CS_313 High Integrity Systems/ CS_M13 Critical Systems

Course Notes

Chapter 7: Verification, Validation, Testing

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7 (a) Basic Notions

7 (b) Dynamic testing

7 (c) Static Analysis

7 (d) Modelling

(a) Basic Notions

- **Verification** is the process of determining whether the output of a life cycle phase fulfils the requirements specified in the previous phase.
  - So task is
    - **not** to demonstrate that the **output** of a development phase is **actually correct**,
    - but that the **output of a phase conforms to its input**.
  - Therefore mistakes in early phases of a project may **propagate** through later stages without detection.

Validation

- **Validation** is the process of confirming that the specification of a phase or of the complete system is appropriate and is consistent with the customer requirements.
- Validation
  - might be performed on individual phases,
  - but is usually performed on the complete system.

Testing

- **Testing** is the process used to verify or validate a system or its components.
  - Sometimes **testing** is used for testing, in which one executes the software in order to check whether it is performing as required.
  - We use testing in the wider sense and **dynamic testing** for this more restricted version of testing.

Testing

- Testing is performed at various stages during the life cycle of a system.
- There are three main activities.
  - **Module testing**.
  - **System integration testing**.
  - **System validation testing**.

Main Testing Activities

- **Module testing** is the evaluation of small, simple functions of hardware or software.
  - Faults detected during module testing are usually easy to locate and to rectify.
- **System integration testing** investigates the characteristics of a collection of modules.
  - Usually investigates the correct interaction between modules.
  - Faults are more difficult to find and more expensive to rectify.

Main Testing Activities

- **System validation testing** tests whether the complete system satisfies the requirements.
  - Problems detected at this stage are usually due to weaknesses of customer requirements or the specification.
  - Problems detected are usually extremely costly to correct, since modifications have to propagate through the entire development process.

Testing Methods

- There are three main testing methods:
  - **Dynamic testing.**
  - **Static analysis.**
  - **Modelling.**

Dynamic Testing

- **Dynamic testing** is the execution of a system or component in order to investigate its characteristics.
- The tests may be carried out
  - in the **system's natural working environment**,
  - or within **simulation of that environment**.
    - Often more cost effective.

Dynamic Testing and Simulation

- Dynamic testing might as well be carried out on one or a few system components by using **simulation**.
  - Especially of advantage if one simulates **hardware** which has **not** been **developed yet**.
  - Then simulation is **cost effective**, since it allows to compare various designs of the hardware involved.
  - However, simulation **never** provides **complete information** on the system behaviour, e.g.
    - **real-time operation**,
    - **problems with timing**.

Static Analysis

- **Static analysis** is the investigation of the characteristics of a system or component without operating it.
- **Examples:**
  - Walkthroughs,
  - formal proofs,
  - data flow analysis.
- Automated software testing packages which carry out static analysis are called **static code analysis tools**.
- Many engineers mean by testing only dynamic testing, not static analysis.

Modelling

- **Modelling** means the mathematical representation of the behaviour of a system or component.
  - Usually carried out at an early stage, in order to investigate the basic nature of the proposed system or its environment.
  - **Animation** of a formal specification is an example of modelling.

Use of Testing Methods

- Typically, a software life cycle involves
  - dynamic testing,
  - static analysis,
  - some form of modelling.

Black/White Box Testing

- Testing methods can be categorised by the information available when performing the work.
  - **Black box testing** means the test engineer has no knowledge about the implementation of the system.
  - **White box testing** means that the test engineer has access to the implementation of the system.

Black Box Testing

- In black box testing, the test engineer relies completely on the specification of the system.
- Therefore it is sometimes called **requirements-based testing**.
- May be applied to individual modules or (more common) to subsystems or the complete system.
- Is widely used for testing software tools like compilers.

Comparison

- **Advantage of Black Box Testing:**
  - Greatest level of independence between developer and evaluator.
- **Advantage of White Box Testing**
  - The test engineer can use information about the implementation in order to develop better tests.

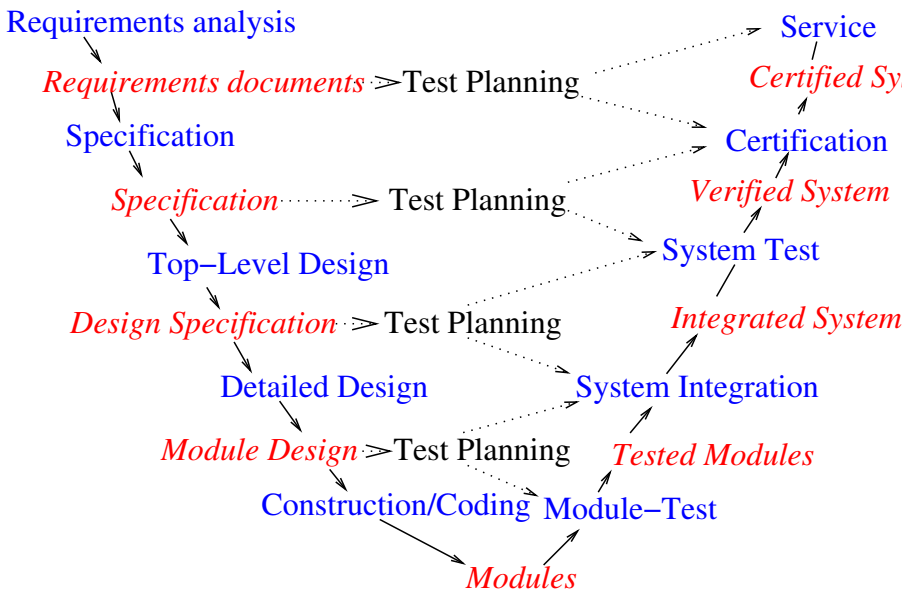
Black/White-Box vs. Static/Dynamic

- **Dynamic testing** can be white-box and black-box testing.
- **Static analysis** is necessarily white-box testing.
- **Mathematical modelling** doesn't use the system software and hardware, so categories white/black-box testing don't apply to it.

Planning for Verification and Validation

- **Test planning** is an essential part of the software life cycle.
- The next slide shows test planning within the V-model.

V-Model and Test Planning



Testing for Safety

- **Overall safety validation** is the test that a system is in accordance with the safety requirements.
  - The results of it are documented in an **overall safety validation report**.
- Some standards require **traceability**, i.e. that the key safety requirements are traceable throughout all stages of the software life cycle.

Testing for Safety

- Testing for safety requires that that tests are performed which show that **each identified hazard is effectively countered**.
  - **Dynamic testing** might be **sufficient**.
  - Since **exhaustive dynamic testing** is impossible, usually **static analysis** and **mathematical modelling** is **required**.
  - Properties like **reliability** and **failure rates** can usually **not** be **tested dynamically**, therefore static analysis is required.

The Roles of Testing

- Testing has three purposes in a safety-critical project:
  - **Development testing.**
  - **Validation testing.**
  - **Production testing.**

Development/Validation Testing

- **Development testing** is aimed at **locating** faults within the system, so that they may be removed.
  - Uses dynamic, static and modelling techniques.
- **Validation testing** aims at demonstrating the absence of faults and to demonstrate other positive features.
  - Uses again dynamic, static and modelling techniques.

Production Testing

- **Production testing** aims at testing whether a individual unit has defects as a result of manufacturing or component fault.
  - Tests the accuracy of the replication of the appropriate design.
  - Production tests of software are easy and use usually techniques like checksums.
  - Production tests of hardware are very complicated,
    - since the number of possible faults is extremely big.
  - Production testing is always **dynamic**.

Material Moved to Additional Material

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