Investigating the Temporal Behavior of Defect Detection in Software Inspection and Inspection-Based Testing

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Motivation & Goals

- Early detection and removal of defects, e.g., in the design phase, helps increasing software quality and decrease rework effort and cost.
- Analytical Quality Assurance (QA) typically includes
  - Reviews and Inspection for systematic V&V in early phases.
  - Software Testing, i.e., test case definition and execution in late phases.

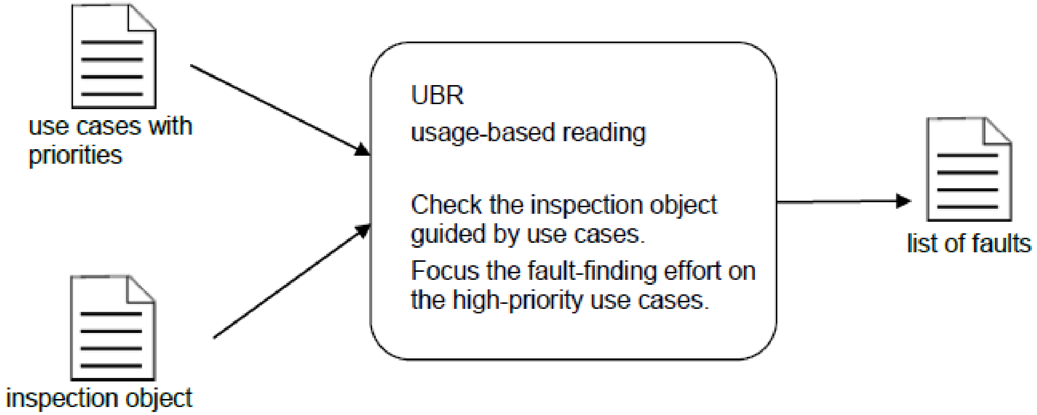
- Goal is the early definition of test cases based on inspection results (test-first approach).
  - Early defect detection as contribution of software inspection.
  - Improved understanding of customer requirements.
  - Test case generation based on requirements and inspection results.

- Key research questions focus on:
  - How can inspection support early test case definition?
  - What are the effects on defect detection performance (inspection vs. inspection-based test case generation)?

Software Inspection

- Software Inspection …
  - is a static analysis technique to verify quality properties of software artifacts.
  - does not require executable code (applicable to design documents).
  - focuses on defined defect types and locations in the inspected object.
  - provides active guidance of inspectors with reading techniques and guidelines (how to traverse a software document).

- "Best-practice" approach: Usage-Based Reading (UBR)
  - Well-investigated reading technique approach in business IT software development projects.
  - Focus on users and use cases.
  - Prioritization acc. to value/risk.
  - Application of use cases and scenarios.



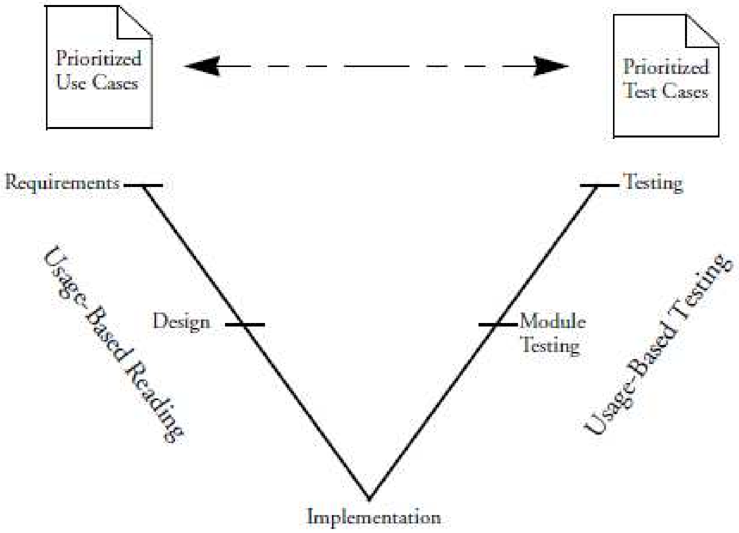
UBR
usage-based reading

Check the inspection object guided by use cases.
Focus the fault-finding effort on the high-priority use cases.

Usage Based Testing with Inspection

Usage-Based Testing (UBT)

- Test case generation based on use cases.
- Prioritized test cases late in the development process.
- Focus on executable code.



Usage-Based Testing with inspection (UBT-i)

- Bundling benefits of early Inspection and UBT
  - Early defect detection with inspection.
  - Early test-case definition based on prioritized use cases.

- Previous studies showed benefits of UBT-i with respect to isolated best-practice inspection.
- Empirical study on the temporal behavior of defect detection performance.

Dependent Variables and Hypothesis

Performance measures:

- Inspection effort includes individual preparation time and inspection / test-case generation duration.
- Effectiveness is the number of defects related to the overall number of seeded (and important) defects.
- Efficiency is the number of defects found per time interval.
- False Positives is the number of "wrong defects detected" by individual participants.

Time limitations:

- Upper study execution was 300 min (5hrs).
- Suggestions for review/inspection duration: 120 min (focus of the evaluation)

Hypothesis:

- Higher effectiveness (H1) & efficiency (H2) for UBR within 120 min of method application.
- Higher number of false positives (H3) in UBR within 120 minutes.

Experiment Description

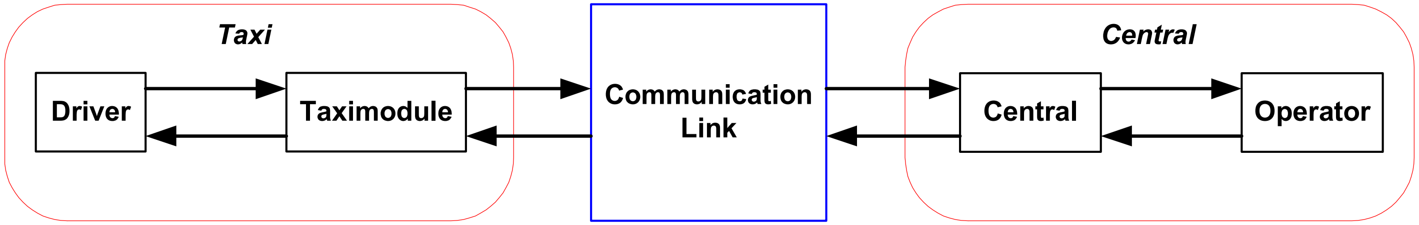
- Experiment Phases

  (a) Training & preparation.

  (b) Study execution: briefing, session 1 (taxi) and session 2 (central).

  (c) Data submission and evaluation.

- Subjects are 41 master students with SE and QA background.



- Study Material is a Taxi Management System in 2 parts
  - Snapshot of an agile software development project.
  - Textual requirements specification (8p), 2 Component diagrams, design document (8p), 24 prioritized use cases, appx. 1400 LOCs.
  - 60 seeded defects at 3 defect severity classes (29 defects in the taxi part and 31 in the central part)
  - Supporting material: guidelines and questionnaires.

Threats to Validity

Internal validity:

- Avoidance of communication between individuals during the study execution.
- Participants could take individual brakes, whenever necessary (break durations reported).
- Limitation of the overall study duration was 300 minutes, focus on the first 120 minutes (suggested inspection durations).
- Experience questionnaire to get an insight on prior knowledge.
- Feedback questionnaire to see if the participants followed the study process properly and to capture individual strategies.

External validity:

- Well-known application domain to avoid domain-specific interpretation problems.
- Pilot test and reviews to assure correctness of experiment material.
- Control of variables due classroom setting.

Effort and First Real Defect Reported

Effort

- No significant differences between UBR and UBT-i in both sessions.

Duration [min]	Session 1 (Taxi)		Session 2 (Central)	
	UBR	UBT-i	UBR	UBT-i
No of Subjects	20	21	21	20
Mean	272,5	268,8	281,3	276,2
Std.Dev.	38,01	29,13	35,32	30,11

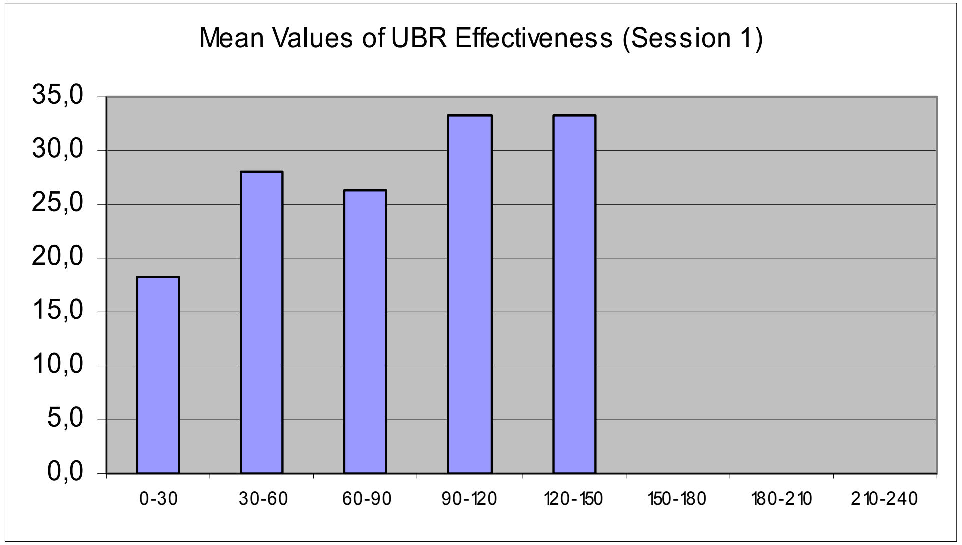
First Real Defect Reported

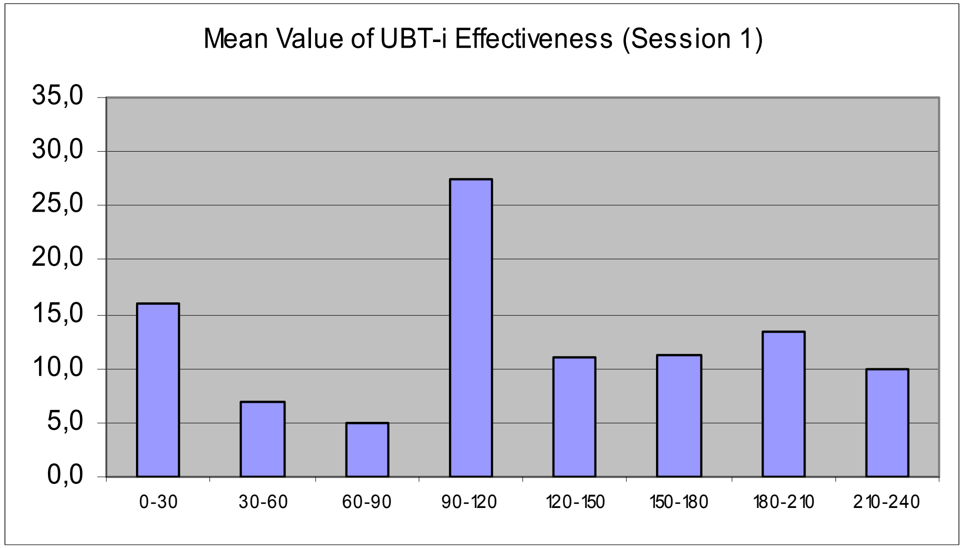
- Significant differences in session 1 and session 2

	Session 1 (Taxi)		Session 2 (Central)	
	UBR	UBT-i	UBR	UBT-i
Mean	12,2	17,6	15,4	17,4
Std.Dev.	10,59	10,39	10,93	10,42

Results: Effectiveness

- Expectations: UBR is significantly more effective than UBT-i.
- Comparable overall effectiveness for critical and important defects
  - 18.9 (UBR) and 16.9 (UBT-i), no significant differences.
- Time Interval Evaluation (first session)
  - No significant differences during the first 30 min.
  - Significant differences for all other time intervals.
  - No matched defects for t>240





- Assuming additional effort for test case generation might limit defect detection effectiveness.

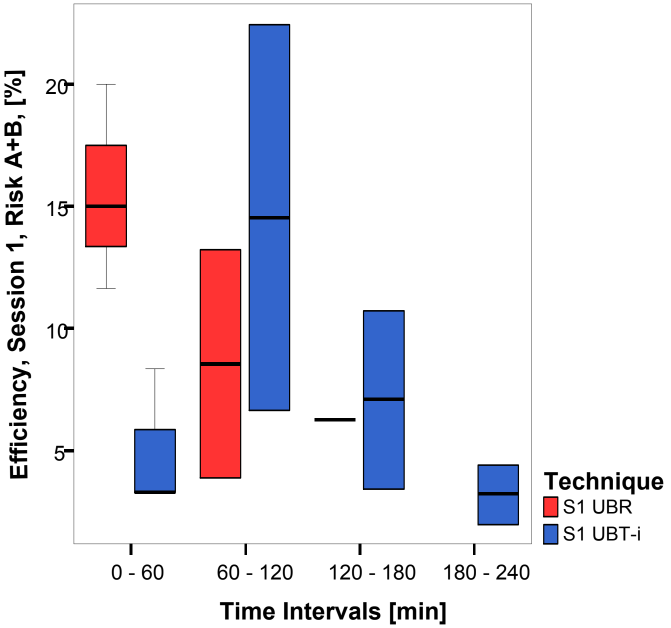
Results: Efficiency

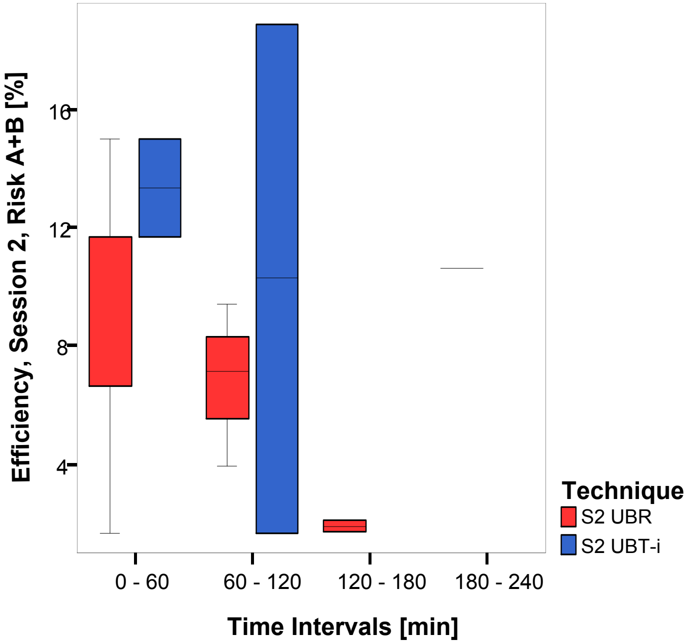
- Expectations: UBR is significantly more efficient than UBT-i.
- Measurement: Defects per hour.

- Session 1:
  - UBR are most efficient in the first hour.
  - UBT-i is most efficient in the second hour.
- Session 2:
  - UBT-i outperforms UBR inspection in the first 2 time intervals.

- Significant differences between all groups.

- Possible explanation is a changed defect detection approach of UBT-i in the second session: defect detection and test case generation in sequential order.

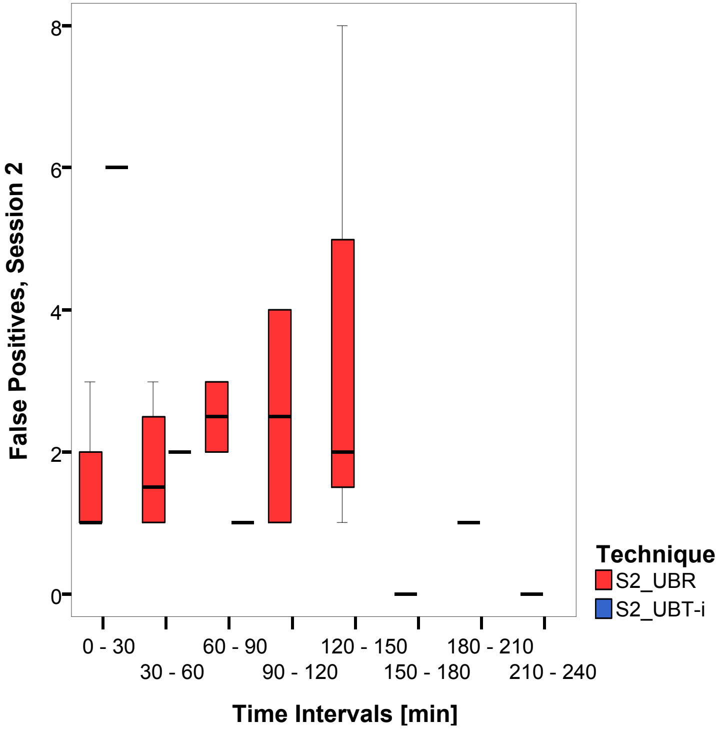




Results: False Positives

- Expectations: UBR report significantly more false positives (FP).

- Session 1:
  - Higher amount of FP at the begin and at the end of the study duration.
- Session 2:
  - Decreasing number of FP during the course of the study for UBT-i.
  - Increasing number of FP during the course of the study (up to 150 min) for UBR.



- Significant differences for all time intervals.
- Possible explanation seems to be a strong advantage for UBT-i participants who focused on test case generation (i.e., testability considerations).
- Nevertheless, results of effectiveness and false positives must be investigated in more detail for verification of the results strengthening the findings.

Summary and Further Work

Summary:

- Test case generation based on inspection results is a promising approach for bundling benefits of early defect detection.
- UBR performed very effective and efficient in a time interval up to 120 min.
- UBT-i requires more time for test case generation to achieve comparable defect detection results.
- We observed partly benefits in certain time intervals and notable differences between the two sessions → further investigations are required.
- Support of planning QA activities in SE projects.

Further Work:

- More detailed investigation of the study outcome regarding performance measures, defect types and document locations.
- In-depth analysis of the temporal behavior of defect detection performance because of partly contradictory results in two study sessions.

Thank you ...

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