Radio Channel Emulation Challenges in 3GPP LTE

Securing product performance in the field by using laboratory channel emulation can give a competitive edge to companies that use these solutions.

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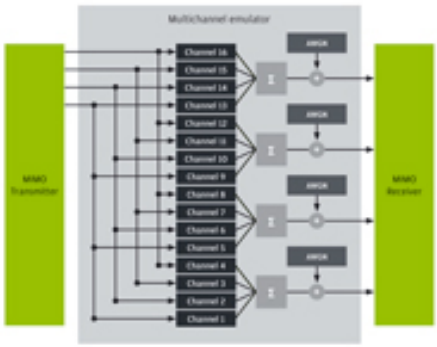
In recent years there has been a major change in the way people communicate. Now wireless connections are nearly everywhere. A wireless connection is subject to unpredictable phenomena and therefore is far more complex than a wired system. The received signal in the terminal is often very different than the original signal transmitted from the base station. The received signal level, phase and frequency change continuously in a real network. In addition, interference from other wireless transmitters in the neighborhood distorts the received signal. However, a modern receiver should be capable of receiving an increasing amount of data, even in very challenging network conditions.

3GPP (long-term evolution) LTE is one the main cellular technologies that will provide higher data rates in future. The development and testing of devices for LTE requires controllable and fully repeatable test systems in the laboratory. As the conditions in real networks are continuously changing, it is impossible to develop a testing strategy based on live network testing only. Therefore, instruments capable of emulating real network conditions in a fully repeatable laboratory environment are needed. These instruments are called radio channel emulators and they are crucial to the development of wireless products. Figure 1 illustrates the idea. Potential users of radio channel emulators are terminal OEMs, network infrastructure developers, operators, chipset developers and wireless telecommunication research.

Overview of LTE Technology



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3GPP long-term evolution (LTE) standardization is proceeding fast and some parts of the standard are already frozen. LTE is defined in 3GPP release 8. It is estimated that full standard will be frozen in February 2009. Release 8 will introduce major changes to currently deployed systems. The main targets set for 3GPP LTE are higher data rates, more efficient spectrum usage and better end-user experience. The target peak data rate for downlink (DL) communication from eNodeB (LTE base station) to UE is 100 Mb/s. For uplink the target is 50 Mb/s. New technologies must be developed to reach this level of performance. One of the system parameters contributing to improved data rate is system bandwidth. The LTE system will have flexible bandwidth allocation with bandwidths of 1.4, 3, 5, 10, 15 and 20 MHz. The highest signal bandwidth is much wider compared to current technologies like HSxPA or CDMA2000. This has a big impact on the radio channel model requirements for testing LTE products.

LTE will use multiple-input-multiple-output (MIMO) technology to improve data rates and spectrum efficiency. Standard LTE MIMO configurations for DL will be 2x2 and 4x2. The most likely configurations are 1x2, 2x2 and 2x4 in the UL direction. Networks will utilize 2x2 MIMO in early LTE deployment and later MIMO configurations will use 4 antennas in BTS. LTE defines two different MIMO schemes: single-user MIMO (SU-MIMO) and multi-user-MIMO (MU-MIMO). In SU-MIMO the data stream from/to UE is coded to multiple data streams and antennas transmit different data to the radio channel. This improves the throughput in good radio channel conditions. In MU-MIMO multiple users send data during the same resource block (the smallest data unit in LTE). This improves the cell capacity because data from different users can be sent simultaneously in the same frequency.

Radio Channel Emulation in LTE

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A lot of standardization effort has been used to define more accurate test models for LTE MIMO testing. 3GPP release 8 (LTE) defines conformance test models for terminal and eNodeB testing. The conformance test models are used to verify minimum product performance and to ensure that products launched to commercial networks are in some way verified. The spatial channel model for extended bandwidths (SCME) is a radio channel model specified jointly by 3GPP and 3GPP2. This model is closer to reality and is designed to find the real LTE UE/eNodeB performance in the network by modeling the radio environment with the highest accuracy. The geometrical modeling used in SCME is based on defining the actual UE and BTS antenna characteristics and geometries. In addition, the locations of up to 24 clusters, i.e. propagation paths, are randomly drawn from statistical distributions.

Introduction of MIMO in LTE will have a major impact on performance testing requirements. In addition to new channel models, the emulation hardware has to be updated to support new test scenarios. Standard LTE test scenarios like 2x2, 2x4 and 4x4 require more channel emulation capacity. For example, a standard conformance test case for 4x4 MIMO scenario actually requires 16 fading channels, since each transmit signal has to be linked through a fading channel to each receiving antenna port. An ideal channel emulator for 4x4 MIMO has 4 RF input/output ports and fading channels are implemented at the baseband domain. This provides the highest accuracy and cost effective solution for LTE product developers. One of the most important parameters for the channel emulator is correlation accuracy between fading channels. The actual channel model implemented in software has exact correlation values. Any distortion in emulation hardware will decrease the accuracy. Emulator architecture that enables the 4x4 emulation in a one-box adds minimum distortion to the test results.

System Level Testing in the Laboratory

Performance testing can be generally categorized by link level and system level testing. In link level testing, the test signal for DUT is generated by using a tester designed for this purpose. These products are often called communication testers, one-box testers or system simulators. The only purpose of link level testing is to verify the DUT receiver performance. Just the downlink or the uplink is considered in the testing.

The purpose of the system level testing is to measure the performance of DUT when it is a part of a similar system to be deployed in a real network. In system level

testing, real network elements and user devices are used and the total performance with up- and down link is measured. Actually, it is difficult to improve the network performance or capacity by optimizing only a single link between a terminal and a base station sector. Much more improvement in the network is available by optimizing the joint uplink and downlink performance in the test setup with multiple terminals and base station sectors. Figure 3 illustrates the idea of network testing.

In a system level test solution provided by EB, real multipath fast fading and shadowing effects are included. This enables much more realistic system performance optimization and verification. Without fast fading, the setup is incomplete and the difference compared to a real environment is too big for laboratory testing. The setup consists of a multichannel fading emulator, real base stations and controllers, user devices and control software. Radio channel data is collected during a single drive test with suitable measurement tools. During the measurement multiple links between several BTS and user device are recorded.

System level testing with real fast fading emulation has many benefits. The need for time consuming field testing is reduced and products can enter the market faster. An operator can use system level testing to benchmark different terminals in controllable laboratory conditions. Network infrastructure developers can use system level testing to optimize network performance, for example, by implementing handover test setup in the laboratory. User device developers can record the real environment in the field and use it to easily verify terminal performance after every software update.

Conclusion

3GPP LTE is one of the future technologies providing better services to the end users. An improved service portfolio sets high demands for technology development and LTE will introduce several improvements to enhance, for example, network capacity. Advanced technology needs high quality testing. Securing product performance in the field by using laboratory channel emulation can give a competitive edge to companies that use these solutions. Product verification with conformance testing only is not enough. Before launching products on the market, it is necessary to test beyond conformance level to make sure that products operate in the field as planned.

Link level performance testing is always necessary, but overall network capacity can be improved by using advanced system level test solutions in the laboratory. In system level testing the real devices and network elements are used. Three steps are needed: 1) measurement of the radio environment with suitable tools; 2) post-processing the measurement data to create realistic test scenarios for laboratory testing, and 3) real time radio channel emulation with the post-processed models.

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