Measuring user experience under lab conditions

User equipment (UE) test specifications published by standardization forums focus on characteristics that ensure error-free operation on the network. While testing of subjective criteria such as sound and picture quality is not mandatory, these are key factors for success on the market. An award-winning[1] test solution from Rohde & Schwarz now makes it possible to measure these features as well.

What matters is the user experience

Anyone purchasing a cell phone can safely assume that any commercially available model will perform as intended. This is ensured through a comprehensive test program that every device must pass before market introduction. However, when it comes to assessing how a device stands up to everyday use and where its strengths and weaknesses lie, potential customers rely on consumer portals and magazines. These assessments increasingly govern the quality discussion, with emphasis on keywords such as user experience, quality of experience (QoE) and quality of service (QoS). However, the user experience is not solely a product of the UE characteristics, but rather results from the interaction between the network, the UE hardware and firmware and the software applications, i.e. apps. This is why all market participants – including network operators, UE manufacturers and app developers – are interested in test solutions that enable the objective measurement of subjective assessment criteria. Walk and drive test products for QoE measurements in real networks, such as those offered by Rohde & Schwarz, lack the necessary reproducibility, and they take the local network characteristics (the analysis of which is their primary purpose) as a given. This makes them unsuitable for the applications described here. In order to achieve fast and reproducible results during development, what is needed instead is a lab solution where all parameters affecting quality, especially with respect to the network, are configurable. This need is filled by the tried and true R&S®CMW500 wireless tester, which serves as the basis of a small test system controlled by the R&S®CMWrun test sequencer software application.

The test system

The R&S®CMW500 can emulate two wireless systems simultaneously and analyze all conceivable data traffic criteria between the network and the UE. Internal data handling is taken care of by a data application unit (DAU) that includes the IP multimedia system (IMS) that is also key to voice transmission in LTE. An audio board provides the voice codecs specific to each standard. Specialized instruments are integrated for measuring audio and video quality as well as power consumption, including the R&S®UPV audio analyzer, the R&S®VTE video analyzer (both of which are capable of objective quality measurements[2]) and the R&S®NGMO2 dual-channel analyzer/power supply. R&S®CMWrun is a test automation software application for remotely controlling R&S®CMW based test systems and processing their results. The individual, ready-to-use test steps are stored in a library and then combined on the user interface into application-specific test plans. Available tests include the carrier acceptance tests that large network operators require for UEs in their networks. Fig. 1 shows the test setup.

Audio – a compulsory exercise …

In the days of GSM, a cell phone was primarily a telephone. On an LTE smartphone, however, voice is just one of many services; one that even has to be added by means of IMS. This is because LTE was optimized for data services, not for analog applications (see NEWS 214, page 18). However, telephony remains such an essential component of cell phone usage that good audio quality is taken for granted by users and should therefore not be neglected by manufacturers. In fact, new broadband codecs make it possible to pamper users with a voice quality that will seem a revelation in comparison to fixed network telephony with its bandwidth-limited 3.4 kHz. However, achieving this quality with VoLTE requires that the parameters relevant for digital realtime systems, such as path quality (radio conditions), packet loss, packet delay, jitter strength, jitter distribution and latency, remain within permissible limits. It is also necessary to test interaction with users who connect via non-IP-based technologies such as GSM, WCDMA or CDMA2000®.

1) See Newsgrams on page 63.
2) Although this term has become commonplace in the literature, it is misleading because it actually means the opposite. The goal is to simulate the human physiology of perception for computerized analysis, i.e. to objectivize it.

The R&S®CMWrun software provides all of the measurement functions required to assess audio and voice quality for all conventional standards. Only a few mouse clicks are needed to set up customized test campaigns that include all signaling and radio parameters and conditions that can affect audio quality and its subjective perception. The ITU-T test algorithms PESQ and POLQA are used in the audio analyzer to capture subjective perception. These algorithms digitally compare the test signal to a reference signal and assesses the difference in terms of perception. The following signaling settings can be made: establishment of a voice or video call via the IMS server, RoHC, SPS, TTI bundling, dedicated bearer and QoS, IPv4/IPv6, delay, jitter, packet loss and fading profile.

Video tests – gaining in importance in the multimedia age

Videos are currently responsible for approximately 50 % of the data volume in cellular networks. The Ericsson Mobility Report calculates that this will increase to 70 % by 2021. Given these numbers, it is understandable that the cellular industry works to optimize its infrastructure and UEs for this application. Running the necessary tests on R&S®CMWrun does not require deep understanding of video because the software configures all settings. The network is emulated by the R&S®CMW500 and includes an HTTP streaming server (DASH). The transmission channel can be influenced with IP impairments and fading scenarios. All access technologies that support E2E video streaming can be incorporated into the tests, i.e. LTE (FDD/TDD), WCDMA/HSPA, (E)GPRS and WLAN. The tests can be performed in two different ways:

- Via an A/V interface (HDMI™/MHL/Miracast) using the R&S®VTE video tester
  The video signal is supplied to the DUT either via a wired connection (HDMI™/MHL) or via a wireless connection using an adapter box (Miracast). The R&S®VTE uses its reference image based quality analysis functions (SNR/SSIM/MOS) to analyze the decoded signal.
- Visually via a barcode reader with appropriately prepared video material
  R&S®CMWrun permits this test method even without a connected video tester. Instead, the R&S®CMW-Z17 high-speed barcode reader is used. It is connected via USB to the control PC running the R&S®CMWrun software. The DASH server in the R&S®CMW500 delivers a prepared video whose individual frames contain sequentially numbered barcodes. The barcode reader scans the codes from the UE display and sends them to the PC for evaluation. Missing

User experience test scenario

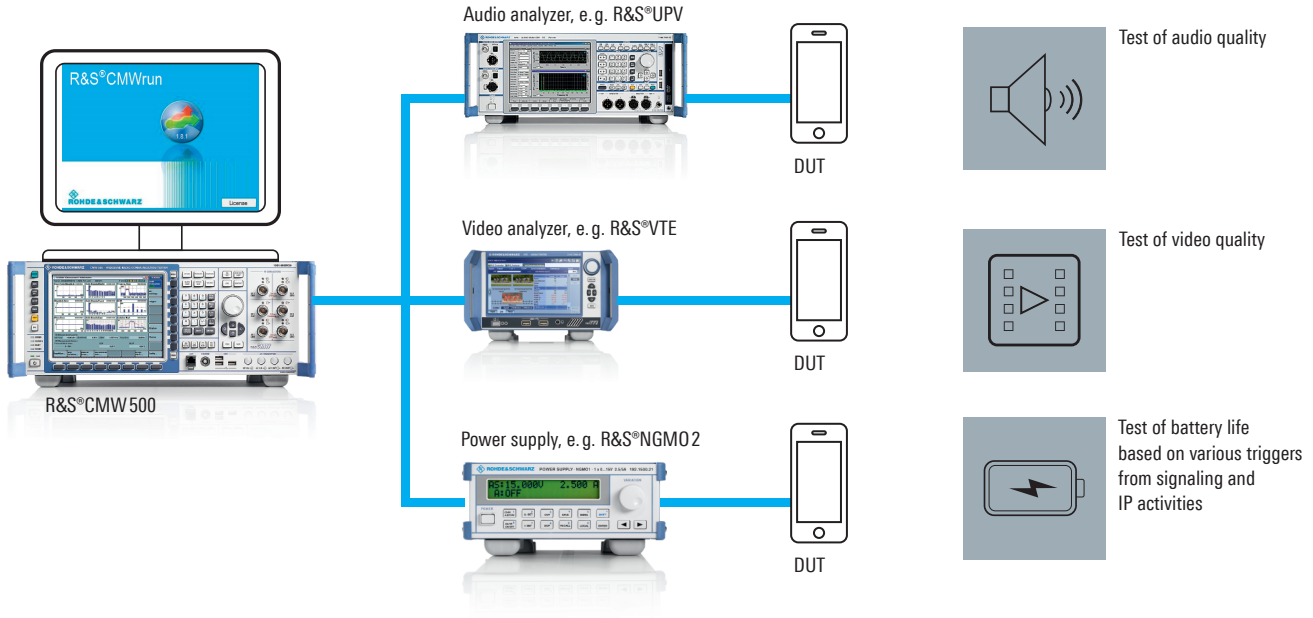

Fig. 1: Test setup for quality of experience measurements under lab conditions.

frames, delayed frames or out-of-sequence frames can be reliably detected. This setup can also be used to test bit rate adjustments made by the DASH server under changing channel conditions. This option includes barcoded videos.

Battery life – a key quality feature

Everyone who has forgotten to plug in their cell phone at night knows the aggravation of waking to a dead battery. Many apps run in the background without the user's knowledge, increasing power requirements. Power-saving mechanisms, such as discontinuous reception (DRX) in LTE, manage device resources fairly efficiently by ensuring that only the components currently needed remain in a waiting state. But to sustainably reduce power consumption, every device function and every app must be individually monitored. The R&S®CMW-KT051 option for R&S®CMWrun provides the means to test this. In the test setup, the R&S®NGMO2 power supply replaces the integrated battery. R&S®CMWrun precisely logs the power consumption in the form of a continuous measurement trace (Fig. 2). However, this log only becomes truly useful when combined with overlaid event markers that make it possible to correlate power consumption with device-internal activities. This can include trigger events at the signaling level, e.g. establishment of a VoLTE call, or processes at the IP level that the IP analysis option makes

Fully automated battery life tests, IP throughput tests, as well as IP analysis with R&S®CMWrun

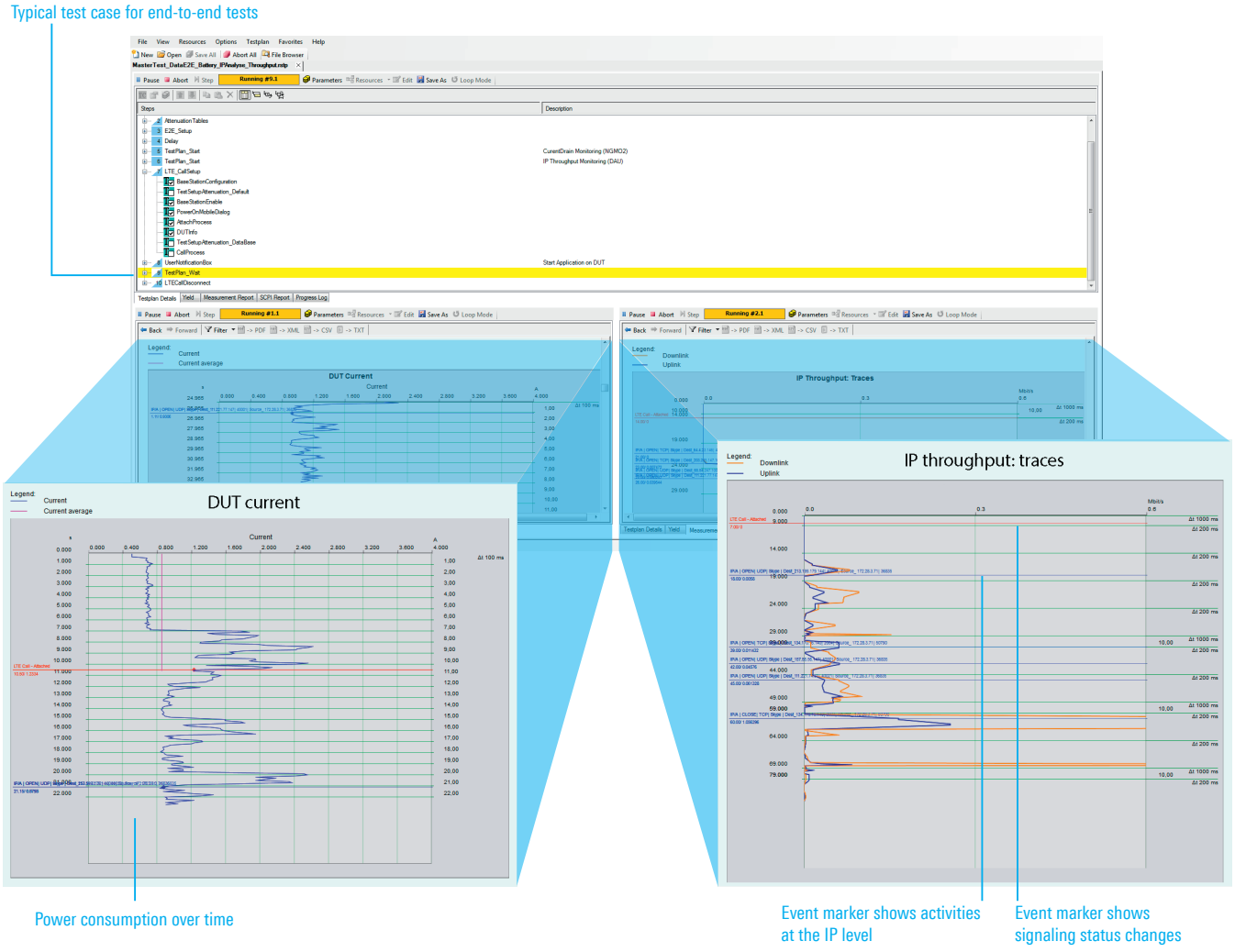

Fig. 2: Event markers can be used to correlate the power consumption with device-internal processes at the signaling or IP level.

accessible to users. By integrating the R&S®UPV audio analyzer into the setup, the power consumption can be correlated with the audio quality, which is measured with DRX switched on and off. Another very telling correlation results from combining power consumption and IP throughput measurements. The IP throughput is recorded in a second measurement trace over time (also with overlaid event markers) that is time-synchronized with the power consumption measurement. The measurement results provide an estimation of the operating time with a charged battery under various (IP) load conditions. On Android mobile devices, the R&S®CMWrun app with its iPerf and FTP functions supports the automation of these measurements.

Summary

Audio and video quality, battery life and throughput performance are key criteria for the success of products such as smartphones, apps, IoT modules and car-to-car modules. With a setup consisting of the R&S®CMW500 and T&M instruments for audio, video and power consumption, these criteria (which can be summarized as quality of experience) can be tested flexibly, comprehensively and without additional programming effort. The solution permits development engineers to monitor factors affecting QoE during every phase of the development process. It allows network operators to determine under lab conditions whether UEs provide the QoE they require for their networks. App developers can monitor the QoE of their creations on a variety of UEs without having to rely on a real network.

The table below summarizes the measurement options.

Fernando Schmitt; Volker Bach

Measuring user experience for all standards with the R&S®CMW500 / R&S®CMWrun

	Features / conditions	Measurement results
Throughput tests		
	▪ Upload / download ▪ iPerf / FTP / UDP ▪ Browsing / streaming ▪ IP impairments and fading	▪ Throughput monitoring over time ▪ IP events over time (IP analysis) ▪ Throughput versus modulation coding method ▪ BLER versus modulation coding method
Audio performance		
	▪ End-to-end voice quality ▪ VoLTE / circuit-switched ▪ Handovers, incl. SRVCC ▪ IP impairments and fading ▪ Voice / loopback call	▪ Voice quality / performance (MOS: POLQA / PESQ) ▪ Audio delay (ms) ▪ Acoustic measurements
Video analysis		
	▪ Streaming (HTTP streaming server / DASH) ▪ Video call, incl. ViLTE ▪ IP impairments and fading	▪ Wired (HDMI™ / MHL interface) ▪ Via optical interface (embedded barcode) ▪ Lost frames, frame delays, request for repeated frames ▪ Pixel errors ▪ Subjective quality assessment (SNR / SSIM / MOS)
Battery life test		
	▪ With voice, video, data ▪ With defined profiles ▪ With signaling and IP event markers	▪ Power consumption (mW) ▪ Current drain (mA) ▪ Estimated battery life (h)
Coexistence tests		
	▪ WLAN RX desensitization ▪ LTE RX desensitization	▪ Desensitization by distance of aggressor (dB) ▪ Desensitization by UL power of aggressor (dB)