Testing, Debugging, and Verification

Testing, Part I

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08 November 2018

[1] Slides based on material from Wolfgang Aherndt,...

Let's review the course contents

- Testing and Debugging (lab)
- Formal Specification (lab)
- Formal Program Verification (lab)
- Property Based testing
- Loop Invariant Generation

Some practical things

- Make sure you are registered for the course (see Student Office). Otherwise your marks cannot be recorded.
  - Even if you are repeating the course, only taking labs or exam.
  - If in doubt, contact the student office to double check.
- Please sign up for the google group (follow News link)
- Exam date: 15 January 2019.
- About labs in general
  - Use Fire system
  - Working in pairs is mandatory
  - If there are any problems, notify us immediately (don't wait until the day of the deadline...).

Some practical things

Testing block consists of

- 4 lectures (2 lectures this week + 2 lecture next week)
- 1 exercise (Thursday next week)
- 1 lab assignment

Motivation for Course Unit on Testing

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Testing is not the only, but the primary method that industry uses to evaluate software under development.

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A few basic software testing concepts can be used to design tests for a large variety of software applications.

The testing techniques present in the literature have much more in common than is obvious at first glance.

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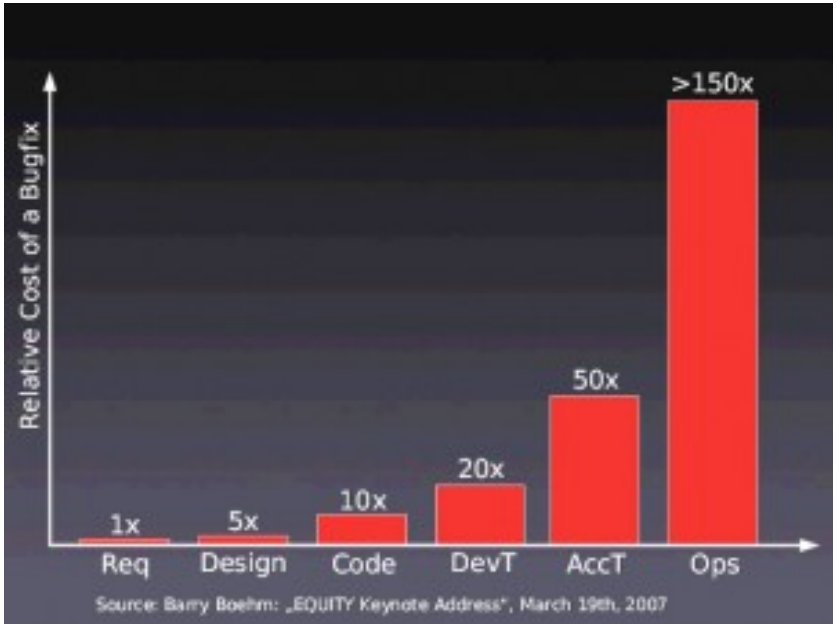


A Quiz

A simple program

Input

Read three integer values from the command line.
The three values represent the lengths of the sides of a triangle.

Output

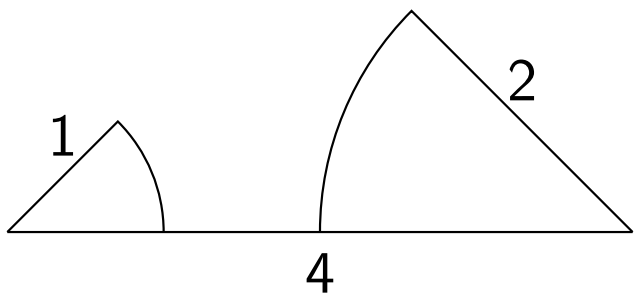
Tells whether the triangle is

Scalene:	no two sides are equal
Isosceles:	exactly two sides are equal
Equilateral:	all sides are equal

Create a Set of at least 15 Test Cases for this Program

Solution — 1 Point for each Correct Answer

Q 1: An invalid triangle? e.g. (4,1,2)



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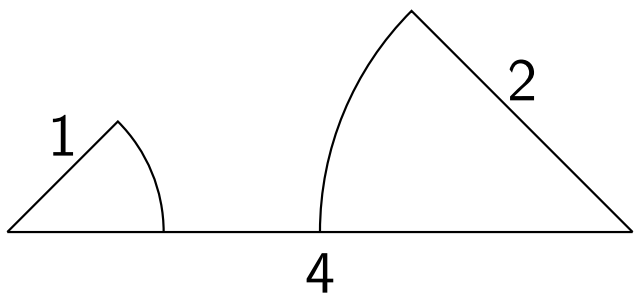

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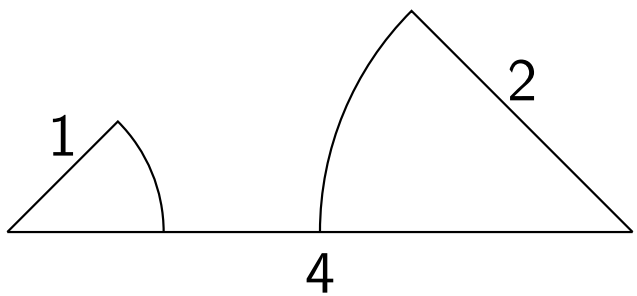


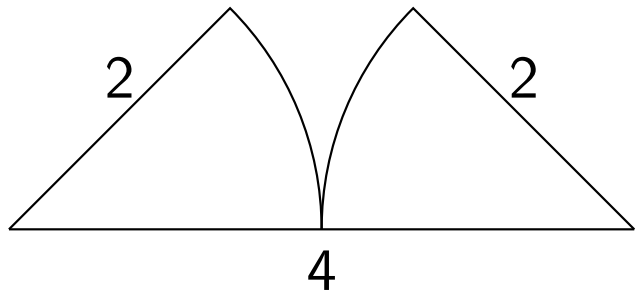
Why not a valid triangle? (a,b,c) with $a > b + c$

Solution — 1 Point for each Correct Answer

Q 2: Some permutations of previous? e.g., (1,2,4), (2,1,4) are still invalid.

Solution — 1 Point for each Correct Answer

Q 3: An invalid triangle with equal sum? e.g., (4,2,2)

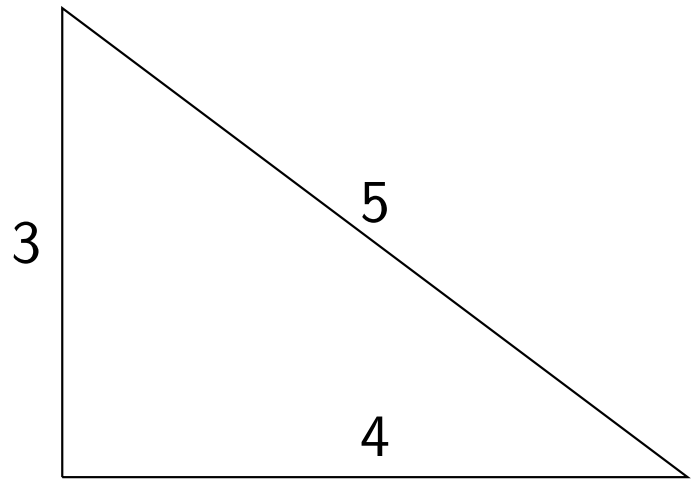


Solution — 1 Point for each Correct Answer

Q 4: Some permutations of previous? e.g., (2,2,4), (2,4,2)

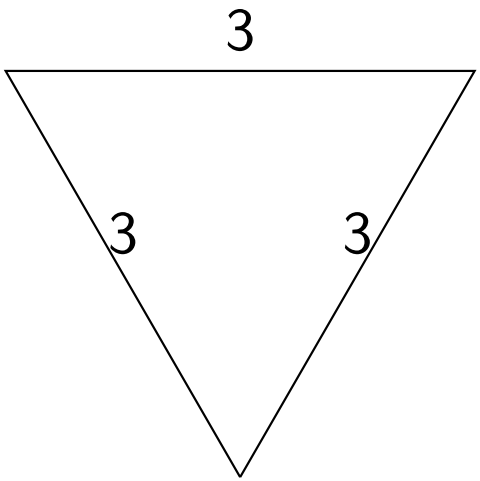
Solution — 1 Point for each Correct Answer

Q 5: A valid scalene triangle? e.g., (3,4,5)



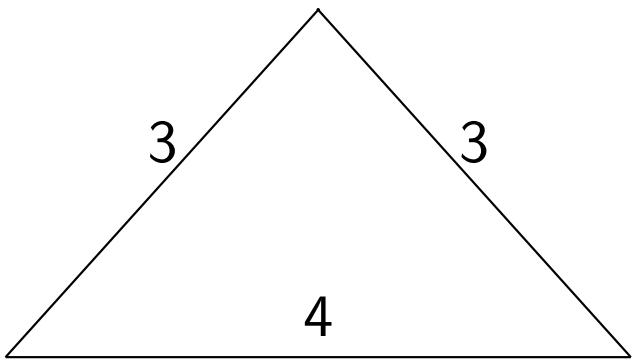
Solution — 1 Point for each Correct Answer

Q 6: An equilateral triangle? e.g., (3,3,3)



Solution — 1 Point for each Correct Answer

Q 7: A valid isosceles triangle? e.g., (3,4,3)



Solution — 1 Point for each Correct Answer

Q 8: All permutations of valid isosceles triangle?

(3,4,3), (3,3,4), (4,3,3)

Solution — 1 Point for each Correct Answer

Q 9: One side with zero value? e.g., (0,4,3)

Solution — 1 Point for each Correct Answer

Q 10: One side with negative value? e.g., (-1,4,3)

Solution — 1 Point for each Correct Answer

Q 11: All sides zero? e.g., (0,0,0)

Solution — 1 Point for each Correct Answer

Q 12: At least one value is non-integer? e.g., (1,3,2.5)

Solution — 1 Point for each Correct Answer

Q 13: wrong number of arguments, e.g., (2,4) or (1,2,3,3)

Solution — 1 Point for each Correct Answer

Q 14 (the most important one):

Did you specify the expected output in each case?

About the Quiz

- Q 1–13 correspond to failures that have actually occurred in implementations of the program
- How many questions did you answer?
  < 5? $5 - 7$? $8 - 10$? > 10? All?

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- Q 1–13 correspond to failures that have actually occurred in implementations of the program
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- Highly qualified, experienced programmers score 7.8 on average

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The discipline of Testing is all about Test Cases

well, almost ...

Remark: At Ericsson, ca. 35% of code is test cases!

Brainstorming

- What is the purpose of testing?

...

Test Process Maturity Level in an Organisation

(adapted from [Beizer] and [AmmannOffutt])

Level 0 There is no difference between testing and debugging.

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- Level 1 Purpose of testing: show correctness.
- Level 2 Purpose of testing: show that the software does not work.
- Level 3 Purpose of testing: reduce the risk of using the software.
- Level 4 Testing is a mental discipline helping IT professionals to develop higher quality software.

Level 0 Thinking

Testing is the same as debugging

- Does *not* distinguish between incorrect behaviour and defects in the program
- Does not help develop software that is reliable or safe

Level 1 Thinking

Purpose: showing correctness

- Correctness is (almost) impossible to achieve
- Danger: you are subconsciously steered towards tests likely to not fail the program.
- What do we know if no failures?

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  good software? or bad tests?
- Test engineers have:
  - no strict goal
  - no real stopping rule
  - no formal test technique

Level 2 Thinking

Purpose: showing failures

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- Puts testers and developers into an adversarial relationship
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This describes most software companies.

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Purpose: reduce risk

- Whenever we use software, we incur some risk
- Risk may be small and consequences unimportant
- Risk may be great and the consequences catastrophic
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Level 4 Thinking

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- Testing only one way to increase quality
- Test engineers can become technical leaders of the project
- Primary responsibility to measure and improve software quality
- Their expertise should help developers
- Purpose of testing: improve ability of developers to produce high quality software

Activities if Test Engineer

Test engineer: IT professional in charge of test activities, including:

- designing test inputs
- running tests
- analysing results
- reporting results to developers and managers

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Test engineer: IT professional in charge of test activities, including:

- designing test inputs
- running tests
- analysing results
- reporting results to developers and managers
- automating any of the above

Developer $=$ or $\neq$ Test Engineer?

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different takes on this:

Contra: Test Principles in [Myers]

Principle: Programmer should avoid testing his/her own program.
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Pro: Extreme Testing (ET) [BeckGamma]

Principle: Developers create tests first

Principle: Developers re-run test on all incremental changes

Tool: JUnit designed for ET

Testing Levels Based on Software Activity

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assess software with respect to user requirements

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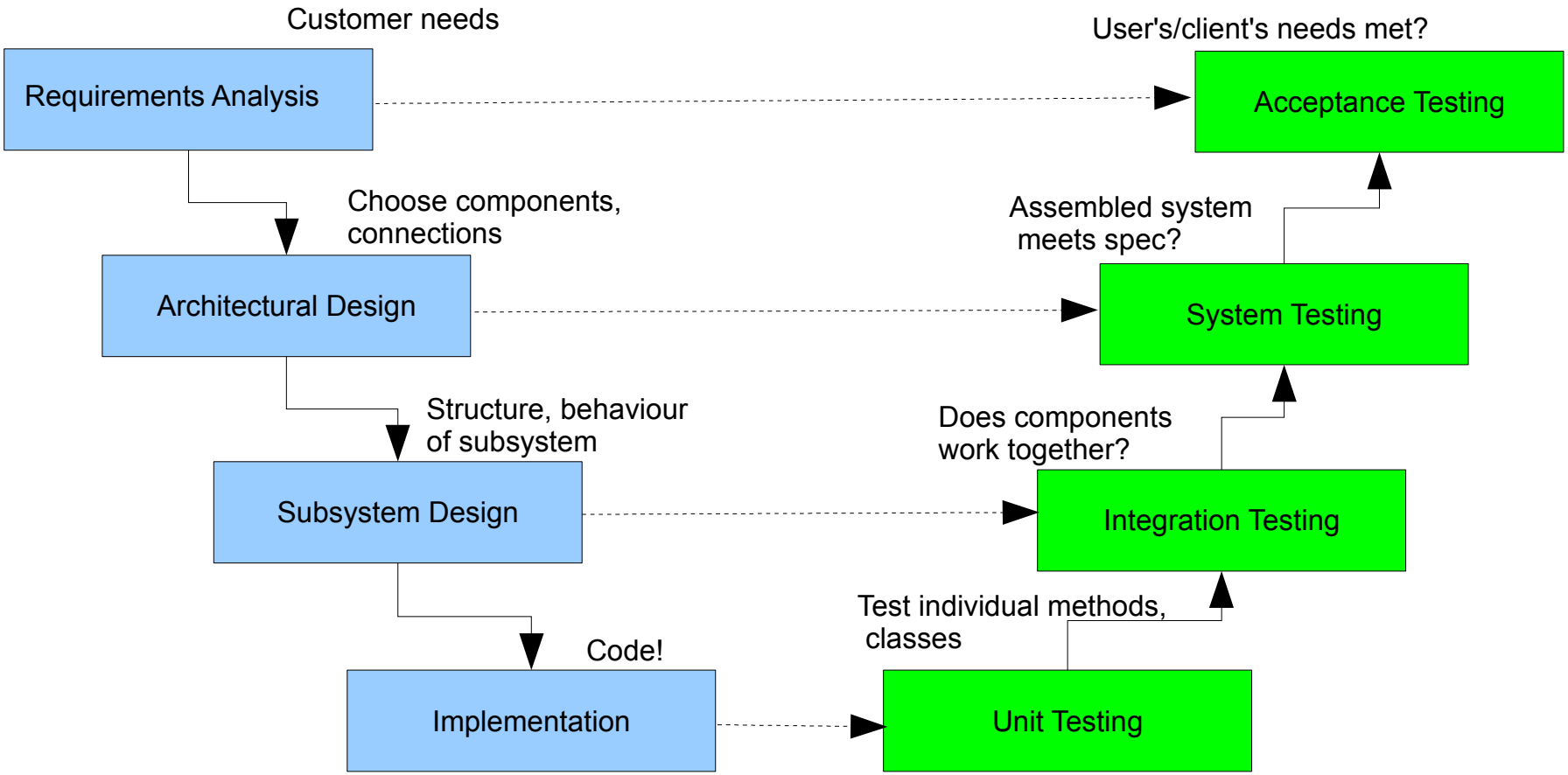
remarks:
– terminology, and depth of this hierarchy, varies in literature

V-Model



(many variants!)

Testing Levels Based on Software Activity (cont'd)

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This course focuses on lower level: unit testing

Literature related to this lecture

- Introduction to Software Testing - by Paul Ammann, Jeff Offutt
  - Testing levels (Chapter 1)