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Progress on "LTE Advanced" - the new 4G standard

Eiko Seidel, Chief Technical Officer
Nomor Research GmbH, Munich, Germany,
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Summary

LTE standardization has come to a mature state by now where changes on the specification are limited to corrections and bug fixes. Often the future LTE standard is seen as 4G standard which is not correct since it is a 3G technology. In 3GPP work on LTE Advanced was started recently. It is likely that major enhancements to LTE will be introduced in Release 10 after a correction and improvement phase in Release 9. LTE Advanced shall fulfil the 4G requirements as set by ITU. As can be seen from the work plan, the schedule within ITU and 3GPP are quite harmonized. Not surprisingly 3GPP will firstly contribute its requirements to ITU and later on its technology proposals.

The paper gives an overview about the latest activities in 3GPP including the first agreements on LTE Advanced requirements. Furthermore some first technology proposals are introduced and discussed. Also Nomor Research started working on first simulations for LTE Advanced and will be happy to support your activities in a related area.

3GPP Workshop on LTE Advanced

A 3GPP TSG RAN workshop on IMT-Advanced was held (in the week after the RAN WG meetings) on April 7-8, 2008 in Shenzhen, China hosted by ZTE Corporations with the following intentions:

- Presentations on requirements and technical proposals
- "Friendly" discussions on LTE-Advanced
- Identify a baseline of the requirements for LTE-Advanced and identify study areas

The goal of the workshop was to investigate what are the main changes that could be brought forward to evolve the eUTRA Radio Interface as well as the eUTRAN in the context of IMT-Advanced. The discussions from the workshop should be used to define further work in RAN and will be elaborated in subsequent TSG RAN meetings. 58 Tdocs (+ draft and final report) were submitted to the workshop which had 168 participants.

During the workshop operators and manufacturers views on possible requirements for LTE Advanced as well as ideas/proposals for LTE Advanced were exchanged and shortly discussed.

The main conclusions from the workshop are:

- LTE Advanced shall be an evolution of LTE
- All requirements/targets in TR25.913 apply to LTE-Advanced. LTE-Advanced requirements shall fulfill IMT-Advanced requirements within the ITU-R time plan.
- Same intra and inter-RAT interworking capability with at least same performance as in LTE Release 8
- As a way forward for LTE-Advanced it was agreed to establish a TSG RAN email reflector for LTE-Advanced and to kick-off of discussions about LTE-Advanced requirements

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LTE Advanced Requirements

The requirement specification TR 36.913 has already been approved in TSG-RAN#40. Detailed technical proposals will be investigated within the working groups.

Current agreements on the requirements for LTE Advanced:

- Peak data rate DL: 1 Gbps, UL: 500 Mbps
- Transmission bandwidth: Wider than approximately 70 MHz in DL and 40 MHz in UL
- Latency: C-plane from Idle (with IP address allocated) to Connected in <50 ms and U-plane latency shorter than 5 ms one way in RAN taking into account 30% retransmissions (FFS)
- Cell edge user throughput 2 times higher than that in LTE
- Average user throughput 3 times higher than that in LTE
- Capacity (spectrum efficiency) 3 times higher than that in LTE
- Peak spectrum efficiency DL: 30 bps/Hz, UL: 15 bps/Hz
- Spectrum flexibility: Support of scalable bandwidth and spectrum aggregation
- Mobility: Same as that in LTE
- Coverage should be optimized or deployment in local areas/micro cell environments with ISD up to 1 km
- Backward compatibility and interworking with LTE with 3GPP legacy systems

General thoughts

According to WRC07 new spectrum in the lower and higher bands will become available soon. Nevertheless not all of it will be available on global scale, making global deployment and roaming difficult.

Lower frequency bands must be used to increase coverage, higher frequency bands to get broadband experience for small cell sizes and low mobility. Requirements for LTE Advanced are similar to LTE, but peak data rates and spectral efficiency are to be increased.

Generally the gain in latency is questionable. Only a negligible improvement in Quality of Experience can be expected if the E-UTRAN round trip time is reduced from 8ms to 6ms or if the transmission time interval is reduced from 1ms to 0.5ms.

Technology proposals

The 3GPP working groups, mainly RAN1 working on the physical layer, are currently starting to look at technical proposals.

The proposals could roughly be categorized into:

- Various concepts for Relay Nodes
- UE Dual TX antenna solutions for SU-MIMO and diversity MIMO
- Scalable system bandwidth exceeding 20 MHz, Potentially up to 100MHz
- Local area optimization of air interface
- Nomadic / Local Area network and mobility solutions
- Flexible Spectrum Usage
- Cognitive Radio
- Automatic and autonomous network configuration and operation
- Enhanced precoding and forward error correction
- Interference management and suppression
- Asymmetric bandwidth assignment for FDD
- Hybrid OFDMA and SC-FDMA in uplink
- UL/DL inter eNB coordinated MIMO

As can be seen most of the technologies are PHY related technologies. Therefore most activities will be within RAN1 working group. Inter eNB coordination for interference management and suppression and coordinated MIMO relies on communication between eNBs and will thus affect the X2 interface as standardized in RAN3.

Support of larger bandwidth in LTE Advanced

In 4G bandwidths up to 100MHz are foreseen to provide peak data rates up to 1 Gbps. In general OFDM provides simple means to increase bandwidth by adding additional subcarrier. Since the Release 8 UE capabilities only support 20MHz bandwidth, the scheduler must consider a mix of terminals.

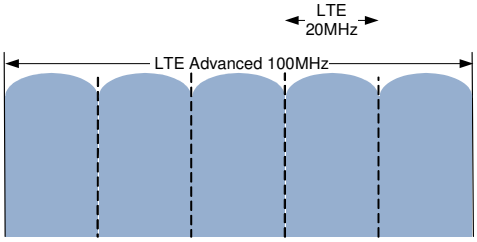

Figure 1: Support of larger bandwidths

Due to a fragmented spectrum the available bandwidth might also be not contiguous. To ensure backward compatibility to current LTE the control channels such as synchronisation, broadcast or PDCCH/PUCCH might be needed per 20MHz.

Some of the main challenges for 100 MHz terminals are:

- Availability of RF filter for such an large bandwidth and bandwidths of variable range
- Availability of Analog Digital Converter with such a high sampling rate and quantization resolution
- Increased decoding complexity e.g. for channel decoding and increased soft buffer size

Next the possible multi-carrier operations are reviewed. Minimum changes to the specifications will be required if Resource Allocation, MIMO, Link Adaptation, HARQ etc are done per 20MHz carrier as depicted in Figure 2. The scheduler must operate across the bandwidth and there will be a larger number of transport blocks per transmission time interval.

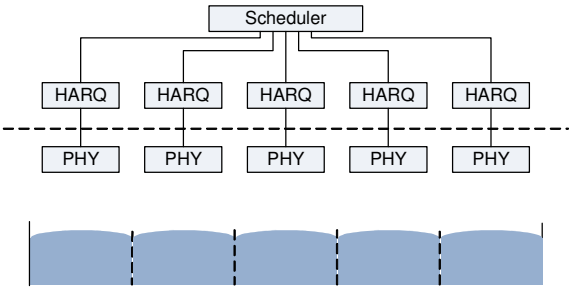

Figure 2: Possible for 100 MHz multi-carrier operation

Currently the Frequency Division Duplex (FDD) schemes as defined for LTE in Release 8 are limited to operate in a fully symmetric allocation of paired spectrum.

This makes it difficult to find suitable FDD spectrum allocations and also cannot efficiently support asymmetric traffic. For LTE Advanced more flexible bandwidth allocations as shown in Figure 3 are considered.

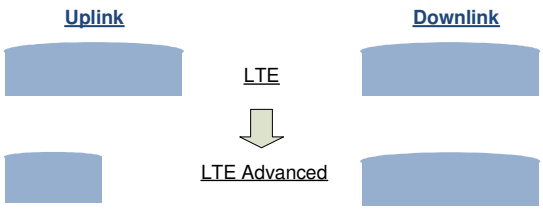

Figure 3: Support of asymmetric bandwidths for LTE Advanced

Summary

LTE Advanced will be standardised in the 3GPP specification Release 10 and will be designed to meet the 4G requirements as defined by ITU. Amongst others 4G technologies must support various bandwidth allocations up to 100MHz and shall support peak data rates up to 1 Gbps for stationary terminals. LTE Advanced, which is likely to be the first true 4G technology, will be a smooth evolution of the LTE standard will be based on same principles and numerology. Work on the requirements is already progressing in 3GPP while work on technology proposals is expected to go on for some time within the working groups. Several changes on the physical layer can be expected to support larger bandwidths with more flexible allocations and to make use of further enhanced antenna technologies. Coordinated base stations with coordinated scheduling, coordinated MIMO or interference management and suppression will also require changes on the network architecture.

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