Application Note

2-cell Test Environment

MD8475A

Signalling Tester

1. Background to LTE Rollout

Mobile phones appearing in the late 1980s soon experienced rapid evolution of functions from 1990 to 2000 and also spread worldwide as key communications infrastructure. The mobile phone is not limited to just two-way communications between two people but also supports sending and receiving of Short Message Services (SMS), web browsing using the Internet, application and video download, etc., and has become a popular and key cultural tool supporting a fuller lifestyle for many people.

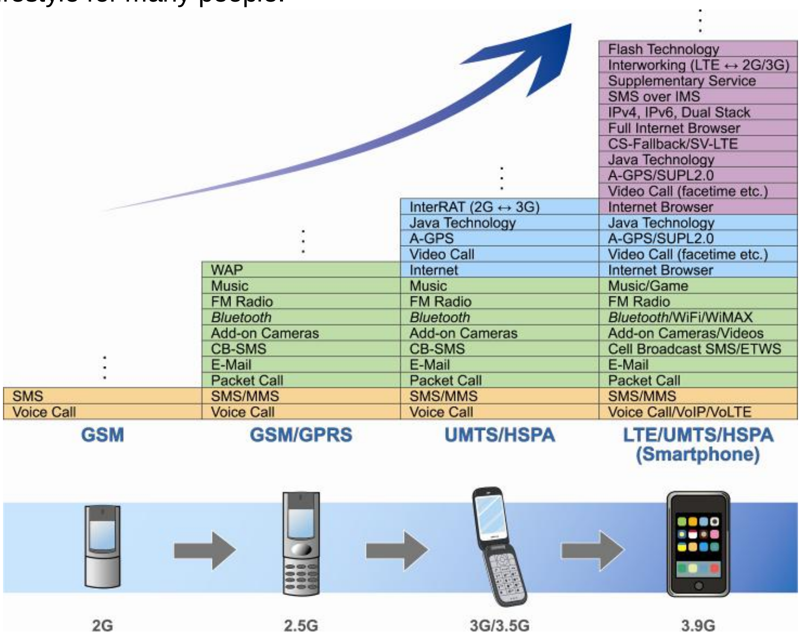

Figure 1. Evolution on UE

According to one research company, total mobile phone (terminal) shipments at the end of 2010 were valued at $38 billion split between 45% for 2G phones and 49% for 3G.

Table 1. Mobile Terminal Shipments

	Mobile Terminal Shipments ($38 billion total)
LTE	1.3%
WiMAX	4.0%
W-CDMA	40.0%
CDMA	9.3%
GSM	45.4%

The purpose of the shift from 2G to 3G systems was to make more efficient use of frequency bandwidths and was closely related to the explosive growth of the Internet. While still maintaining the easy portability of a mobile phone, users were able to access the information they needed easily at any time and place using the Internet.
Similarly to growth of 3G technology, the requirements of LTE systems, which is are positioned in the market as 3.9G to maintain competitiveness with coming 4G systems, are being examined. Connectivity with IP-based core networks must be maintained to support multimedia applications and ubiquitous networks using the packet domain. A key network design feature is assuring high data-rate throughputs at 100 Mbps as well as low latency. Users expect to be able to use wireless IP communications at similar data throughputs to wired xDSL networks, so achieving download speeds of 100 Mbps via LTE technology will play a pivotal role in the user experience.

2. Communication Infrastructure at LTE Introduction

The first LTE services were rolled out in 2010 followed by service expansion in N. America and Asia. The regional operators are rapidly expanding service areas supporting LTE by installing base stations that can handle LTE. However, increasing the coverage to 100% requires massive infrastructure investment and there is a limit to the speed at which this support can be achieved.

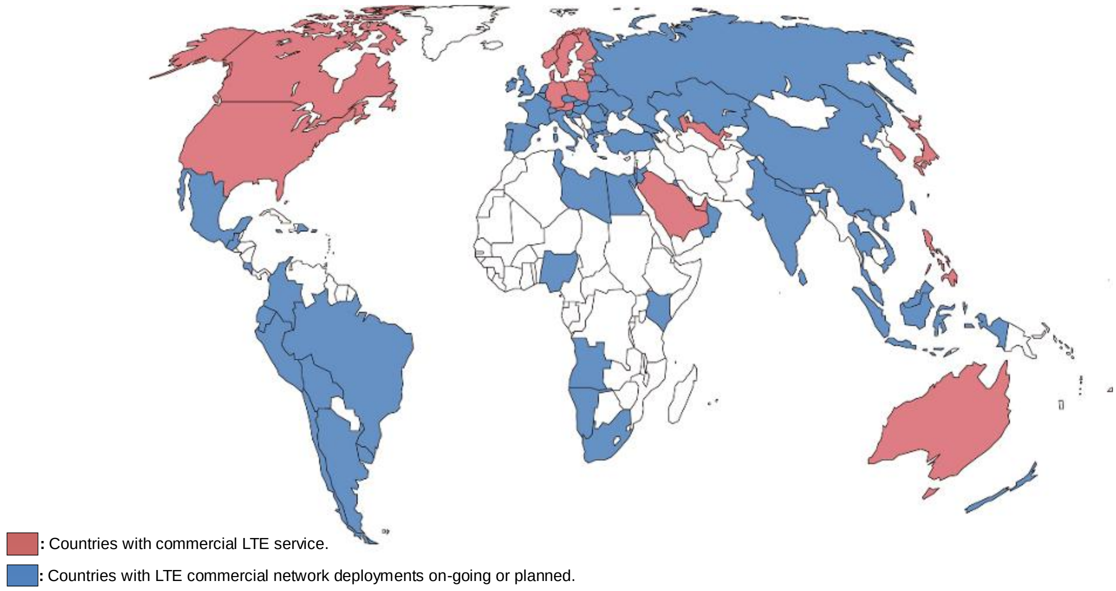

Figure 2. LTE Service Coverage

On the other hand, users think high-speed mobile services are very important and, based on this idea, the connection between the terminal and the network is most important in mobile communications. Consequently, at LTE rollout, not only must the mobile terminal connect to LTE services, it is also necessary to assure compatibility with existing 3G and 2G services enjoyed by nearly all the world and especially the G8 countries. In other words, it is necessary to provide maximum download throughput speeds of 100 Mbps within LTE service areas as well as automatic switching to 3G services outside LTE service areas.

Table 2. LTE System Requirements (extract from 3GPP TS 25.913)

Item		Contents
VSpectrum	Bandwidth	1.4, 3, 3.2, 5, 10, 15, 20 MHz
	Duplex	FDD and TDD support
Switching mode		Only packet switching mode
Through put (max.)		Download: 100 Mbps, Upload: 50 Mbps (Cat. 3)

However, LTE systems do not support the circuit switching currently used by wireless cell systems. The Evolved Packet Core (EPC) technology used by next-generation mobile core networks is an IP-based technology offering seamless transparent mobility control for the different bearers of mobile users that supports multiple wireless access networks including not only 3G and LTE but also wireless LAN. In other words, voice communications supported by circuit switching up to 3G will be replaced by VoLTE (Voice over LTE). Offering voice communications using VoLTE will require core networks to use an IMS Server (IP Multimedia Subsystem Server) configuration. However, since the above-described IMS Server configuration will require large investment costs in network infrastructure at introduction, rollout of voice communications using VoLTE will be done in stages. In concrete terms, 3G circuit switching technology will be used at the same time. Due to the difference between LTE and shared 2G/3G systems as well as the differences in services offered by operators, it will be necessary to use CS Fallback and various technologies such as SV-LTE, SR-VCC, etc. By using these technologies, it will be possible to receive voice calls at mobiles while connected over LTE. In particular, the CS Fallback function is an especially important test item at introduction of LTE terminals.

3. 2-cell Tests Required for UE R&D

As touched upon earlier, mobile terminal mobility connectivity tests at LTE introduction are split into different types, including bearer types. This section explains mobile terminal cell selection first. Next, it explains the relationship between LTE and 2G/3G circuit switching technologies. As mentioned earlier, LTE voice communications use VoLTE, creating a necessity for control using network infrastructure at LTE introduction.

Cell Selection Technology

- **Selection**

  The mobile terminal sweeps all channels in the supported frequency band to select the cell on which to camp. This operation is performed at mobile power-on. In addition, the selected cell is determined by the strength of the signal received from the base station and a cell selection algorithm in the mobile.

- **Reselection**

  Reselection is the process when a mobile camping on one cell moves to camp on another cell with a better download signal quality from the base station. When the mobile is idling (waiting to receive), it moves from the original camping cell to another cell. This operation is directed by the mobile terminal.

- **Redirection**

  Redirection is performed when an LTE mobile terminal leaves a cell covered by LTE while performing packet communications for example and enters a cell covered by W-CDMA. In this case, at the same time as entering the W-CDMA cell coverage, the terminal also changes to the W-CDMA idle state. Redirection is a type of handover; the LTE communications are cut immediately after the network receives the handover message. The specified W-CDMA cell search is executed to perform reconnection. However, this Redirection operation is directed by the network using the Measurement Report function such as the reception level notified by the mobile terminal to the base station.

- **Active Handover**

  Active Handover is performed when an LTE mobile terminal leaves a cell covered by LTE while performing packet communications for example and enters a cell covered by W-CDMA. The difference from Redirection is that the packet communications are maintained and the idling state is not entered when the terminal enters the W-CDMA cell coverage. Similar to Redirection, it is directed by the network using the Measurement Report function.

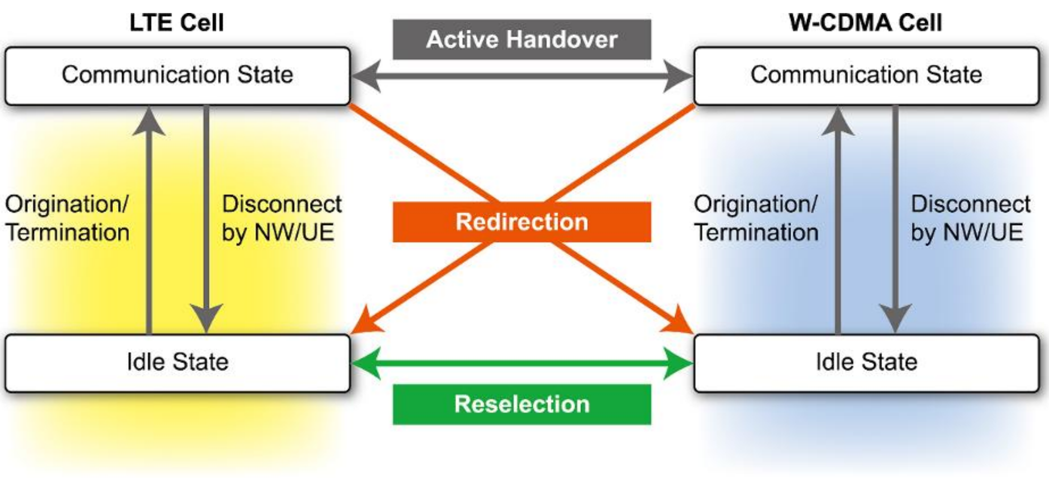

Figure 3. Case of UE Connection Cell in LTE and W-CDMA

Technology Linked with 2G/3G System Circuit Switching

- **CS Fallback**

  With LTE cells, when a mobile terminal is connected to and communicating with a packet-switched network, sometimes an incoming call is received from the mobile network side via a 2G or 3G switching circuit but it is not possible to notify the mobile about the incoming call because it is connected to the LTE packet-switching network. Although mobiles have evolved as key tools offering a variety of services, voice calls are still the most basic and important service and the importance of notifying the mobile terminal about an incoming call in some way is still paramount. CS Fallback is the technology for solving this problem.

  In concrete terms, when the mobile is connected to an LTE packet switching network and an incoming call arrives from a 2G or 3G network, the call is routed simultaneously to the LTE mobile from the circuit switching network via EPC (Evolved Packet Core). The mobile receiving this simultaneous call, recognizes the incoming call from the circuit switching network and switches to 2G or 3G circuit switching communications. The response of the mobile to this is to send by 2G or 3G circuit switching and then voice communications proceed as normal using the 2G or 3G circuit switching connection.

- **SV-LTE (Simultaneous Voice LTE)**

  SV-LTE is service between LTE and cdma2000. Mobiles with this function can connect simultaneously to LTE and cdma2000 cells. In other words, they can connect independently to a cdma2000 circuit switched network while connected using LTE to a packet switched network. However, since this technology operates both the baseband processing block and the RF TRx circuits simultaneously, the battery power drain is very high.

  When the mobile is connected to the LTE packet switching network and an incoming call arrives from the cdma2000 circuit switching network during packet communications, it can be notified about the incoming call because the mobile can send and receive two waves simultaneously.

- **SR-VCC (Single Radio Voice Call Continuity)**

  In this system, voice calls can be made by VoIP while in an LTE cell and if the mobile moves into a cell of the 2G/3G system while using VoIP, the voice call connection is maintained by performing Active Handover to the 2G/3G system. When moving between cells, the wireless communications switches from the LTE packet switching network to the 2G/3G system circuit switching network and the voice call remains connected. In addition, Handover can also be performed when a mobile connected to a 2G/3G system circuit switching network moves to an LTE packet switching network.

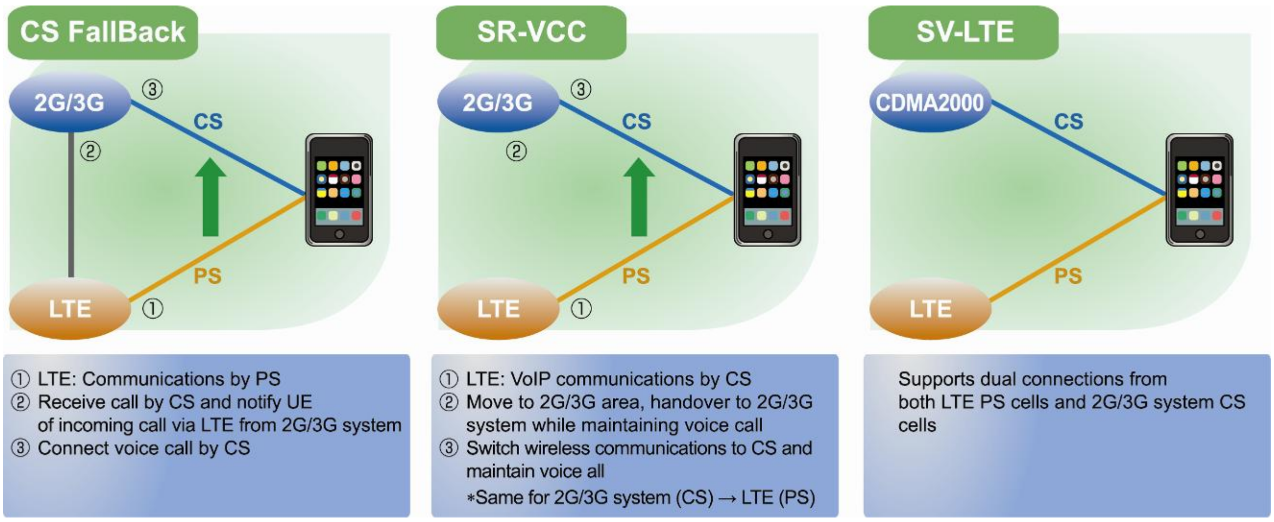

Figure 4. Technology Linked with 2G/3G System Circuit Switching

4. Anritsu Test Platform

Currently, nearly 100% of the world's population is covered by GSM 2G systems and W-CDMA or cdma2000 3G systems; 3.9G LTE leading to 4G seems likely to spread everywhere. Mobile users have high expectations and a mobility environment offering stress-free services using high data throughput communications is needed. Obviously voice communications are taken for granted and are a commonplace requirement under every circumstance. Consequently, mobile vendors require test equipment with functions for testing normal voice communications of multifunction mobile terminals.

Previously, it was necessary to edit scenarios defining the mobile operation in accordance with the 3GPP specifications prior to testing. Scenarios required for mobile function tests were created and tests were run while checking that the mobile operation was in accord with the scenario objectives. Objectively, this cannot be described as an efficient test environment.

This problem is solved instantly by installing SmartStudio™ in the Anritsu MD8475A.

Mobile terminals can be evaluated simply by using the SmartStudio™ GUI to set the required parameters and then pressing the Simulation Start button.

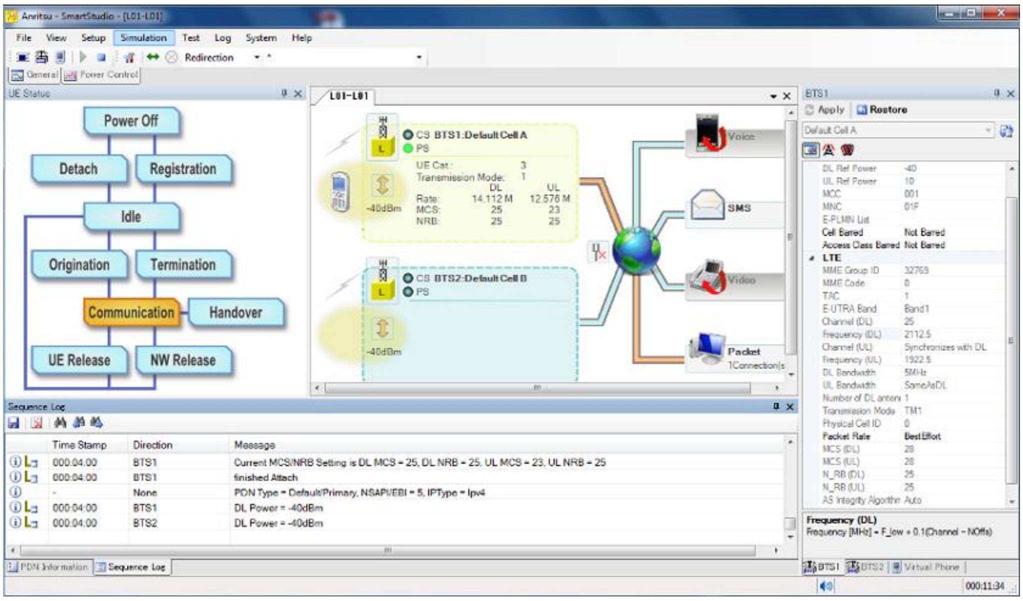

Figure 5. UE Connects to BTS1 (LTE)

Using this test platform supports function tests, such as cell selection and 2/3G system combinations without the need for scenarios and fewer execution operations.

The following pages explain:

- Redirection tests for LTE and W-CDMA systems
- CS Fallback tests for LTE and W-CDMA systems

◆ **Redirection Tests for LTE and W-CDMA Systems**

Set the mobile UE test environment.

Use the GUI to select the LTE and W-CDMA test simulation model.

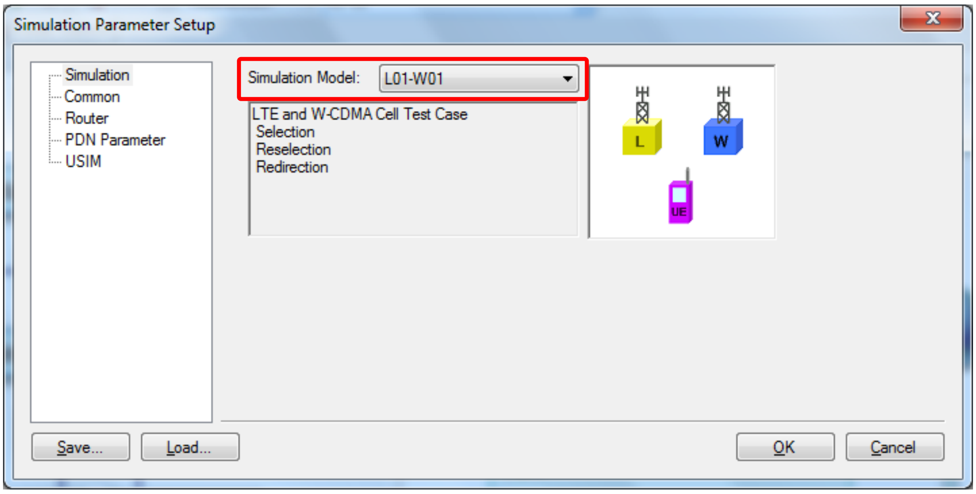

Figure 6. Simulation Parameter Setup (L-W Redirection)

Set the LTE and W-CDMA cells. Set BTS1 for LTE and BTS2 for W-CDMA. These settings depend on the test environment. An example is shown below.

Table 3. BTS1 parameters (EUTRA: LTE)

Parameters	BTS1 Example	Note
DL Ref Power	–40 dBm	(1)
UL Ref Power	10 dBm	(1)
TAC	1	
E-UTRA Band	Band1	(1)
Channel (DL)	25	(2)
Channel (UL)	Synchronized with DL	
DL Bandwidth	5 MHz	(2)
UL Bandwidth	Same as DL	

(1) Setting depends on UE specifications

(2) The channels of both cells should be separated by more than the bandwidth.

Bandwidth is a variable parameter for LTE and the value depends on the band setting. For Band1, it is listed as 5, 10, 15, and 20 MHz. On the other hand, the W-CDMA bandwidth value is fixed to 5 MHz.

Table 4. BTS2 parameters (UTRA: W-CDMA)

Parameters	BTS2 Example	Note
DL Ref Power	–40 dBm	(1)
UL Ref Power	–20 dBm	(1)
Band	Band I	(1)
NMO	NMO I (Combined)	(3)
Channel (DL)	10563	(2)
Channel (UL)	Synchronized with DL	(2)

(1) Setting depends on UE specifications

(2) The channels of both cells should be separated by more than the bandwidth.

Bandwidth is a variable parameter for LTE and the value depends on the band setting. For Band1, it is listed as 5, 10, 15, and 20 MHz. On the other hand, the W-CDMA bandwidth value is fixed to 5 MHz.

(3) NMO (Network Mode of Operation) should be set as NMO I (Combined).

Connect the MD8475A RF Main connector and a mobile terminal using an RF cable and press the “Simulation Start” icon at the SmartStudio™ main screen. The LTE mobile performs Registration and connects with the BTS1 LTE system to operate the mobile. As a result, the BTS1 LTE system communication state transitions to that shown in the following figure.

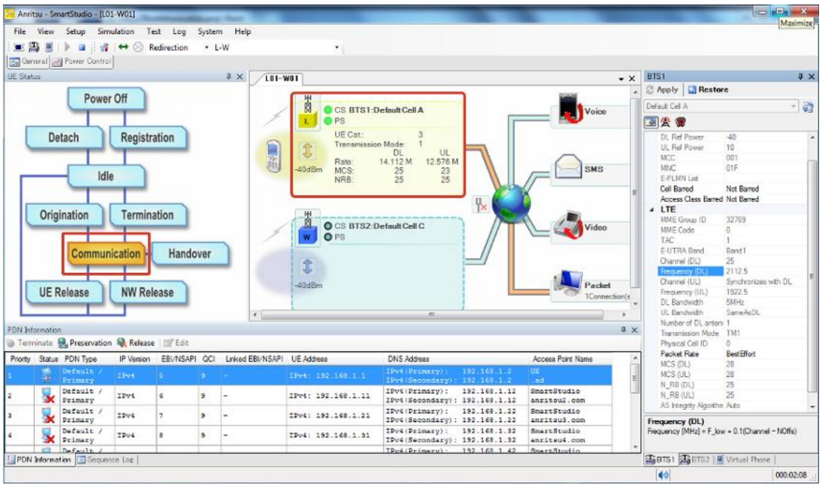

Figure 7. UE Connects to BTS1 (LTE)

To test Redirection to W-CDMA, which is BTS2, select the test case in the main screen as shown below.

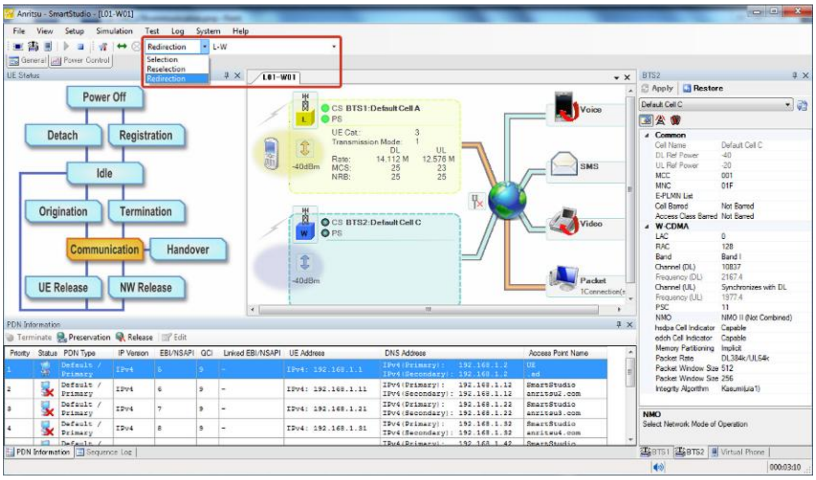

Figure 8. Set Redirection Test Mode

Then, press the “Start Test Case” button to execute the Redirection test.

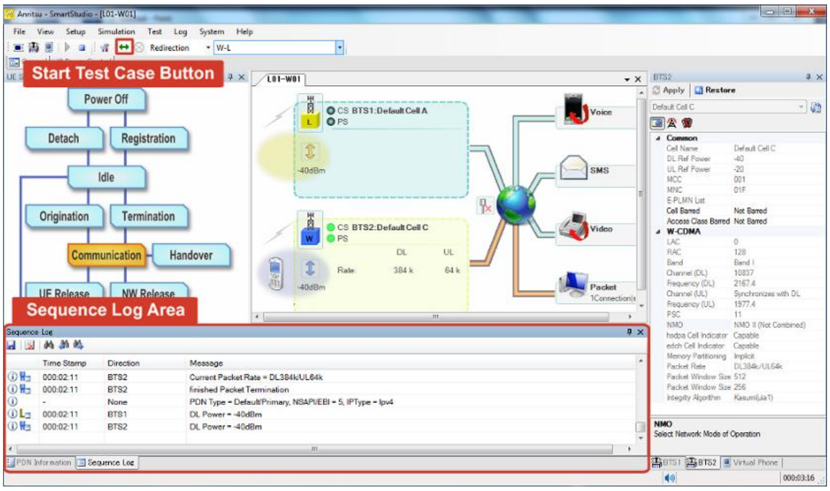

Figure 9. Set Redirection Mode

The Sequence Log Area displays the RF output level and PDN information set at the Test Case editing screen and the set Packet Rate information and Redirection operation can be monitored.

The LTE/W-CDMA Redirection follows the protocol sequence shown below and is explained according to the MD8475A Trace Log screen.

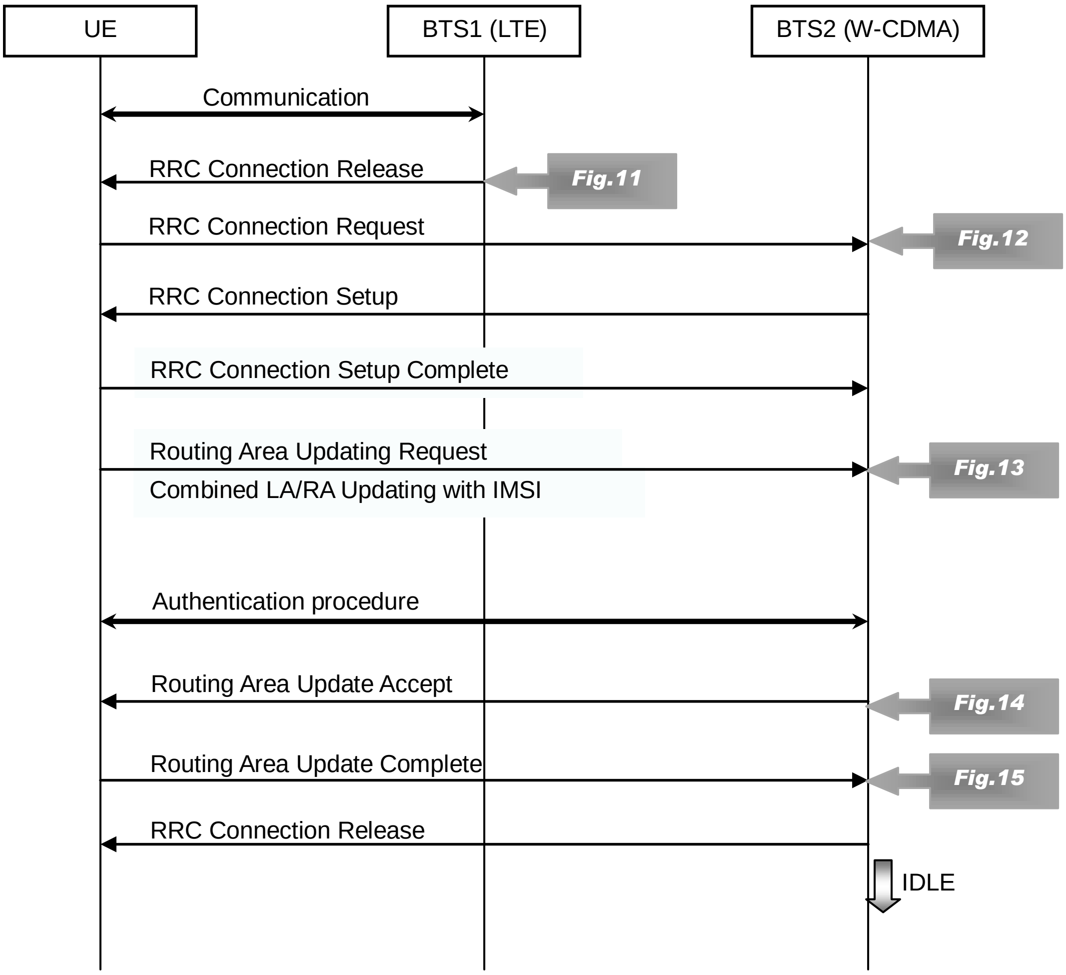

Figure 10. Protocol Sequence in LTE W-CDMA Rediection

<u>RRC Connection Release:</u>

First, to make the LTE connection, the MD8475A executes RRC Connection Release at the mobile.

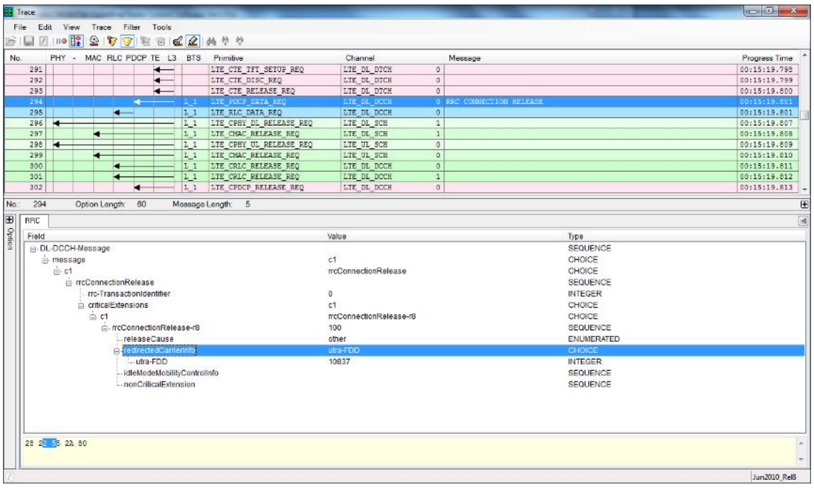

Figure 11. RRC Connection Release

RRC Connection Request:

Then, the mobile sends the RRC Connection Request to BTS2 operating as the W-CDMA cell after receiving RRC Connection Release.

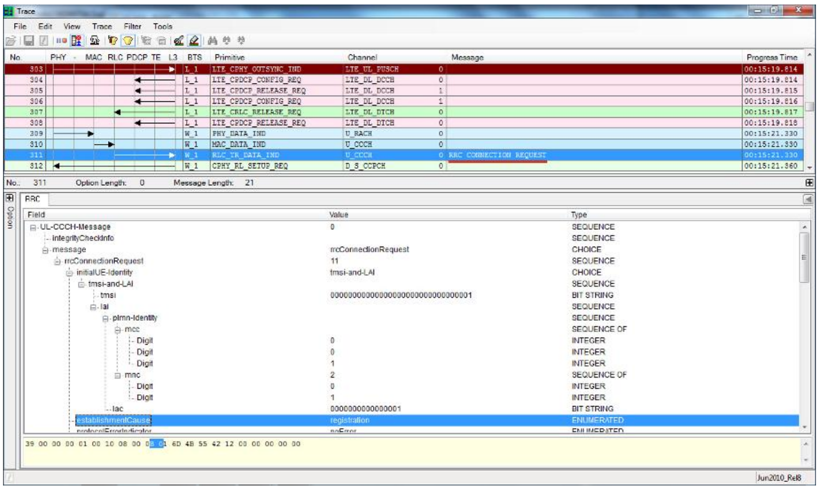

Figure 12. RRC Connection Request

Next, the W-CDMA cell and mobile execute the RRC Connection Setup message and when the mobile completes the processing, RRC Connection Complete is sent.

Routing Area Update Request:

Next, the mobile sends the Routing Area Update Request to the W-CDMA cell.

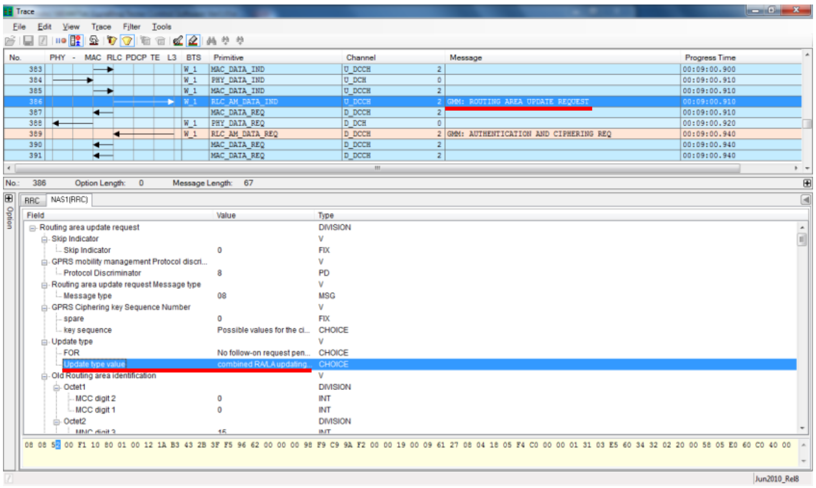

Figure 13. Routing Area Update Request

Routing Area Update Accept:

After the acceptance procedure between the mobile and W-CDMA cell is completed, Routing Area Update Accept is sent from the W-CDMA cell.

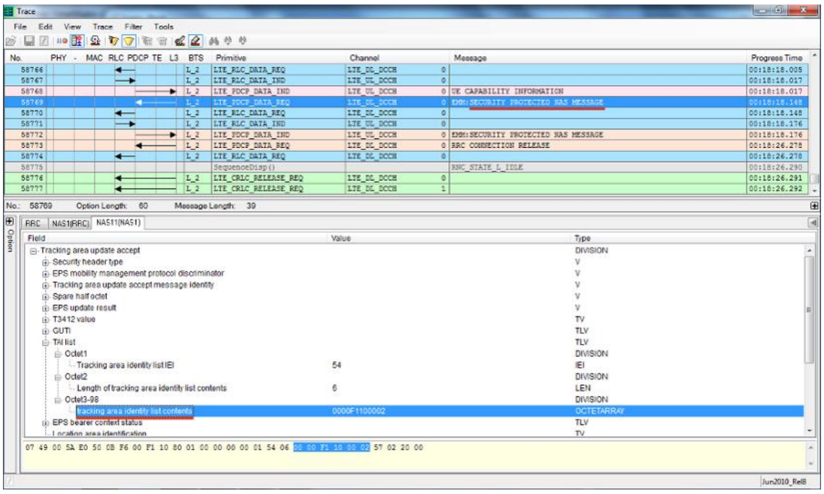

Figure 14. Routing Area Update Accept

Routing Area Update Complete:

The mobile that received Routing Area Update Accept sends Routing Area Update Complete to the W-CDMA cell to complete Redirection and establish W-CDMA cell communications.

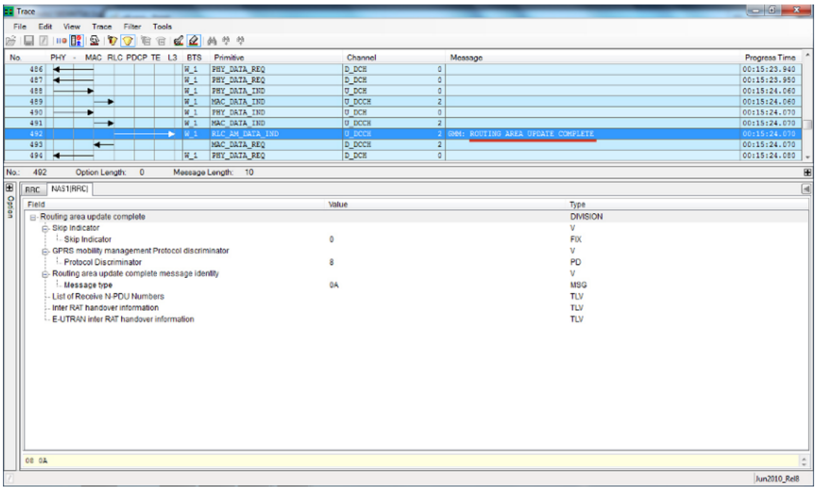

Figure 15. Routing Area Update Complete

◆ CS Fallback Tests for LTE and W-CDMA Systems

Like the above-described Redirection test, set the LTE and W-CDMA system simulation model using SmartStudio™.

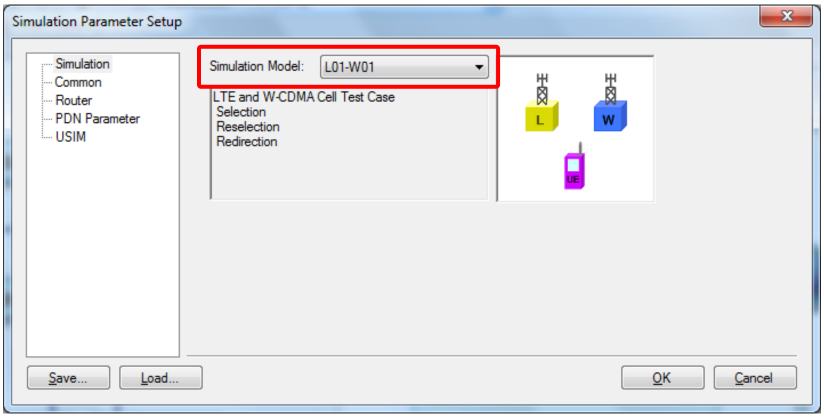

Figure 16. Simulation Parameter Setup

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(1) Setting depends on UE specifications
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(1) Setting depends on UE specifications
(2) The channels of both cells should be separated by more than the bandwidth.
Bandwidth is a variable parameter for LTE. It is listed as 5, 10, 15, and 20 MHz. On the other hand, the W-CDMA bandwidth value is fixed to 5 MHz.
(3) NMO (Network Mode of Operation) should be set as NMO I (Combined).

Connect the MD8475A RF Main connector and mobile terminal using an RF cable and press “Simulation Start” icon in the SmartStudio™ main screen. The LTE mobile performs Registration and connects with the BTS1 LTE system to operate the mobile. As a result, the BTS1 LTE system communication state transitions to that shown in the following figure.

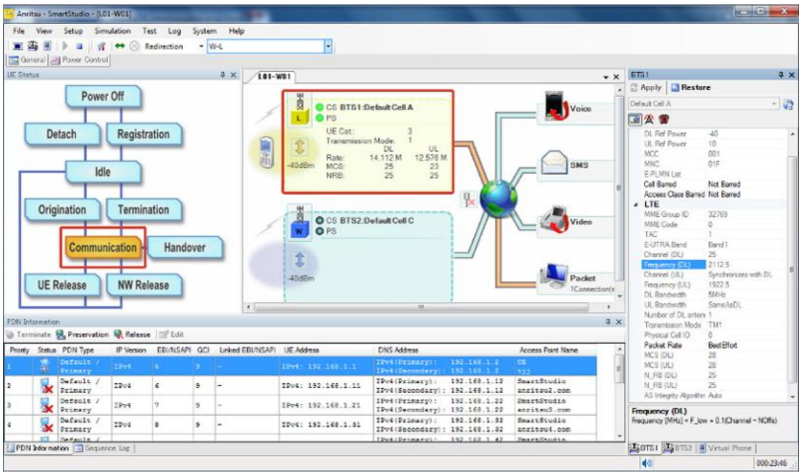

Figure 17. UE Connects to BTS1 (LTE)

With the mobile connected to the LTE system packet communications network, use Virtual Phone provided by the SmartStudio™ GUI to connect to the W-CDMA circuit switching network and make a voice call from the network side. Operate Virtual Phone on the SmartStudio™ main screen.

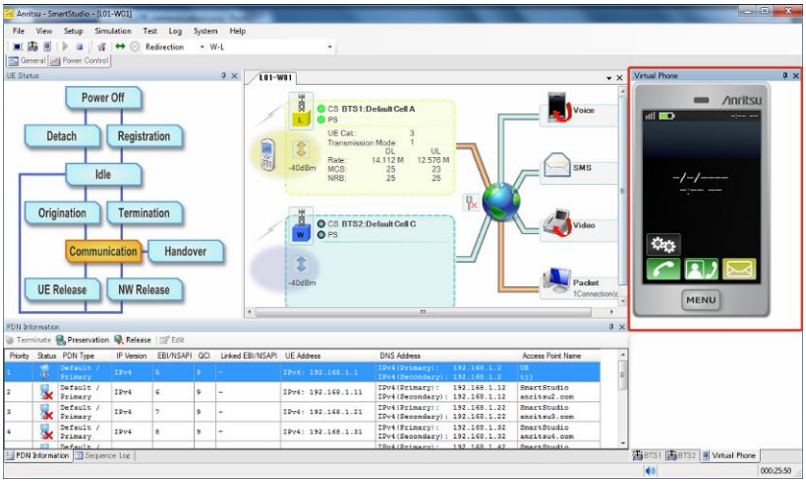

Figure 18. Open Virtual Phone

When the call is made from Virtual Phone, LTE system packet communications are temporarily cut and the LTE system transitions to the Idle state; to receive the call from the W-CDMA system circuit switching network the system transitions to the Registration, Idle, and Origination states and then to the Communication state to receive the incoming call at the mobile.

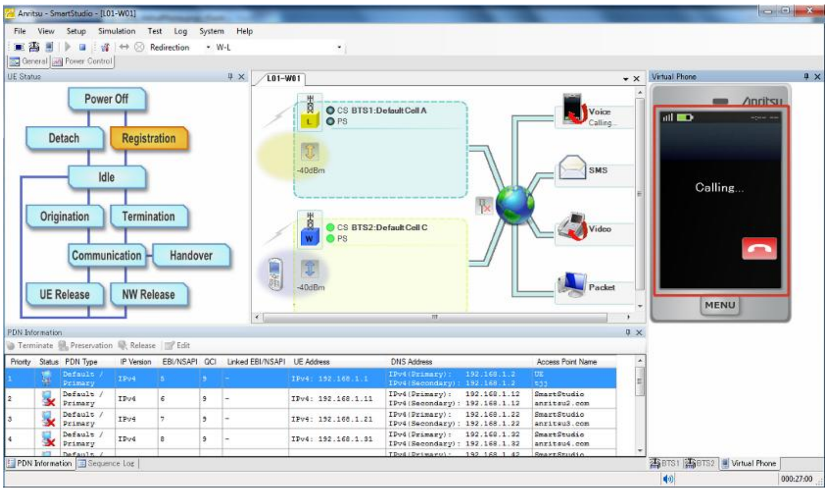

Figure 19. Calling Message in Virtual Phone

As a result, the CS Fallback operation for the LTE and W-CDMA systems is tested using the protocol sequence shown below.

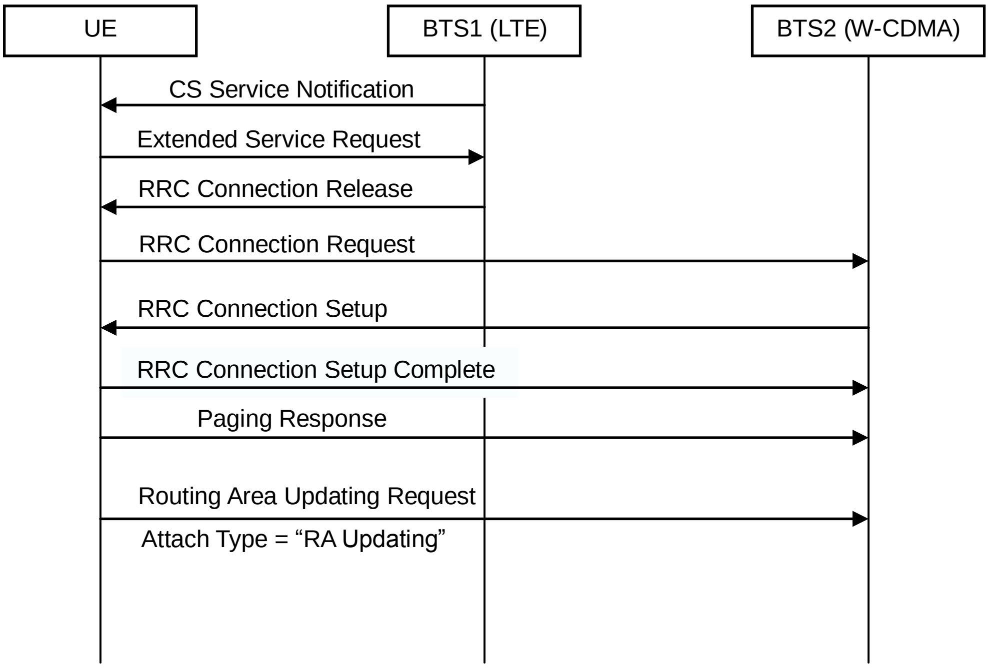

Figure 20. Protocol Sequence in LTE W-CDMA CS Fallback

5. Summary

This guide provides a simple and easy explanation of how to use Anritsu's MD8475A SmartStudio™ products and the need for mobility tests of 2G and 3G mobiles with the introduction of LTE systems.

However, the MD8475A is not limited to just this.

For example, it is an extremely effective test platform for high-speed download access networks such as 100-Mbps LTE systems. As mobiles continue to evolve with addition of smartphone functions, etc., not only will more wireless technologies such as wireless LAN and NFC (Near Field Communications) be incorporated into ever smaller multicellular devices, but they will also be running more applications in parallel. Using the MD8475A with its optimum throughput displays, measurement and PHY monitor functions for throughput measurement and application debugging will play a key role in hardware and software design of increasingly complex smartphones.

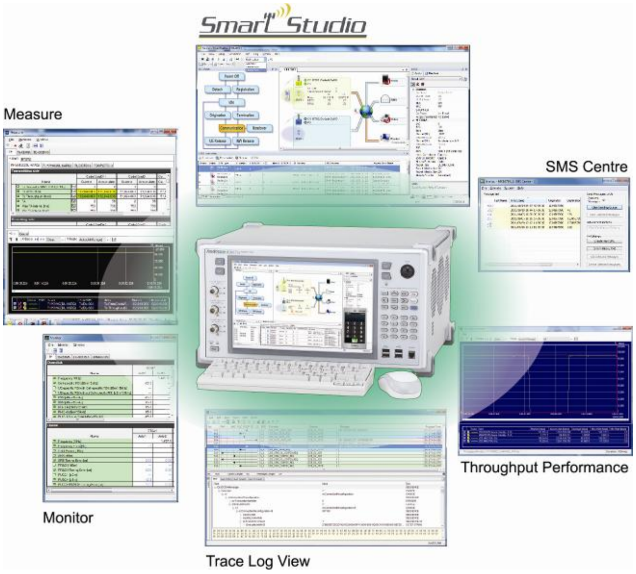

Figure 21. MD8475A includes Test Functions for Smartphone Development

Furthermore, the MD8475A offers an ideal environment for quantitative mobile measurements to improve battery life. For example, sending reports using the flexible settings, such as Periodic Update Timer and Paging Cycle as well as System Information Block (SIB), all of which have a direct impact on battery life, can play a powerful role in smartphone battery consumption tests.

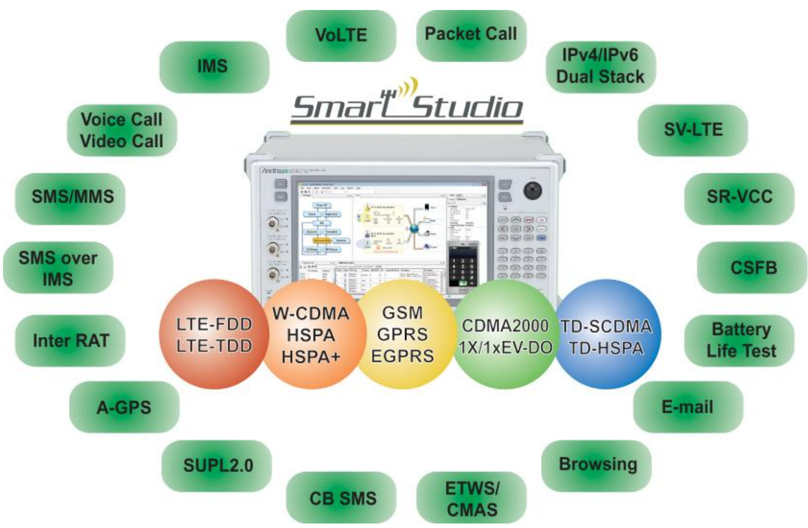

Figure 22. MD8475A will Continue Evolving as Smartphone Evaluation

Moreover, the MD8475A SmartStudio™ will continue evolving as a smartphone evaluation platform in parallel with smartphone developments. For example, it will be the ideal solution for every aspect of smartphone development such as supporting IMP (IP Multimedia Subsystem) for evaluating voice communications using VoLTE, Emergency PWS (Public Warning System) such as ETWS (Earthquake and Tsunami Warning System), etc.

- Note -

Specifications are subject to change without notice.

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