Design of data source system for LTE-Advanced uu monitoring analyzer

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Abstract. According to the LTE-A air interface protocol, an air interface monitoring study was conducted to establish a multi-user service and monitor the user's behavior and analysis of the signalling process and data traffic. The monitor and road measurement system jointly perform active testing as a third-party test tool to evaluate the consistency of the network and the terminal. The data source of the LTE-A system provides a standard comparison for the development of the LTE-A physical layer, and also provides a reference for the accuracy of the monitoring data. The platform design is based on protocol standards to complete the analysis and provides meter data sources through modularization ideas and development. The results show that the data can meet the instrument indicators and are of great significance to the development of the LTE-A air interface monitoring analyzer and the optimization of the base station network.

1. Introduction
The air interface is an important interface for ensuring the interconnection of communication devices of different manufacturers or manufacturers in a completely open environment. A plurality of radio bearer services is built and configured between the base station and the terminal. The overall construction plan of LTE-A monitoring analyzer adopts many key technologies such as LTE-A protocol parsing, physical layer algorithm, carrier aggregation, multi-user random access and service behavior monitoring and analysis to realize L1, L2, L3 cross layer correlation analysis, protocol stack monitoring, service tracking and signaling parsing process monitoring. In a word, the LTE-A monitoring analyzer is still a three-tier architecture with IP interfaces, which are data acquisition, data processing and presentation. In the stable environment of network operation, the instrument is mainly used as an important means of network planning and optimization for operators. It focuses on the presentation and analysis of protocol messages and the networking and cascade functions of signaling monitoring instruments in LTE-A network. The main functions of the LTE-A monitoring analyzer are to support the upstream and downstream reception of air ports. On the basis of full-system and full-band, multi-cell and multi-terminal large-capacity monitoring, vertical and horizontal correlation analysis and off-line storage analysis of raw data and analytical data are realized. The upper layer service analysis and monitoring is associated with the LTE-A core network analysis system and the road test system to form a complete end-to-end analysis system [1].
All links involved in the development of system and FPGAs of the monitoring analyzer, including RF, algorithm, baseband hardware, protocol stack processing, log database system design, and software analysis platform RF module development all require related technical indicators and support. The current LTE-A monitoring analyzer supports distributed end-to-end testing while end-to-end network performance monitoring needs to combine air interface parameters with core network parameters to facilitate trouble-shooting in the testing process. Due to the lack of effective testing methods, it is necessary to monitor relevant parameters from the core network side in order to obtain relevant indicators of the wireless network. This method of adjusting parameters by experience will result in some improvement in monitoring means, but it does not truly achieve high performance end-to-end real-time monitoring. At present, there are few air testing technologies and related instruments and products in China. This thesis introduces the system architecture analysis of the data source provided by the LTE-Advanced air interface monitoring analyzer during the development and testing phase, and gives the platform design and analysis of simulation results in the corresponding scenarios.

2. LTE-A system composition and frame model
The data source simulation of LTE-A is based on the LTE-A air interface protocol, in which the PDU structure of each layer of the protocol stack is associated with logical channel and transmission channel. Simultaneously generating the encoding data, combined with the key technologies of the LTE physical layer downlink, decoding and verifying the data generated by the encoding to establish a complete LTE-A air interface simulation platform. The hardware baseband block restores the radio frequency raw data received by the antenna into bit stream data and encapsulates the bit stream data into a PCIE 2.0 protocol frame for deframing operation with the support of the software platform. The LTE-A bit stream data is restored to TCP/IP packet according to the architecture of the protocol stack. These modules that are stored in L2 and L3 layers are analyzed in real time are also used to resolve the signalling process and user data when the call is established, and to detect the current network user behavior.

![Figure 1. Instrument ideal scene.](image1)

![Figure 2. Instrument architecture.](image2)
service processing and signalling analysis, which form a multi-layer network type structure. The L1 processing module collects air interface signalling from the antenna end and stores it as IQ data to the local. In addition, it also needs to forward the L1 data storage to the L2 processing module. The L2 processing module will parse the L1 data by using the layer 2 method after the storage process is completed, and store the L2 data to the L3 and the service processing module after the parsing is completed. L3 and the service processing module will decode the stored L2 data and store the decoded result synthesis CDR into the database by using RRC and NAS layer decoding synthesis and IP, application user name protocol analysis. Its functional architecture is shown in Figure 3:

![Functional architecture](image)

**Figure 3.** Functional architecture.

The data generated by the data source simulation as the interface of antenna information is connected with the baseband board which contains the physical layer protocol module. The method of generating data take modularity and openness into account, which is conducive to the serialization of products and the long-term evolution of standards. According to the standard of reference [2] [3] [4], the design and development scheme is composed of three parts: data coding, channel generation and data decoding. The system is hierarchically divided into a channel and a signal generation module, wherein the channel generation module is composed of a source generation, a symbol mapping, an antenna configuration, and a framing process. Additional decoding steps include submodules such as time-frequency offset estimation and channel estimation to test data, therefore, the concrete implementation of the data source simulation architecture of the LTE-A air interface monitoring analyzer is shown in Figure 4:

![Development logic](image)

**Figure 4.** Development logic.

In the test of LTE-A project, the purpose of the simulation system is to simulate the physical layer capability, the basic performance of the instrument and the function analysis of the protocol to verify the performance test of the monitoring analyzer.
3. Analysis and design of data source system
The system based on LTE-A is a test and development platform which makes full use of the existing LTE-A physical layer standard protocol. It provides the physical layer algorithm of the decoder for data verification and provides the data interface to the hardware. The system uses the design component of the MATLAB GUI to develop the link-level simulation platform and realizes the analysis and comparison between the eNodeB side real-time simulation data source and the simulation results.

3.1. Channel generation
From the downlink process analysis of the LTE-A physical layer, the process includes cell search, acquiring system information, establishing connection after random access, and data transmission. The submodule has synchronization signal, reference signal, five physical channels, and signaling content such as DCI. Five channel modules are initialized by setting the simulation parameters of the system. The scrambling module scrambles the code bits of each code word transmitted on the physical channel. The data encoded by MIMO is mapped to the common frame structure together with the reference signal to complete the transmission of the antenna port by OFDM modulation.

The data objects generated by the software platform are in units of subframes, and the data structure is in the form of a matrix of 1200*14. The broadcast channel first needs to simulate the system information of the cell for the access of the instrument. The logical channel BCCH is mapped to the BCH transmitting the MIB information and the DL-SCH transmitting the SIB information, so the bit information of the BCH is generated by the eNodeB information set to obtain bit information of the PBCH. After the broadcast channel is generated, the eNodeB needs to notify the UE of the number of OFDM symbols occupied by the control region of the downlink subframe due to the continuity of the subframe, and the control format bits generated for the same reason acquire the bit information of the PCFICH. LTE-A system transmits each DCI logically continuous CCE according to channel quality allocation. The DCI format scheme can be determined by the transmission mode configured in the random-access process and the corresponding instrument in RNTI type information to decode the PDCCH, so as to determine the relevant PDSCH transmission scheme. The last PHICH channel module is used to identify whether the eNodeB has correctly received a transmission on the uplink shared channel. Since the information bits repeat on three BPSK modulated symbols, the PHICH group formed by PHICH mapped to the same resource particle set needs to be configured before generating the PHICH modulated symbol information. The location of the channel module in the subframe is identified as shown in Figure 5.

![Figure 5. Channel identification.](image)

3.2. Signal analysis
The data source system and the LTE-A monitoring analyzer serve as both transmitting and receiving sides, and the downlink control information is an important basis for realizing data demodulation for the device. Multiple types of DCI are configured according to the latest protocol of the physical layer, and instruments under different information are used. The CRC is checked and the DCI is parsed using the corresponding RNTI and CCE in the basis of the current state. In addition to the DCI module, the physical signals of the downlink include reference signals and synchronization signals, which are necessary conditions required for the physical layer processing.
In the LTE-A system, the first step of the synchronization process is to perform downlink synchronization. When the receiver performs the initial access and uses the cell search process to identify and obtain the downlink synchronization of the cell, the synchronization signal module plays a key role, including primary synchronization signal of the ZC sequence with good autocorrelation and the secondary synchronization signal interleaved by two binary sequences of length 31 are identified as shown in FIG. 6. After the modulation symbol information of the above several modules is generated, it is mapped one by one to the corresponding position in the subframe structure and assembled into one subframe data block [5].

4. Simulation results and analysis
The verification mainly includes the capability and basic performance of the physical layer protocol module to generate data. The data decoding module decodes the obtained constellation diagram to judge the accuracy and rapidity of the generated data, and ensures the fast and easy-to-operate target and physical layer capability in the method of generating the subframe data. This thesis mainly completes the feasibility goal of simplification in the protocol.
Table 1. Downlink parameter configuration table (Ideal channel estimation)

| Parameter             | Value     | Parameter             | Value     | Parameter             | Value     |
|-----------------------|-----------|-----------------------|-----------|-----------------------|-----------|
| Bandwidth             | 20MHZ     | Carriers/UE           | 12        | MIMO S/R              | SDM/MMSE  |
| FFT                   | 2048      | Modulation            | QPSK      | Frame length          | 10ms      |
| △f                   | 15kHZ     | Code block            | 40-120bits | CP                  | 4.69 μs   |
| OFDM symbols          | 7         | Wireless channel      | flat Rayleigh fading | Symbol time | 71.43 μs   |
| PRB max               | 100       | Antenna configuration | MIMO 2*2  | TTI                   | 1ms       |

Under the condition of SNR determination, the simulation process of encoding and decoding frame by frame according to each transmission mode simulates sending a subframe at the base station side. The constellation map of each independent channel submodule is mapped at the receiver, and the constellation map effect is compared and analyzed under different channel conditions using different parameters and mode schemes.

Figure 7. Channel resolution constellation.
Figure 7 is a data constellation diagram for the generation of an initial data source with an MCS modulation scheme index of 12. It can be seen that after the data analysis side starts to simulate cell search and synchronization and extracts the data of each subframe of wireless frame 0, the constellation is gathered and there is no phase rotation, which verifies the accuracy and completeness of the data source simulation. Time-frequency estimation and correction of frequency offset and delay are added to the constellation, which can imitate the advantage of the receiver to demodulate the signal correctly. Based on the above discussion, according to the configuration of the simulation parameters table, the simulation in the 20MHZ system bandwidth, different block size, MIMO scheme and modulation mode parameters change uses ideal channel estimation, artificial frequency offset and time delay correction to get constellation map to judge the correctness and rapidity of the simulation.

5. Conclusion
This thesis simulates the process of generating data frames from random binary data sources through physical protocol block processing. The platform considers channel coding and decoding based on LTE R10 standard. It not only supports multiple MIMO schemes and transmission modes, but also includes time-frequency synchronization, channel equalization and other basic functions. Through the detailed design of the key process and the core algorithm, we can effectively provide the data source and verify the data source. The overall results show that the data generation method is accurate and conforms to the protocol process.

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