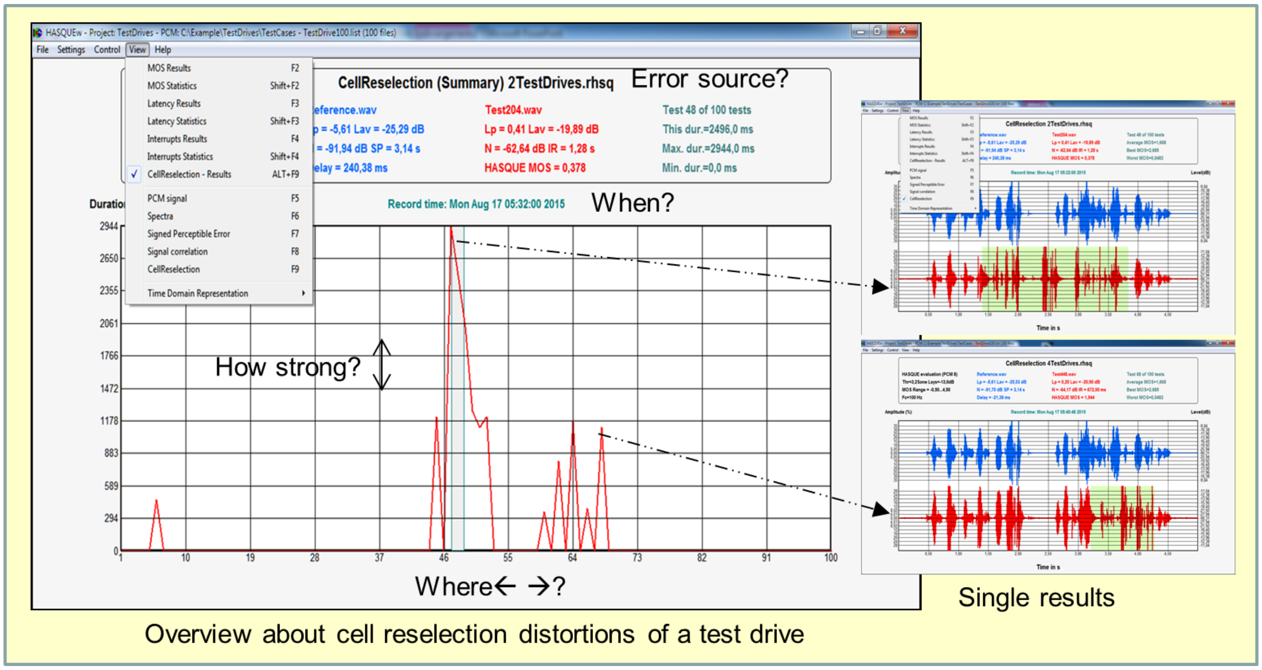
Sound acoustics

Research, Development, Implementation

Programmable error tracer for individual sources of distortions



Cover figure: Error tracing and documentation of an error, classified as cell reselection distortion.

Abstract

The evaluation and optimization of telecommunication systems is supported by objective measurement systems of today. However many handmade tasks are necessary for the correct interpretation of the cause of failure. If we trace for special distortions from several hundreds of records, we can't do it without additional effort for comparison tests and additional measurements. If the cause of failure is found by expensive listening tests, additional effort for measurements and documentations are necessary to make representative statements about the real strength of the traced errors possible.

These time consuming tasks can be saved nearly totally by the artificial intelligence of the error tracer and the extended measurement possibilities of the HASQUE measurement systems as presented here.

This report explains the principle of the error recognition, demonstrates the easy capturing of a new classified error by a wizard controlled scanner and how this error is traced and indicated in large test series.

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Quality slumps by different causes

Temporary quality slumps of telecommunication systems may have different causes. If we try to enhance a system or to remove such quality slumps, we must know what it is.
Is it only a sound overdrive? Are the distortions generated by a poor radio connection? Are there only signal interrupts by funk holes or rather by cell reselections during movements in the environment? How strong might be the distortion of a Martins horn during a test drive?

Correct answers for these questions require as a first step the classification of the error type. Afterwards all recordings of a test drive must be examined and documented for each different error type separately.

The following chapters explain the error recognition principle, the determination of error types by the users interface and the accuracy of the programmable error tracer.

Error recognition by neuronal synthesis of signal properties

Any classified error owns properties which differ from the properties of other errors. Narrowband distortions are easily to recognize by the frequency range and the bandwidth. Another distortion might show signal superposition and interrupts within a certain interval or the signal correlation with the reference signal goes towards zero.

Subjective error recognition takes place over listening tests, whereas the subjects have raised awareness for the searched error type due to former training of the error properties. From neurobiological view the single outputs of nerve cells (Axons), which reflect the perceptible signal properties as loud, silent, wide, narrow, high, low are handed off to the inputs (Dendrites) of a following nerve cell over so called Synapses. Synapses are crossings with variable gaining or attenuating weight, which results from the training.

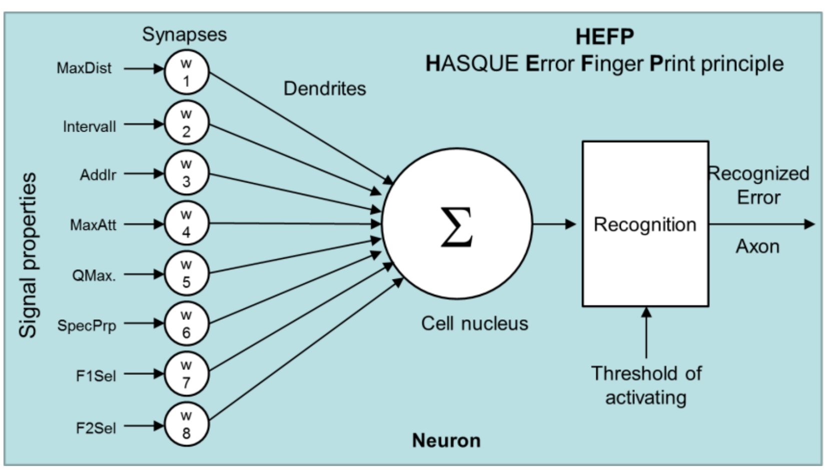

Figure 2: Neuronal processing

Figure 2 shows the simulation of the neuronal processing. The signal properties are connected over the Synapses with trained weights to the inputs (Dendrites) of the cell nucleus.
The output of the cell nucleus indicates from the threshold of activating the recognized error. The training of the weights is carried out within the HASQUE measurement system by scanning of the zoomed signal passages indicating the error under test.

A reliable recognition of former trained error types is possible, if enough "perceptible" properties for the error differentiation are present. The more signal properties are captured and made available, the higher the recognition rate during the tracing of a searched error source. HASQUE measurement systems

provide eight perceptible properties with high resolution of up to 32 Bit or $R=2^{32}$, which are used for the creation of a finger print for error recognition.
Because mainly the perceptible measured values of the HASQUE measurement system come to use, the recognition principle was baptized **HEFP**-principle derived from **H**ASQUE **E**rror **F**inger **P**rint.

Recognition rate with the HEFP-principle

The properties of a classified error can cover an unknown set of conditions. Hence the forecast about the real recognition rate is not easy. From mathematical view are up to K^N = 390625 different error types with a recognition rate of nearly 100% is possible if we reduce above mentioned resolution to wider ranges with R=5 and N=8 Signal properties. However weak errors belonging to the same classified error type can be dropped, if only one of the signal properties falls below the indicated range.
Hence we use only 2 conditions for each signal property for a more reliable estimation of the recognition rate. Under this assumption at least 256 error types with a recognition rate of 99.6 % is possible. The comparison between subjective examined test series with the HEFP recognition results confirm this row approximation with results shown in Table 1

	Subj. Weighted	HEFP measured	Number of Measurements	Errors	Recognition rate (%)
Martins horn	3	3	103	0	100
Cell Reselection	13	14	103	1	99.03
Funk Holes	91	92	103	1	99.03
Martins horn	0	1	660	1	99.85
Cell Reselection	15	16	660	1	99.85
Funk Holes	92	92	660	0	100
Martins horn	0	0	3364	0	100
Cell Reselection	0	0	3364	0	100
Funk Holes	177	179	3364	2	99.95

Table 1: Verification of the recognition rate by comparison with subj. results

The results in Table 1 are based on three different test series. The test series with 103 recordings was put together from different test drives and includes the classified error types Martins horn, cell reselection and funk holes. The test series with 660 test cases was created during a nearly one hour test drive in a difficult environment with cell reselections and funk holes, but without Martins horn. The big test series with 3364 recordings includes neither distortion from cell reselections nor from a Martins horn but only different types of signal interrupts.
These results confirm a very high recognition rate but relate to the limited number of 4721 Single tests with a whole recording time of 5.7 hours.

Error classification and capturing

A proper training guarantees a proper recognition. HASQUE measurement systems are fitted with the wizard shown in Figure 3. The wizard leads the user to classification, training (scan, test, verify) with up to 10 different test scenarios and the save of the “Finger print” which is derived from all scanned properties.

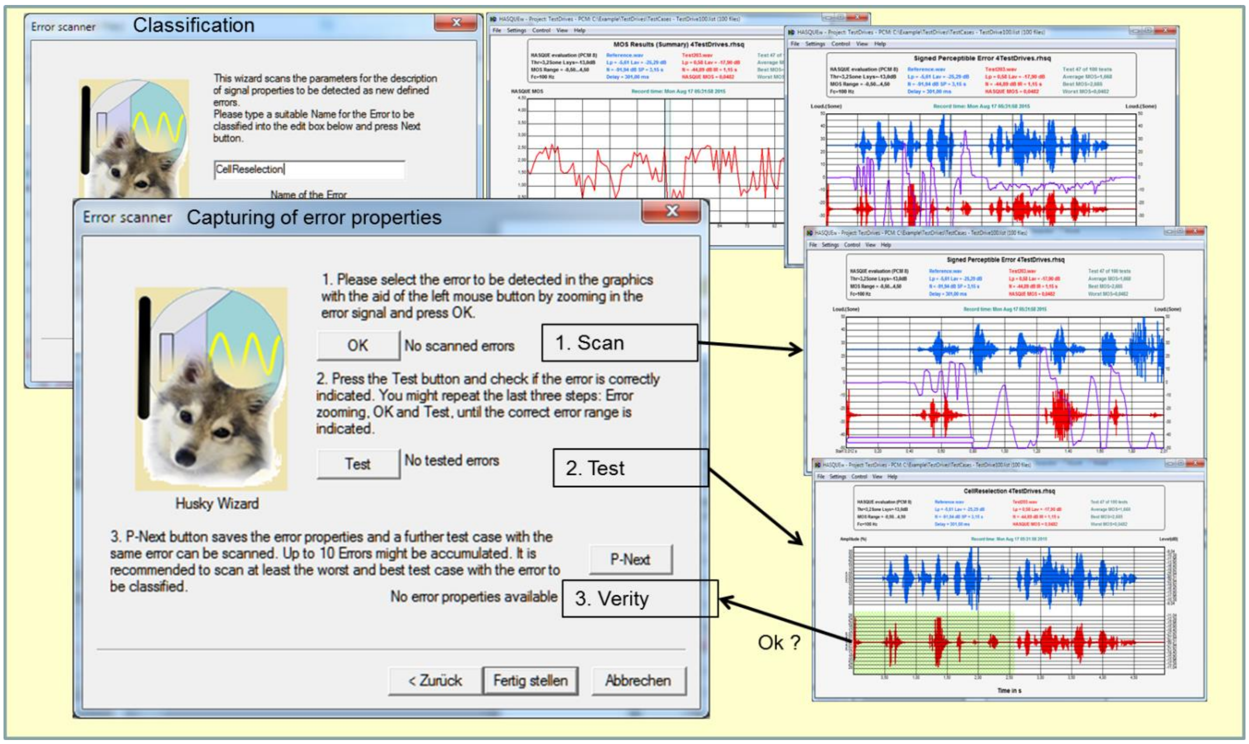

Figure 3: Wizard for error classification and capturing

The user can classify different error types, scan and apply for the error tracer. Each error type can be saved in an error property page (*.prp → property) and is available on request at any time. Predefined “finger prints” of following classified errors are made available from version 8.80 of the HASQUE measurement software:

1. CellReselection.prp : Distortion by cell reselection
2. FunkHoles.prp : Distortion by funk holes.
3. Martinshorn.prp : acoustic superposition by Martins horn

The access to a desired error type is carried out with the aid of the error tracer dialog box.

Errortracer results

Basically error tracing is computationally intensive and needs for a large test series some minutes to create the overview graphics with the desired error type indicating the strength of the searched distortion for each test case. To avoid unnecessary recalculations, result tables are created and saved automatically in the test case directory for each measurement series, in order to make quick indication of overview results with the desired error type possible.

The affiliation to the belonging measurement series is derived from the name of the current measurement. The user will be informed only, if a recalculation is needed. The recalculation starts automatically (the user has nothing to do) to avoid decision mistakes by the user.

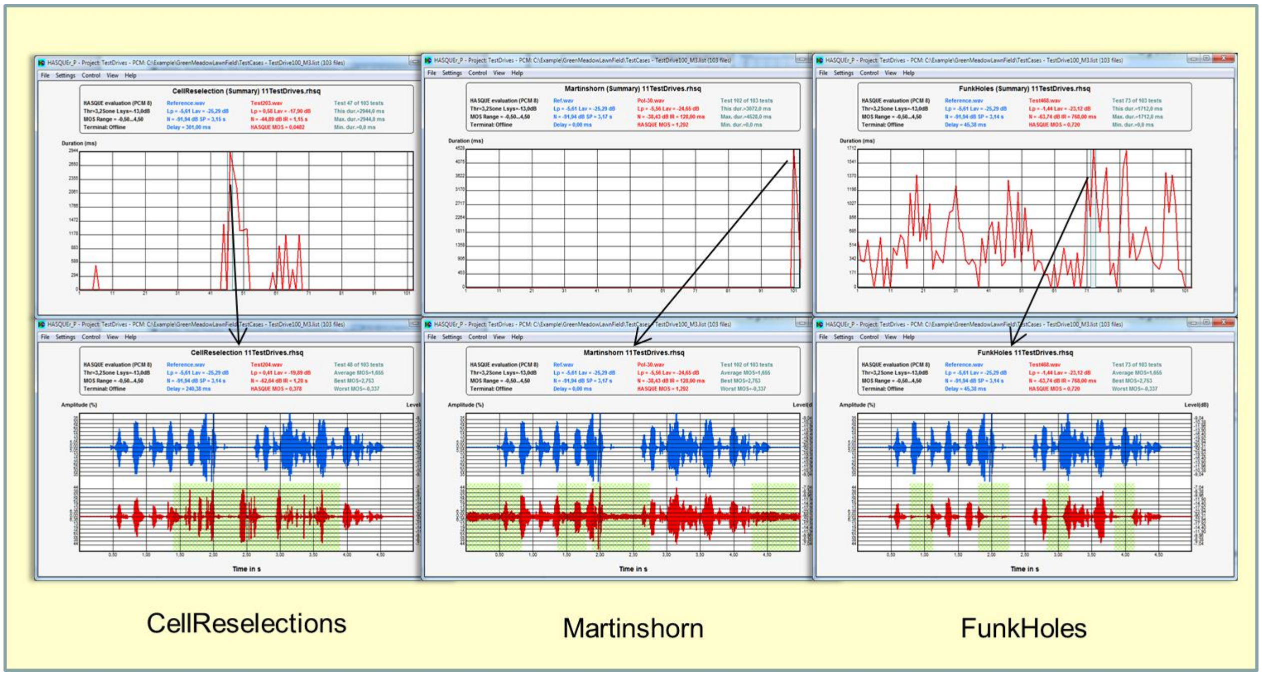

Figure 4: Three different causes of errors at one and the same test series

Figure 4 shows an example with 103 consecutively test recordings. The upper graphics indicate the test results of a classified error over all test cases and the below indicated graphic shows the passages which are distorted by the error type of interest. The black arrow indicates which test case of the whole test series is selected. Any test case can be selected by mouse click directly in the overview graphics.

Conclusion and outlook:

The current implementation of the HEFP principle in all HASQUE measurement systems makes error tracing of former trained new error types possible. The time spent on previous manual tasks, such as listening to hundreds of test cases required for a report and Documentation, with overview graphics and individual results, can be completely saved. That is done by the programmable error tracer.

Manual measurement and estimation errors belong to history due to the automation and the high recognition rate of the error detection.

The GUI of the HASQUE measurement system makes from “top view” within a time interval of hours the selection and access of these test cases immediately possible, which were found end indicated by the error tracer. Even so the indicated distorted range of a single test result can be zoomed in further examinations in a “bottom view” of some milliseconds.

As the error tracer is made available offline, even so any former recordings can be examined, analyzed evaluated and documented with nearly no expense.

The neuronal processing of the HEFP principle for error recognition is modular designed and can be extended if new systems with today unknown new error types require extended error properties.

Appendix:

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