Development of MD8430A for LTE-Advanced Tests

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[Summary] As part of the expansion of LTE (Long Term Evolution) mobile communications systems standardized by 3GPP (The 3rd Generation Partnership Project), the faster LTE-Advanced standard supporting much larger data capacity is being adopted by more operators worldwide. The MD8430A base station simulator provides an unrivalled test environment for developing LTE terminals, chipsets, and protocols as well as for testing the performance of wireless signals and data communications. This new development has expanded the range of MD8430A functions such as Carrier Aggregation Mobility and higher–order MIMO (Multiple-Input and Multiple-Output) required by LTE-Advanced.

1 Introduction

The LTE (Long Term Evolution) standard is being deployed by mobile network operators starting with smartphones. More recently, the need to support faster and larger-capacity data communications is driving the rollout of faster LTE-Advanced (3GPP Rel. 10) networks using CA (Carrier Aggregation) technologies.

Anritsu markets its Signalling Tester MD8430A as a base station simulator for developing chipsets and protocols used by LTE UE (User Equipment). However, since the MD8430A must also support the LTE-Advanced standard, it requires the following expanded functions:

(1) Support for CA (Carrier Aggregation) tests
- Support for more CCs (Component Carriers)
- Support for higher-order MIMO (Multiple-Input and Multiple-Output)

(2) Support for faster throughput

This paper describes the new functions supporting LTE-Advanced tests and the development procedure.

2 Development Concept

Protocol development requires equipment simulating a base station with LTE-Advanced functions. Moreover, chipset development requires support for more CCs and higher-order MIMO as well as a Fading function simulating spatial propagation paths.

Based on these needs, the key concepts for developing the MD8430A with LTE-Advanced functions were as follows:

- Support for more CCs
- Support for higher-order MIMO
- Support for faster throughput
- Support for CA Mobility
- Support for Fading function (simulated spatial propagation path)

Our development targets were support for 4 CCs and 600 Mbps throughput. Additionally, we aimed to develop a futureproof hardware design supporting even more CCs and faster throughput (1 Gbps, etc.) Figure 1 shows an example of the MD8430A system setup.

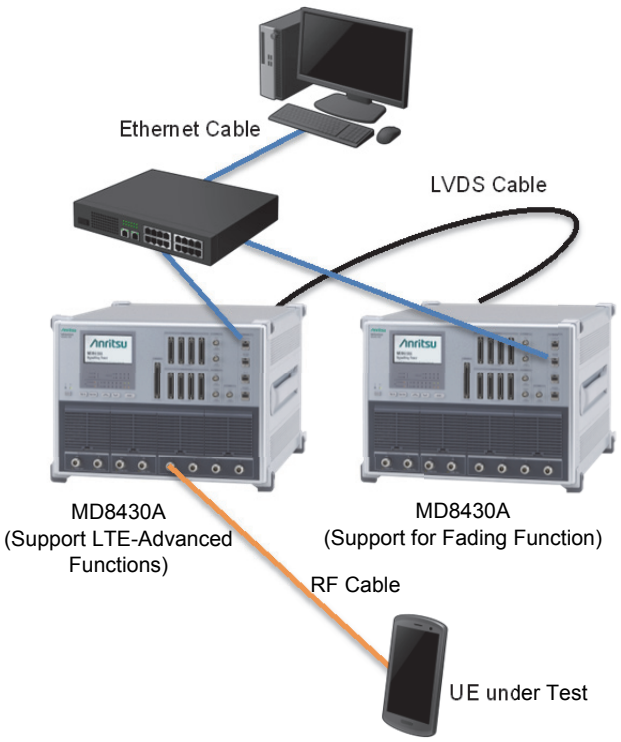


Figure 1 Example of Signalling Tester System Setup

3 LTE-Advanced Functions

3.1 Carrier Aggregation

As well as assuring backwards compatibility with LTE, the LTE-Advanced development aims were to achieve a wider bandwidth (up to 100 MHz) and add functions supporting CA. The CA function is a technology for implementing a wider bandwidth by aggregating up to five existing LTE frequency bands as 5CCs. By using this function, E-UTRAN (Evolved Universal Terrestrial Radio Access Network) and UEs can achieve higher throughput speeds while retaining backwards compatibility with LTE.

In addition, the following functions were either expanded or added, based on the CA functions.

- Timing Advance Groups
- Different UL/DL configuration for TDD inter-band carrier aggregation
- TDD-FDD Joint Operation including Carrier Aggregation (TDD-FDD CA)

  DL: Downlink

  UL: Uplink

  FDD: Frequency Division Duplex

  TDD: Time Division Duplex

Figure 2 shows the LTE-Advanced Layer2 structure.

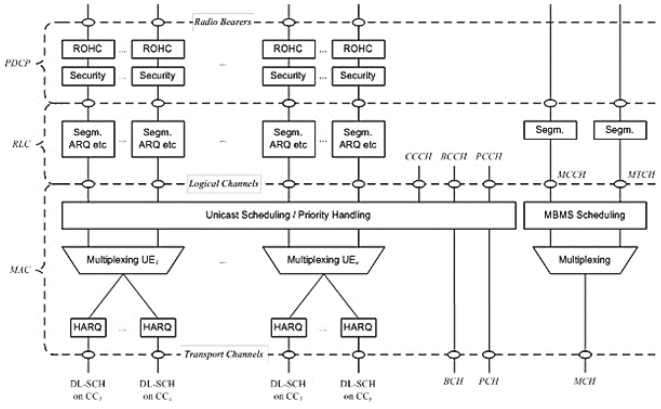


Figure 2 Layer-2 Structure for DL with CA configured in 3GPP TS36.300 Figure 6.4-1[1)]

3.2 MIMO

Along with the CA functions, we added support for LTE-Advanced higher-order MIMO technologies as follows:

- Multi-antenna transmission with up to 8 antenna ports
  - Single User MIMO (SU-MIMO)
  - Multi User MIMO (MU-MIMO)
- CoMP (Co-ordinated Multi-Point Transmission)
- CSI (Channel State Information) Reference Signal
- Downlink 256QAM (Quadrature Amplitude Modulation)

Using these technologies offers LTE-Advanced an approximately twofold increase in peak propagation efficiency for frequency compared to LTE.

3.3 UE Category

3GPP Rel. 12[2)] defines new UE DL and UL categories (Tables 1 and 2, respectively) for increasing maximum communications speeds by increasing propagation speed by expanding the CA and higher-order MIMO functions.

The MD8430A supports UE DL Category 12 (DL 600 Mbps) and UE UL Category 13 (UL 150 Mbps).

Table 1 Typical UE DL Categories

UE DL Category	Modulation Method	DL Speed
DL Category 6	64QAM	300 Mbps
DL Category 9	64QAM	450 Mbps
DL Category 11/12	64QAM or 256QAM	600 Mbps
DL Category 15	64QAM or 256QAM	750 Mbps to 800 Mbps
DL Category 16	256QAM	970 Mbps to 1050 Mbps

Table 2 Typical UE UL Categories

UE UL Category	Modulation Method	UL Speed
UL Category 3	16QAM	50 Mbps
UL Category 5	64QAM	75 Mbps
UL Category 7	16QAM	100 Mbps
UL Category 13	64QAM	150 Mbps

4 Hardware System Design

We achieved our first design target of support for 4CCs and 600 Mbps throughput and implemented the following features to support more CCs and higher throughput (1 Gbps) expected in the near future.

- Assured future expandability by using world-beating large-scale FPGA (Field-Programmable Gate Array) using the latest processes
- Implemented >1 Gbps U-Plane packet bandwidth with two 1000BASE-T Ethernet ports for U-Plane
- Assured compatibility by keeping function blocks previously in separate FPGAs in one large-scale FPGA
- Assured data transmission band using new PCIeGen2(×2) between DSP (Digital Signal Processor) and FPGA

- Improved data throughput by changing U-Plane data path from DSP to FPGA (section 5)
- Adopted latest, world-leading tools
- Supported tracking operation between two MD8430A sets by using I/F for LVDS Cable to implement increased RF inputs/outputs (Figure 3).

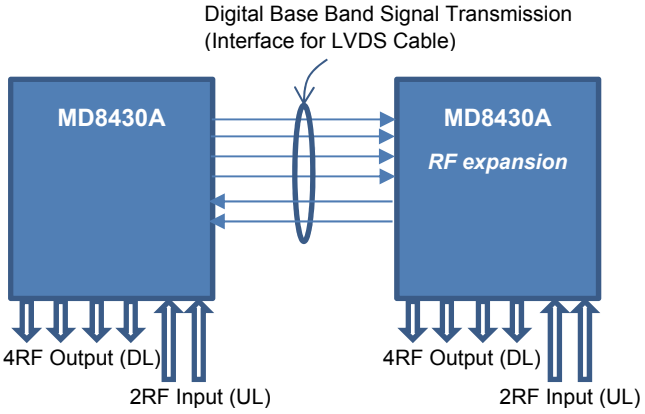


Figure 3 Example of Tracking Operation (DL: 8RF/UL: 4RF)

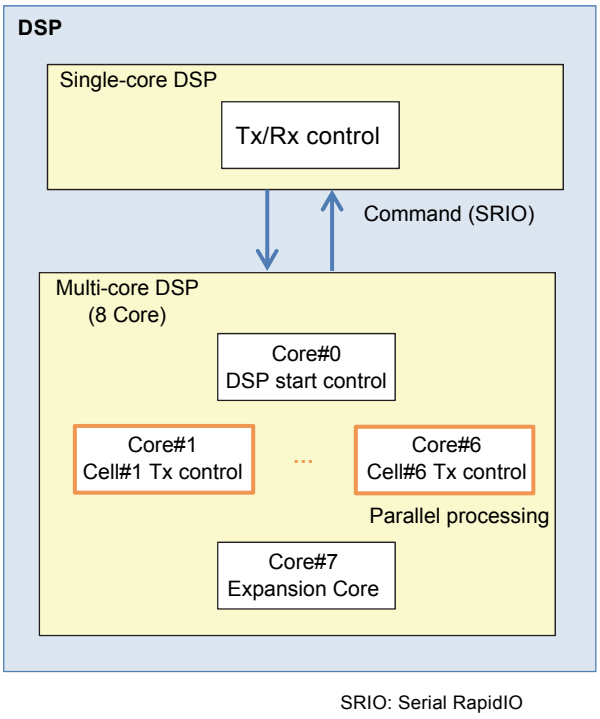


Figure 4 PHY Layer Processing

5 Software System Design

5.1 PHY Layer

Increasing the number of LTE-Advanced CCs and supporting higher-order MIMO are key issues in shortening processing times in the PHY (Physical) Layer. In considering future expandability, we solved these issues by increasing the multi-core DSP and using parallel processing. Figure 4 shows the PHY Layer DSP configuration.

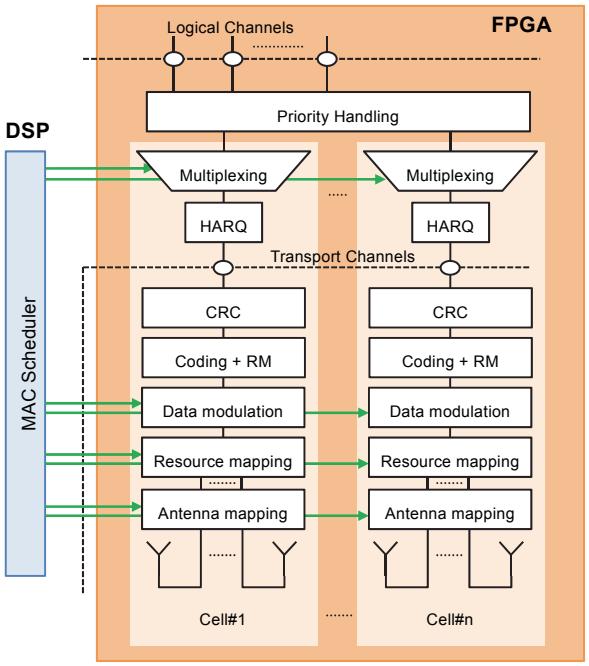
Multi-core DSP assigns 1 cell for Tx control to each core and uses parallel processing, making it easier to increase the number of CCs in the future.

5.2 MAC Layer

The number of CCs has been increased and support for higher-order MIMO and Carrier Aggregation Mobility has been added in the MAC (Medium Access Control) Layer.

MD8430A sets prior to this upgrade used DSP to process DL-SCH (Downlink Shared Channel) and UL-SCH (Uplink Shared Channel) data, causing increased processing times with increasing transmission speeds. With this new development, this data processing is performed by the FPGA, supporting faster processing speeds. On the other hand, the MAC Scheduler processing related to scheduling is now performed by the previous DSP. Figure 5 shows this configuration. As a result, the configuration for easy support of additions or changes to specifications is maintained and increased LTE-Advanced transmission speeds are supported with implementation of up to 4-layer MIMO (8×4 MIMO, 4×4 MIMO) and 4CCs.

In addition, it is also possible to implement the PHY layer and MAC Layer settings including scheduling offered by 1CC prior to 3GPP Rel. 9 for each CC. Furthermore, Primary Cell and Secondary Cell tests can be changed during testing, offering easy Mobility tests for each CA.



HARQ: Hybrid Automatic Repeat Request
CRC: Cyclic Redundancy Check
RM: Rate Matching

Figure 5 MAC Layer Processing

5.3 RLC Layer

High throughput is now supported in the RLC (Radio Link Control) Layer.

Increasing the number of CCs to 2CCs and 3CCs increases the volume of data processed by the RLC two and threefold, respectively. Like the MAC Layer, data processing is performed by the FPGA to support this increase.

Although the FPGA is best for handling large data volumes, performance is adversely affected at complex condition evaluation processing. Consequently, the RLC Scheduler is handled by DSP as previously. Figure 6 shows the configuration.

For example, in the SDU (Service Data Unit) reassembly shown in Figure 6, the DSP receives Rx data header information from the FPGA and generates the Rx data Reassemble instructions from this information as instructed by the FPGA.

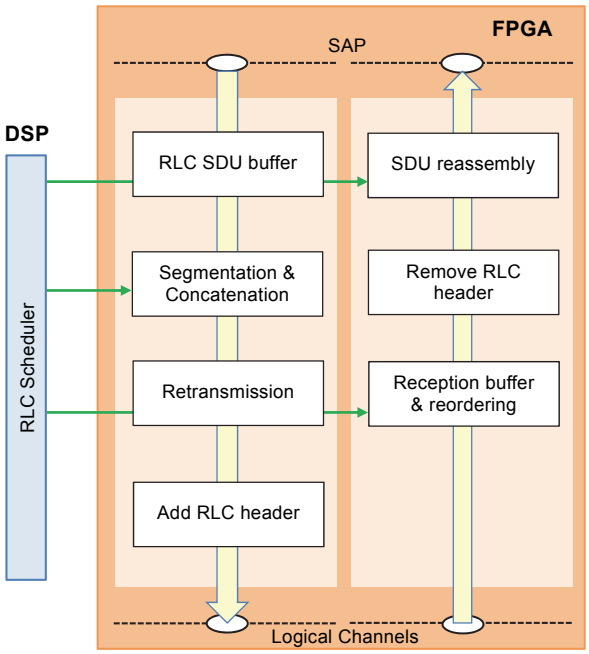


Figure 6 RLC Layer Processing

5.4 Gateway/PDCP Layer

High throughput is now supported in the Gateway/PDCP (Packet Data Convergence Protocol) Layer.

MD8430A sets before this upgrade supported up to UE Category 4 defined in 3GPP Rel. 8. However, supporting up to UE DL Category 12 and UE UL Category 13 required increasing throughput in the Gateway/PDCP Layer as well as increasing the number of packets that can be processed in 1TTI (Transmission Time Interval). To solve this issue, like the MAC and RLC Layer, the processing performed by DSP in the MD8430A before upgrading is now handled by parallel processing using the FPGA. Figure 7 shows a block diagram of the Gateway/PDCP Layer software and FPGA key functions.

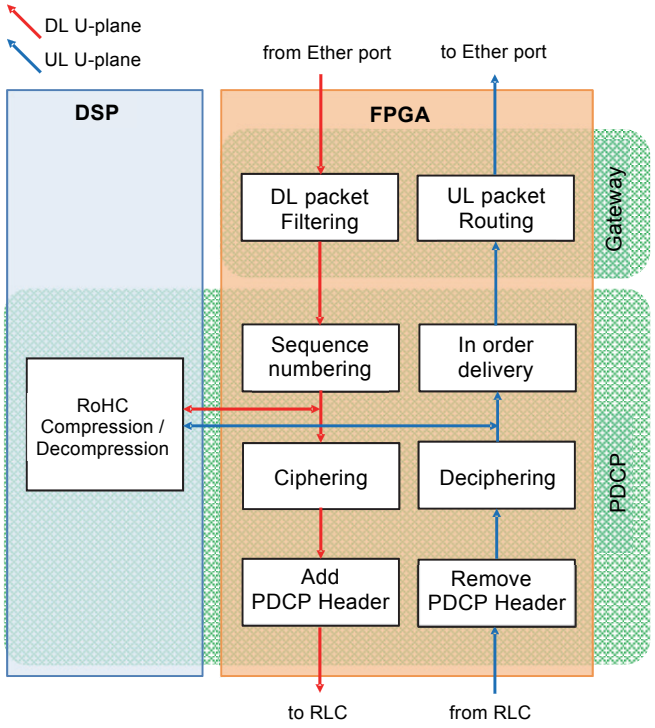


Figure 7 Gateway/PDCP Layer Processing Flow

MD8430A sets before this upgrade used DSP for all Gateway/PDCP processing but with this development, nearly all processing is handled by the FPGA. The resulting parallel operation in processing block units supports faster speeds.

As shown in Table 3, in comparison to the MD8430A sets before this upgrade, the developed MD8430A has greatly increased throughput and numbers of processed packets.

Table 3 Comparison of MD8430A Functions Before and After This Development

	MD8430A Before Upgrade	MD8430A After Upgrade
UE Category	Category 4	DL Category 12/ UL Category 13
DL Max Throughput	150 Mbps	600 Mbps
UL Max Throughput	50 Mbps	150 Mbps
Max DL Packets Processed per TTI	20 packet/ms	100 packet/ms

6 Fading Functions

The fading function has been implemented by linking two MD8430A sets using an interface for the LVDS Cable.

The MD8430A now supports the higher-order 4×4MIMO, 8×2MIMO, and 8×4MIMO multipath fading propagation model defined in the 3GPP measurement standards that are not supported by the previous Fading Simulator MF6900A.

Support for the fading simulator function has been implemented using software and the MD8430A FPGA configuration. Linking two MD8430A sets as shown in Figure 1, supports a high-order MIMO fading test environment with the following functions while maintaining backwards compatibility with the MF6900A.

Table 4 Supported Fading Functions

Main Fading Function	MF6900A	MD8430A Fader
2×2MIMO	2 Cell	6 Cell
4×2MIMO	1 Cell	3 Cell
4×4MIMO	Not supported	3 Cell
8×2MIMO	Not supported	1 Cell
8×4MIMO	Not supported	1 Cell

7 Summary

We have expanded the functions of the MD8430A, targeting development of UE chipsets and protocols supporting development of LTE-Advanced services now being deployed by mobile operators.

The MD8430A is an invaluable tool for verifying LTE and LTE-Advanced technologies requiring complex signal processing and high performance; it is targeted at major chipset and UE vendors worldwide. In addition, it can also be used as a key component in conformance and carrier acceptance test systems to help improve service quality. Mobile communications systems are moving forward with standardizing specifications to assure high data speeds and larger capacities. Anritsu will continue providing measurement solutions supporting new technologies in growth and development of mobile communications systems.

References

1) 3GPP TS 36.300: "Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2".
2) 3GPP TS 36.306: "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio access capabilities".

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