Software Testing & Quality Assurance

Review of Functional Testing Techniques

- Boundary Value Testing
- Equivalence Class Testing
- Decision Table-Based Testing
- Testing effort, efficiency and effectiveness issues

Credits & Readings

The material included in these slides are mostly adopted from the following books:

- *Software Testing: A Craftsman's Approach*, by Paul Jorgensen, CRC PRESS, third edition, ISBN: 0-8493-7475-8
- Cem Kaner, Jack Falk, Hung Q. Nguyen, "*Testing Computer Software*" Wiley (see also http://www.testingeducation.org/)
- Paul Ammann and Jeff Offutt, "*Introduction to Software Testing*", Cambridge University Press
- Glen Myers, "*The Art of Software Testing*"

Functional Testing

- We saw three types of functional testing
  - Boundary Value Testing
  - Equivalence Class Testing
  - Decision Table-Based Testing
- The common thread among these techniques is that they all view a program as a <u>mathematical function</u> that maps its inputs to its outputs
- We now look at questions related to
  - Testing <u>effort</u>
  - Testing <u>efficiency</u>
  - Testing <u>effectiveness</u>

Boundary Value Test Cases

Test Case	a	b	c	Expected Output
1	100	100	1	Isosceles
2	100	100	2	Isosceles
3	100	100	100	Equilateral
4	100	100	199	Isosceles
5	100	100	200	Not a Triangle
6	100	1	100	Isosceles
7	100	2	100	Isosceles
8	100	100	100	Equilateral
9	100	199	100	Isosceles
10	100	200	100	Not a Triangle
11	1	100	100	Isosceles
12	2	100	100	Isosceles
13	100	100	100	Equilateral
14	199	100	100	Isosceles
15	200	100	100	Not a Triangle

- For each variable, select five values (keep the others constant)
  - Minimum
  - Just above the minimum
  - Nominal
  - Just below the maximum
  - Maximum

Equivalence Class Test Cases

Test Case	a	b	c	Expected Output
WN1	5	5	5	Equilateral
WN2	2	2	3	Isosceles
WN3	3	4	5	Scalene
WN4	4	1	2	Not a Triangle
WR1	-1	5	5	a not in range
WR2	5	-1	5	b not in range
WR3	5	5	-1	c not in range
WR4	201	5	5	a not in range
WR5	5	201	5	b not in range
WR6	5	5	201	c not in range

- Weak Normal test cases (WN1-WN4) are derived by using one variable from each equivalence class (i.e. equilateral, isosceles, scalene, invalid)
- Weak Robust test cases (WR1-WR6) are derived by considering one invalid input and keeping the rest valid (i.e. a, b, c not in range)

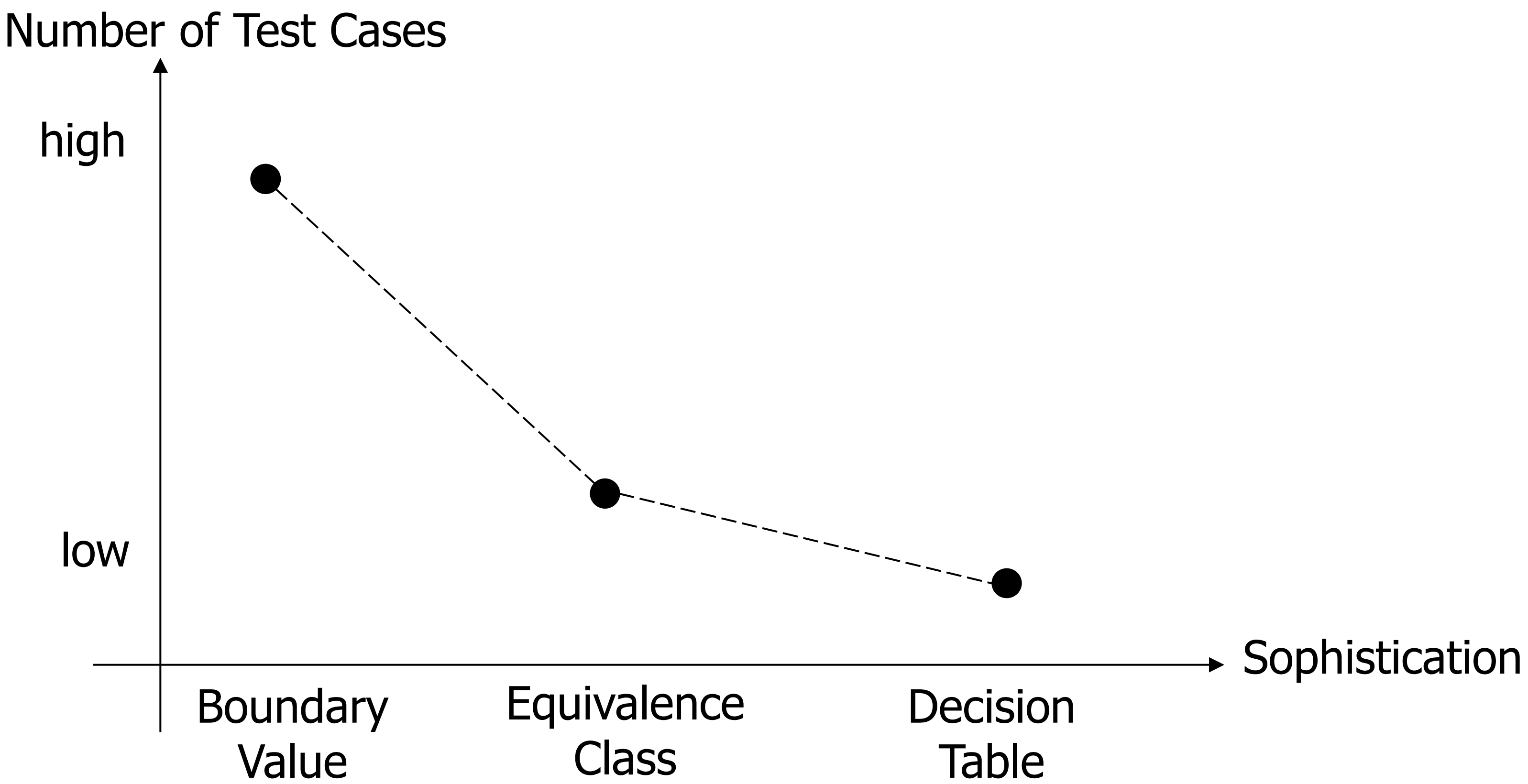
Decision Table Test Cases

Test Case	a	b	c	Expected Output
DT1	4	1	2	Not a Triangle
DT2	1	4	2	Not a Triangle
DT3	1	2	4	Not a Triangle
DT4	5	5	5	Equilateral
DT5	?	?	?	Impossible
DT6	?	?	?	Impossible
DT7	2	2	3	Isosceles
DT8	?	?	?	Impossible
DT9	2	3	2	Isosceles
DT10	3	2	2	Isosceles
DT11	3	4	5	Scalene

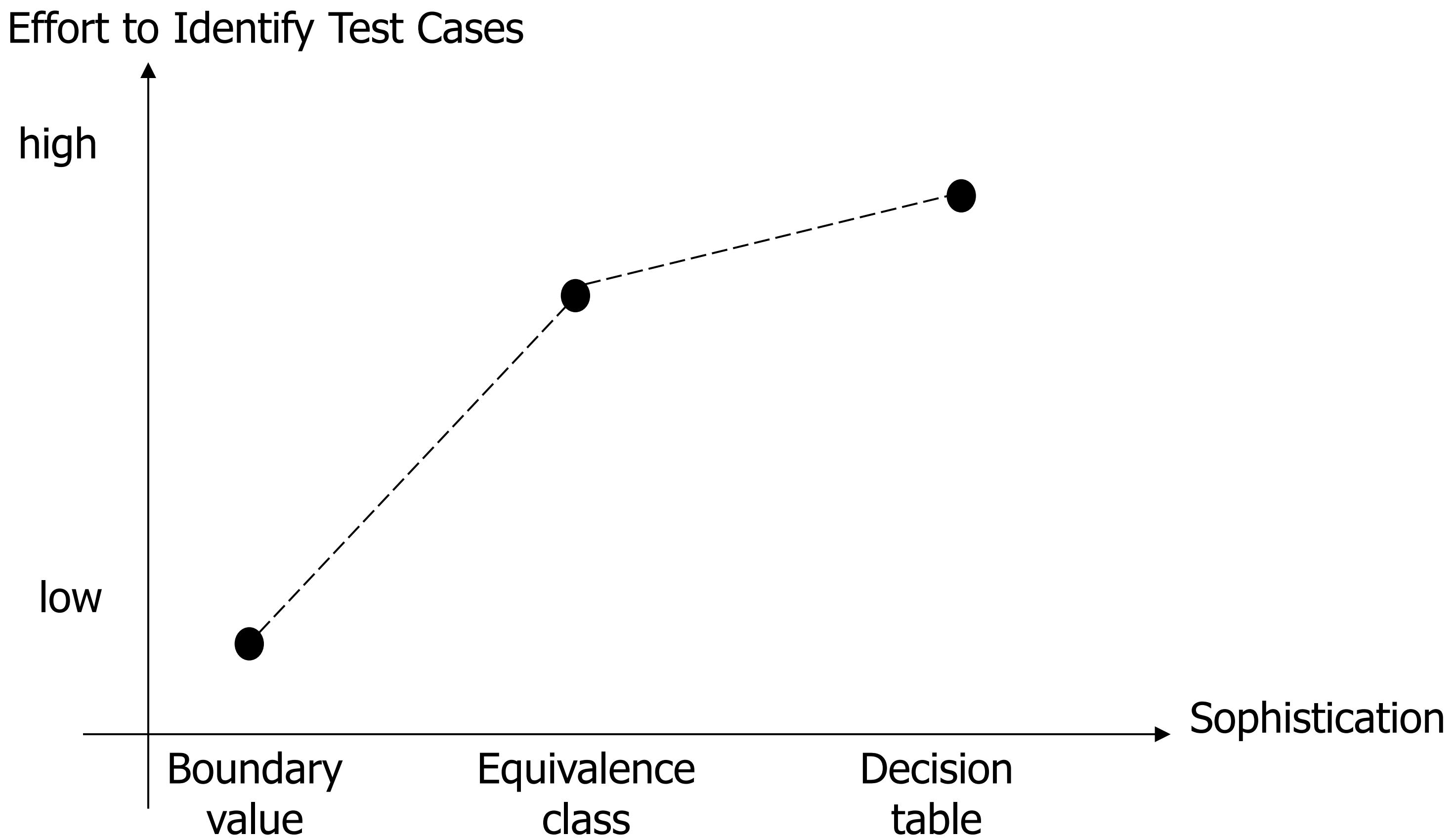
C1: a < b+c?	F	T	T	T	T	T	T	T	T	T	T
C2: b < a+c?	-	F	T	T	T	T	T	T	T	T	T
C3: c < a+b?	-	-	F	T	T	T	T	T	T	T	T
C4: a = b?	-	-	-	T	T	T	T	F	F	F	F
C5: a = c?	-	-	-	T	T	F	F	T	T	F	F
C6: b = c?	-	-	-	T	F	T	F	T	F	T	F
A1: Not a Triangle	X	X	X								
A2: Scalene											X
A3: Isosceles							X		X	X	
A4: Equilateral				X							
A5: Impossible					X	X		X			

- From the decision table we derive 11 test cases that correspond to actions taken (denoted by X in the decision table)

Testing Effort[1]



Testing Effort[2]



Testing Effort[3]

- Boundary Value Testing has no recognition of data or logical dependencies
  - Mechanical generation of test cases
- Equivalence Class Testing takes into account data dependencies
  - More thought and care is required to define the equivalence classes
  - Mechanical generation after that

Testing Effort[4]

- The decision table technique is the most sophisticated, because it requires that we consider both data and logical dependencies
  - Iterative process
  - Allows manual identification of redundant test cases
- Tradeoff between test identification effort and test execution effort

Testing Efficiency

- Fundamental limitations of functional testing
  - Gaps of untested functionality
  - Redundant tests
- Testing efficiency question: *How can we create a set of test cases that is "just right"?*
  - Hard to answer. Can only rely on the general knowledge that more sophisticated techniques, such as decision tables, are usually more efficient
  - Structural testing methods will allow us to define more interesting metrics for efficiency

Testing Efficiency Comparison

For the *NextDate* program

- The worst case boundary analysis generated 125 cases
  - These are fairly redundant (check January 1 for five different years, only a few February cases but none on February 28, and February 29, and no major testing for leap years)
- The strong equivalence class test cases generated 36 test cases 11 of which are impossible
- The decision table technique generated 22 test cases (fairly complete)

Testing Effectiveness

- How effective is a method or a set of test cases for finding faults present in a program?
- Hard to answer because
  - It presumes we know all faults in a program
  - It is impossible to prove that a program is free of faults
- The best we can do is to work backward from fault types
- Given a fault type we can choose testing methods that are likely to reveal faults of that type
  - Use knowledge related to the most likely kinds of faults to occur
  - Track kinds and frequencies of faults in the software applications we develop

Guidelines[1]

- Kinds of faults may reveal some pointers as to which testing method to use
- If we do not know the kinds of faults that are likely to occur in the program then the attributes most helpful in choosing functional testing methods are:
  - Whether the variables represent physical or logical quantities
  - Whether or not there are dependencies among variables
  - Whether single or multiple faults are assumed
  - Whether exception handling is prominent

Guidelines[2]

- If the variables refer to physical quantities and/or are independent then we consider
  - domain testing or
  - equivalence testing
- If the variables are dependent then we consider
  - decision table testing
- If the single-fault assumption is plausible to assume then consider
  - boundary value analysis and
  - robustness testing

Guidelines3

- If the multiple-fault assumption is plausible to assume then we consider
  - worst case testing
  - robust worst case testing
  - decision table testing
- If the program contains significant exception handling then we consider
  - robustness testing and
  - decision table testing
- If the variables refer to logical quantities, then consider
  - equivalence class testing and
  - decision table testing

Functional Testing Decision Table

C1: Variables (P=Physical, L=Logical)?	P	P	P	P	P	L	L	L	L	L
C2: Independent Variables?	Y	Y	Y	Y	N	Y	Y	Y	Y	N
C3: Single fault assumption?	Y	Y	N	N	-	Y	Y	N	N	-
C4: Exception handling?	Y	N	Y	N	-	Y	N	Y	N	-
A1: Boundary value analysis		X								
A2: Robustness testing	X									
A3: Worst case testing				X						
A4: Robust worst case testing			X							
A5: Weak robust equivalence testing	X		X			X		X		
A6: Weak normal equivalence testing	X	X				X	X			
A7: Strong normal equivalence testing			X	X	X			X	X	X
A8: Decision table					X					X

Case Study

- Apply and compare functional testing methods on the following example (page 123):
  - Consider an insurance premium program that computes the semi-annual car insurance premium based on two parameters
    - The policy holder’s age
    - Driving record
  - It uses the following formula:

`Premium = BaseRate * ageMultiplier – safeDrivingReduction`

`ageMultiplier` is a function of the policyholder’s age

`safeDrivingReduction` is given when traffic points are below an age cutoff