Rohde & Schwarz
IOT & VoLTE

Stone Lin
Assistant Manager
Wireless Terminal
Agenda

IOT
I. Terminal Acceptance Testing - IOT
II. Lab Based IOT
III. Performance Quality Analysis (PQA)

IMS and VoLTE
I. IMS basic
II. VoLTE testing
Terminal Acceptance Testing
Solutions for Operators Network

Process Description
# Device Testing in Lab and Field

**Assessment of the different methods for terminal handset testing**

<table>
<thead>
<tr>
<th>GCF / PTCRB Lab Conformance Testing</th>
<th>Operator IOT Lab Testing</th>
<th>Field Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>◆ Based open standards for testing</td>
<td>◆ Values performance equal to conformance</td>
<td>◆ Close to real user experience</td>
</tr>
<tr>
<td>◆ Industry recognized committees</td>
<td>◆ Tailored to specific operator needs</td>
<td>◆ Limited test coverage, e.g. - difficult to test failure cases</td>
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<tr>
<td>◆ Scalable due to Industry consensus</td>
<td>◆ Flexible and fast delivery of test solutions suitable for new technology introduction</td>
<td>◆ bound to network feature support</td>
</tr>
<tr>
<td>◆ Consensus driven approach hampering progress</td>
<td></td>
<td>◆ Requires significant resources and planning</td>
</tr>
<tr>
<td>◆ Focus on conformance</td>
<td></td>
<td>◆ Limited scalability</td>
</tr>
</tbody>
</table>

GCF / PTCRB conformance, Operator IOT and Field Test complement each other. They need to be balanced depending on requirements and particular business models of operators.
How IOT is achieved? – On the field test

Objective of Field Test:
- Check signaling performance of UE
- Let operator understand how UE behaves in a “LIVE” network
Lab IOT Process – Initial Phase

- Operator is specifying test requirements for terminal testing
- T&M partner implements test solution
- Test cases are verified in cooperation with UE vendor
- Operator publish UE testing requirements
- T&M partner makes release

Test specification

Review & Discussion

Implementation and verification

Acceptance

Roll out

T&M Partner reviews Test Plan from operator
Discussion about detailed collaboration model

Operator runs acceptance test procedure with T&M partner to approve Test solution
How IOT is achieved? – Lab Based IOT

Why Lab based IOT?
- Test in a controlled environment
- Allow testing of new technologies (Rel 8/9/10…)
- Discover UE issues early and perform rectification
- Cost effective solution
Motivation of IOT: Growth of Mobile Manufacturers

Number of UE manufacturers have grown tremendously in the past 10 years
Motivation of IOT: Growth of Mobile Manufacturers

Increasing sales of Smart Phones/Handy Pads
- Handy Pads are usually a handheld tablet (expanded smartphone: example: Ipad/Galaxy tab)
- Smartphones and Handy Pads sales will outsell conventional PC by next year

Observation by Operators:
- Might not be able to provide required data for subscribers due to increasing smartphone/device sales
- Both local and Overseas subscribers are hogging their network
- Operators putting on “Data cap” on subscriber mobile plan
Motivation of IOT: Network Implementation changes

- Operator need to deal with multiple technology growth (HSPA, HSPA+, LTE)
- InterRAT handover between different technologies (GSM=>UMTS/HSPA=>LTE)
- Network/Mobility management due to different implementation
Lab based IOT
CMW500 – IOT (Signaling Protocol Performance)

Basic Features/Functions
- Production Test
- RF Test (Callbox)
- Protocol Conformance Test (GCF Protocol conformance)
- Interoperability Test (IOT) – (Operator Specific)

Objective of IOT test system
- Design Operator specific test plan
- Network simulation will analyze UE signaling state
- Record potential signaling impact of device
- Analyze if applications run on the real-life mobile network.

Target Customers
- Chipset Design/R&D
- Mobile Manufacturers
- Network Operators
Data Throughput Measurements
- This setup can be extended to consider fading simulation
- Ability to simulate mobile network environment in an even more realistic fashion
- Mobile applications can be tested by connecting the system to internal or external data servers
- Data Throughput measurements are therefore possible
- Using a network simulator, different smart devices can be evaluated and their behavior in terms of signaling measured as part of comprehensive device performance or comparison tests.

Target Customer
- Manufactures
- Test House
- Network Operators
Performance Quality Analysis (PQA)
Why Throughput testing is important

- HSPA/HSPA+/LTE network promises high data rate
- Revenue comes mainly from data instead of circuit services like SMS
- Voice over IP will be commonly used in LTE network (VoLTE)
- Next wave will be “Video over LTE”
- Throughput testing provides confidence to UE & Chipset manufacturer (during R&D stage)
- Throughput testing based on network operators environment adds confidence to network operators
Why does Lab Performance Testing makes sense?
Example: Throughput Comparison of two Mobiles

UE#1:
- UE is perfectly able to cope with specific radio environment

UE#2:
- UE starts with higher data rate than UE#1 but looses connection and goes out of sync under same RF conditions.

LAB controlled KPI tests are an important quality gateway
CMW-PQA: Throughput

Supported Parameters and Services

- Network and cell parameters
- Call parameter
- Powers
  - lor, lor/loc (S/N), Power Sweep
- Fading
  - All 3GPP fading profiles are supported
  - User defined fading profiles (future release)
- Data Sources
  - IPERF, FTP, HTTP, PING
  - External data applications (Only on external PC)
Testing R&S IOT Packages
## Operator IOT Testing - Summary

<table>
<thead>
<tr>
<th>Operator</th>
<th>Key Features</th>
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</thead>
</table>
| **at&t** | - WCDMA: +500 test case for WCDMA, HSDPA, HSUPA, HSPA+  
- LTE: +230 test case for basic procedures, LTE mobility, iRAT, CSFB  
  data throughput and suppl. RF test cases |
| **verizon** | - Full provider for LTE testing  
- Suppl. RF test cases  
- LTE protocol tests (Data Retry, Suppl. Signaling)  
- IMS (basic procedures, SMS over IMS, VoLTE) |
| **Sprint** | - Suppl. RF test testing based on Sprint RCT Supplemental RF Test Plan  
- LTE & 1xEVDO Data Throughput tests  
- InterRAT protocol tests |
| **U.S. Cellular** | - Suppl. RF test cases  
- 15 TC based on U.S. Cellular LTE Compliance Test Plan  
- Support of FDD Band 2, 4, 5 & 12 |
Operator IOT Testing - Summary

- In cooperation with R&S +230 3G/HSPA+ test cases have been specified
- First test cases will be released in Q3/2012
- Protocol testing incl. Cell Selection, InterRAT and 3G functional tests
- Performance testing (Data Throughput) - Planned

- Approx 100 TCs specified
- LTE (Basic Procedures, QoS, Intra LTE Mobility, multiple PDNs)
- eHRPD (Basic Procedures, eHRPD – LTE Mobility)
- e1xCSFB (mobile originated/terminated, mobile capability)
Deutsche Telekom uses PQA for LTE data throughput testing
Agreement with R&S to implement LTE protocol test cases
Test case requirements are under discussion

Approx 630 TCs specified
LTE (Cell Barred, Reselection, HO re-direction, etc)
UMTS (Cell Barred, Handover, SMS, Tx diversity, etc)
Emergency Call (SUPL, AGPS)
Customer References & Still growing....
Our Statement – Moving a step forward

Our Statement

I  IOT Test is essential to help ensure device performance and subscribers satisfaction
I  Time & cost to bring HSPA/LTE devices to market with traditional methods is excessive as HSPA/LTE mobile devices are becoming more complex
I  PQA ensures reliable throughput performance to the operators and subscribers

Solution

I  A “Tailor-made” test standard process to certify HSPA/LTE mobile devices to work in your network environment!
VoLTE and IMS Application

Stone Lin
Assistant Manager
Wireless Terminal
Contents

Basics
- IMS IP Multimedia Subsystem
- SIP Session Initiation Protocol
- CMW500 - Data Application Unit

VoLTE Test Concepts
- Principle of PESQ Measurements – POLQA enhancements
- Functional Test
- Audio Quality Analysis
- Performance Quality Analysis
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Introduction IMS – IP Multimedia Subsystem

Definition

- IMS (IP multimedia subsystem) itself is not a technology, it is an architecture
- IMS is an all-IP service layer between transport and application layer based on common Internet protocols
- IMS architecture enables the connection to networks using multiple mobile and fixed devices and technologies
- IMS defines an architecture for the convergence of audio, video and data to enable integrated Multimedia Sessions over fixed and wireless networks
Introduction IMS – IP Multimedia Subsystem

Definition

- IMS is based on Internet standards which is the major way to deliver services on new networks
  - SMS over IMS
  - Voice over IMS
  - Video over IMS

- IMS aims to support
  - Quality of Service (QoS) mechanisms
  - Roaming
  - Inter-working with Internet and CS networks
  - Rapid service creation with or without standardisation

- One of the key enablers for the architecture is the Session Initiation Protocol (SIP)
Introduction IMS – IP Multimedia Subsystem

**Definition**

IMS is a global access-independent and standard-based IP connectivity and service control architecture that enables various types of multimedia services to end-users using common Internet-based protocols.

**Services:**
- SMS over IMS
- Voice over IMS
- Video over IMS
SIP - Session Initiation Protocol

Key functions

- SIP is used in many applications and has been adopted as the signaling protocol for use with Voice over IP (VoIP).

- The SIP protocol can be used for creating, modifying and terminating two-party (unicast) or multiparty (multicast) sessions.

- SIP is supported by practically every manufacturer of IP Phones, Gateways, Call Manager and is used for VoLTE (Voice over LTE).

- SIP is part of the IP Multimedia Subsystem (IMS).
SIP - Session Initiation Protocol

Key functions

- **User location and name translation**
  Enables data to reach a party regardless of location. To achieve this, **Session Initiation Protocol addresses** are used.
  - similar to email addresses, having elements such as a domain name and a user name or phone number.

- **Feature negotiation**
  Different mobiles may have different features that are supported; it is necessary that both ends communicate in a way that both can support. For that the **Session Description Protocol** is used to negotiate the required settings.
  - e.g. codec negotiation

- **Participant management**
  Sessions need to be managed to enable users to enter or leave sessions.
SIP - Session Initiation Protocol

Example

A typical SIP session diagram of a call:

Typical SIP session's diagram:

1. USER 1 generates an INVITE request, which is sent to the proxy at USER 2.
   The INVITE message contains: Session Description Protocol (SDP) parameters: type of media, codec to use and the protocol for transporting the media.

2. USER 2 acceptance is sent back through the proxy to USER 1. The acceptance includes SDP parameters defining the selected media offered.

3. USER 1 responds to the acceptance with an ACK (acknowledgement) directly to USER 2, telling it is ready to start the call.

4. Media Session is hold

5. At the end of the conversation, USER 2 hangs up and a BYE message is send directly to USER 1. USER 1 responds with a 200-OK message directly to USER 2, and ends the session.
VoLTE – Voice over LTE
From IMS to VoLTE

| IMSstandardization laid the ground work with an all-over-IP service network architecture already in 3GPP Rel5 |
| Network roll-out hampered by “IMS complexity trap” |

| One Voice Industry Initiative specified a particular profile for voice & SMS over IMS to reduce complexity and specify a minimum feature set |
| Includes Single Radio Voice Call Continuity (SRVCC) |

| GSMA VoLTE Initiative has adopted One Voice specification |
| Focus on entire end-to-end voice and SMS service and emphasize on Roaming and Interconnect Interfaces |
| Promoting CSFB as gap filler until SRVCC is available |
| Now industry standard also promoted by NGMN Alliance |
| R&S is planning to provide a complete test solution for VoLTE |
CMW500 – Data Application Unit
The easy way to VoLTE

CMW500 integrated server:
- IP scenarios (IPv4 and IPv6)
  - CMW500 standalone mode
  - Static IP configuration
  - Company LAN scenario
- Integrated IMS Server
  - establish Voice or Video Call
  - SMS over IMS
- IP Impairments
  - Delay
  - Jitter
  - Packet losses
- IP Logging
  - Tracking SIP Communication
  - Tracking IP Traffic
CMW500 integrated IMS Server
Data Application Unit
CMW500 integrated IMS Server
Data Application Unit

- IMS solution:
  - An IMS solution integrated on the DAU in CMW500 available with V3.0.10
  - DAU solution supports IMS registration and SMS over IMS (and VoLTE* )
  - Release planned in 3.0.20 firmware

- Required Options for IMS Server
  KAA20 (IMS Basic) with KA100 (IPv4), KA150 (IPv6)
  via Data Application Unit (B450A)

*Beta available
CMW500 IP Logging
Data Application Unit

- **IP Logging**
  - Tracking SIP Communication
  - Tracking IP Traffic

- **WireShark**
  - For analysis of the IP and SIP communication
CMW500 Network Impairment Data Application Unit

Emulate characteristics of a real network

- Impairments:
  - Delay
  - Jitter
  - Packet Loss
  - Packet Corruption
  - Packet Duplication
  - Packet Re-ordering

NOTE: Network Impairment are only available for traffic going out of the DAU
CMW500 Network Impairment Features
Data Application Unit

- UP to 7 different Impairment per DAM possible
- Impairments are identified by a filter rule
  - IPv4 address filter
  - IPv6 address/prefix filter
  - Additionally an optional TCP/UDP Port filter
- Feedback provided when error occurs
Contents

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- SIP Session Initiation Protocol
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VoLTE Test Concepts
- Principle of PESQ Measurements – POLQA enhancements
- Functional Test
- Audio Quality Analysis
- Performance Quality Analysis
VoLTE: Different test setups for different test purposes
Different test setups for different test purposes

To verify features under ideal conditions
- Verify LTE attach sequence
- Verify IMS registration
  - „Is the UE able to register to the IMS Server?“
- Verify Session Initiation Protocol (SIP) to establish voice communication
  - „Is the UE able to make a VoLTE call?“
- Verify the basic Audio functionality by basic echo verification in loopback mode

- Test setup:
  - CMW 500 + PC Workstation
Functional Test: IMS Terminal Testing

Protocol Tester Setup

PC Workstation

IMS Server Simulation and Test Cases

Automation Manager

Serving Scenario

CMW Protocol Tester
Functional Test: IMS Terminal Testing Solution
Use Case: IMS Testing

When the scope of testing is IMS

- Test purpose:
  - SIP header & signalling
  - IMS registration & authentication
  - VoLTE signaling
  - SMS signaling
Functional Test: IMS Testing Solution
Use Case: IMS as a Service

When the scope of testing is not IMS but IMS is a service required to achieve the test purpose

- Required for several Test Plans
- Seamless integration with MLAPI
- IMS Registration
- SMS and VoLTE MO/MT
# IMS and VoLTE – Voice over LTE

## R&S Test Solutions - Overview

<table>
<thead>
<tr>
<th>Conformance</th>
<th>Operator specific Verizon Wireless</th>
<th>Operator specific at&amp;t</th>
<th>R&amp;D</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMW-KAC11: SMS</td>
<td>CMW-KAF70: SMS over IMS Multimode</td>
<td></td>
<td>SMS</td>
</tr>
<tr>
<td>CMW-KAC10: MTSI</td>
<td>CMW-KAF73: IMS VoIP</td>
<td></td>
<td>VoLTE (Audio/Video)</td>
</tr>
<tr>
<td>CMW-KAC14: Emergency</td>
<td>CMW-KAF74: RCS/Video</td>
<td></td>
<td>SRVCC</td>
</tr>
<tr>
<td>CMW-KAC15: RCS-e</td>
<td>CMW-KAF75 IMS Retry LTE</td>
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<td>Emergency</td>
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<tr>
<td></td>
<td>CMW-KAF76 IMS Retry MM</td>
<td></td>
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</table>
## Functional test – IMS

Conformance Test Solutions - Overview

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>GCF WI</th>
</tr>
</thead>
</table>
| CMW-KAC13: IMS-CC | IMS Call Control  
|               | Testing P-CSCF discovery, registration and authentication                      | WI31     |
| CMW-KAC11: IMS-SMS | SMS over IMS  
|               | Mobile terminated & mobile originated SMS                                    | WI128    |
| CMW-KAC10: MTSI  | Multimedia Telephony Services for IMS  
|               | SIP session handling and supplementary services                              | WI103    |
| CMW-KAC14: Emergency | Emergency Calls in IMS  
|               | release planned Q4/2012                                                       | WI tbd   |
| CMW-KAC15: RCS-e | GSMA based protocol conformance test cases  
|               | release planned Q1/2013                                                       | WI tbd   |
Different test setups for different test purposes

- Analysis of the Audio Quality
- Verification of the audio quality with established mechanisms like PESQ*
- „What is the audio quality of the VoLTE call a UE can perform?“
- Test setup: + UPV Audio Analyzer

- Acoustic analysis of the signal according to 3GPP TS 26.132 Release 10
- Test setup: + Sound isolated chamber, artificial mouth and artificial ear are needed

*PESQ = Perceptual evaluation of speech quality
CMW500 Basic Speech Verification
Basic test setup using loopback mode

- CMW500 Protocol Tester (PT) or CMW500 Call Box (CB) establishes IMS connection to UE
- UE establishes a VoLTE call with virtual CMW500 phone
- User talks in the UE and IMS media entity on top of CMW500 echoes back

Test focus:
- User analyzes the echo qualitatively
- Verification of uplink and downlink communication
- IP and SIP communication analysis
- Influence of IP impairments
Audio Quality Test:
Test concept for IMS and VoLTE

- Test concepts outlined in this presentation are based on:
  - The R&S®CMW500 Radio Communication Tester acting as LTE network emulator with IMS protocol support
  - The R&S®UPV Audio Analyzer supporting the PESQ and POLQA algorithms

PESQ = Perceptual evaluation of speech quality
POLQA = Perceptual Objective Listening Quality Analysis
Audio Quality Test:
 Principle of PESQ measurements

- PESQ (Perceptual Evaluation of Speech Quality) is an established mechanism for speech quality measurements.
- It rates speech quality scale from -0.5 (bad) to 4.5 (excellent).
- PESQ is supported by the R&S® UPV Audio Analyzer.
Perceptual Objective Listening Quality Analysis (POLQA)

- Standardized in ITU-T P.863.
- Successor of PESQ (ITU-T P.862).
- Compared to PESQ, POLQA is designed for the following additional test applications:
  - Super Wideband (SWB) mode: 50 Hz ~ 14000 Hz
  - Terminal testing, influence of the acoustical path and the transducer in sending and receiving direction.
    (NOTE – Acoustical path in receiving direction only for SWB mode.)
  - Bandwidth extensions
  - Voice Activity Detection (VAD), Automatic Gain Control (AGC)
  - Voice Enhancement Devices (VED), Noise Reduction (NR)
  - Discontinuous Transmission (DTX), Comfort Noise Insertion
- POLQA is supported by the R&S®UPV Audio Analyzer (Option UPV-K63)
Audio Quality Test:

- Application note 1MA204 describes how to test Voice over LTE Speech Quality Measurement.

- The measurements are based on recommendations ITU-T P.862 and ITU-T P.863.

- Automatic measurement by CMWrun software.

- www.rohdeschwarz.com/file/1MA204_1e.pdf
Step : Audio Quality Analysis
Integrated IMS with separate DL/UL Analysis - Downlink

- CMW500 PT or CB establishes IMS connection to UE
- Downlink verification: PESQ/POLQA sequence from UPV is digitized (USB soundcard) and provided to CMW500; CMW500 provides VoIP data in downlink to UE; audio received by UE is analyzed by UPV
- Test focus:
  - UPV analyzes the audio according to PESQ
  - Acoustic tests according to 3GPP TS 26.132
  - Verification of downlink only

*Media Server functionality:
- Coding digital speech data (e.g. AMR WB)
- Packaging speech data into RTP
Step : Audio Quality Analysis
Integrated IMS with separate DL/UL Analysis - Uplink

- CMW500 PT or CB tester establishes IMS connection to UE
- Uplink verification: PESQ/POLQA sequence from UPV is provided to UE and sent in uplink to CMW500; received VoIP data is converted to analog (USB soundcard) and analyzed in UPV
- Test focus:
  - UPV analyzes the audio according to PESQ
  - Acoustic tests according to 3GPP TS 26.132
  - Verification of uplink only

*Media Server functionality:
- De-packaging speech data from RTP
- De-Coding digital speech data (e.g. AMR WB)
Step: VoLTE Acoustic measurements
Integrated IMS with separate DL/UL Analysis and artificial Head

- CMW500 PT or CB tester establishes IMS connection to UE
- DL or UL verification: 3GPP defined tests performed by UPV using an artificial head
- Test focus:
  - Acoustic tests according to 3GPP TS 26.132
  - Verification of uplink or downlink

*Media Server functionality:
- De-packaging speech data from RTP
- De-Coding digital speech data (e.g. AMR WB)
Final Test Setup for VoLTE Acoustic measurements
Integrated IMS, integrated Audio Board for separate DL/UL Analysis

- CMW500 PT or CB tester establishes IMS connection to UE
- DL or UL verification: 3GPP defined tests performed by UPV using an artificial head
- Test focus:
  - Acoustic tests according to 3GPP TS 26.132
  - Verification of uplink or downlink

Integrated Audioboard

IMS server
Audio Codecs
RF

To DL
From UL

From loudspeaker
to microphone

DL
UL

PESQ/POLQA analysis
VoLTE Speech Quality Measurement with R&S®CMWrun*

*under development

ROHDE & SCHWARZ
Different test setups for different test purposes

- Impact of noise, fading, IP traffic impairment on audio quality
- „How well does the UE cope with IP traffic impairments?“
- „How does fading influence the audio quality of a VoLTE call?“
- Test setup: CMW + UPV audio analyzer + AMU
- Automation available by CMW-PQA for PT or CMWrun for CB environment
CMW-PQA for VoLTE Performance Testing

- Comprises of BS simulator CMW500 + AMU200 fading simulator
- State of the art GUI based on RS CONTEST
- Flexible configuration of throughput and call performance tests
- Fully automated test system
- Powerful graphical logging and reporting tools
Step: VoLTE Performance Testing – Integrated IMS for separate DL/UL Analysis

- CMW500 PT or CB tester establishes IMS connection to UE
- DL or UL verification: 3GPP defined tests performed by UPV
- Test focus:
  - Acoustic tests according to 3GPP TS 26.132
  - Verification of uplink or downlink
  - Verification under non-ideal conditions
    - Fading
    - IP-Impairments
      - Delay
      - Packet losses
Final Test Setup: VoLTE Performance testing
Integrated IMS, integrated Audio Board for separate DL/UL Analysis

- CMW500 PT or CB tester establishes IMS connection to UE
- DL or UL verification: 3GPP defined tests performed by UPV
- Test focus:
  - Acoustic tests according to 3GPP TS 26.132
  - Verification of uplink or downlink
  - Verification under non-ideal conditions
    - Fading
    - IP-Impairments
    - Delay
    - Packet Losses
Different test setups for different test purposes

- **Functional Testing**
  - To verify protocol and features under ideal conditions
  - Test setup: CMW 500 + PC Workstation

- **Audio Quality Analysis and Acoustic Analysis**
  - Analysis of the signal through comparison of reference signal with received signal
  - Test setup: CMW 500 + UPV
  - Acoustic analysis of the signal
  - Test setup: Sound isolated chamber, artificial mouth and artificial ear are needed

- **Performance Testing**
  - Impact of noise, fading, IP impairments on audio quality
  - CMW500 + UPV + AMU200
Thank you for your attention!