

Static Testing

Dr. Durga Prasad Mohapatra
Professor, Dept. of CSE
N.I.T Rourkela

Drawbacks of Dynamic Testing

- Uncovers the bug at a later stage of SDLC
 - Costly to debug
- It is expensive and time consuming, as it needs to create, run, validate and maintain test cases.

2

Drawbacks of Dynamic Testing cont...

- The efficiency of code coverage decreases with the increase in size of the system.
- It provides information about the bugs-
 - It is difficult and time-consuming to trace a failure from a test case back to its root cause.
- Dynamic testing cannot detect all the potential bugs.

3

Static Testing

- Static testing is a complimentary to dynamic testing technique to acquire high quality software.
- Static testing techniques do not execute the software and do not require the bulk of test cases.
- Static testing reveals the errors which are not shown by dynamic testing.
- This type of testing is also known as non-computer based testing or human testing.

4

Static Testing cont...

- Static testing can be applied for most of the verification activities.
- They check the software product at each SDLC stage for conformance with the required specification or standards.

5

Static Testing cont...

- Requirements, design specifications, test plans, source code, user's manuals, maintenance procedures are some of the items that can be statically tested.
- Static testing has proved to be a cost-effective technique of error detection.
 - 60% of errors in a program can be detected

6

Benefits of Static Testing

- As defects are found and fixed, the quality of the product increases.
- A more technically correct base is available for each new phase of development.
- Overall software life cycle cost becomes lower.
- Effectiveness of dynamic test activity is increased & less time needs to be devoted for testing the product.
- Immediate evaluation and feedback about quality improvement is available.

7

Objectives of Static Testing

- To identify errors in any phase of SDLC as early as possible.
- To verify that the components of software are in conformance with its requirements.
- To provide information for project monitoring.
- To improve the software quality and increase productivity.

8

Types of Static Testing

- Software Inspections
- Walkthroughs
- Technical reviews

9

Types of Static Testing cont ...

- After a module has been coded:
 - code inspection and code walk through are carried out
 - ensures that coding standards are followed
 - helps detect as many errors as possible before testing.

Types of Static Testing cont ...

- Detect as many errors as possible during inspection & walkthrough:
 - detected errors require less effort for correction
 - much higher effort needed if errors were to be detected during integration or system testing.

Inspections

- Software inspections were first introduced at IBM by Fagan in the early 1970s.
- These can be used to tackle software quality problems because they allow the detection and removal of defects after each phase of SDLC.

Inspection

- Code inspection aims mainly at discovery of commonly made errors.
- During code inspection:
 - the code is examined for the presence of certain kinds of errors.

Inspection

- For instance, consider:
 - classical error of writing a procedure that modifies a formal parameter
 - while the calling routine calls the procedure with a constant actual parameter.
- It is more likely that such an error will be discovered:
 - by looking for this kind of mistakes in the code,
 - rather than by simply hand simulating execution of the procedure.

Inspection

- Good software development companies:
 - collect statistics of errors committed by their engineers
 - identify the types of errors most frequently committed.
- A list of common errors:
 - can be used during code inspection to look out for possible errors.

Commonly made errors

- Use of uninitialized variables.
- Nonterminating loops.
- Array indices out of bounds.
- Incompatible assignments.
- Improper storage allocation and deallocation.
- Actual and formal parameter mismatch in procedure calls.
- Jumps into loops.

Inspections cont...

- Inspection process is an in-process manual examination of an item to detect bugs.
- It may be applied to any product or partial product of the software development process.
- These are done in the early stages of each product development.

Inspections cont...

- This process does not require executable code or test cases
 - With inspection, bugs can be found on infrequently executed paths that are not likely to be included in test cases.
- It does not execute the code, so
 - It is machine independent
 - Requires no target system resources
 - Does not require to change program's operational behavior.

Inspections cont...

- The inspection process is carried out by a group of peers.
- The group first inspects the product at individual level.
- After this, they discuss the potential defects of the product observed in a formal meeting.

19

Inspections cont...

- The second important thing about inspection process is that it is a formal process of verifying a software product.
- The documents which can be inspected are SRS, SDD, Code, and test plan.

20

Inspections cont...

- An inspection process involves the interaction of the following elements:
 - Inspection steps,
 - Role for participants,
 - Item being inspected.

21

Inspections cont...

- The entry and exit criteria are used to determine whether an item is ready to be inspected.
 - Entry criteria mean that the item to be inspected is matured enough to be used.
 - Exit criterion is that once the item has been given for inspection, it should not be updated,
 - Otherwise it will not know how many bugs have been reported and corrected and the whole purpose of inspection is lost.

22

Inspection team

- For the inspection process, a minimum of the following four team members are required:
 - Author/Owner/Producer
 - Is a programmer or designer responsible for producing the program or documents.
 - He is also responsible for fixing defects discovered during the inspection process.

23

Inspection team cont...

- Inspector
 - A peer member of the team.
 - He is not directly related to the product under inspection and may be concerned with some other products.
 - He finds errors, omissions, and inconsistencies in programs and documents.

24

Inspection team cont...

- Moderator
 - A team member who manages the whole inspection process.
 - He schedules, leads and controls the inspection session.
 - He is the key person with the responsibility of planning and successful execution of the inspection.

25

Inspection team cont...

- Recorder
 - Who records all the results of the inspection meeting.

26

Inspection process

- A general inspection process has the following stages:
 - Planning
 - Overview
 - Individual preparation
 - Inspection meeting
 - Rework
 - Follow-up

27

Inspection process cont...

- Planning:
 - During this phase the following is executed:
 - The product to be inspected is identified.
 - A moderator is assigned
 - The objective of the inspection is stated.

28

Inspection process cont...

During planning the moderator performs the following activities

- Assures that the product is ready for inspection
- Selects the inspection team and assigns their roles.
- Schedules the meeting venue and time.
- Distributes the inspection materials like the item to be inspected, check lists, etc.

29

Inspection process cont...

- Overview:
 - The inspection team is provided with the background information for inspection.
 - The author presents the rationale for the product, its relationship to the rest of the product being developed, its function and intended use, and the approach used to develop it.
 - The opening meeting may also be called by the moderator to explain the objective of inspection to the team members

30

Inspection process cont...

- Individual preparation:
 - After the overview, the reviewers individually prepare themselves for the inspection.
 - They point out potential errors or problems found and record them in a log.
 - The moderator compiles the logs of different members and gives a copy to the author of the inspected team.
 - The inspector reviews the product for general problems as well as specific problems.

31

Inspection process cont...

- The product being inspected is also checked against standard documents to assure correctness.
- After reviewing, the inspector records the defects found and the time spent for preparation.
- Completed preparation logs are then submitted to the moderator prior to the inspection meeting.

32

Inspection process cont...

- The moderator reviews the logs to determine whether the team is adequately prepared.
- Moderator also checks for trouble spots and the areas of major concern that may require extra attention .
- If the team is not adequately prepared then the meeting is rescheduled.
- After this, the compiled log file is submitted to the author.

33

Inspection process cont...

- Inspection meeting:
 - The inspection meeting starts with the author of the inspected team.
 - Author discusses every issue raised by different members in the compiled log file.
 - They arrive at a consensus to accept the concerns as errors or not.
 - If a new error is found during the meeting then it is also recorded and discussed.

34

Inspection process cont...

- During the meeting effort is put only to identify the bug and not to fix them.
- The author later fixes the identified bugs.
- It is the duty of the moderator that the meeting remains focused towards its objective and the author is not discouraged in any way.
- At the end the moderator concludes the meeting and produces the summary of the inspection meeting.

35

Inspection process cont...

- Rework:
 - The summary list of the bugs that arise during the inspection meeting needs to be reworked by the author.
 - The author fixes all these bugs and reports back to the moderator.

36

Inspection process cont...

- Follow-up:
 - Moderator checks that all the bugs found have been addressed and fixed.
 - He prepares a report, the document is then approved for release.
 - If this is not the case, then the unresolved issues are mentioned in a report and another inspection meeting is called.

37

Benefits of Inspection process

- Bug reduction
- Bug prevention
- Productivity
- Real-time feedback to software engineers
- Reduction in development resource
- Quality improvement
- Project management
- Checking coupling and cohesion
- Learning through inspection
- Process improvement
 - Finding most error prone modules
 - Distribution of error types

38

Effectiveness of inspection process

- The effectiveness of the inspection process lies in the rate of inspection
- Refers to how much evaluation of an item has been done.
 - Rate is high
 - Coverage of item to be evaluated is high.
 - Rate is slow
 - Means coverage is not much.
- Rate should be considered in the perspective of detection of errors
 - Too high means less errors detected, and too slow increases the cost of project.

39

Effectiveness of inspection process cont...

- It may be calculated as the error detection efficiency of the inspection process, as given below:

Error detection efficiency =

$$\frac{\text{Error found by an inspection}}{\text{total error in the item before inspection}} \times 100$$

- It also depends on the experience of the team, programming language and the application domain.

40

Cost of Inspection

- With at least four members involved the cost of inspecting 100 lines of code is roughly equivalent to one person-day of effort.
 - Assuming that inspection takes 1 hr &
 - Each member spends 1-2 hrs preparation
- Testing costs are variable and depend on number of faults in the software.
- Effort required for inspection is half the effort that would be required for dynamic testing.
- It is estimated that, the cost of inspection can be 5-10% of the total cost of the project.

41

Thank You

Static Testing cont...

Dr. Durga Prasad Mohapatra
Professor, Dept. of CSE
N.I.T Rourkela

Variants of inspection process

Active Design Reviews (ADR)

- Several reviews are conducted targeting a particular type of bug and conducted by the experts in that area.
- These are conducted in the following stages:
 - **Overview** - The overview explains the modular structure in case it is unfamiliar to reviewers, and shows them where the module belongs in the structure.
 - **Review**- Reviewers are assigned sections of the document to be reviewed and questionnaires based on the bug type.
 - **Meeting** - The designers read the completed questionnaires and meet the reviewers to resolve any queries that the designers may have about the reviewer's answers to the questionnaires.

3

FTArm

- Stands for Formal Technical Asynchronous review method (FTArm)
- It is a type of asynchronous inspection process that is carried out without having a meeting of the members.
- This process consists of the following steps
 - **Setup** (choosing the members and preparing the document)
 - **Orientation** (same as overview step of inspection process)
 - **Private review** (same as preparation phase of inspection process)
 - **Public review** (all comments provided privately are made public and all inspectors are able to see each other's comments and put forward their suggestions.)
 - **Consolidation** (the moderator analyses the result of private and public reviews and lists the findings)
 - **Group meeting** (any unresolved issues are discussed in this step)
 - **Conclusion** (final report of the inspection with analysis is produced)

4

Gilb inspection

- Defect detection is carried out by individual inspector at his level rather than in a group.
- Three different roles identified:
 - **Leader** is responsible for planning and running the inspection
 - **Author** of the document
 - **Checker** is responsible for finding and reporting the defects in the document.

5

Steps of Gilb inspection

- **Entry** - The document must pass through an entry criteria so that the inspection time is not wasted on a document which is fundamentally flawed.
- **Planning** -The leader determines the inspection participants and schedules the meeting.
- **Kick-off** - The relevant documents are distributed, participants are assigned roles and briefed about the agenda of the meeting.
- **Checking** - Each checker works individually and finds defects.

6

Steps of Gilb inspection cont ...

- **Logging** - Potential defects are collected and logged.
- **Brainstorming** - In this stage, process improvement suggestions are recorded based on the reported bugs.
- **Edit** - After all the defects have been reported, the author takes the list and works accordingly.
- **Follow-up** - The leader ensures that the edit phase has been executed properly.
- **Exit** - The inspection must pass the exit criteria as fixed for the completion of the inspection process.

Humphrey's inspection

- Preparation phase emphasizes the finding and logging of bugs, unlike Fagan inspection.
- Includes an analysis phase wherein individual logs are analyzed & combined into a single list.
- The steps are:
 - Planning
 - Overview
 - Preparation
 - Analysis
 - Inspection
 - Rework
 - Follow-up

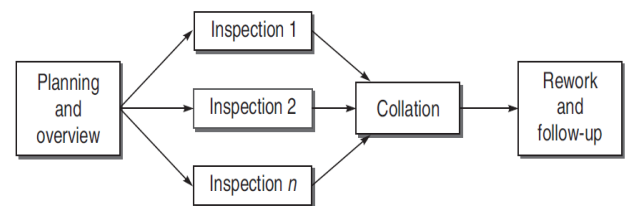
8

N-Fold inspections

- Inspection process's effectiveness can be increased by replicating it by having multiple inspection teams.
- This process consists of the following stages:
 - Planning and overview
 - Inspection stages
 - Collation phase
 - Rework and follow-up

9

N-fold inspection



Phased inspection

- Phased inspections are designed to verify the product in a particular domain by experts in that domain only.
- There are two types of phases:
 - **Single inspector**
 - A rigorous checklist is used to verify the features specified.
 - **Multiple inspector**
 - Checklist cannot be used.
 - Each inspector prepares their self developed questionnaire.

11

Reading techniques

- Reading technique can be defined as a series of steps whose purpose is to guide an inspector to acquire a deep understanding of the inspected product.
- It can be regarded as a mechanism or strategy for the individual inspector to detect defects in the inspected product.

12

Reading techniques cont ...

- The various reading techniques are:
 - Adhoc method
 - No direction or guidelines provided for inspection
 - Checklists
 - Scenario-based reading
 - Perspective-based reading
 - Usage-based reading
 - Abstraction driven reading
 - Task driven reading
 - Function-point based scenarios

Reading techniques

- Checklists
 - Are in the form of questions and are used by the inspection team members to verify the item.
 - Drawbacks:
 - The questions are not sufficiently tailored to take into account a particular development environment.
 - Instructions for using them are missing.
 - Probability of missing defects, not detected earlier.

14

Structured Walkthroughs

- The idea of structured walkthrough was proposed by Yourdon.
- An informal code analysis technique:
 - Undertaken after coding of a module is complete.
- A few members of the development team select some test cases:
 - simulate execution of the code by hand using these test cases.

Structured Walkthroughs cont ...

- Even though an informal technique:
 - several guidelines have evolved over the years
 - making this naive but useful analysis technique more effective.
 - These guidelines are based on
 - personal experience, common sense, and several subjective factors.

Structured Walkthroughs cont ...

- The guidelines should be considered as examples:
 - rather than accepted as rules to be applied dogmatically.
- Discussion should focus on discovery of errors:
 - and not on how to fix the discovered errors.
- To foster cooperation:
 - avoid the feeling among engineers that they are being evaluated in the code walk through meeting,
 - managers should not attend the walk through meetings.

Structured Walkthroughs

- The team performing code walk through should not be either too big or too small. Ideally, it should consist of between three to seven members.
- A typical structured walkthrough team consists of the following members:
 - Coordinator
 - Organizes, moderates, and follows up the walkthrough activities.
 - Presenter/developer
 - Optional member, introduces the item to be inspected.

18

Structured Walkthroughs cont...

- Scribe/recorder
 - Notes down the defects found and suggestions proposed by the members.
- Reviewer/tester
 - Finds the defects in the item
- Maintenance Oracle
 - Focuses on the long term implications
- Standards Bearer
 - Assesses adherence to standards
- User representative/ Accreditation agent
 - Reflects the needs and concerns of the user.

19

Structured Walkthroughs cont...

- The steps of the walkthrough process are:
 - Organization
 - Preparation
 - Walkthrough
 - Rework and follow-up

20

Walkthrough vs Inspection

- Walkthrough is less formal and rigorous than inspection, has fewer steps and does not use a checklist, whereas the inspection team uses a checklist for uncovering errors.
- In walkthrough, the tester brings in test cases that are mentally executed in the meeting, i.e. the test data are walked through the logic of the program, whereas in inspection, the program is simply read and discussed during meeting.

21

Technical reviews

- A technical review is intended to evaluate the software in the light of development standards, guidelines and specifications.
- A review is similar to an inspection and walkthrough, except that the review team also includes management.
- Therefore considered to be a higher level technique.

22

Technical reviews cont...

- Review agendas focus less on technical issues and more on foresight.
- The purpose is to evaluate the system relative to specifications and standards.
- The moderator should gather and distribute the documentation to all team members.

23

Technical reviews cont...

- A set of indicators is prepared to measure the following points:
 - Appropriateness of the problem definition and requirements
 - Adequacy of all underlying assumptions
 - Adherence to standards
 - Consistency
 - Completeness
 - documentation

24

Technical reviews cont...

- The moderator may also prepare check list to help team focus on key points.
- The result of the review is a document recording the events of the meeting, deficiencies and recommendations.
- Appropriate actions are then taken to correct any deficiency and address recommendations.

25

Clean Room Testing

- The term **cleanroom** was first coined at IBM by drawing analogy to the semiconductor fabrication units where defects are avoided by manufacturing in an ultra-clean atmosphere.
- This type of testing relies heavily on walkthroughs, inspection, and formal verification.
- The programmers are not allowed to test any of their code by executing the code other than doing some syntax testing using a compiler.

Clean Room Testing cont...

- This technique reportedly produces documentation and code that is more reliable and maintainable than other development methods relying heavily on code execution-based testing.
- Software testing in the cleanroom process is carried out as a statistical experiment.
- Based on the formal specification, a representative subset of software input/output trajectories/paths is selected and tested.
- This sample is then statistically analysed to produce an estimate of the reliability of the software, and a level of confidence in that estimate.

Limitations of Clean Room Testing

- The main problem with this approach is that testing effort is increased as walkthroughs, inspection, and verification are time consuming for detecting all simple errors.
- Also testing-based error detection is efficient for detecting certain errors that escape manual inspection.

Summary

- Discussed variants of inspection technique.
- Discussed about structured walkthrough – a kind of static testing technique.
- Briefly explained technical reviews - a kind of static testing technique.
- Presented the concept of clean room testing.

References

1. Rajib Mall, Fundamentals of Software Engineering, (Chapter – 10), Fifth Edition, PHI Learning Pvt. Ltd., 2018.
2. Naresh Chauhan, Software Testing: Principles and Practices, (Chapter – 6), Second Edition, Oxford University Press, 2016.



Thank You