specific lines of code involved	No – it can be hard to find the cause of the failure

4.1 Introduction of Black-Box Testing

- Typical black-box test design techniques:
  - Boundary Value Analysis
  - Equivalence Partitioning
  - Decision Table
  - Cause-Effect Graph

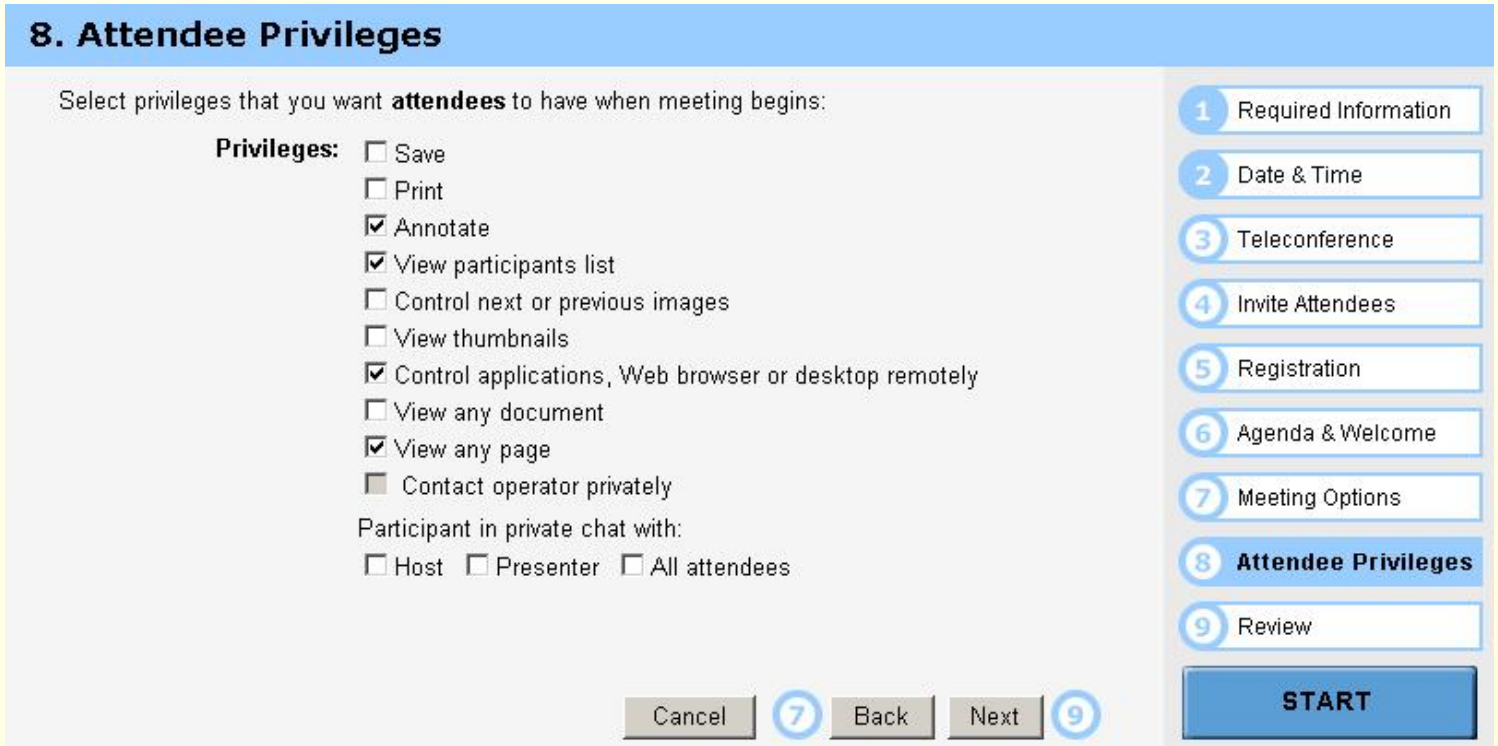
Boundary test

If you can safely and confidently walk along the edge of a cliff without falling off, you can almost certainly walk in the middle of a field.



4.2 Boundary Value Analysis

- The rationale behind boundary value testing is that errors tend to occur near the extreme values of an input variable. In another word, errors tend to congregate at the boundaries.
- Examples: array, loop, ≤ ...
- The basic idea of boundary value analysis is to use input variable values at their ***min, min+, nom, max-, and max.***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1 Required Information
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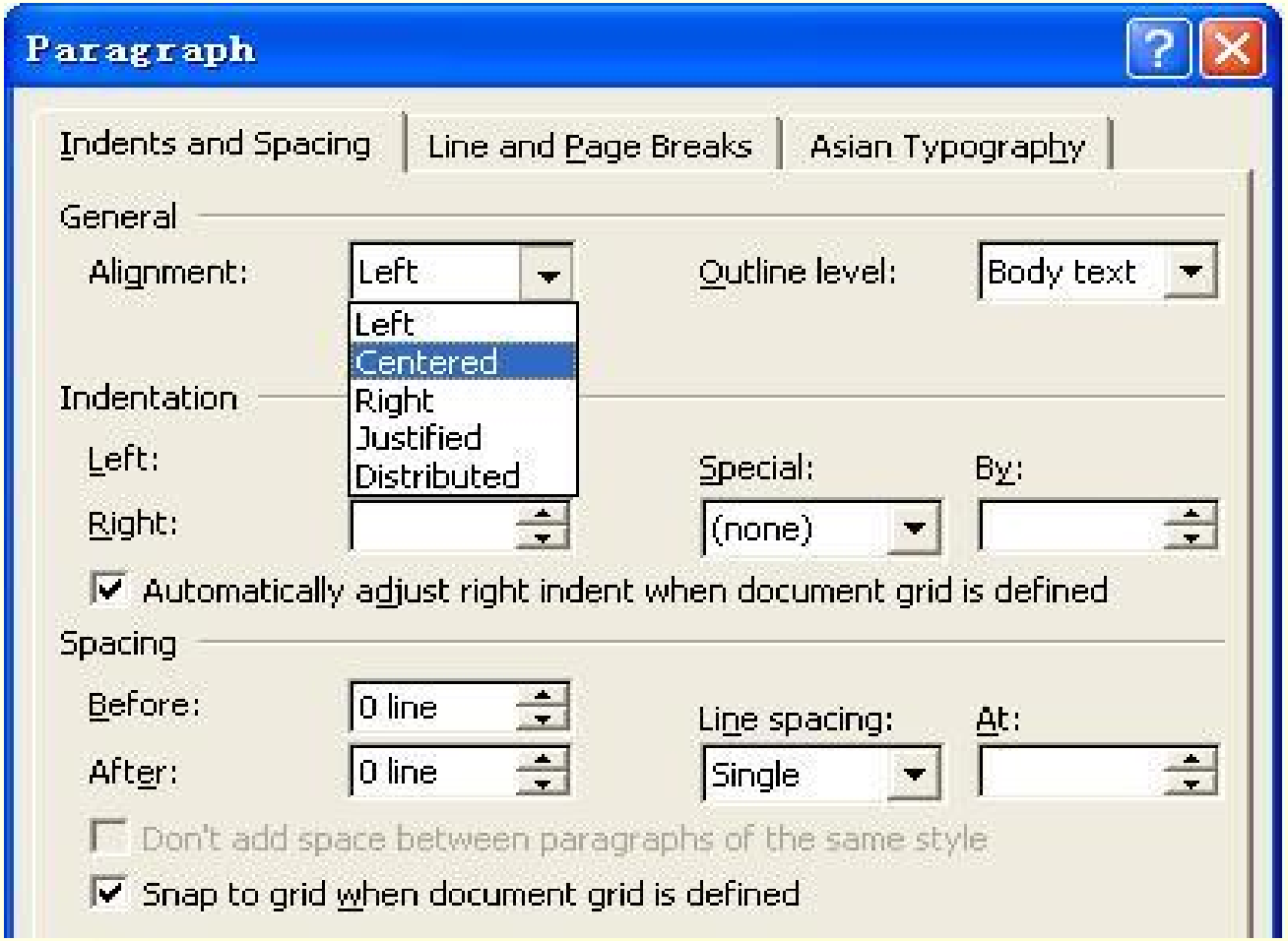
START



Default

Empty

Blank

Null

Zero

None

4.2 Boundary Value Analysis

Example1 (with one variable):

* “Input can range from integers 0 to 100,”
* Test cases include:
  * Min: 0
  * Min+: 1
  * Nom: 56
  * Max-: 99
  * Max: 100

4.2 **Boundary Value Analysis**

- What happens when a physical quantity exceeds its maximum?
- Robustness Testing
  - Robustness testing is a simple extension of boundary value analysis
  - We see what happens when the extreme are exceeded with a value slightly greater than the maximum (max+) and a value slightly less than the minimum (min-)

4.2 Boundary Value Analysis

- It is based on single fault assumption:
  - "Failures are only rarely as a result of the simultaneous occurrence of two or more faults"
  - Normal Boundary Values
  - Robustness Boundary Values
- It is interested in what happens when more than one variable has an extreme value.
  - Multiple Variable of Boundary Values (Worst-Case Testing)
  - Robust Multiple Variable of Boundary Values (Robust Worst-Case Testing)

4.2 **Boundary Value Analysis**

- Boundary Value Analysis techniques include:
  - Normal Boundary Values
  - Robustness Boundary Values
  - Multiple Variable of Boundary Values
    - (Worst-Case Testing)
  - Robust Multiple Variable of Boundary Values
    - (Robust Worst-Case Testing)

4.2 Boundary Value Analysis

Example2 (with two variables):

* Function F with two variables x, and y
  * a =< x =< b
  * c =< y =< d
* At least how many test cases should be created by using boundary value analysis?

测试用例	X1	X2	预期输出
T1	X1nom	X2min	F1
T2	X1nom	X2min+	F2
T3	X1nom	X2nom	F3
T4	X1nom	X2max-	F4
T5	X1nom	X2max	F5
T6	X1min	X2nom	F6
T7	X1min+	X2nom	F7
T8	X1max-	X2nom	F8
T9	X1max	X2nom	F9

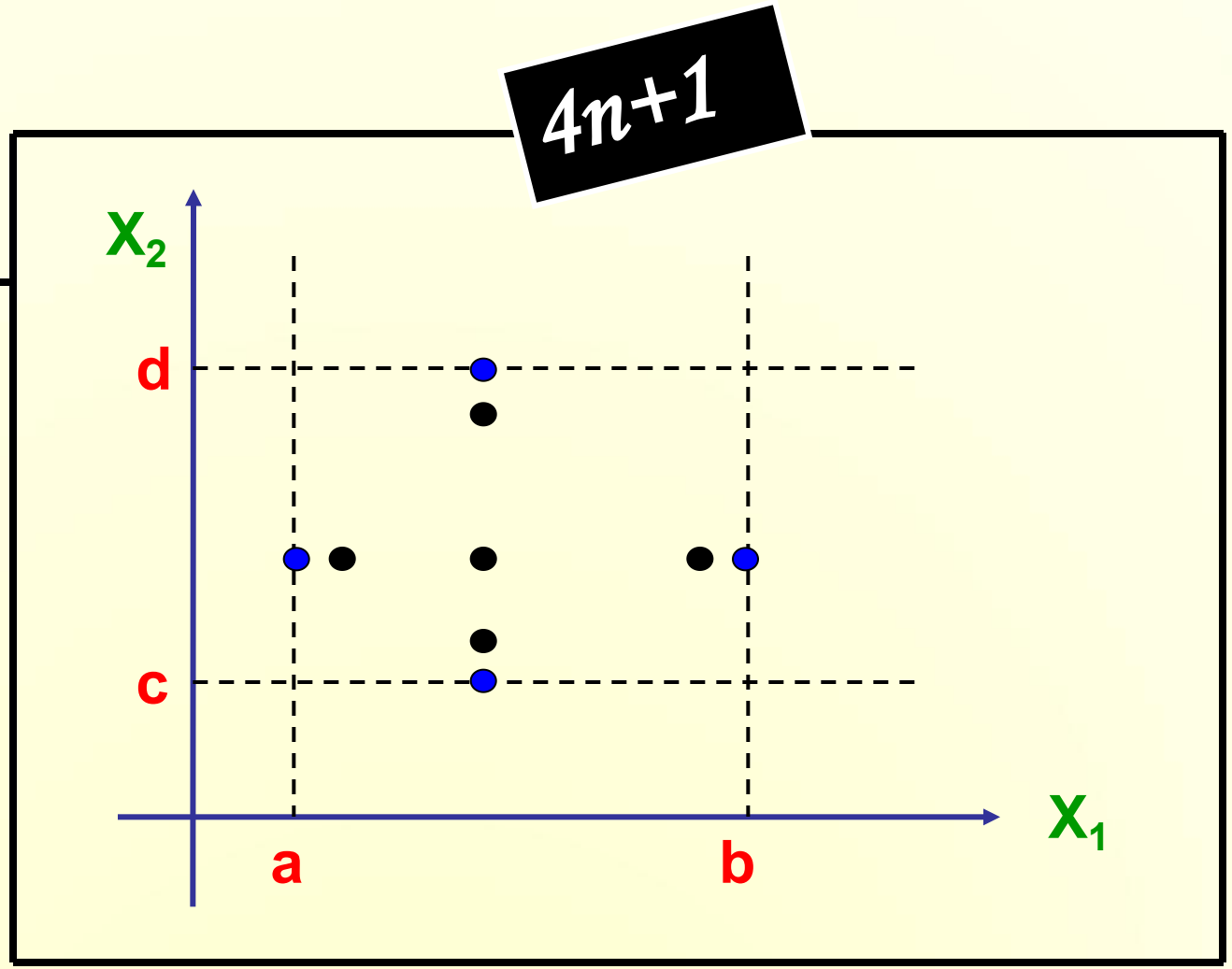
X1取正常值

X2依次取各种边界值

X1依次取各种边界值

X2取正常值

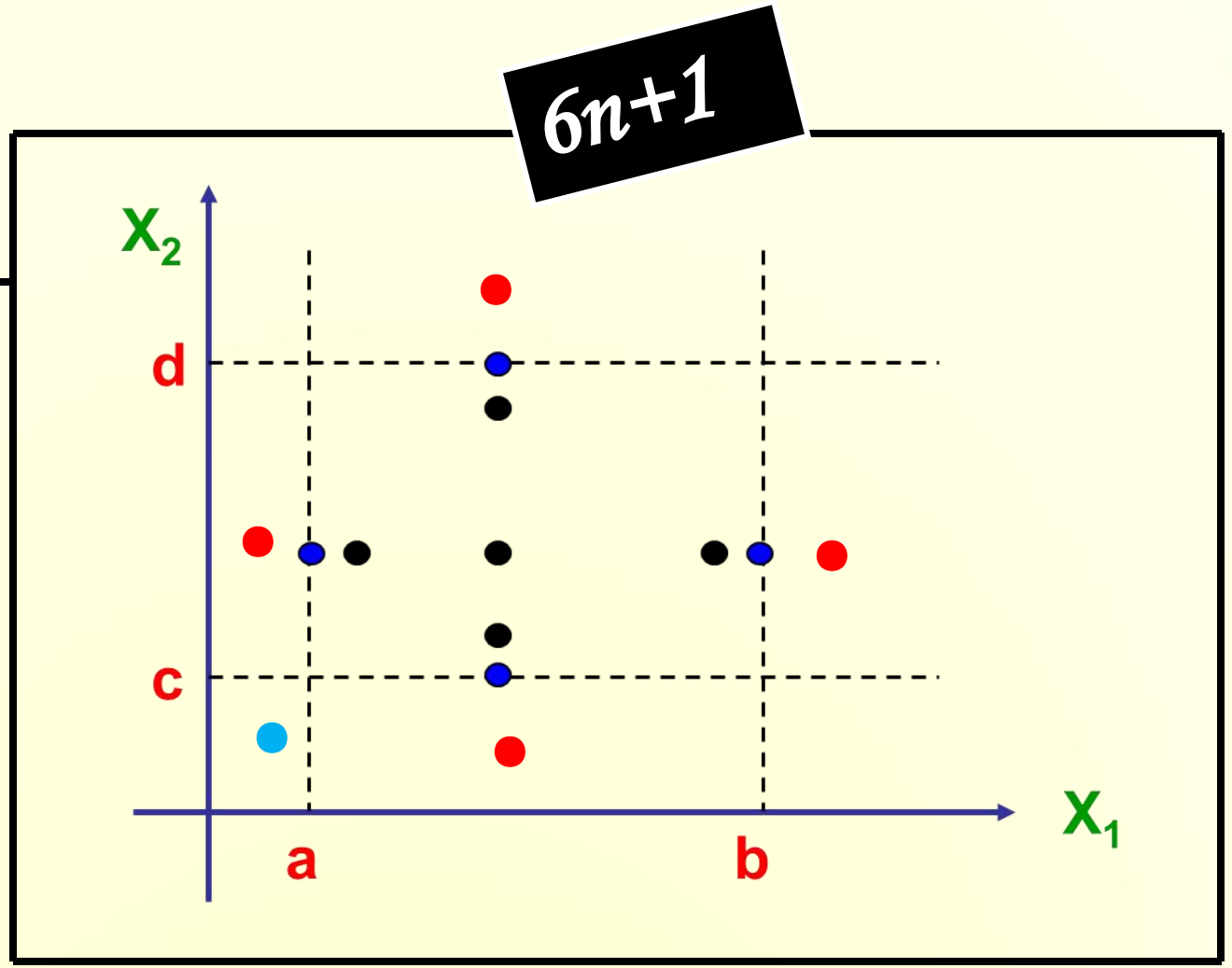
边界值分析



Normal Boundary Values

2 variables to n variables?

健壮性
边界值
测试

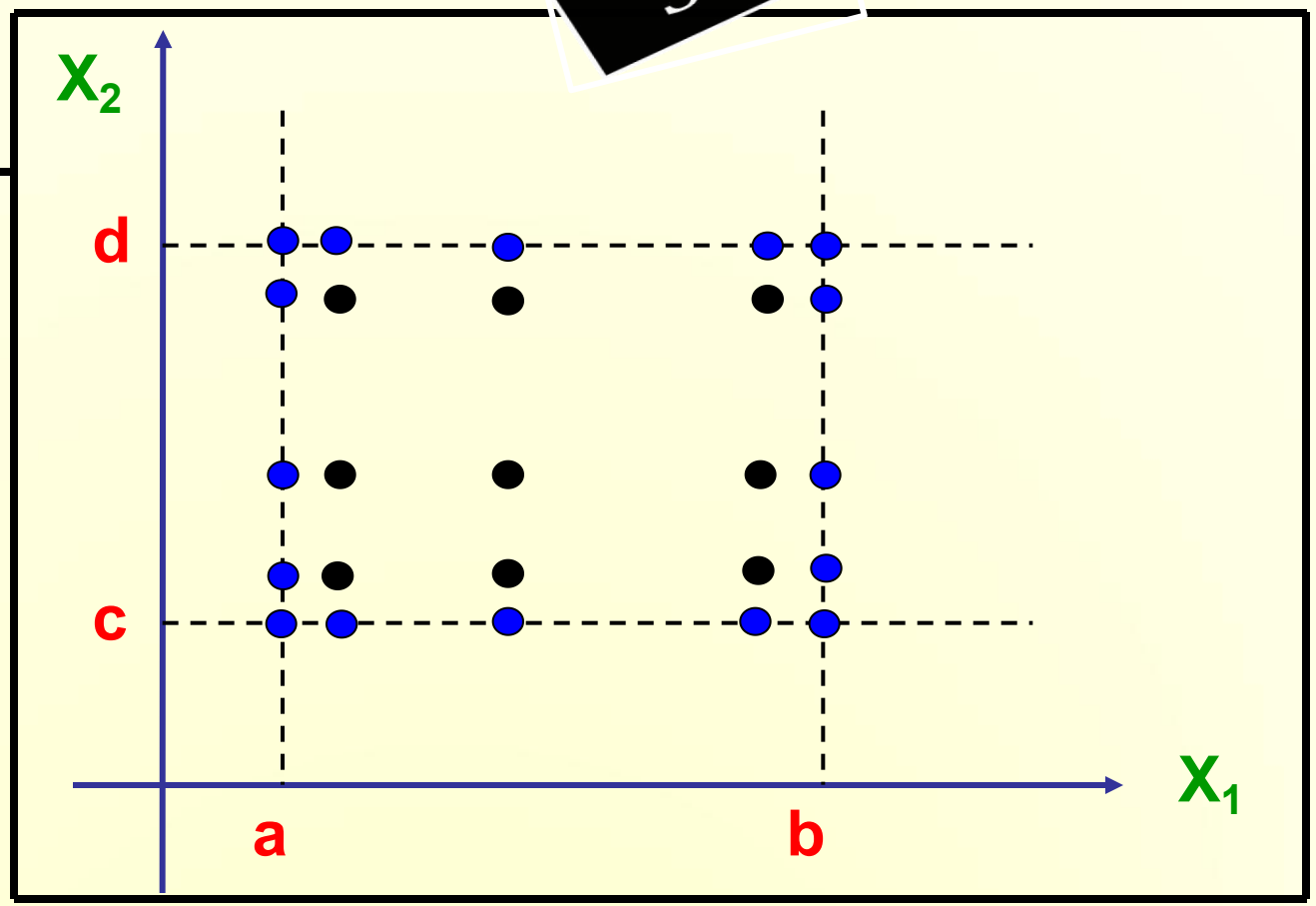


Robustness Boundary Values

Multiple Variable of Boundary Values / Worse-Case Testing

最坏情况

边界值分析

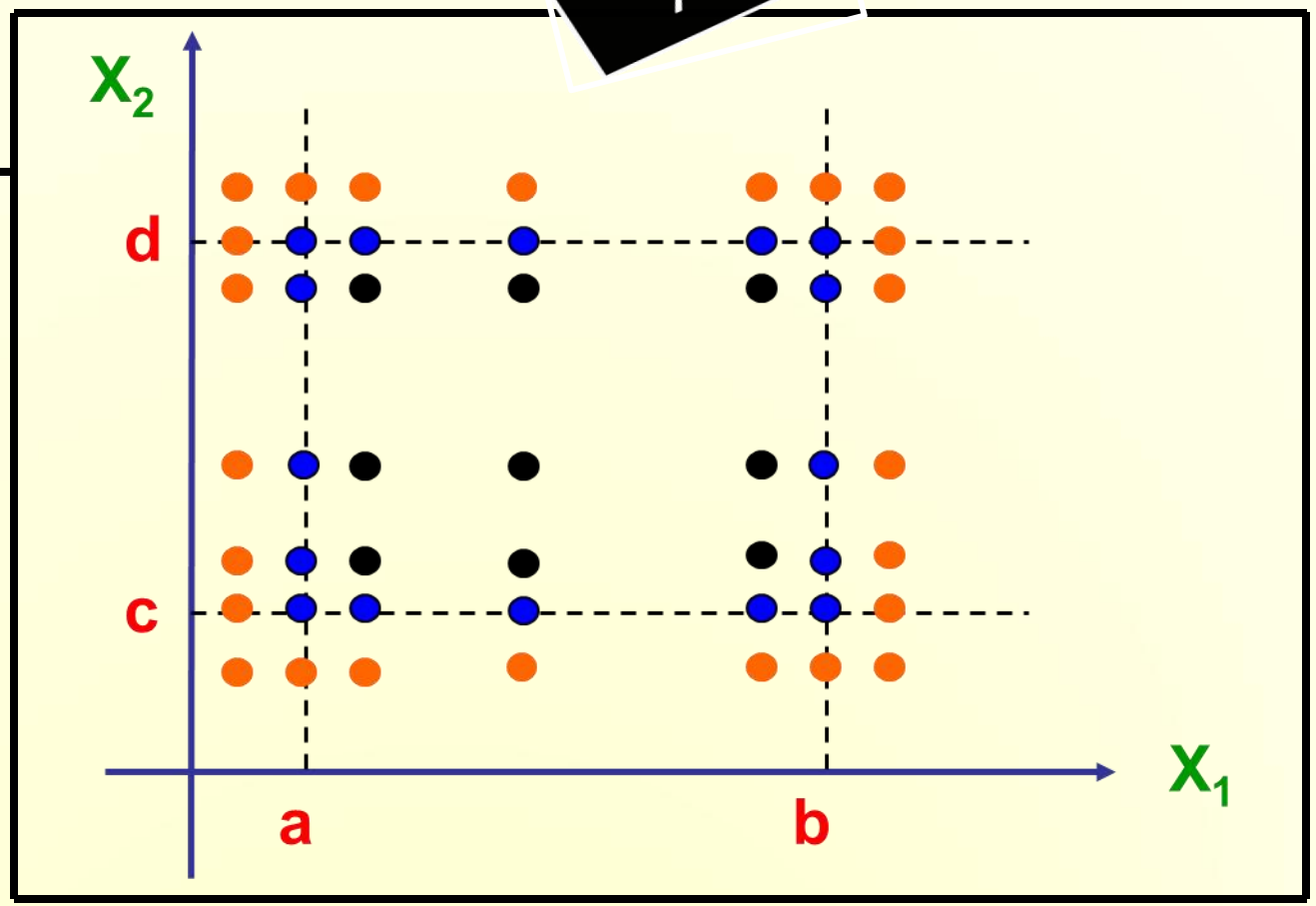


Test all the combinations of extreme values!

Useful for failure which appears only when two or more variable are at the boundary values

Robust Multiple Variable of Boundary Values / Robust Worst-Case Testing

健壮最坏情况
边界值分析



Also test the invalid extreme values.

4.2 Boundary Value Analysis

* Description of Boundary Value?

4.2 **Boundary Value Analysis**

Examples:

* Characters with input range condition [1, 255]
  * boundary values: 1, 255
* Read and Write CD-R
  * boundary values: Empty file, full files
* Printer:
  * boundary values: 1 page and maximum pages

4.2 Boundary Value Analysis

Examples:

* The Triangle Problem
* The NextDate Problem
* The Commission Problem

The Triangle Problem

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

C1: 1=<a=<200	**C4: a < b+c**
C2: 1=<b=<200	**C5: b < a+c**
C3: 1=<c=<200	**C6: c < a+b**

- The output of the program is the type of triangle determined by the three sides: Equilateral, Isosceles, scalene, or NotATriangle.

The Triangle Problem

- How to implement the triangle problem?
  - Pseudo code
- How to test the triangle program
  - Test case design:
    - Boundary value analysis
    - Robustness testing
    - Worst-Case Testing
    - Robust worst-case testing

4.2 Boundary Value Analysis

* The Triangle Problem
  * Test cases for boundary value analysis

13 test cases

NO.	a	b	c	Expected results
1	100	100	1	I(Isosceles)
2	100	100	2	I
3	100	100	100	E(Equilateral)
4	100	100	199	I
5	100	100	200	N(NotATriangle)
6	100	1	100	I
7	100	2	100	I
8	100	100	100	E
9	100	199	100	I
10	100	200	100	N
11	1	100	100	I
12	2	100	100	I
13	100	100	100	E
14	199	100	100	I
15	200	100	100	N

4.2 **Boundary Value Analysis**

- The Triangle Problem
  - Design test cases for Robustness Boundary Values.
  - How many test cases for Multiple Variable of Boundary Values(Worst-case testing) ?
  - How many test cases for Robust Multiple Variable of Boundary Values(Robust Worst-Case Testing)?

4.2 Boundary Value Analysis

- The NextDate Problem
  - Inputs are three integers: month, date, year
  - Output is the next date of the input
  - Satisfy the following conditions:
    - C1: 1<= month <= 12
    - C2: 1<= day <= 31
    - C3: 1812<= year <= 2012

4.2 Boundary Value Analysis

- How to test the NextDate problem?
  - For month: 0, 1, 2, 6, 11, 12, 13
  - For day: 0, 1, 2, 15, 30, 31, 32
  - For year : 1811, 1812, 1813, 1900, 2011, 2012, 2013
- Some impossible test cases
  - 2-30-1900, 6-31-2012…
- Miss some important test cases
  - 28 or 29 in February
  - Leap year: 2000

The Commission Problem

A rifle salesperson sells rifle locks, stocks, and barrels. Locks cost $45, stocks cost $30, and barrels cost $25. The salesperson had to sell at least one complete rifle per month, and production limits were such that the most the salesperson could sell in a month was 70 locks, 80 stocks, and 90 barrels.

Suppose the commission is computed as follows: 10% on sales up to (and including) $1000, 15% on the next $800, and 20% on any sales in excess of $1800.

The commission program produces a monthly sales report that gave the total number of locks, stocks, and barrels sold, the salesperson's total dollar sales, and, finally, the commission.

佣金程序的问题描述

- 步枪销售商在亚利桑那州境内销售制造商制造的步枪锁、准星和枪管
- 枪锁卖45美元，准星卖30美元，枪管卖25美元
- 销售商每月至少要售出一枝完整的步枪，生产限额考虑到大多数销售商在一个月内可销售70个枪锁、80个准星和90个枪管
- 销售商在每访问一个镇子之后，给制造商发出电报，说明在那个镇子中售出的枪锁、准星和枪管数量

佣金程序的问题描述（续）

- 到了月末，销售商要发出一封很短的电报，通知—1个枪锁被售出，以便制造商知道当月的销售情况
- 销售商的佣金为：销售额不到（含）1000美元的部分，为10%，1000（不含）到1800（含）美元的部分，为15%，超过1800美元的部分为20%
- 佣金程序生成月份销售报告，汇总售出的枪锁、准星和枪管总数，销售商的总销售额，以及佣金

```
1   Program Commission (INPUT,OUTPUT)

2       Dim locks,stocks,barrels As Integer
3       Dim lockPrice,stockPrice,barrelPrice As Real
4       Dim totalLocks,totalStocks,totalBarrels As Integer
5       Dim lockSales,stockSales.barrelSales As Real
6       Dim sales,commission As Real

7       lockPrice = 45.0
8       stockPrice = 30.0
9       barrelPrice = 25.0
10      totalLocks = 0
11      totalStocks = 0
12      totalBarrels = 0
```

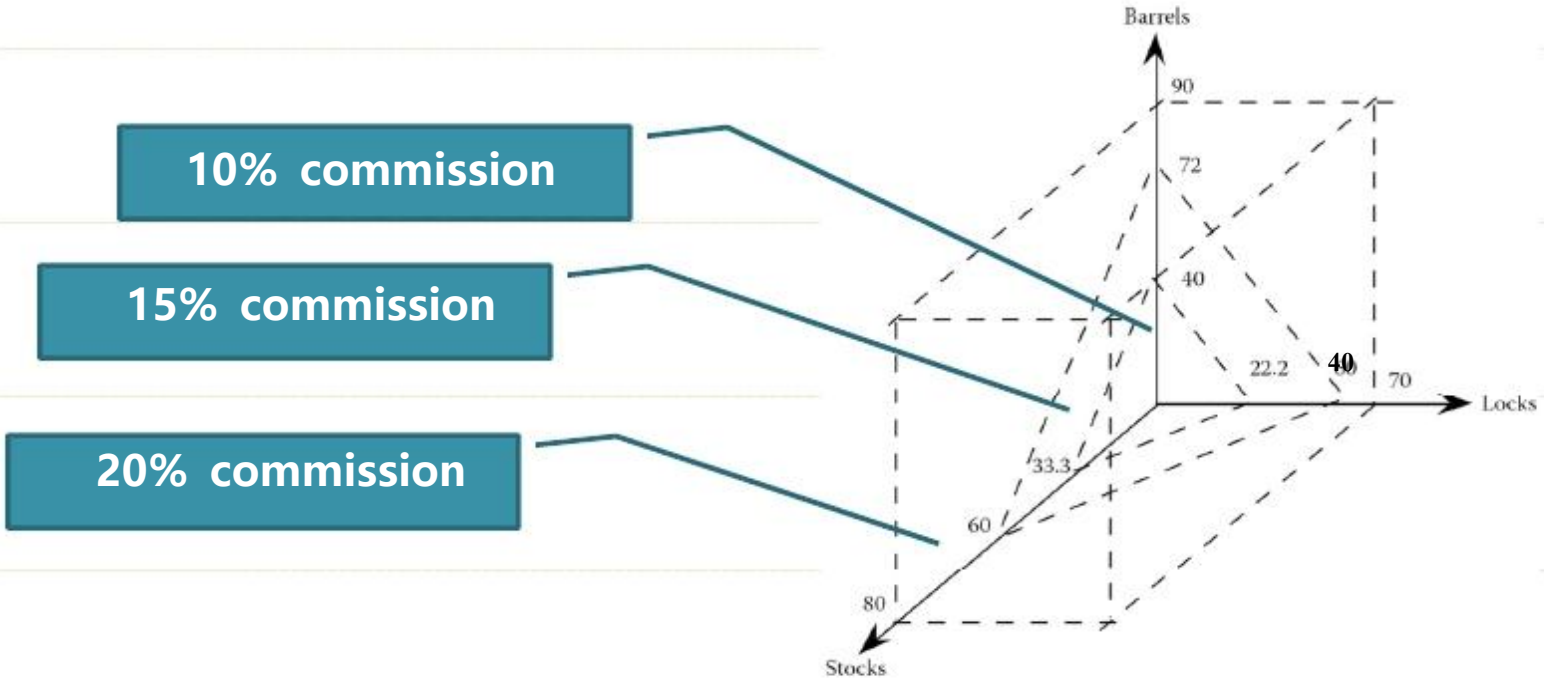
```
13      Input(locks)
14      While NOT(locks = -1)      'loop condition uses-1 to indicate end of
15          Input(stocks,barrels)
16          totalLocks = totalLocks + locks
17          totalStocks = totalStocks + stocks
18          totalBarrels = totalBarrels + barrels
19          Input(locks)
20      EndWhile

21      Output("Locks sold:",totalLocks)
22      Output("Stocks sold:",totalStocks)
23      Output("Barrels sold:",totalBarrels)
24      lockSales = lockPrice * totalLocks
25      stockSales = stockPrice * totalStocks
26      barrelSales = barrelPrice * totalBarrels
27      sales = lockSales + stockSales + barrelSales
28      Output("Total sales:",sales)
```

```
29      If(sales>1800.0)
30          Then
31              commission = 0.10 * 1000.0
32              commission = commission + 0.15 * 800.0
33          commission = commission + 0.20 * (sales - 1800.0)
34      Else If(sales>1000.0)
35          Then
36                      commission = 0.10 * 1000.0
37                      commission = commission + 0.15 * (sales - 1000.0)
38              Else commission = 0.10 * sales
39                EndIf
40       EndIf
41       Output("Commission is $",commission)
42       End Commission
```

Test Cases for the Commission Problem

We focus on boundary values for the output range,especially near the threshold points of $1000 and $1800.



Commission Problem Output Boundary Value Analysis Test Cases

Case	Locks	Stocks	Barrels	Sales	Commission	Comment
1	1	1	1	100	10	Output minimum
2	1	1	2	125	12.5	Output minimum +
3	1	2	1	130	13	Output minimum +
4	2	1	1	145	14.5	Output minimum +
5	5	5	5	500	50	Midpoint
6	10	10	9	975	97.5	Border point –
7	10	9	10	970	97	Border point –
8	9	10	10	955	95.5	Border point –
9	10	10	10	1000	100	Border point
10	10	10	11	1025	103.75	Border point +
11	10	11	10	1030	104.5	Border point +
12	11	10	10	1045	106.75	Border point +
13	14	14	14	1400	160	Midpoint
14	18	18	17	1775	216.25	Border point –
15	18	17	18	1770	215.5	Border point –
16	17	18	18	1755	213.25	Border point –
17	18	18	18	1800	220	Border point
18	18	18	19	1825	225	Border point +
19	18	19	18	1830	226	Border point +
20	19	18	18	1845	229	Border point +
21	48	48	48	4800	820	Midpoint
22	70	80	89	7775	1 415	Output maximum –
23	70	79	90	7770	1414	Output maximum –
24	69	80	90	7755	1411	Output maximum –
25	70	80	90	7800	1420	Output maximum

Sales<=1000

1000<Sales<=1800

Sales>1800

4.2 **Boundary Value Analysis**

- Boundary Value Analysis techniques include:
  - Normal Boundary Values
  - Robustness Boundary Values
  - Multiple Variable of Boundary Values
    - (Worst-Case Testing)
  - Robust Multiple Variable of Boundary Values
    - (Robust Worst-Case Testing)
- It can be applied for the input/output range

边界值检验的主要类型

边界类型	输入
数字	最大、最小
字符	首位、末位
位置	上、下
重量	最高、最低
速度	最快、最慢
方位	最高、最低
尺寸	最长、最短
空间	空、满
...	...

Limitation of BVA

Boundary value analysis works well when the program to be tested is a function of several physical quantity variables that represent bounded physical quantities (e.g. as temperature, pressure, air speed, angle of attack, load,), physical boundaries can be extremely important.

As an example of logical (versus physical) variables, we might look at PINs or telephone numbers. It is hard to imagine what faults might be revealed by testing PIN values of 0000, 0001, 5000, 9998, and 9999.

4.2 **Boundary Value Analysis**

Questions?

* What is the advantages of Boundary Value Analysis?
* What is the limitations of Boundary Value Analysis?

4.2 Boundary Value Analysis

- What is the advantages of Boundary Value Analysis?
  - Given the boundary, it is easy and cheap to design test cases
  - N parameters produce $4n+1$, $6n+1$, 5^n, 7^n test cases
  - Different data type have different boundary value selection
- What is the limitations of Boundary Value Analysis?
  - Suppose parameters are independent
  - Ignore the semantic information of parameters
  - Boundary value analysis is not useful for a Boolean variable

Exercise 1

- There are three integer inputs x, y, z, corresponding to the length, width and height of a rectangle respectively. All of these three inputs are in the range of [2, 20], the output is the volume of the rectangle.
  - List the number of test cases that needed by four types of boundary value analysis respectively.
  - Design the test cases by Robustness Boundary Value Analysis.