LTE-Advanced

Original Circular Letter

- LTE-Advanced will be an evolution of LTE. Therefore LTE-Advanced must be backward compatible with LTE Release 8.
- LTE-Advanced requirements will meet or even exceed IMT-Advanced requirements following the ITU-R agenda.
- LTE-Advanced should support significantly increased instantaneous peak data rates in order to reach ITU requirements. Primary focus should be on low mobility users. Moreover, it is required a further improvement of cell edge data rates.

Key Requirements

- Improved Spectrum Efficiency
- Support for Wider Bandwith : up to 100 MHz
- Downlink Transmission
  - 8X8 MIMO
  - 1 Gbps (low-mobility)
  - 100 Mbps (high-mobility)
- Uplink Transmission
  - Up to 500 Mbps
- Reduced Latency
- Relay Functionality
- Backward Compatibility & Interworking

Capacity-related Requirements

	Rel. 8 LTE	Rel. 10 LTE-Advanced
Peak data rate	Downlink – 300 Mbps Uplink – 75 Mbps	Downlink – 1 Gbps Uplink – 500 Mbps
Peak Spectrum Efficiency	Downlink – 15 [bps/Hz] Uplink – 3.75 [bps/Hz]	Downlink – 30 [bps/Hz] (8X8 MIMO) Uplink – 15 [bps/Hz] (4x4 MIMO)
Scalable Bandwidth Support	Up to 20 MHz	Up to 20 MHz, with band aggregation up to 100 MHz
Capacity	200 active users per cell in 5 MHz	3 times higher than LTE
Latency	Control-plane – 50 msec User-plane – 4.9 msec	Control-plane – 50 msec User-plane – 4.9 msec

Source: 3GPP TR 36.913

Capacity-related Requirements

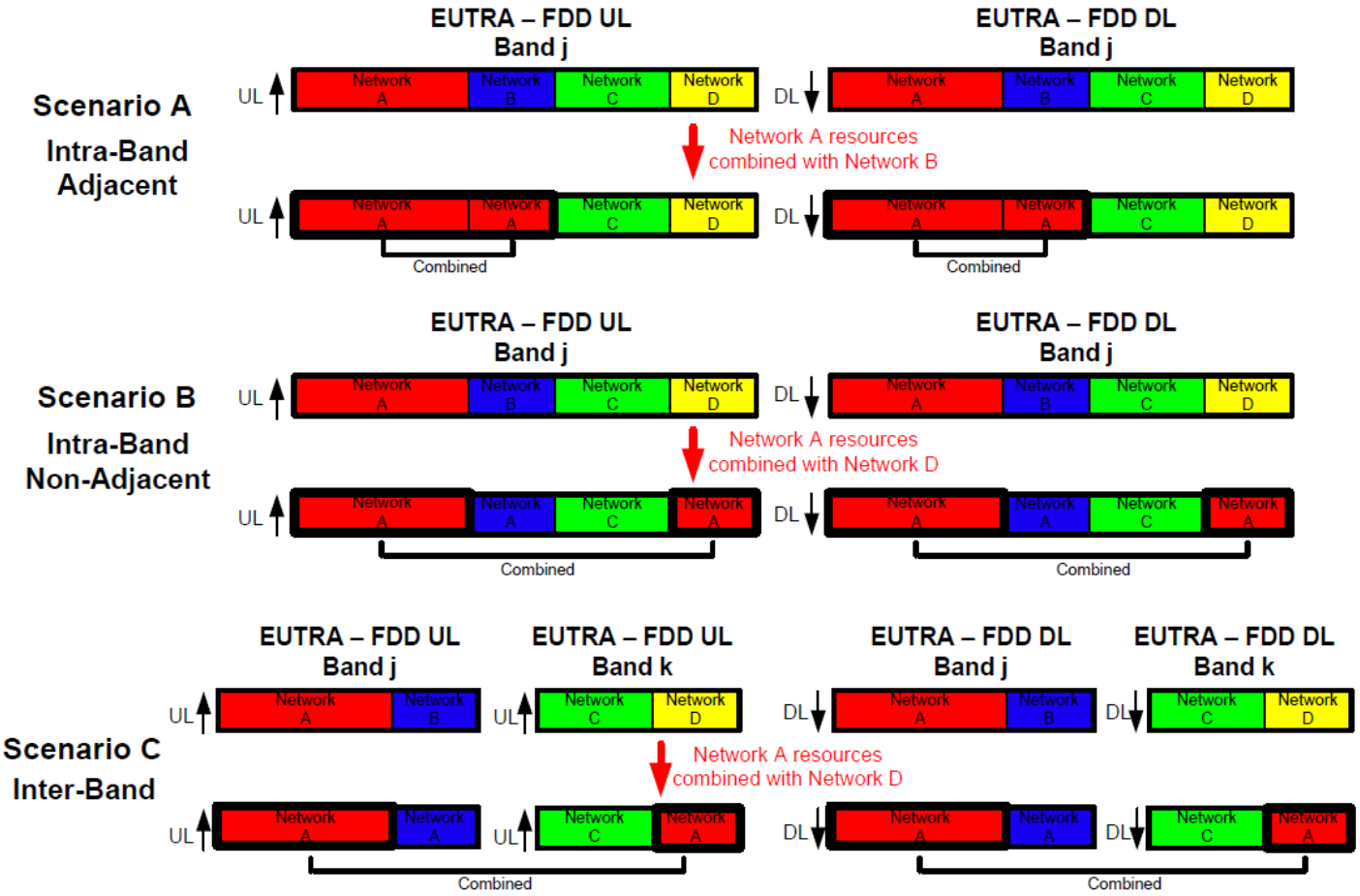
Item	IMT-Advanced Requirement	LTE-Advanced Projected Capability
Peak Data Rate Downlink		1 Gbps
Peak Data Rate Uplink		500 Mbps
Spectrum Allocation	Up to 40 MHz	Up to 100 MHz
Latency User Plane	10 msec	10 msec
Latency Control Plane	100 msec	50 msec
Peak Spectral Efficiency DL	15 bps/Hz (4X4)	30 bps/Hz (8X8)
Peak Spectral Efficiency UL	6.75 bps/Hz (2X4)	15 bps/Hz (4X4)
Average Spectral Efficiency DL	2.2 bps/Hz (4X2)	2.6 bps/Hz (4X2)
Average Spectral Efficiency UL	1.4 bps/Hz (2X4)	2.0 bps/Hz (2X4)
Cell-Edge Spectral Efficiency DL	0.06 bps/Hz (4X2)	0.09 bps/Hz (4X2)
Cell-Edge Spectral Efficiency UL	0.03 bps/Hz (2X4)	0.07 bps/Hz (2X4)

LTE-Advanced Features

- Support of Wider Bandwith
- Uplink Transmission Enhancements
- Downlink Transmission Enhancements
- Advanced Relaying
- Heterogeneous Network Support
- MBMS Enhancements
- SON Enhancements

3GPP published Release 10 of the standard in March 2011 and froze the features set for LTE-Advanced. Completion of Release 10 is the final step in the four year process to ensure that the 3GPP radio interface will meet the formal requirements of IMT-Advanced.

Support of Wider Bandwith



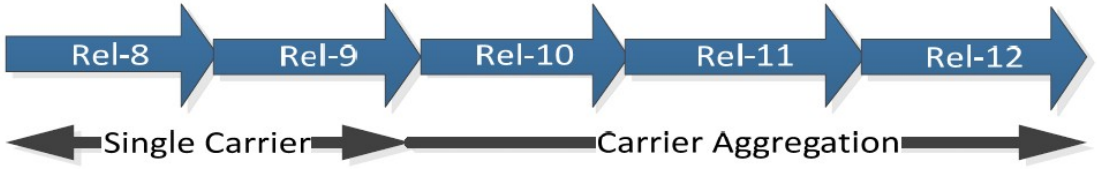
Source : 3GPP Release 10 and Beyond – 4G Americas

LTE & Carrier Aggregation

- LTE Rel 8 & 9
  - Single-carrier operation
  - Bandwith from 1.4 MHz, through 3, 5, 10, and 15, up to 20 MHz
- LTE Rel 10
  - Aggregation of up to 5 “component carriers” i.e. the LTE Rel 8 & 9 carriers
  - As a result, up to 100 MHz (i.e. 5 X 20 Mhz)
  - Each component fully compatible with Rel 8 & 9 i.e. co-existence of Rel 8, 9, & 10 UEs possible
  - 3 band scenarios
    - TDD Intra-band (band 40)
    - FDD Inter-band (Band 1 & 5)
    - FDD Inter-band (Band 3 & 7)

LTE-Advanced Carrier Aggregation

- Peak data rates of 1 Gbps on downlink and 500 Mbps on uplink.
- Up to five carriers can be aggregated, where each carrier is called a “component carrier”.
- Each component carrier can have any of the bandwidths supported in LTE Rel-8 (1.4, 3, 5, 10, 15 and 20 MHz). As a result, LTE carrier aggregation can support operation on transmission bandwidths of up to 100 MHz by aggregating five 20 MHz carriers.
- Each component carrier is fully backward compatible to Release-8/9. This backward compatibility to Release 8/9 allows the technologies developed for LTE Release-8/9 to be fully reused in Release-10. It also allows the coexistence of Release 8 and 9 UEs together with Release-10 UEs, which is very important for seamless system transition from Release 8 and 9 to Release 10.
- A carrier aggregation capable UE can simultaneously receive and transmit in one or multiple component carriers.



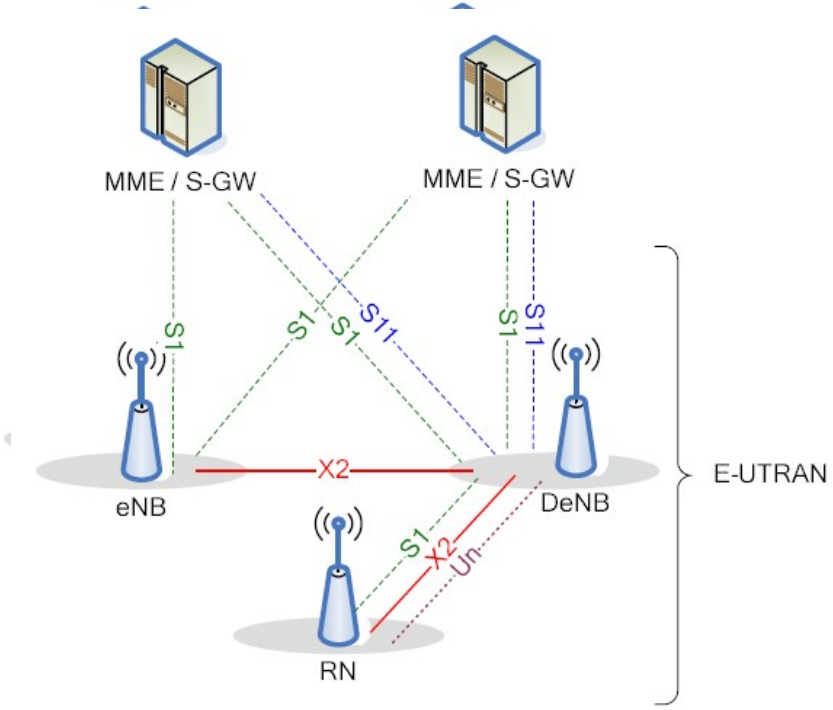
The Benefits of Carrier Aggregation

- Increase system's peak data rate and throughput performance, as LTE spectral efficiency increases with bandwith
- Provide load-balancing across frequencies and systems, thus improving quality-of-service by reducing network congestion on one band or frequency
- Alleviate the inefficiencies inherent to non-contiguous or narrow (5 MHz or less) channel bandwidths

UL&DL Transmission Enhancements

- Support up to eight transmission layers in DL i.e. 8X8 MIMO
- Support up to four transmission layers in UL i.e. 4X MIMO
- UE-specific reference signals for demodulation of up to eight layers
- Feedback of channel-state information (CSI) based on a separate set of reference signals – CSI reference signals (sparse signals)

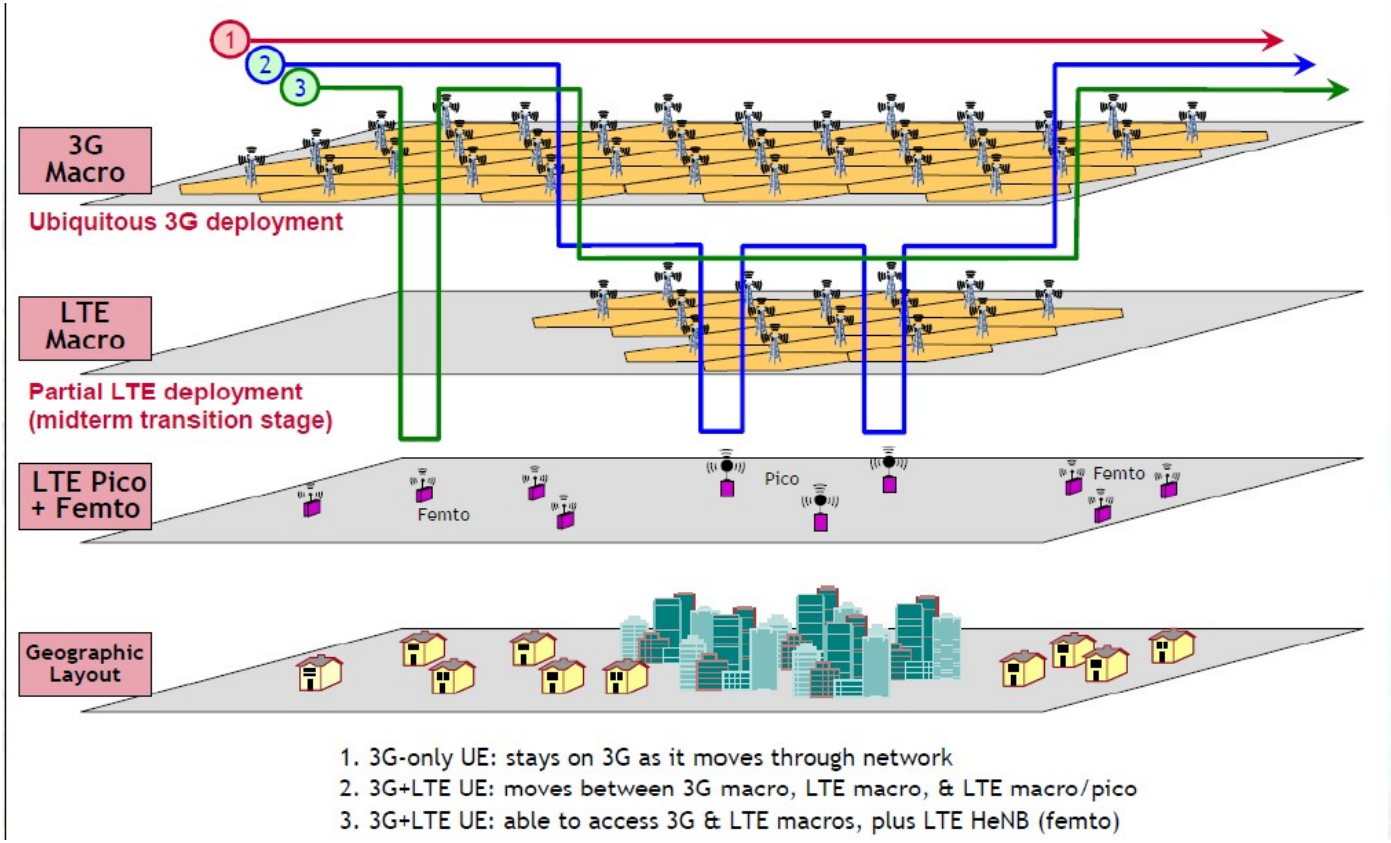
Advanced Relaying



Source: 3GPP TS 36.300

- The eNB-to-relay link is operating in the same carrier frequency as eNB-to-UE link.
- The Relay Node (RN) has the following characteristics:
  - It control cells, each of which appears to a UE as a separate cell distinct from the donor cell
  - The cells shall have their own Physical Cell ID (defined in LTE Rel-8) and the relay node shall transmit its own synchronization channels, reference symbols, …
  - The UE shall receive scheduling information and HARQ feedback directly from the relay node and send its control channels (SR/CQI/ACK) to the relay node
- No UE impact, and all legacy LTE UEs shall be served by the relay cell.
- Two use-cases: Coverage-area extension and Capacity/data-rate area extension

Heterogeneous Networks



Heterogeneous Networks Support]

- **Enhanced Inter-Cell Interference Control (ICIC) for non-Carrier Aggregation (CA) based deployments of heterogeneous networks for LTE**
- **Objective:** Identify and evaluate non-CA based strategies of heterogeneous network deployments, as well as determine the standardization work necessary to support enhanced inter-cell interference coordination solutions for control and data channels if need is identified (targeted for completion by RAN#49)
  - The study shall include consideration of Rel-8/9 techniques and ensure backward compatibility for Rel-8/9 terminals as well as minimize physical layer air interface impact
- Following completion of the above feasibility evaluation, specify suitable solutions considering enhanced ICIC techniques for control and data channels

MBMS Enhancements

- **Objective:** to specify RAN enhancements for functionality to support MBMS over E-UTRAN as follows:
- Enable statistical multiplexing gains for variable bit rate services.
- Support of Allocation and Retention Priority (ARP) pre-emption function for MBMS E-RABs.
- Specify a simple mechanism to enable the network to know the reception status of UEs receiving a given MBMS service in the RRC connected mode;
  - To allow network to know whether or not it is appropriate to activate/deactivate the service via MBSFN.
  - The impact of such mechanisms on legacy devices should be minimized (it is tolerable if reception status of legacy devices stays unknown to the network).
  - RAN groups should liaise with SA and CT according to the progress of aspects related to the non RAN parts of the solution

SON Enhancements

Coverage and Capacity Optimization (CCO)

- Enabling detection of following problems:
- Priority 1: coverage problems, e.g. coverage holes
- Priority 2: capacity problems

Mobility Robustness Optimization (MRO) enhancements

- Enabling detection and possible correction of following problems:
- Connection failures in inter-RAT environment:
  - Priority 1: at HOs from LTE to UMTS/GSM
  - Priority 2: at HOs from UMTS/GSM to LTE
- Obtaining UE measurements in case of unsuccessful re-establishment after connection failure
- Ping-pongs in idle mode (inter-RAT and intra-LTE environment)
- Ping-pongs in active mode (inter-RAT)
- HO to wrong cell (in intra-LTE environment) that does not cause connection failure (e.g. short stay problem)

Mobility Load Balancing (MLB) enhancements

- The use case is to fulfil following objectives:
- Improving reliability of MLB in intra-LTE scenarios
- Improving functionality of the MLB in inter-RAT scenarios (the transport method agreed for Rel-9 should be used for Rel-10).

LTE-A Announcements

OPERATORS

- **NTT DoCoMo** is undertaking field experiments of LTE-Advanced in real radio environments in the cities of Yokosuka and Sagamihara. NTT DoCoMo has confirmed the performance of LTE-Advanced technologies using simulators in its R & D center, achieving transmission data rates of approximately 1 Gbps on the downlink and 200 Mbps on the uplink.
- The **Korea Communications Commission and the Korean Ministry of Knowledge Economy** held a demonstration of an LTE-Advanced system, which featured 'evolved Multimedia Broadcast and Multicast Service' indoors and an in-vehicle demonstration outdoors demonstrating 3D full HD broadcasting and HD video calling.
- **SK Telecom** plans to launch an LTE Advanced network in 2013.
- Other operators who have announced plans to deploy LTE-A in a similar timeframe include **AT&T Mobility, Clearwire, Dish Network**, and **Sprint**.
- **YOTA Networks** and **Huawei** Launch World's First LTE-Advanced Commercial Network (Oct 2012)

VENDORS

- **Ericsson** demonstrated a working version of LTE-Advanced to the Swedish Post and Telecom Agency in June 2011. Downlink speeds more than 10 x faster than today‟s LTE deployments were shown. 60MHz of aggregated spectrum was used, compared to 20 MHz maximum possible with the current LTE standard. Also 8x8 MIMO was used on the downlink.
- **Nokia Siemens Networks** demonstrated LTE-Advanced at CommunicAsia 2011 in Singapore.

Source: GSA Evolution to LTE Report – January 2012

LTE Device Categories

UE Category	Peak Datarate (Mbps)		Modulation		Max RF Bandwith (MHz)	MIMO (Max)
	DL	UL	DL	UL	DL	DL
1	10	5	QPSK, 16QAM, 64QAM	QPSK, 16QAM	20	1X1
2	50	25	QPSK, 16QAM, 64QAM	QPSK, 16QAM	20	2X2
3	100	50	QPSK, 16QAM, 64QAM	QPSK, 16QAM	20	2X2
4	150	50	QPSK, 16QAM, 64QAM	QPSK, 16QAM	20	2X2
5	300	75	QPSK, 16QAM, 64QAM	QPSK, 16QAM, 64QAM	20	4x4
6	300	50	QPSK, 16QAM, 64QAM	QPSK, 16QAM	20-40	4x4
7	300	150	QPSK, 16QAM, 64QAM	QPSK, 16QAM	20-40	4x4
8	1200	600	QPSK, 16QAM, 64QAM	QPSK, 16QAM, 64QAM	20-40	8X8

Release-10 Categories

Source: 3GPP TS 36.306

THANK YOU