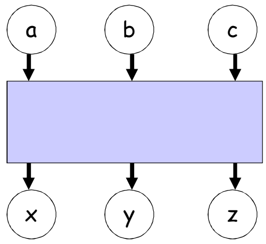
5. Boundary Value testing

Boundary Value Analysis
Robustness
Worst-Case
Robust Worst-Case
Special Value
Random
Equivalence classes

Boundary Value analysis

- Any software to be tested can be thought of as a function that associates its inputs with its outputs



Boundary Value analysis

- Any software to be tested can be thought of as a function that associates its inputs with its outputs

sets

$f: X \rightarrow Y$

Domain | Range

Triangle example: <x1, x2, x3> <Equilateral, Isosceles, Scalene>

Blood pressure

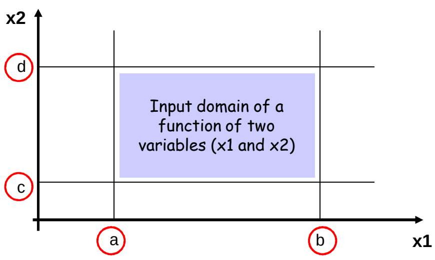
sets

$f: X \rightarrow Y$

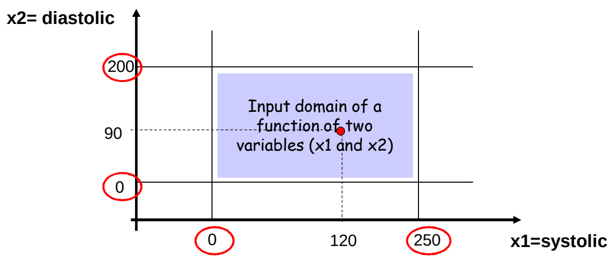
Domain | Range

Blood pressure: <x1=systolic, x2=diastolic> <Low, Normal, High>

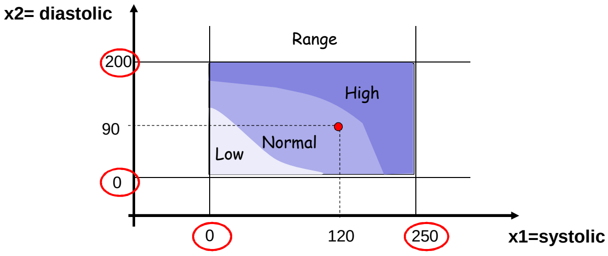
Boundary Value analysis



Boundary Value analysis



Boundary Value analysis



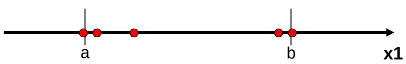
Boundary Value analysis

- Boundary value analysis focuses on the boundaries of the domain
- Rationale: errors occur most frequently on or near the boundary
- It makes a Single Fault Assumption:

"Failures are only rarely the result of the simultaneous occurrence of two or more faults."

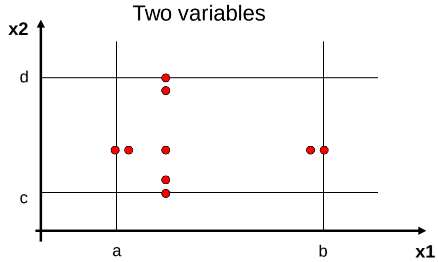
Boundary Value analysis

Single variable



Boundary Value analysis

Two variables

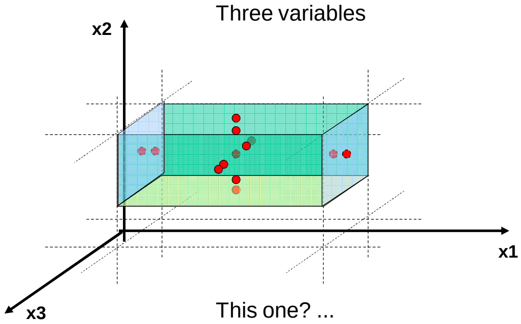


- How many boundary tests for 2, 3, …, n variables?

4n + 1

Boundary Value analysis

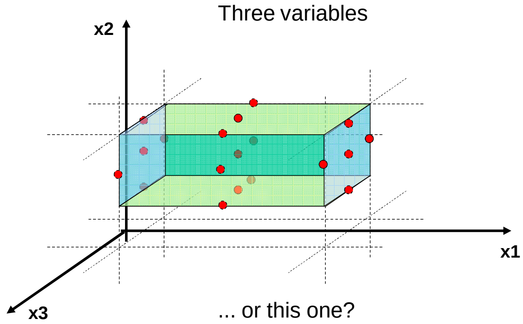
Three variables



This one? ...

Boundary Value analysis

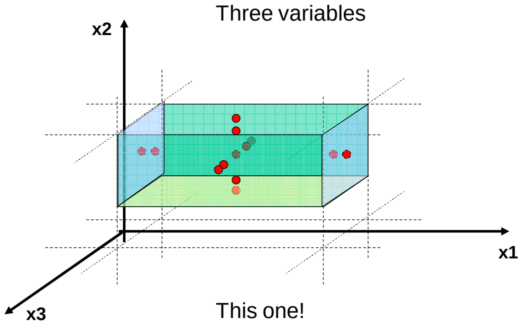
Three variables



... or this one?

Boundary Value analysis

Three variables



The triangle problem – full specification

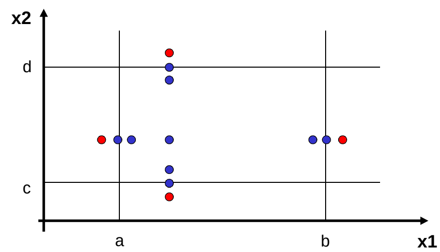
Specify boundary tests for the triangle problem

Boundary Value analysis Problems and limitations

- Bounds may not be always obvious (e.g. an upper bound for the triangle problem)
- Bounds may not be appropriate (e.g. for boolean values; Decision Table Testing is better)
- No bounds in cases of enumerated variables (e.g. in bank transactions “deposit”, “withdrawal”, “query”)
- No testing for negative cases √

Robustness testing

- Extension of the Boundary Value Analysis
- Examines the cases when the boundaries are slightly exceeded (negative testing)



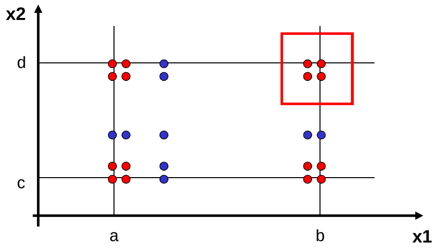
Robustness testing

- Main value of robustness testing: focuses attention on exception handling
- This can also influence implementation:
  - Do we carry out explicitly exception handling for every case OR
  - Do we let the behaviour associated with “strong typing” to take its course and abort execution? Do we treat such a case as a “FAILED” test?

Worst case testing

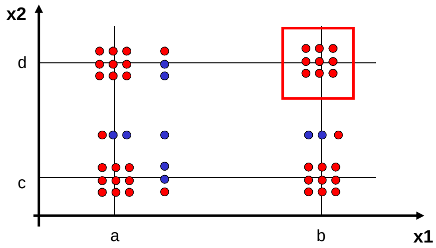
- Boundary Value Analysis makes the “single fault” assumption
  Failures are only rarely the result of the simultaneous occurrence of two or more faults
- Worst case testing is interested in what happens when more than one variable has an extreme value simultaneously
- Best used when variables may have complex interactions and where the impact of failure is large

Worst case testing



- How many boundary tests for 2, 3, …, n variables?
  5^n

Robust Worst-Case testing (Paranoid Testing)



- How many boundary tests for 2, 3, …, n variables?
  7^n

NextDate function

NextDate is a function of three variables:
- month
- day
- year

It returns the date of the day after the input date in the form of three variables <month, day, year>.

The month, date and year variables have integer values subject to the following conditions:

- $1 \leq \text{month} \leq 12$
- $1 \leq \text{day} \leq 31$
- $1820 \leq \text{year} \leq 2020$

NextDate function

- What is the Domain for the NextDate problem?
- What is the dimension of the Domain?
- What is the Range for the NextDate problem?
- How many boundary values are there in total?
- Variable types (SNM / ROV / GV):
  - month?
  - day?
  - year?
- Is the Boundary Value testing likely to uncover most of the errors?

Special value testing

- Tester uses the domain knowledge and experience to select test values
- Ad hoc and not based on any principles
- The least systematic and least uniform of the methods
- Can be of value when used in addition to one of the systematic methods
- Example: computing next date

Random testing

- Random values are picked from the specified ranges
- The main question: how many values are sufficient?

  (Test Coverage Metrics can provide the answer)

- Example – random test cases for the NextDate program

NextDate function

- What is the key reason why the Boundary Value analysis alone is not adequate for the NextDate function?

Boundary Value analysis Problems and limitations

- Bounds may not be always obvious (e.g. an upper bound for the triangle problem)
- Bounds may not be appropriate (e.g. for boolean values; “Decision Table” Testing is better)
- No bounds in cases of enumerated variables (e.g. in bank transactions “deposit”, “withdrawal”, “query”)
- No testing for negative cases
- Inadequate when there are dependencies between the variables.

Dependency between variables

- Testing for the cases where there are dependencies between the variables is better done using the Equivalence Class Testing methods (next unit)

Equivalence classes

- In mathematics, given a set X and an equivalence relation ~ on X, the **equivalence class** of an element a in X is the subset of all elements in X which are equivalent to a:
- $[a] = \{ x \in X \mid x \sim a \}$

- If X is the set of all cars, and ~ is the equivalence relation "has the same colour as", then one particular equivalence class consists of all green cars.
- The set of equivalence classes could be naturally identified with the set of all car colours.

Equivalence classes

- Because of the properties of an equivalence relation, it holds that
  - the element a is in the equivalence class $[a]$
  - any two equivalence classes, according to the same equivalence relation, are either equal or disjoint.
- The set of all equivalence classes of X forms a partition of X:
  - every element of X belongs to one and only one equivalence class
  - every partition of X also defines an equivalence relation over X
  - $a \sim b$ if and only if $[a] = [b]$.

Partition of the set X of cars according to the equivalence relation “has the same colour as”