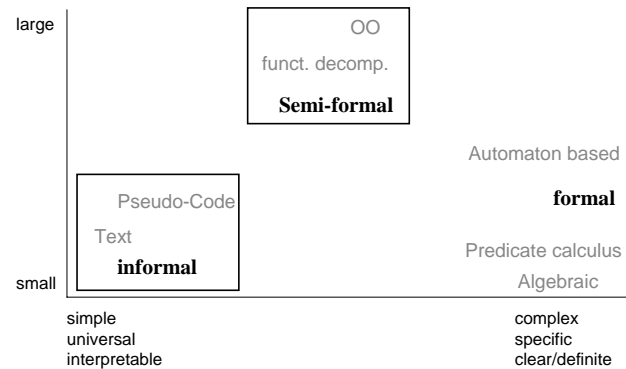


Overview

Content

- ☐ Situation Analysis
- ☐ Consequences
- ☐ Classification of Test Methods
- ☐ Test Methods

Construction Methods



Construction Methods: Prognosis

- ☐ Text will be eclipsed increasingly
- ☐ Object-oriented development methods (OOA, OOD, OOP) will establish increasingly due to their excellent properties with regard to the mastery of large software systems
 - The standard for OOA and OOD is UML presently
 - The standards in programming are C++ and Java
- ☐ In some applications functional decomposition techniques (e.g. SA) will be preserved
- ☐ Formal techniques will remain confined to specific application areas

Situation Analysis of Software Development in Practice

- ☐ Question: Who ensures that the construction steps are perfectly done?
- ☐ Answer: Nobody!
- ☐ Consequence: The software development is not completed with the implementation of the code. Often extensive tests are necessary.
- ☐ Typical approach:
 - Ensure that the development processes are suitable => quality management
 - Ensure that the construction steps provided the desired results => quality assurance (can also be done more or less formally)

Software Quality Assurance

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Situation Analysis of Software Development in Practice Increasing Quality Requirements

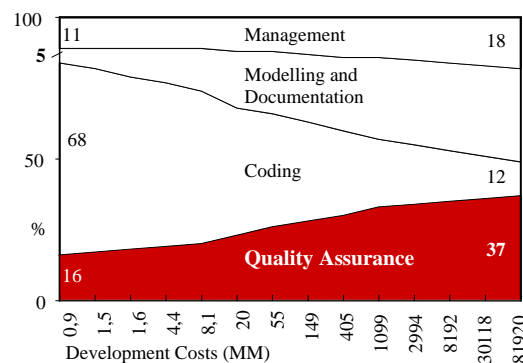
- ☐ For 50% of the failures in the industrial sector software faults are responsible
- ☐ According to Cusumano the located defects have developed in 1000 lines of source code as follows:
 - 1977: on average 7- 20 defects
 - 1994: on average 0,2 - 0,05 defects
 - In 13 years the defect rate could be lowered about 100 fold
- ☐ Increasing burdens
 - Application software is often used 20 years or longer
 - As the application environment of this application software changes permanently this software also has to be adapted constantly. These permanent adaptation processes often cause two-thirds of all software costs.

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Situation Analysis of Software Development in Practice Increasing Importance of Quality Assurance



According to data from: Jones C., *Applied software measurement*, New York: McGraw-Hill 1991

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Situation Analysis of Software Development in Practice

Design methods:

- Still widespread use of informal methods (text)
- High interest in semi-formal methods (in particular OO)
- Minor use of formal methods
- ☐ Quality management:
 - Trend towards the certification of quality management processes (ISO 9001)
 - Stage of capability maturity model-based assessment methods (e.g. SPICE)
- ☐ Quality assurance methods:
 - Informal methods are frequently applied (testing, review techniques)
 - Formal methods (proofs) often fail concerning the complexity of the software and the properties of modern programming languages
 - Stochastic methods are not widespread, but are increasingly required in critical application areas in particular

Software Quality Assurance

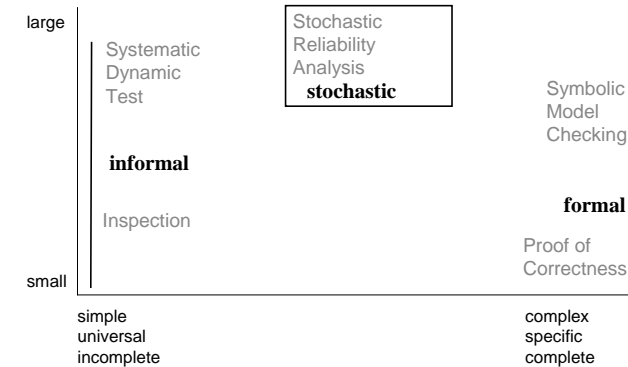
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Categories of Quality Assurance Methods

- ☐ Informal Methods:
Methods based on plausibility which produce incomplete results
 - ☐ Testing
 - ☐ Inspection and review
- ☐ Stochastic Methods:
Methods which produce statistically reliable, quantified results
 - ☐ Stochastic reliability analysis
- ☐ Formal Methods:
Methods which produce formally complete results on the basis of formal specifications
 - ☐ Formal verification techniques (Proofs)

Quality Assurance Methods



Quality Assurance Methods: Prognosis

- ☐ Systematic informal methods are widely used and are obligatory for many application areas where they are required by appropriate standards
 - Function-oriented test planning
 - Tool supported structural testing
- ☐ Test support is essential (e.g. regression tests)
- ☐ Static analyses are additionally used
 - Inspections in early phases
 - Tool supported analyses of code in addition to the analyses performed by the compiler (in particular concerning the languages C / C++ / Java)

Situation Analysis: General Consequences

- ☐ Mature Processes ...
 - ... are necessary, but barely offer a differentiation of competitors
 - ... operate confidence-building, but provide no further statements
- ☐ Design methods:
 - Informal methods are simple and universal, but often insufficient
 - Semi-formal methods allow the description of extensive software, but not the description of critical properties of technical software (e.g. safety).
 - Formal methods are powerful, but are often too specific
- ☐ Quality assurance methods:
 - Informal methods are indispensable, but produce no sufficient completeness (testing, inspection methods)
 - Formal methods (proofs) provide – to some degree – complete results, but often fail due to preconditions, that are not fulfilled
 - Stochastic methods generate well-defined, reliable results, but require mathematical knowledge which is often not given in practice respectively tools which are not available on the market

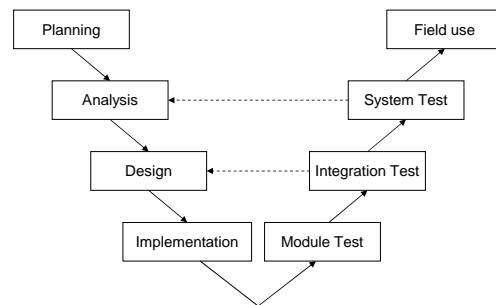
Consequences

- ☐ Software quality has to be assured:
 - Evaluation, validation and improvement of development processes
 - Accompanying quality assurance during the early development phases
 - Testing of the implemented software (the code)
- ☐ The software is large => several test phases are required
- ☐ Highly different demands on software (*experimental prototype up to engine control of a commercial aircraft*) => need of different methods between „trial“ and „proof“
- ☐ It is not possible to guarantee, that code is failure-free => it is required to determine the residual risks => quantitative analysis methods

Test Phases

- ☐ The precondition for testing large software systems is their modular structure. Monolithically realized large systems cannot be tested.
- ☐ Module test
 - Testing of the modules
 - Testing the correct function of a module w.r.t. the module specification.
- ☐ Integration test
 - Testing of the interaction of the modules
 - Incremental assembly of the modules building the integrated system. Testing of their correct interaction.
- ☐ System-/Acceptance test
 - Testing of the functionality and efficiency of a software with regard to the requirements determined in the definition phase.
- ☐ Benefit of testing in different phases is the reduction of the respective complexity to a reasonable level.

Test Phases



Classification of the Test Methods

- ☐ The analytic quality assurance techniques are
 - dynamic or
 - static.
- ☐ They aim at either
 - the proof of the correctness,
 - the detection of faults or
 - the determination of particular module properties.
- ☐ Analytical quality assurance can be divided into
 - Formal verification,
 - Symbolic testing,
 - Dynamic Testing, and
 - Static analysis.
- ☐ Sub-categories are necessary.

Test Methods Dynamic Test



- Properties of dynamic testing:
 - The executable program is provided with concrete input values and is executed
 - Program may be tested in the real environment
 - Never complete (it is not possible to test all possible inputs)
 - Correctness of the tested program cannot be proven.
- Characteristics of the application of dynamic test methods in practice:
 - widely-used.
 - Often unsystematically applied.
 - Tests often not reproduceable.
 - Diffuse activity (management difficulties).

Test Methods Static Analysis



- Properties:
 - No program execution is required.
 - No input values are selected.
 - The static analysis concentrates on particular partial aspects.
 - It is no proof of correctness.
 - Some static analyses can detect faults directly.
- Sub-categories:
 - Measurement (Metrics)
 - Generation of diagrams and tables
 - Data flow anomaly analysis
 - Testing of programming conventions
 - Inspection and review techniques

Test Methods Formal Verification



- Properties:
 - Formal verification uses mathematical techniques to prove the consistency between specification and implementation.
 - A formal specification is necessary.
 - Verification may be almost completely automated (exception: e.g. finding loop invariants).
 - Requires preconditions which are often not fulfilled in practice.