Software processes, quality, and standards
Static analysis

Jaak Tepandi, Jekaterina Tšukrejeva, Stanislav Vassiljev, Pille Haug

Tallinn University of Technology

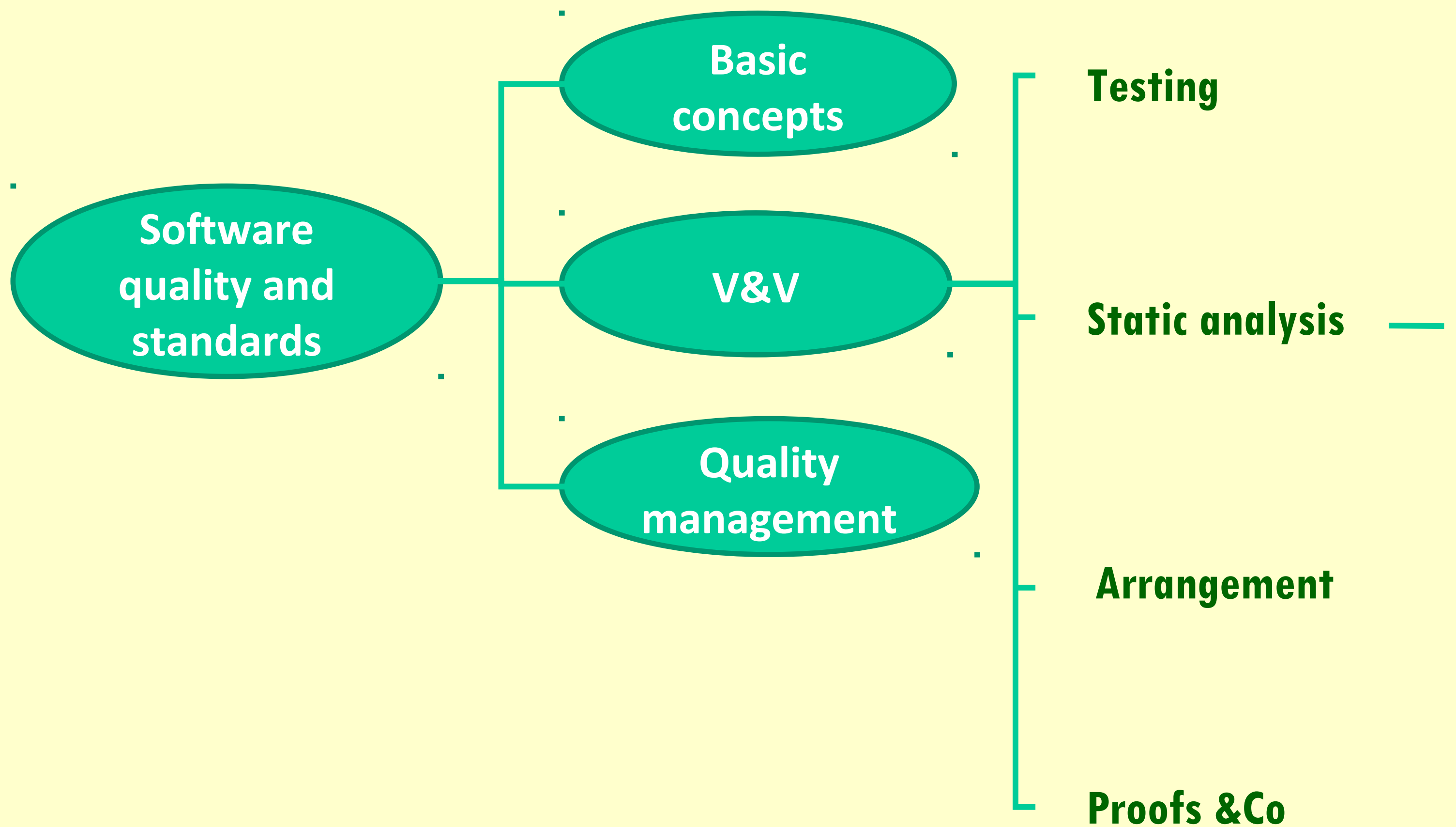
Department of Software Science

Moodle: „Software Quality (Tarkvara kvaliteet)"

Alternate download: tepandi.ee

Version 25.10.2017

Context and content

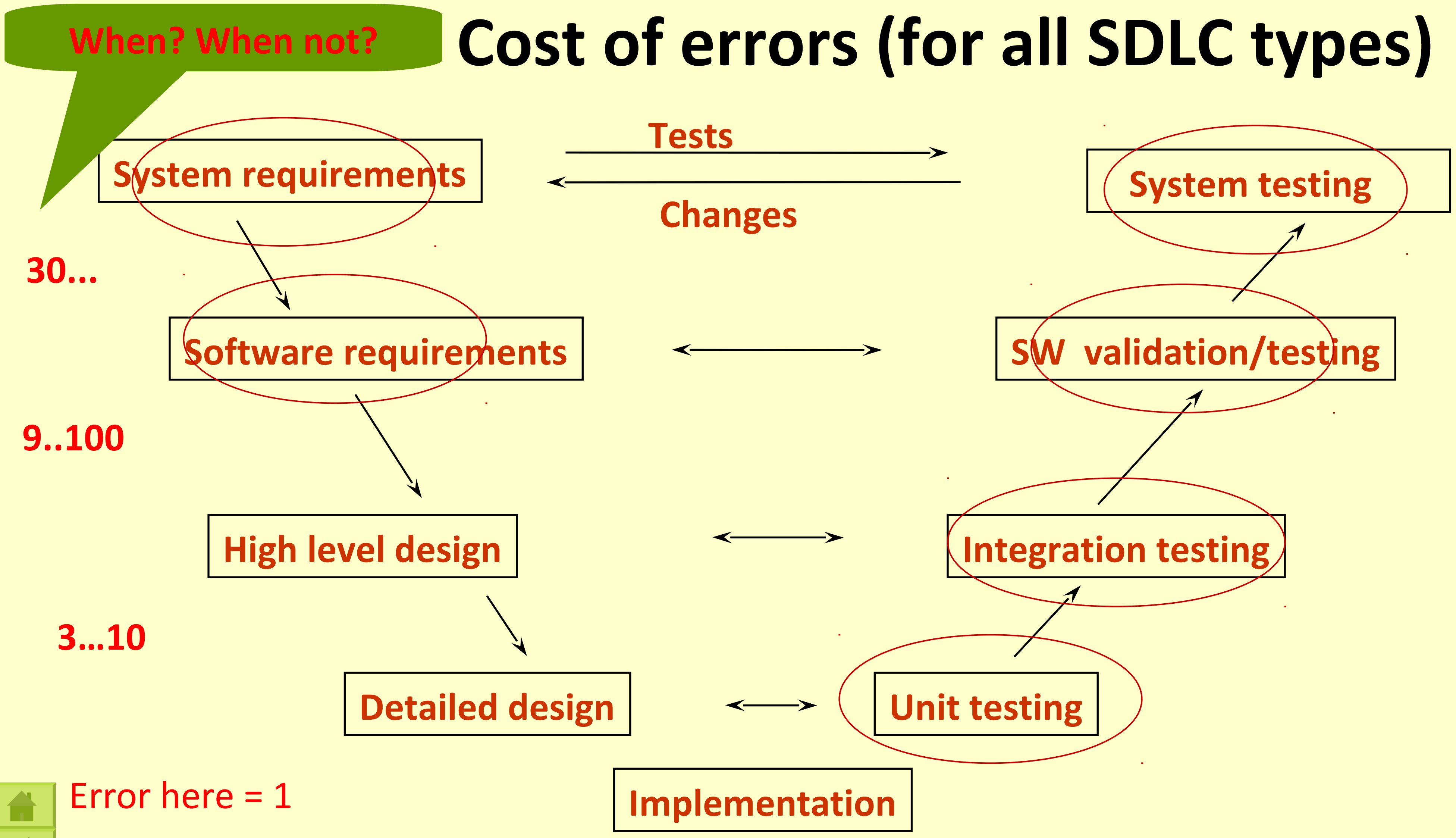


1. What? Why? Why not?
2. Types: Walkthrough, inspection, review etc
3. Tools: Questionnaires, standards etc
4. Planning static analysis

Example: Therac 25

- At least six accidents between 1985 and 1987, in which patients were given massive overdoses of radiation, approximately 100 times the intended dose
- Two of the six patients died as a direct consequence, the total number of fatalities was four
- The failure only occurred when a particular nonstandard sequence of keystrokes was entered, the operator changed the setup too quickly, and an arithmetic overflow occurred
- Testing?

Cost of errors (for all SDLC types)



Static analysis. Why? Why not?

Analysis of software artifacts, e.g. requirements or code, carried out without execution of these software artifacts (ISTQB).

Why?

- Errors are discovered at the early steps of development
- It is not possible to test all situations
- Reliability gained with testing has limits
- Several important system qualities (for example maintenance criteria) are difficult to evaluate by testing

Why not?

- Does not replace testing (even proofs)
- Time, coordination, possible side-effects

Static analysis: arrangement, types, tools

Arrangement, examples
- Analysis by the author
- Walkthrough/Inspection/Review
- ….Programmer`s evaluation
- ...Strong methods, program proofs
- ...Some methods from V&V arrangement, quality management

Types, examples
- Contract review, design walkthrough, code inspection

Tools
- Example: coding questionnaire
- Standard as questionnaire
- Automated tools

Analysis by the author

Recommended:

- finds errors
- cost-effective
- train if not used

Not sufficient: the author

- follows own logic
- is motivated to finish
- may be not motivated to destroy own work

Walkthrough: not only for software development

A walkthrough or walk-through is a form of software peer review in which a designer or programmer leads members of the development team and other interested parties through a software product, and the participants ask questions and make comments about possible errors, violation of development standards, and other problems (ANSI/IEEE 1028)

Walkthrough: advantages

- errors can be found at early steps of development
- the best way of reducing errors
- team contacts improve
- productivity and quality are improving
- people can be replaced

Walkthrough problems

- group members can be from different departments
- group members can be different: with high IQ, impatient, conservative, not very interested of “real world", prefer privacy etc
- nobody likes criticism, in extreme cases co-operation declines
- wrong meeting management

https://www.youtube.com/watch?v=oLmDe8pAc6I&index=2&list=PLaD4FvsFdarQytrGAmCo2qW_rAWcfBKeV

Preconditions

- all group members should have expectation of what they are expected to do
- good co-operation
- materials are available
- participants have prepared for the session, for example everyone have one positive and one negative comment about materials

Participants and their roles

- presenter (not necessarily the author)
- coordinator (manager)
- secretary
- members: team members, standards expert, user's representative
- these roles can be combined
- management participation is not recommended

Arrangements /Recommendations

Arrangement: As many preparations (texts, documents) as needed, as few as possible … Length 30..60 min

- Analyse the product, not the author
- Prepare a plan and follow it
- Do not try to solve all the problems
- Take written notes
- Limit the number of participants, make preparations
- Prepare the questionnaire for each reviewed product
- Reserve resources, including time
- Train the participants
- Learn from past reviews

Results of a walkthrough

- the problems are found and corrected
- a better system
- a signed protocol
- NB not changes in the status or wages of the participants

ANSI/IEEE Std 1028. IEEE Standard for Software Reviews and Audits + others

(Product)	Product ja Project	Project
•(Simulation)	•Technical review	•Management review
•(Formal proofs)	•Software inspection	
	•Walkthrough	
	•Audit	

Example: Scrum meetings

- Sprint planning. At the beginning of the sprint cycle (every 7–30 days)
- Daily Scrum. A daily sprint meeting, 15 minutes
- Sprint review (concerns work done). 2 h
- Sprint retrospective (concerns the process). 1, 5 h
- Backlog refinement.
- Scrum of Scrums. Coordinating multiple teams

Example: XP (planning)

- User stories are written.
- Release planning creates the schedule.
- Make frequent small releases.
- The Project Velocity is measured.
- The project is divided into iterations.
- Iteration planning starts each iteration.
- Move people around.
- A stand-up meeting starts each day.
- Fix XP when it breaks

Static analysis tools

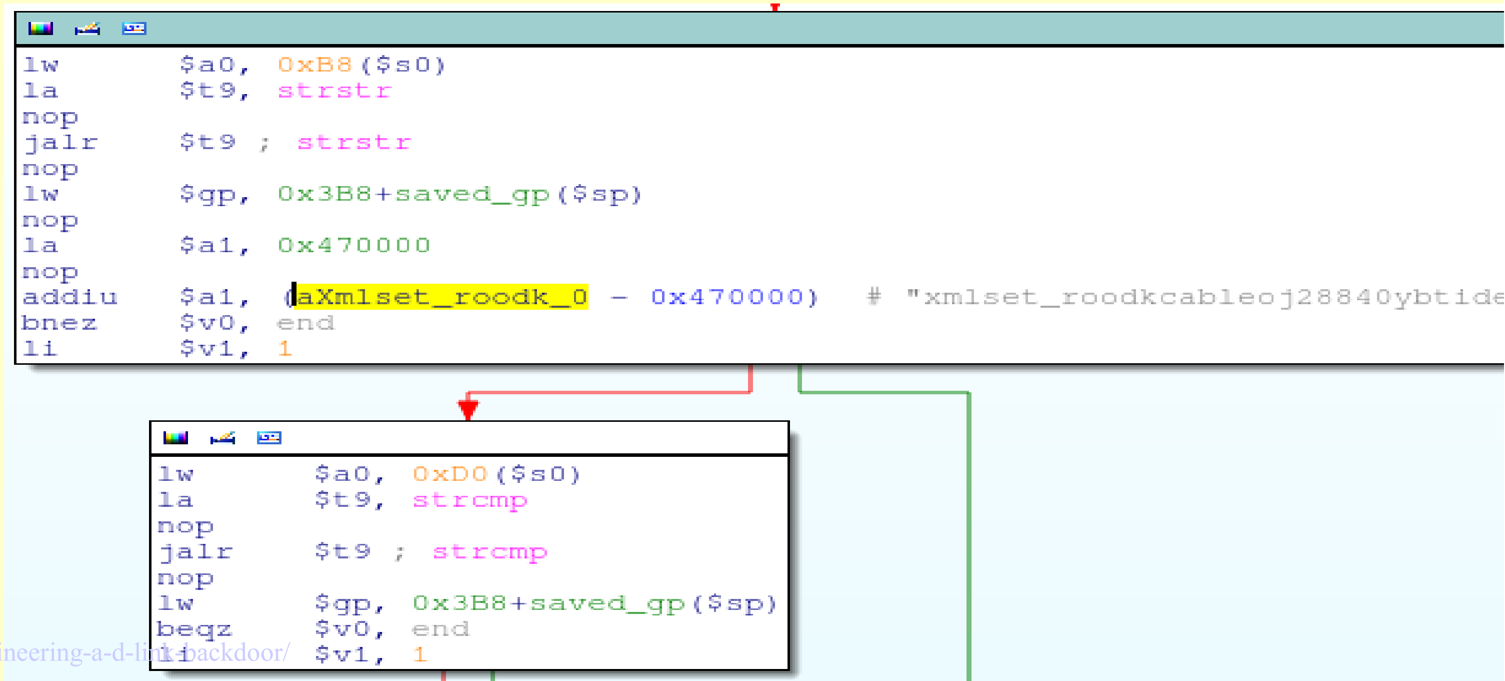
- Questionnaires
- Standards
- General code analysis tools for many programming languages

  eg, .NET, Java, JavaScript, Python...
- Analysis for security vulnerabilities
- Analysis for accessibility
- Analysis for performance degradation
- Design verification tools
- Proofing tools
- Support for analysis arrangement
- ....

How to find by testing?

if ...|| strcmp(request->user_agent, "xmlset_roodkcableoj28840ybtide") == 0)

{ return AUTH_OK; }



```
lw        $a0, 0xB8($s0)
la        $t9, strstr
nop
jalr      $t9 ; strstr
nop
lw        $gp, 0x3B8+saved_gp($sp)
nop
la        $a1, 0x470000
nop
addiu     $a1, (aXmlset_roodk_0 - 0x470000)  # "xmlset_roodkcableoj28840ybtide
bnez      $v0, end
li        $v1, 1
```

```
lw        $a0, 0xD0($s0)
la        $t9, strcmp
nop
jalr      $t9 ; strcmp
nop
lw        $gp, 0x3B8+saved_gp($sp)
beqz      $v0, end
li        $v1, 1
```

Questionnaires

- Different volume (10…1000)
- Different aspects
  - Compliance to coding best practice
  - Application area related
  - Process related
  - …
- + tools

Example of a simple questionnaire: coding

Topics

- Declarations / usage of variables
- Assignments
- Calculations
- Comparisons
- Iterations / Halting
- Calls, input/output
- Security

Compare eg Robert C. Martin. Clean Code

Declarations / usage of variables

- Variable names meaningful?
- Variables declared?
- Default attributes correct?
- Initialization correct?
- Identifiers? VOLT, VOLTS, I1, O0?

Etc

Assignments

- Data conversions correct?
- Does the value exist?
- Index outside limits?
- Index integer?
- Common data structures defined in the same way?
- Etc

Computations

- Incorrect data types?
- Mixed data types?
- Under- / overflow?
- /0?
- Values outside expected limits?
- Multiple small errors?
- Integer arithmetics? Cf 17/3*2, 17*2/3
- Operation priorities?
- Etc

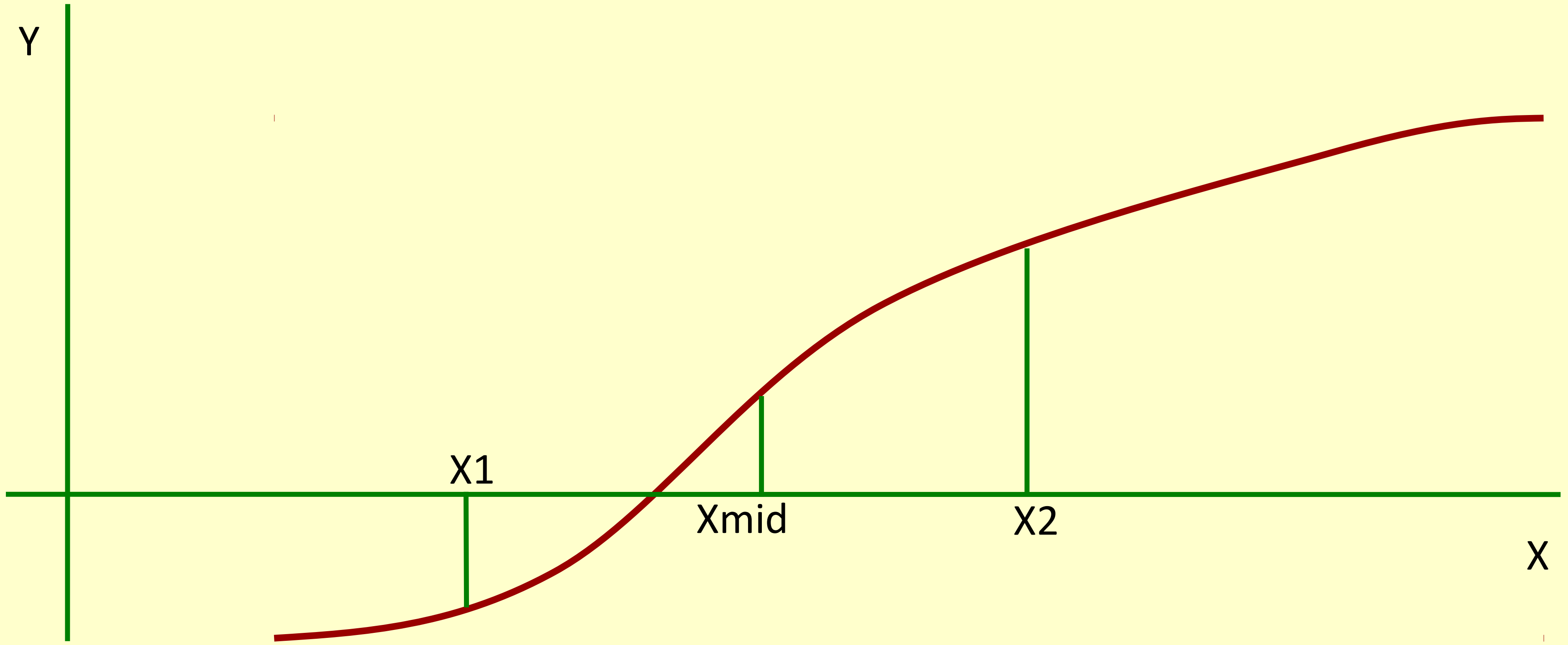
Comparisons

- Mixed types in comparisons?
- Are the specification conditions correctly expressed in the code?
- Priorities correct?
- Result depends on compiler?
- Real variable compared with a value?
- Etc

Iterations / Halting

- Will it stop?
- Condition is F at the start?
- FOR counter start > stop?
- Large number of iterations?
- Etc

Finding a solution



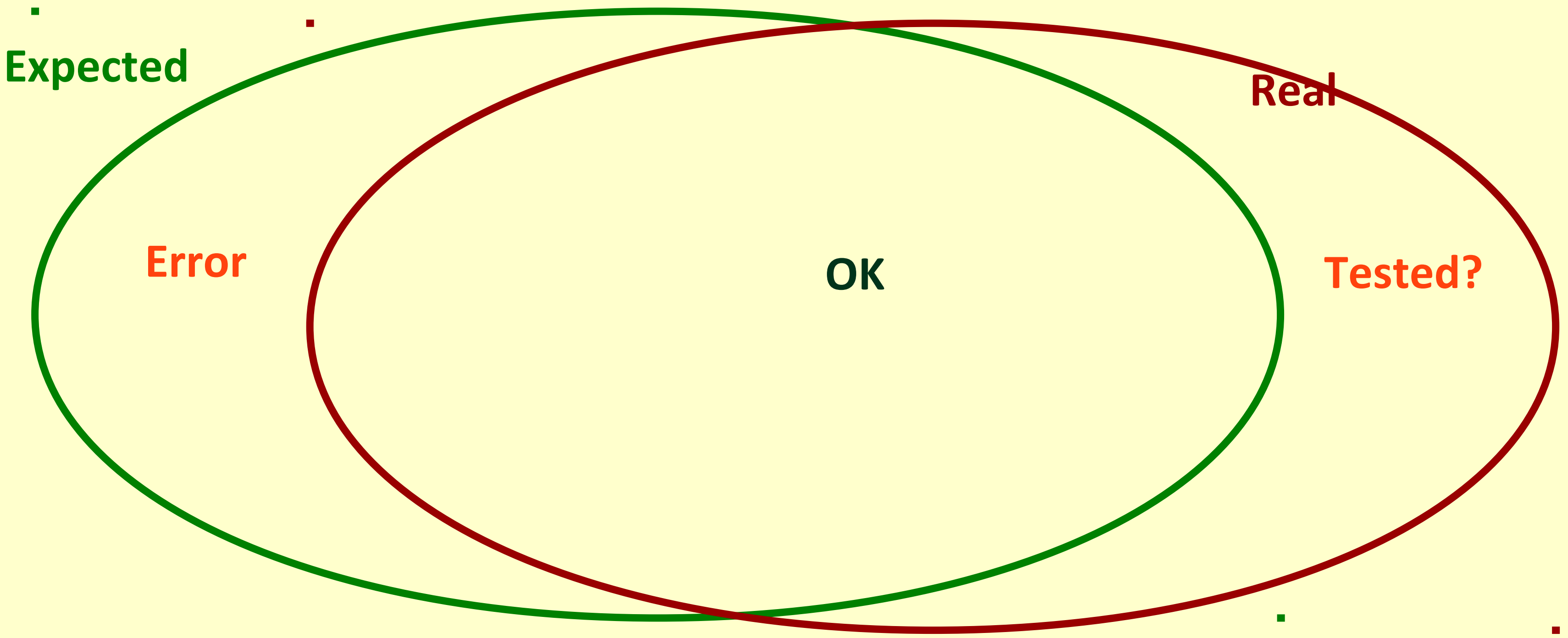
Functions, calls, input/output

- Long list of arguments?
- Multi-purpose functions?
- Are units of measure in the calling program the same as in the function?
- Is parameter ordering the same?
- Are windows closed properly?
- Is error handling correct?
- Etc

NASA: Human error caused loss of Mars orbiter

- Failure to convert English measures to metric values caused the loss of the Mars Climate Orbiter, a spacecraft that smashed into the planet instead of reaching a safe orbit, a NASA investigation concluded Wednesday.
- An investigation board concluded that NASA engineers failed to convert English measures of rocket thrusts to newton, a metric system measuring rocket force. One English pound of force equals 4.45 newtons. The difference between the two values caused the spacecraft to approach Mars at too low an altitude and the craft is thought to have smashed into the planet's atmosphere and was destroyed.
- Ground software - orbiter software

Unspecified behaviour?



Problems?

```
void SomeFunction( char *pszInput )
{
  char szBuffer[10];
  strcpy(szBuffer, pszInput);  . . .
}
```

```
Aut-data = “SELECT Username FROM
Aut-table WHERE Username = ‘ ” &
Request.Form(“Name”) & “ ’Password  = ‘” Request.Form(“Password”) & “ ’ ”
```

Standard as questionnaire (example based on ISO/IEC 12207)

- The acquirer shall conduct acceptance review and acceptance testing of the deliverable software product or service and shall accept it from the supplier when all acceptance conditions are satisfied. The acquirer shall define and document the acceptance strategy and conditions (criteria).

=>

- Has the acquirer conducted acceptance review and acceptance testing of the deliverable software product or service?
- Has the acquirer accepted the product or service when all acceptance conditions are satisfied?
- Has the acquirer defined and documented the acceptance strategy and conditions (criteria)?

Planning the use of static analysis

Mutually non-exclusive options for planning character, frequency, and goals of the static analysis activities:

- As recommended by the software development life cycle used
- On each main stage of development (eg, on entry and exit)
- Parallel to testing in verification and validation activities
- On each major event
- On regular time intervals

Planning of an individual static analysis event

- Goal / object of the event: contract review, progress review, design walkthrough, code inspection, ...
- Participants: presenter, coordinator, members, ...
- Time, place, duration, instructions if needed
- Procedure: eg, steps performed; is written report needed? Signatures?
- Materials to be sent
- Preparations and first responses expected
- Tools to be used, eg coding questionnaire; standard as questionnaire; automated analysis tools; bug tracking
- Expected results
- Follow-up activities needed

Takeaway: static analysis

- What? Analysis of software artifacts, e.g. requirements or code, carried out without execution of these software artifacts
- Why? Errors are discovered at the early steps of development; it is not possible to test all situations; several important system qualities are difficult to evaluate by testing
- How? Planning and performing static analysis
- But: does not replace testing (even proofs); requires time, coordination; possible negative side-effects
- Method examples: Walkthrough/Inspection/Review; analysis by the author; programmer`s evaluation; formal methods; methods from V&V arrangement and quality management
- Examples: contract review, design walkthrough, code inspection
- Tool examples: coding questionnaire; standard as questionnaire; automated analysis tools; bug tracking

Additional reading (examples)

Ian Sommerville. Software Engineering. Ninth Edition. Addison-Wesley, Ch 15.1, 24.3.

Daniel Galin, Software Quality assurance from theory to implementation, Pearson - Addison-Wesley. Chapters 5,8.

Guide to the Software Engineering Body of Knowledge (SWEBOK), IEEE. Chapter 10 Section 2.3.

Robert C. Martin, Clean Code, Prentice-Hall. Chapter 17.

Certified Tester Foundation Level Syllabus, ISTQB. Chapter 3.

Moodle: „Software Quality (Tarkvara kvaliteet)". Alternate download: tepandi.ee