SQAF-DS: A Software Quality Assessment Framework for Dependable Systems

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Dependability

The extent of the user’s confidence that it will operate as they expect and not fail in normal use

A emergent property consisting of

safety + security + reliability + availability

Proposed by Ian Sommerville [41]

Our interest!
“Safety Analysis” of IAEA

**safety analysis.** Evaluation of the potential hazards associated with the conduct of an *activity.*

① *Safety analysis* is often used interchangeably with *safety assessment.* However, when the distinction is important, *safety analysis* should be used for the study of *safety,* and *safety assessment* for the evaluation of *safety* — for example, evaluation of the magnitude of hazards, evaluation of the performance of *safety measures* and judgement of their adequacy, or quantification of the overall radiological impact or *safety* of a *facility* or *activity.*
Safety Analysis Techniques

*Analysis Techniques* for achieving safety

FTA  FMEA  HAZOP  ...  *Hazard Analysis*

*Assessment Techniques* for assessing current status of safety

Review  ...
“All failures identified by FMEA should be analyzed by FTA, and all potential errors (reasons) identified by FTA should be resolved and confirmed throughout the whole life-cycle of software development.”
Dependability Assessment

An important activity as well as dependability analysis (achievement)
   – It helps us determine when to stop the analysis effort

A prompt decision whether to keep the analysis up, while preserving a
required level of dependability
   – One of key factors to cost-effective software development
This Paper Proposes

A way to reduce the effort for dependability assessment:

SQAF-DS (Software Quality Assessment Framework for Dependable System)

– Intends to reduce the assessment time and cost thorough using test cases as a means of the assessment

– First, develop dependability requirements from dependability analysis
– Formally checks inclusion/satisfaction relation between dependability requirements and test cases

– Case study: Safety
A Software Quality Assessment Framework for Dependable System (SQAF-DS)

**Software Dependability Analysis**
- Dependability Requirements
  - Transformation
  - Dependability Properties

**Software Development Process**
- Test Cases
  - Transformation
  - Models of Test Cases

**Formal Checking**
- Dependability Properties ⊆ Test Cases

**Test Execution**
- TRUE
  - Dependability properties are **WELL** implemented.
- FALSE
  - Dependability properties are **NOT** implemented.

**We DO NOT KNOW** whether dependability properties are implemented or not.

**We need OTHER** dependability assessment methods, the same as before.
A Software Quality Assessment Framework for Dependable System (SQAF-DS)

Software Dependability Analysis

- Dependability Requirements
  - Transformation
    - Dependability Properties

Software Development Process

- Test Cases
  - Transformation
    - Models of Test Cases
Formal Checking

Dependability Properties

Models of Test Cases

TRUE

FALSE

Test Execution

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Dependability properties are WELL implemented.

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Case Study: Camera Control SW of Cell Phones

SW requirement specification in UML (excerpted)
An FTA for the failure “Camera button is pressed, but a picture is not taken.”

MINIMAL CUT-SET: Camera button is out of order
| startSnapshot event is ignored
| Camera is not ready to take pictures
Safety Requirement (1):  
“If the camera button is pressed, then startSnapshot event should be executed at first, even if three events occur simultaneously.”

Safety Requirement (2):  
“If the camera button is pressed when the system is ready to take pictures, then it should take a picture, eventually.”

Safety Property (1):  
\[ AG(((state=Preview) \land startSnapshot \land startRecord \land stopPostview) \Rightarrow AX \ (state=Snapshot)) \]

Safety Property (2):  
\[ AG(((state=Preview) \land startSnapshot \land \neg startRecord \land \neg stopPostview) \Rightarrow AF \ (state=Snapshot)) \]
<table>
<thead>
<tr>
<th>Test cases (Input)</th>
<th>Expected output</th>
</tr>
</thead>
<tbody>
<tr>
<td>(state = Preview, startSnapshot = 1)</td>
<td>(state = Snapshot)</td>
</tr>
<tr>
<td>(state = Preview, startRecord = 1)</td>
<td>(state = Recording)</td>
</tr>
<tr>
<td>(state = Preview, startPostview = 1)</td>
<td>(state = Postview)</td>
</tr>
<tr>
<td>(state = Preview, stopPreview = 1, isTimeOut = 1) or (state = Preview, stopPreview = 1, isGotCameraStopEvent = 1)</td>
<td>(state = Stopped)</td>
</tr>
<tr>
<td>(state = Snapshot, restartpreview = 1, isGotCamsensorError = 1) (state = Snapshot, restartpreview = 1, isSavephoto = OK)</td>
<td>(state = Preview)</td>
</tr>
<tr>
<td>(state = Recording, stopRecord = 1, isDotRecordStopEvent = 1) (state = Recording, stopRecord = 1, isMemoryFullled = 1) (state = Recording, stopRecord = 1, isGotCamsensorError = 1)</td>
<td>(state = Preview)</td>
</tr>
<tr>
<td>(state = Postview, stopPostview = 1)</td>
<td>(state = Preview)</td>
</tr>
<tr>
<td>(state = Stopped, exitCamera = 1)</td>
<td>(state = Idle)</td>
</tr>
</tbody>
</table>

A test suite for the UML specification
SMV input program

test cases
A result of SMV model checking

(1) → False
(2) → True
Safety Requirement (1) :

“If the camera button is pressed, then startSnapshot event should be executed at first, even if three events occur simultaneously.”

Safety Property (1) : \textit{False} \[ AG(((\text{state}=\text{Preview}) \& \text{startSnapshot} \& \text{startRecord} \& \text{stopPostview}) \rightarrow AX (\text{state}=\text{Snapshot})) \]

\(\rightarrow\) We don’t know for now
\(\rightarrow\) We need other methods to assess it!
Safety Requirement (2) :

“If the camera button is pressed when the system is ready to take pictures, then it should take a picture, eventually.”

Safety Property (2) : True

\[ AG(((state=Preview) \& startSnapshot \& ! startRecord \& ! stopPostview) \rightarrow AF (state=Snapshot)) \]

→ It may be well implemented (if the test succeeds)
→ Safety assessment has been done!
Needs More Consideration

**Formal Checking : Inclusion vs. Satisfaction**
- Model checking vs. Equivalence checking
- SMV vs. VIS
- SMV input programming language vs. Verilog

**Transformation of safety requirements**
- Safety analysis $\rightarrow$ Safety requirements $\rightarrow$ Safety Properties

**Level of dependability requirements and test cases**
- Scope of dependability analysis (System vs. Software vs. Component)
- System test vs. Unit test
- Model-based testing vs. Functional testing
Thank you

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