Automated system level testing of a software audio platform

Master's Thesis Presentation

Marko E. Takanen

Nokia Research Center

NOKIA

Content

- Introduction
    - Entertainment Audio Platform
    - Software testing
    - Motivation

- Approach

- What actually was tested

- Challenges from parameterization

- Challenges from system level

- Challenges from automation

- Conclusions

NOKIA

Entertainment Audio Platform

- A flexible *software* framework for various audio signal processing components

- Real-time processing

- <u>Core functionality</u>:
    - Audio mixing
        - all common controls supported

    - Sampling rate conversions (SRCs)
        - 48 kHz main rate
        - several input sampling rates

    - Dynamic range controller (DRC),
        - basic full-band

- Functionalities are accessible through a high-level application programming interface (API)

- The object of testing in the thesis

    mtakanen_mst.PPT / 17-02-2005 / MET

NOKIA
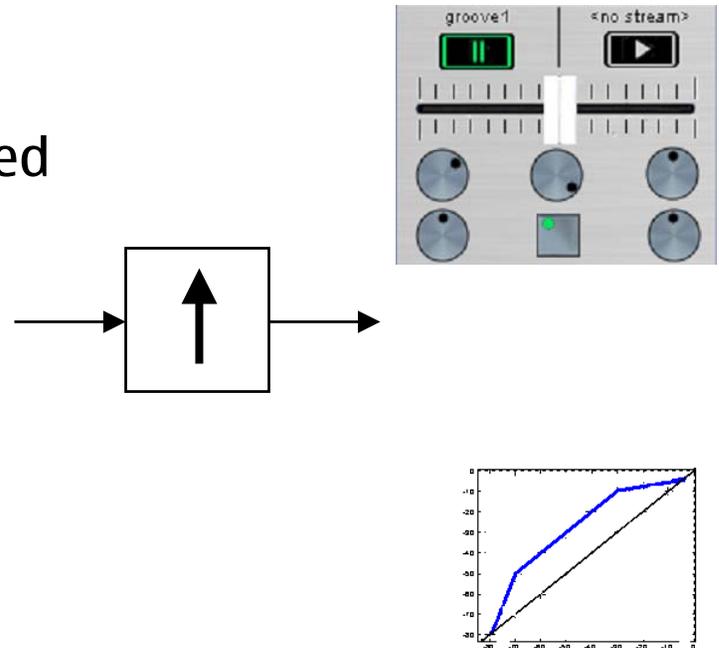
Software testing

- An essential part of software development
- The objective:

  - "Testing is the process of establishing confidence that a program does what it is supposed to do." (Myers, 1979)
    - Requirements –oriented

  - "Testing is the process of executing a program with the intent of finding errors." (Myers, 1979)
    - Less bugs in the release –oriented

- As process (manual -approach)   effort needed
  - Test planning (decisions)   (*   )
  - Test designing (solutions)   (* *   )
  - Test case specifications (selections)   (* * *   )
  - Test execution and error reporting   (* * * * *)
    - monotonous
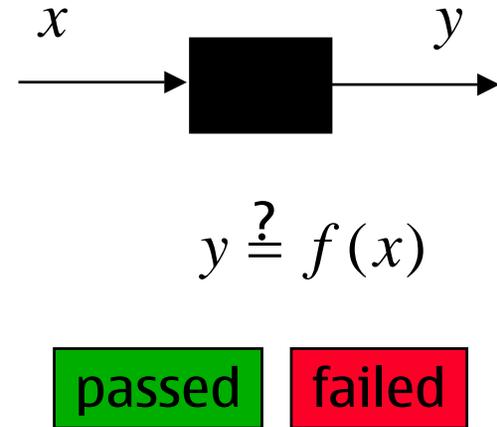   - very prone to mistakes

NOKIA

Motivation for automated testing

- Development rarely ends when v.1.0 has been released
  - functionality is extended
    - new tests required

- Old functionality stays
  - revisited code, iteration, optimized algorithms
    - **has to be tested**!

- Several hardware platforms

- Same tests are executed again and again...

Testing need increases continuously!

NOKIA

Approach

- *Automate* test execution and reporting

- Test on *system level*
  - using the API
  - using black-box testing
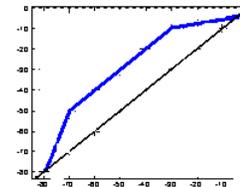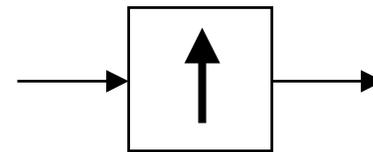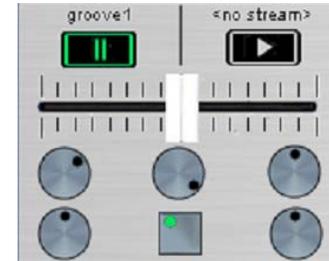
- Parameterize testing
  - using audio signal analysis

$$x \qquad y$$

$$y \overset{?}{=} f(x)$$

passed   failed

- As process (when automated and parameterized) <u>effort needed</u>
  - Test planning (decisions),   (*   )
  - Test designing (solutions),   (* * *   )
  - Test case specifications (selections),   (*   )
  - Test execution and error reporting   (   )
    - monotonous
   - ~~very prone to mistakes~~

NOKIA

What actually was tested

- Mixer controls
  - Instantaneous adjustments
  - Adjustments with ramps

- Sampling rate conversions (all input rates)
  - Filter specification compliance
  - Rate conversion accuracy
  - Anti-aliasing
  - THD+N (with A-weighting)

- Dynamic range controller
  - Static parameters (compression curves)

- And what was *not* tested
  - The real-time requirement
  - Dynamic parameters of the DRC
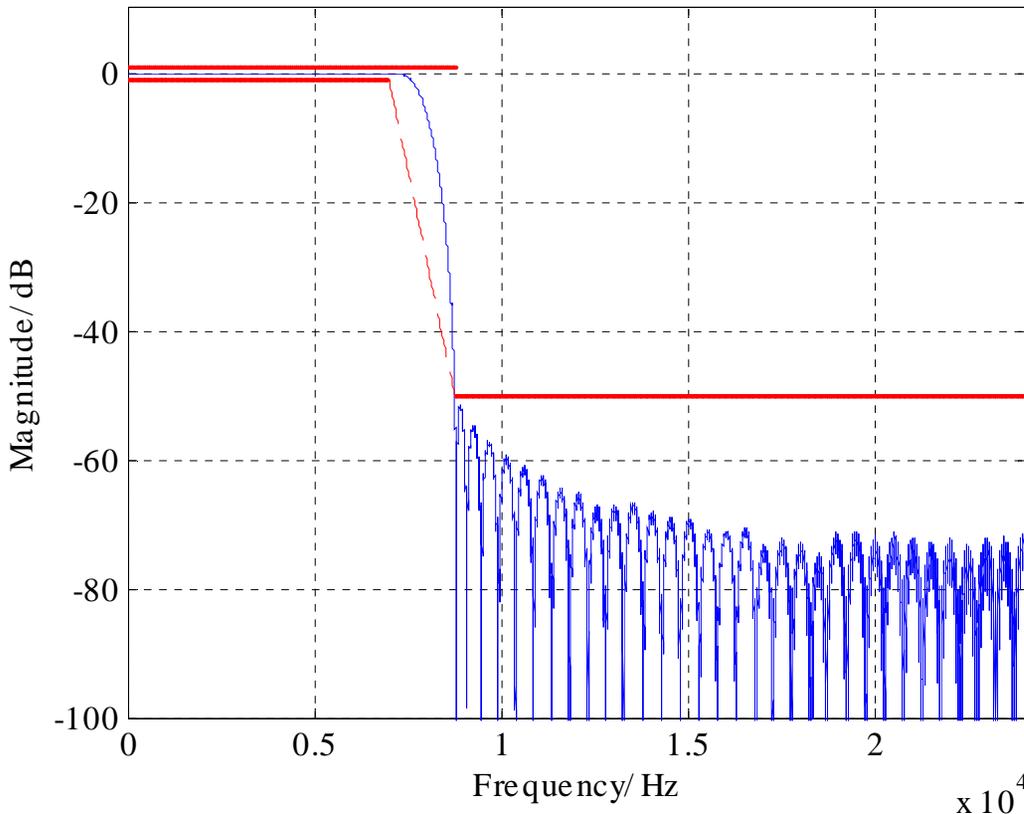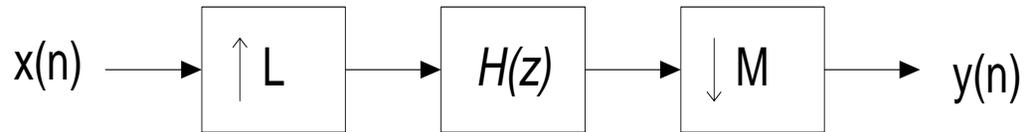
NOKIA

Challenges from parameterization

- Parameter estimation in the verification phase
  - Use Matlab and good tricks!

$$y=abs(hilbert(x))$$
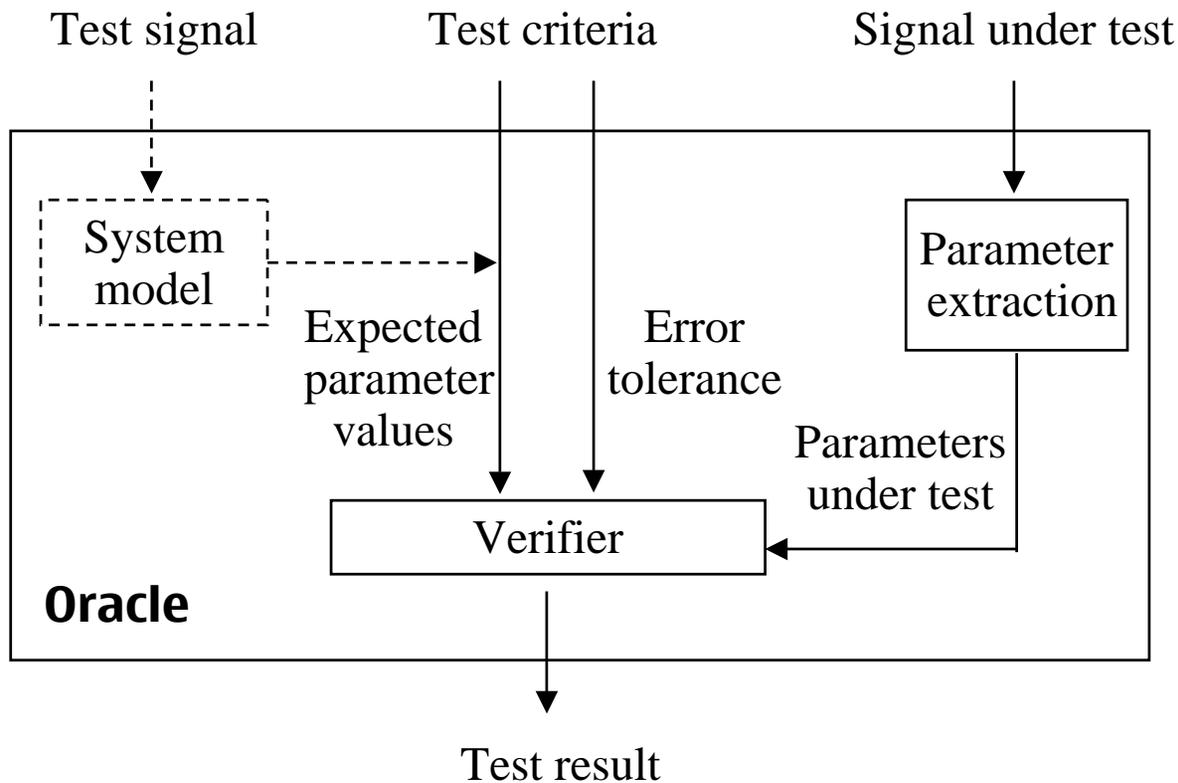
NOKIA
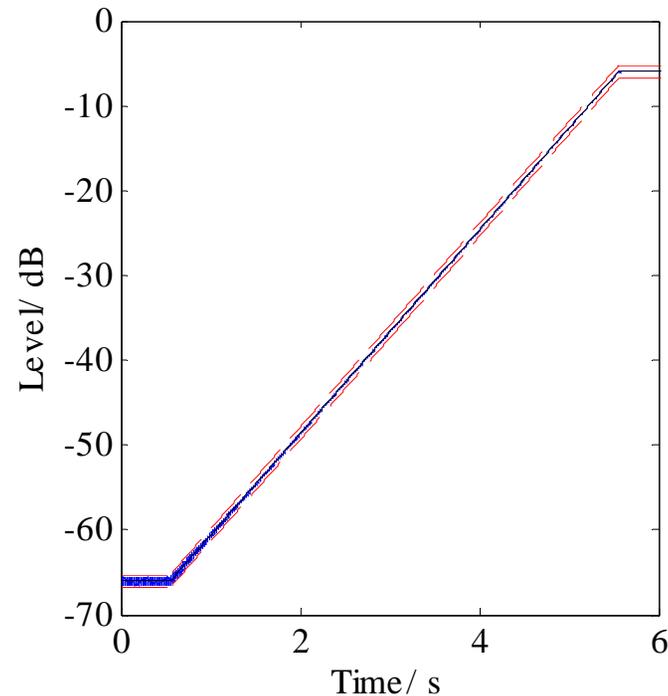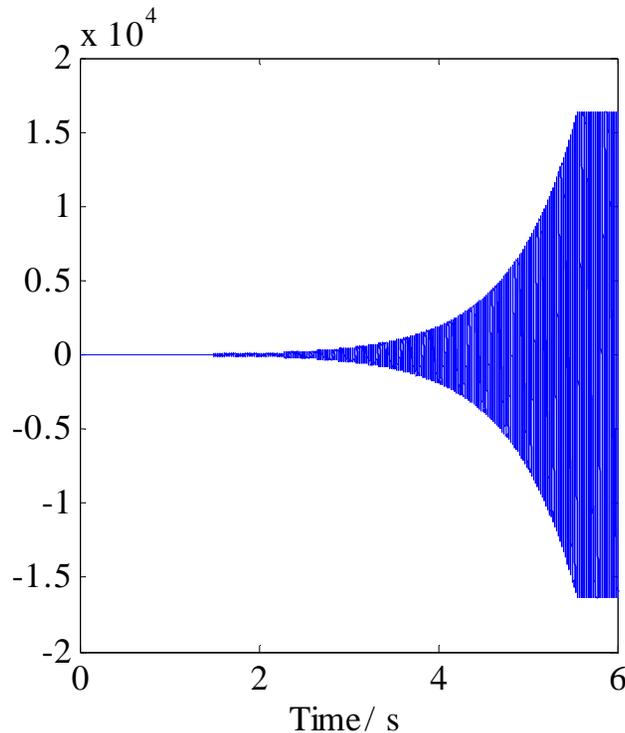
Challenges from *system level ...*

- SRC anti-imaging/ -aliasing filtering

  - $x[n]$ and $y[n]$ are at different rates
    - time-variant system!
- E.g. filter specification tests

$$x(n) \longrightarrow \boxed{\uparrow L} \longrightarrow \boxed{H(z)} \longrightarrow \boxed{\downarrow M} \longrightarrow y(n)$$

$$\frac{Y(z)}{X(z)} \overset{?}{=} H(z)$$

NOKIA

Challenges from *automated*...

- Output verification has to be automated too!
- Test oracle concept from software testing methodology

© NOKIA   mtakanen_mst.PPT / 17-02-2005 / MET

Conclusions and future work

- Methods for automated end-to-end audio functionality testing

- Detailed audio functionality testing is possible on system level
  - SRC filter tests would be more efficient to design on lower level

- Automated tests were designed and implemented for EAP core functionality

- Credibility of the equalization spectrum technique in conversions by non-integer factor
  - Study swept-sine technique (Farina, 2000)

- Only conventional audio quality measures (THD+N, FR function)
  - Consider perceptually motivated AQ

     mtakanen_mst.PPT / 17-02-2005 / MET

NOKIA

Thank you for the interest!

- Questions???

NOKIA

References

- Myers, G., 1979, "*The Art of Software Testing*", John Wiley & Sons, Inc., pp. 170.

- Farina, A., 2000, "Simultaneous Measurement Of Impulse Response And Distortion With A Swept-sine Technique", *110th AES Convention*, Paris 18- 22, February 2000, Preprint 5093, pp. 23.

NOKIA