



THE Mobile Broadband Standard



3GPP Radio Access Networks LTE-Advanced Status

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Contents



 3GPP TSG-RAN standardisation activities

 LTE Release 8&9 overviews

 LTE Release 10 (LTE-Advanced)

- Motivation
- Key requirements
- Key features
- Performance evaluations

 LTE Release 11



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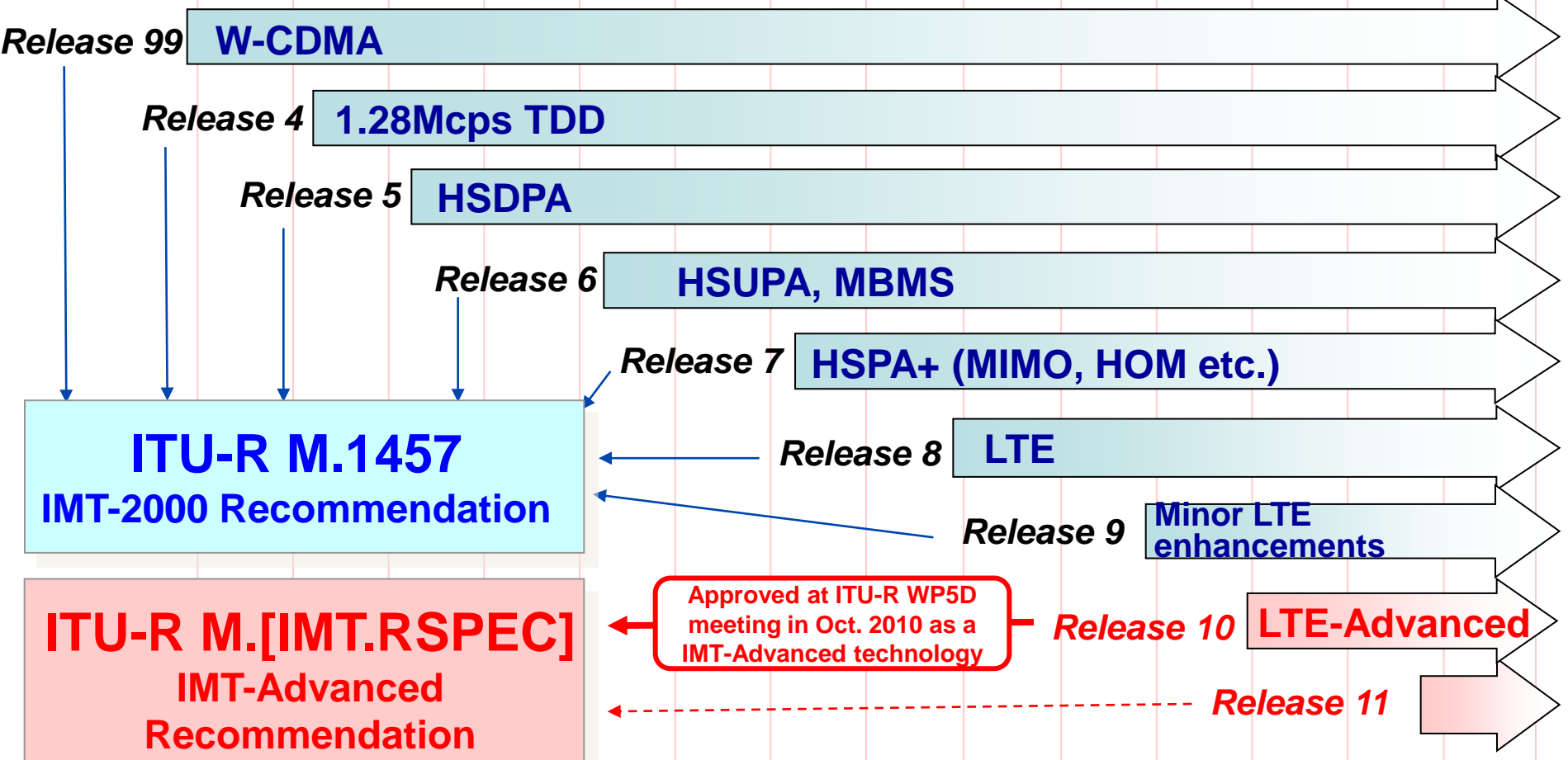
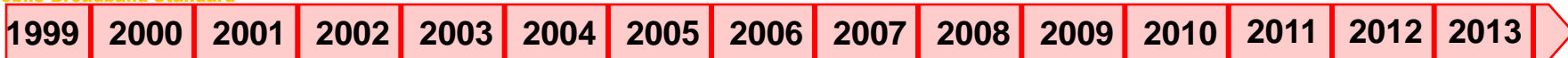


3GPP TSG-RAN Standardisation Activities



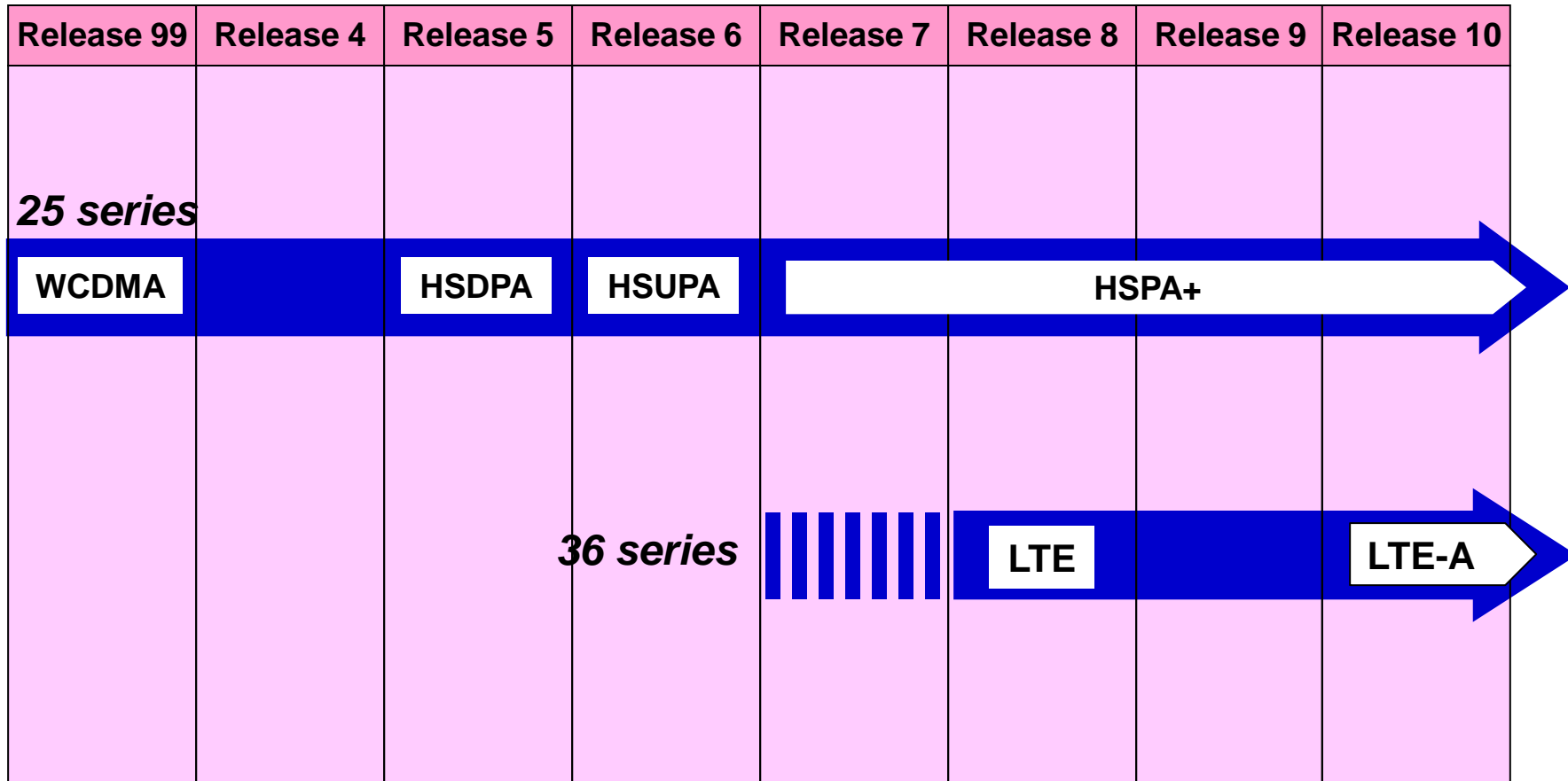
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Releases of 3GPP Specifications





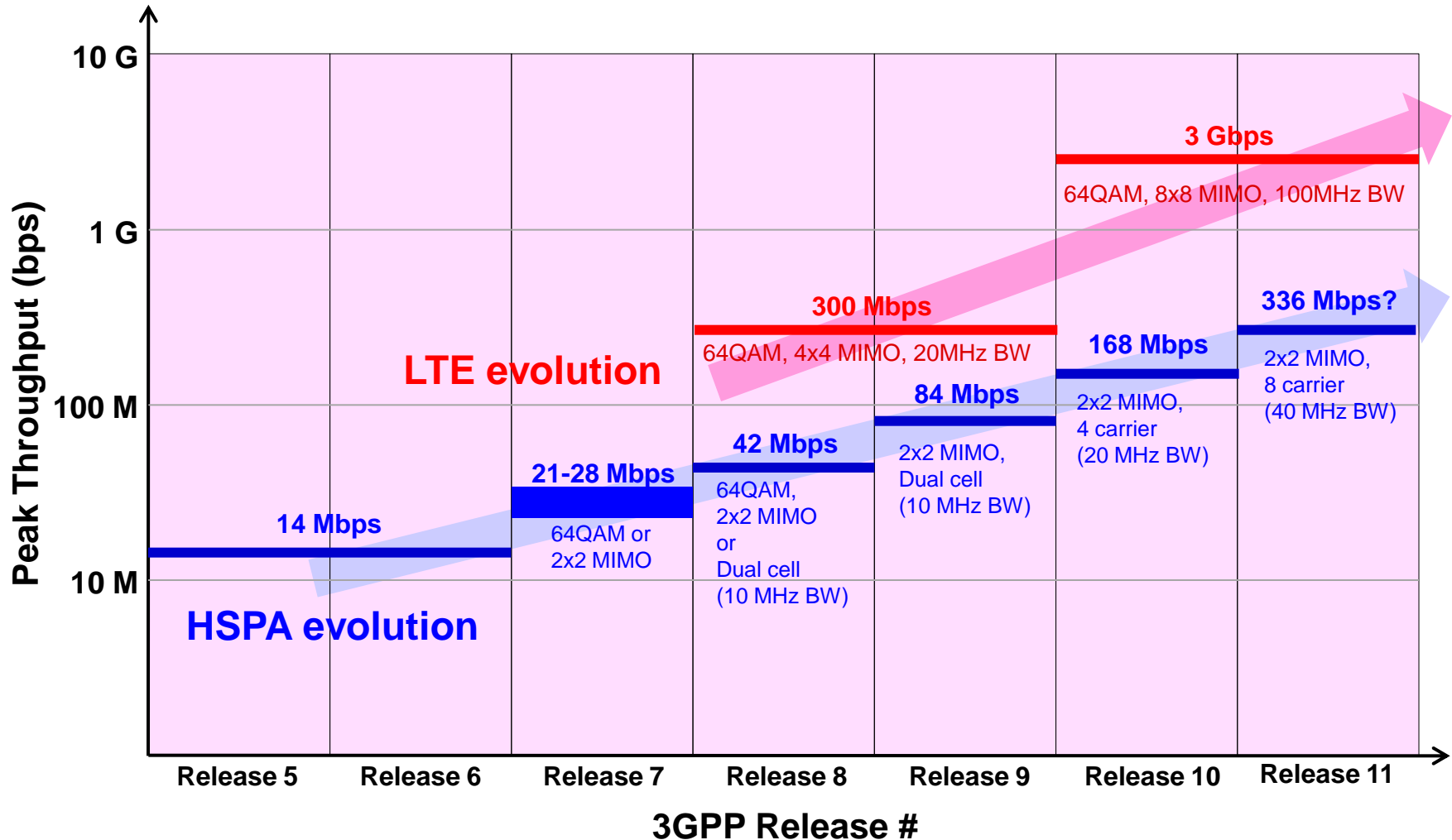
Technology Evolution path in 3GPP Standards





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LTE and HSPA Evolutions





LTE Release 8 & 9





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LTE Release 8 Key Features



- High spectral efficiency
 - OFDM in Downlink
 - Robust against multipath interference
 - High affinity to advanced techniques
 - Frequency domain channel-dependent scheduling
 - MIMO
 - DFTS-OFDM(“Single-Carrier FDMA”) in Uplink
 - Low PAPR
 - User orthogonality in frequency domain
 - Multi-antenna application
- Very low latency
 - Short setup time & Short transfer delay
 - Short HO latency and interruption time
 - Short TTI
 - RRC procedure
 - Simple RRC states
- Support of variable bandwidth
 - 1.4, 3, 5, 10, 15 and 20 MHz





Rel-9 LTE features



Small enhancements from LTE Release 8 mainly for higher layer

- HeNB (Home eNode B)
 - HeNB Access Mode
 - Rel-8: Closed Access Mode
 - Rel-9: Open and Hybrid Mode
 - HeNB Mobility between HeNB and macro
 - Rel-8: Out-bound HO
 - Rel-9: in-bound and inter-CSG HO
- SON (self-organizing networks)
 - Rel-8: Self configuration, Basic self-optimization
 - Rel-9: RACH optimization, etc
- MBMS
 - Rel-8: Radio physical layer specs
 - Rel-9: Radio higher layer and NW interface specs
- LCS (Location Services)
 - Rel-8: U-Plane solutions
 - Rel-9: C-Plane solutions, e.g. OTDOA





LTE Release 10 (LTE-Advanced)





Motivation of LTE-Advanced



- IMT-Advanced standardisation process in ITU-R
- Additional IMT spectrum band identified in WRC07
- Further evolution of LTE Release 8 and 9 to meet:
 - Requirements for IMT-Advanced of ITU-R
 - Future operator and end-user requirements





Key Requirements for LTE-Advanced



- LTE-Advanced shall be deployed as an evolution of LTE Release 8 and on new bands.
 - LTE-Advanced shall be backwards compatible with LTE Release 8
- ➔ **Smooth and flexible system migration from Rel-8 LTE to LTE-Advanced**

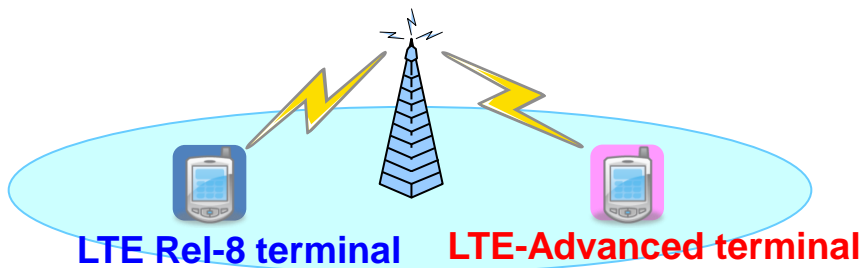
LTE-Advanced (LTE Release 10)



LTE-Advanced contains all features of LTE Rel-8&9 and additional features for further evolution

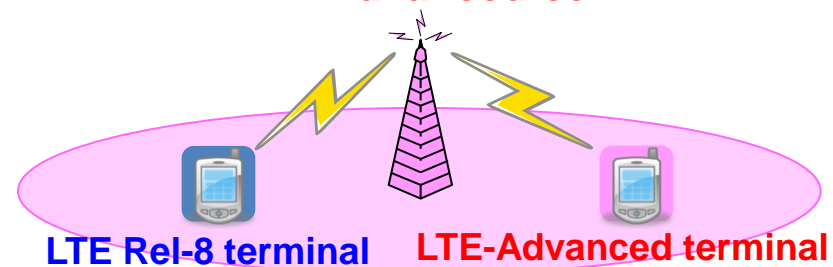
LTE-Advanced evolved from LTE Rel-8

LTE Rel-8 cell



An LTE-Advanced terminal can work in an LTE Rel-8 cell

LTE-Advanced cell



An LTE Rel-8 terminal can work in an LTE-Advanced cell

LTE-Advanced backward compatibility with LTE Rel-8



Target performance of LTE-Advanced



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		Rel. 8 LTE	LTE-Advanced	IMT-Advanced
Peak data rate	DL	300 Mbps	1 Gbps	1 Gbps ^(*)
	UL	75 Mbps	500 Mbps	
Peak spectrum efficiency [bps/Hz]	DL	15	30	15
	UL	3.75	15	6.75

		Antenna configuration	Rel. 8 LTE*1	LTE-Advanced*2	IMT-Advanced*3
Average spectrum efficiency [bps/Hz/cell]	DL	2-by-2	1.69	2.4	-
		4-by-2	1.87	2.6	2.2
		4-by-4	2.67	3.7	-
	UL	1-by-2	0.74	1.2	-
		2-by-4	-	2.0	1.4
Cell edge user throughput [bps/Hz/cell/user]	DL	2-by-2	0.05	0.07	-
		4-by-2	0.06	0.09	0.06
		4-by-4	0.08	0.12	-
	UL	1-by-2	0.024	0.04	-
		2-by-4	-	0.07	0.03



*1 See TR25.912(Case 1 scenario) *2 See TR36.913(Case 1 scenario)

*3 See ITU-R M.2135(Base Coverage Urban scenario)



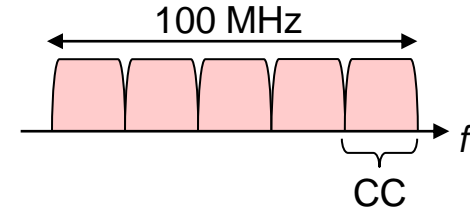
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Key Features in LTE Release 10



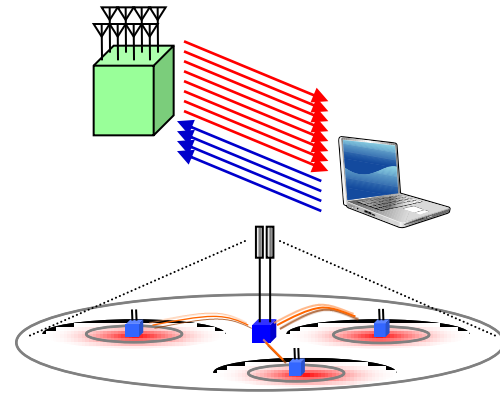
■ Support of Wider Bandwidth(Carrier Aggregation)

- Use of multiple component carriers(CC) to extend bandwidth up to 100 MHz
- Common physical layer parameters between component carrier and LTE Rel-8 carrier
- ➔ Improvement of peak data rate, backward compatibility with LTE Rel-8



■ Advanced MIMO techniques

- Extension to up to 8-layer transmission in downlink
- Introduction of single-user MIMO up to 4-layer transmission in uplink
- Enhancements of multi-user MIMO
- ➔ Improvement of peak data rate and capacity

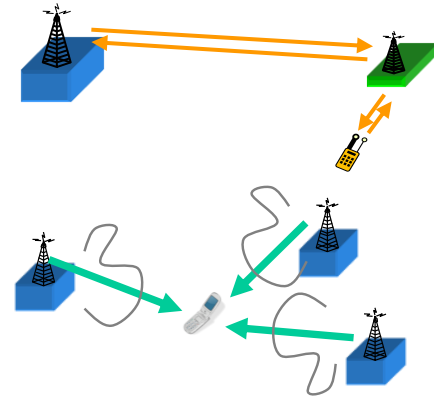


■ Heterogeneous network and eICIC(enhanced Inter-Cell Interference Coordination)

- Interference coordination for overlaid deployment of cells with different Tx power
- ➔ Improvement of cell-edge throughput and coverage

■ Relay

- Type 1 relay supports radio backhaul and creates a separate cell and appear as Rel. 8 LTE eNB to Rel. 8 LTE UEs
- ➔ Improvement of coverage and flexibility of service area extension



■ Coordinated Multi-Point transmission and reception (CoMP)

- Support of multi-cell transmission and reception
- ➔ Improvement of cell-edge throughput and coverage



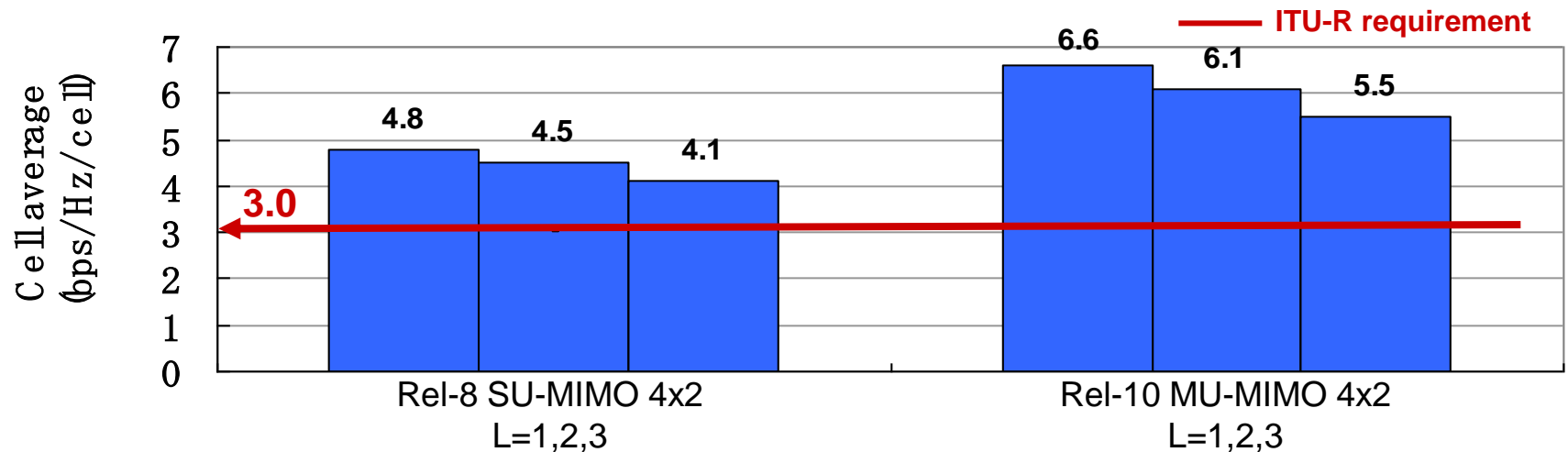
3GPP LTE-Advanced Self-Evaluation



 The self-evaluation results shows:

- For LTE Release 10, FDD RIT and TDD RIT Component meets the minimum requirements of all 4 required test environments, individually.
- Baseline configuration exceeding ITU-R requirements with minimum extension
 - LTE release 8 fulfills the requirements in most cases (no extensions needed)
 - Extensions to Multi-user MIMO from Release 8 fulfills the requirements in some scenarios (Urban Macro/Micro DL)

Spectrum Efficiency: FDD DL, Indoor (InH)



LTE-Advanced Experiments in NTT DOCOMO



DOCOMO developed LTE-Advanced experimental system aligned with 3GPP LTE Release 10 specifications

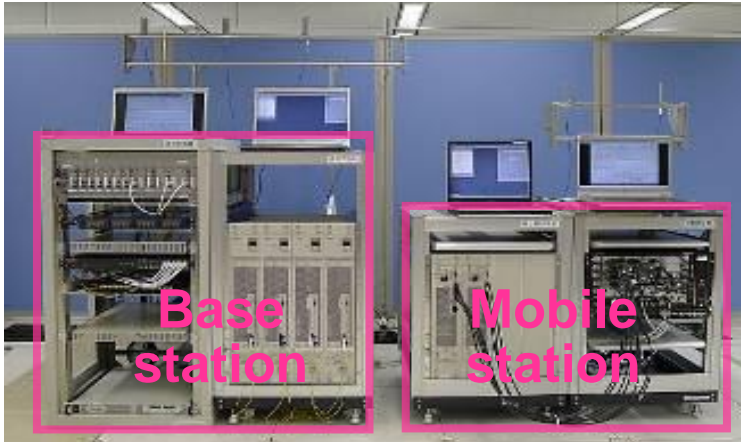
◆ Laboratory experiments

Total throughput of 1 Gbps for 2 Mobile stations in downlink was achieved by applying 4x2 multi-user MIMO technique

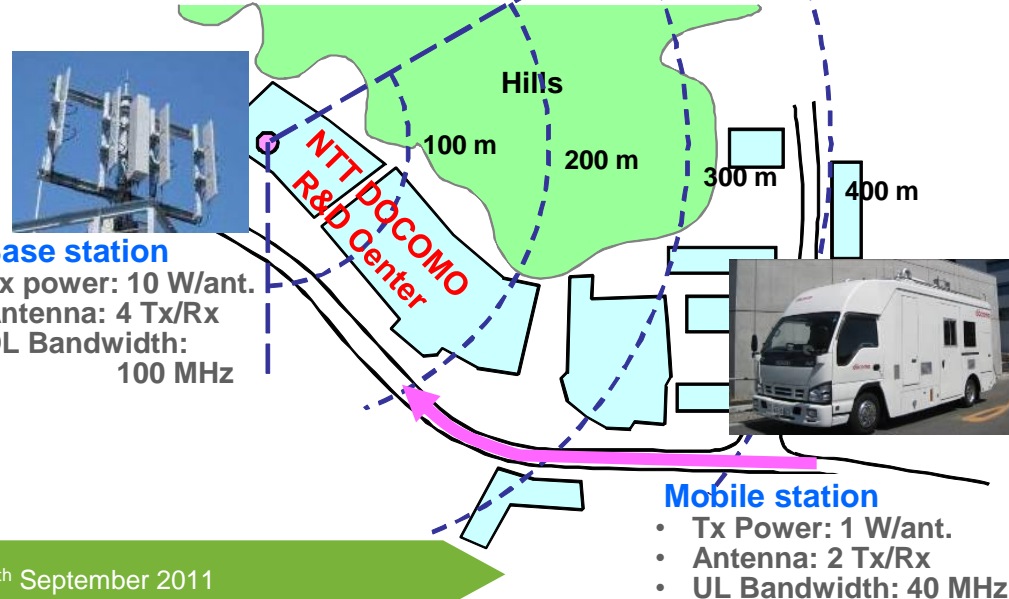
◆ Field experiments

Throughput of **600 Mbps** in downlink and **200 Mbps** in uplink was achieved by applying 2x2 single-user MIMO technique

◆ Laboratory



◆ Field @ Yokosuka, Japan



LTE-Advanced key technologies, e.g., carrier aggregation and enhanced MIMO



NTT DOCOMO Field Trial



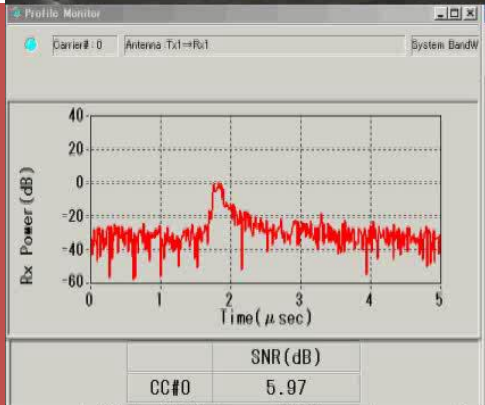
INITIATIVE

Panorama View



10 km/h

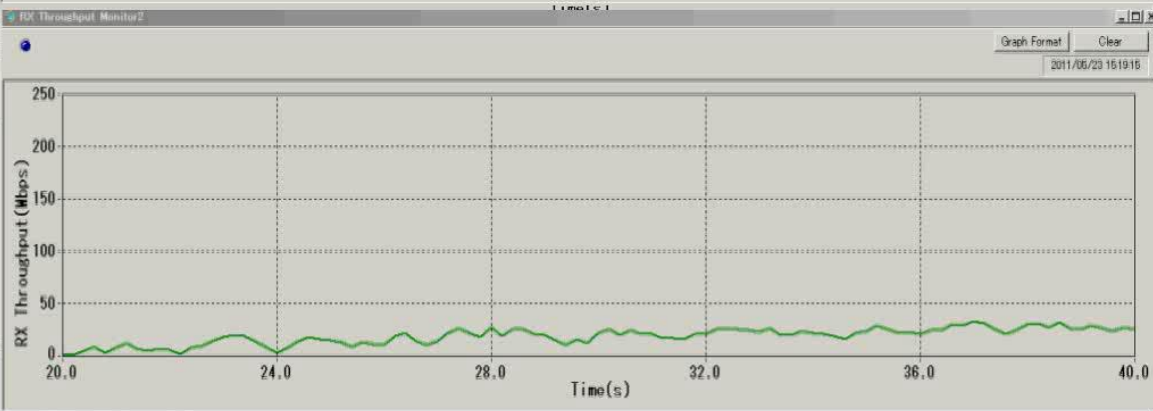
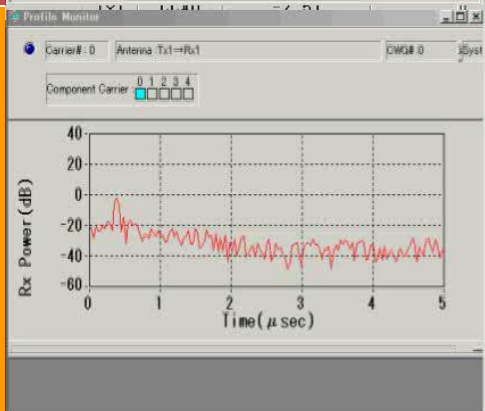
Downlink



◀ 600 Mbps

5 CCs
2x2 SU-MIMO

Uplink



◀ 200 Mbps

2 CCs
2x2 SU-MIMO



LTE Release 11 (LTE-Advanced)





Release 11

Work Items/Study Items



- Release 11 works for further enhancements of LTE-Advanced and HSPA have been started to complete by Sep. 2012
- So many Work Items and Study Items are proposed based on various requirements for further enhancements

WI/SI for LTE or LTE&HSPA	
1	Further Enhanced Non CA-based ICIC for LTE
2	LTE Carrier Aggregation Enhancements
3	Study on Coordinated Multi-Point Operation for LTE
4	Study on Enhanced Uplink Transmission for LTE
5	Study on further Downlink MIMO enhancements for LTE-Advanced
6	Study on Further Enhancements to LTE TDD for DL-UL Interference Management and Traffic Adaptation
7	Coordinated Multi-Point Operation for LTE
8	Provision of low-cost MTC UEs based on LTE
9	Proposed SI on LTE Coverage Enhancements
10	Improvements to LTE Relay Backhaul
11	Study on LTE Device to Device Discovery and Communication - Radio Aspects
12	Network-Based Positioning Support for LTE
13	Service continuity and location information for MBMS for LTE
14	LTE RAN Enhancements for Diverse Data Applications
15	Study on signaling and procedure for interference avoidance for in-device coexistence
16	Study on HetNet mobility enhancements for LTE
17	Study on RAN improvements for Machine-Type Communications
18	RAN overload control for Machine-Type Communications
19	Study Item on Further RAN Improvements for Machine-type Communications
20	study item proposal for LTE and HSDPA Carrier Aggregation
21	Enhancement of Minimization of Drive Tests for E-UTRAN and UTRAN
22	Signalling and procedure for interference avoidance for in-device coexistence
23	Study Item Proposal for Opportunistic Carrier Aggregation across 3GPP-LTE and WLAN
24	Carrier based HetNet ICIC for LTE
25	Study on further enhancements for HNB and HeNB
26	LIPA Mobility and SIPTO at the Local Network RAN Completion
27	Further Self Optimizing Networks (SON) Enhancements
28	SI: Mobile Relay for E-UTRA
29	Network Energy Saving for E-UTRAN

30	UE Over the Air (Antenna) conformance testing methodology- Laptop Mounted Equipment Free Space test
31	UE demodulation performance requirements under multiple-cell scenario for 1.28Mcps TDD
32	Uplink Transmit Diversity for HSPA – Open Loop
33	Non-contiguous 4C-HSDPA operation
34	Study on Measurement of Radiated Performance for MIMO and multi-antenna reception for HSPA and LTE terminals
35	Study on Inclusion of RF Pattern Matching Technologies as a positioning method in the E-UTRAN
36	Relays for LTE (part 2)
37	Enhanced performance requirement for LTE UE
38	Electromagnetic Compatibility (EMC) Requirements for Multi-Standard Mobile Terminals and Ancillary Equipment
39	SI: Passive InterModulation (PIM) handling for Base Stations
40	E-UTRA medium range and MSR medium range/local area BS class requirements
41	SI: Study of RF and EMC Requirements for Active Antenna Array System (AAS) Base Station
42	RF Requirements for Multi-band and Multi-standard Radio (MB-MSR) Base Station

WI/SI for HSPA	
1	Eight carrier HSDPA
2	Uplink Transmit Diversity for HSPA – Closed Loop
3	Study on Uplink MIMO
4	Study on HSDPA multipoint transmission
5	Study item on HSPA enhancement for LCR TDD
6	Four Branch MIMO transmission for HSDPA
7	Uplink MIMO with 64QAM for HSUPA
8	Further Enhancements to CELL_FACH
9	HSDPA Multiflow Data Transmission
10	Single Radio Voice Call Continuity from UTRAN/GERAN to E-UTRAN/HSPA
11	SID: Introduction of Hand phantoms for UE OTA antenna testing



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Spectrum Explosion in 3GPP



E-UTRA operating bands in the latest 3GPP spec

E-UTRA Operating Band	Uplink (UL) operating band		Downlink (DL) operating band		Duplex Mode
	BS receive		BS transmit		
	UE transmit		UE receive		
	F _{UL,low}	F _{UL,high}	F _{DL,low}	F _{DL,high}	
1	1920 MHz	1980 MHz	2110 MHz	2170 MHz	FDD
2	1850 MHz	1910 MHz	1930 MHz	1990 MHz	FDD
3	1710 MHz	1785 MHz	1805 MHz	1880 MHz	FDD
4	1710 MHz	1755 MHz	2110 MHz	2155 MHz	FDD
5	824 MHz	849 MHz	869 MHz	894 MHz	FDD
6 ¹	830 MHz	840 MHz	875 MHz	885 MHz	FDD
7	2500 MHz	2570 MHz	2620 MHz	2690 MHz	FDD
8	880 MHz	915 MHz	925 MHz	960 MHz	FDD
9	1749.9 MHz	1784.9 MHz	1844.9 MHz	1879.9 MHz	FDD
10	1710 MHz	1770 MHz	2110 MHz	2170 MHz	FDD
11	1427.9 MHz	1447.9 MHz	1475.9 MHz	1495.9 MHz	FDD
12	699 MHz	716 MHz	729 MHz	746 MHz	FDD
13	777 MHz	787 MHz	746 MHz	756 MHz	FDD
14	788 MHz	798 MHz	758 MHz	768 MHz	FDD
15	Reserved		Reserved		FDD
16	Reserved		Reserved		FDD
17	704 MHz	716 MHz	734 MHz	746 MHz	FDD
18	815 MHz	830 MHz	860 MHz	875 MHz	FDD
19	830 MHz	845 MHz	875 MHz	890 MHz	FDD
20	832 MHz	862 MHz	791 MHz	821 MHz	FDD
21	1447.9 MHz	1462.9 MHz	1495.9 MHz	1510.9 MHz	FDD
...					
23	2000 MHz	2020 MHz	2180 MHz	2200 MHz	FDD
24	1626.5 MHz	1660.5 MHz	1525 MHz	1559 MHz	FDD
25	1850 MHz	1915 MHz	1930 MHz	1995 MHz	FDD
...					
33	1900 MHz	1920 MHz	1900 MHz	1920 MHz	TDD
34	2010 MHz	2025 MHz	2010 MHz	2025 MHz	TDD
35	1850 MHz	1910 MHz	1850 MHz	1910 MHz	TDD
36	1930 MHz	1990 MHz	1930 MHz	1990 MHz	TDD
37	1910 MHz	1930 MHz	1910 MHz	1930 MHz	TDD
38	2570 MHz	2620 MHz	2570 MHz	2620 MHz	TDD
39	1880 MHz	1920 MHz	1880 MHz	1920 MHz	TDD
40	2300 MHz	2400 MHz	2300 MHz	2400 MHz	TDD

Spectrum band to be standardized by Sep. 2011

- UMTS/LTE 3500MHz
- Extending 850 MHz Upper Band (814 – 849 MHz)

Spectrum band to be standardized by Sep. 2012

- LTE-Advanced Carrier Aggregation of Band 3 and Band 7
- LTE Advanced Carrier Aggregation of Band 4 and Band 17
- LTE Advanced Carrier Aggregation of Band 4 and Band 13
- LTE Advanced Carrier Aggregation of Band 4 and Band 12
- LTE Advanced Carrier Aggregation of Band 5 and Band 12
- LTE Advanced Carrier Aggregation of Band 20 and Band 7
- LTE Advanced Carrier Aggregation Band 2 and Band 17
- LTE Advanced Carrier Aggregation Band 4 and Band 5
- LTE Advanced Carrier Aggregation Band 5 and Band 17
- LTE Advanced Carrier Aggregation in Band 41
- LTE Advanced Carrier Aggregation in Band 38
- LTE Downlink FDD 716-728MHz
- LTE E850 - Lower Band for Region 2 (non-US)
- LTE for 700 MHz digital dividend
- Study on Extending 850MHz
- Study on Interference analysis between 800~900 MHz bands
- Study on UMTS/LTE in 900 MHz band



Conclusions



LTE Release 8

- Specification completed and stable
- Commercially deployed and committed to deploy by many operators all over the world

LTE Release 9

- Small enhancements of LTE Release 8
- Specification completed and stable

LTE Release 10

- Stage 3 frozen and stabilized
- Accepted as a technology of IMT-Advanced by ITU-R WP5D
- Materials and specifications submitted to ITU-R WP5D for ITU-R recommendation M.[IMT.RSPEC]

LTE Release 11

- Started with many Work Items and Study Items for further enhancements of LTE Release 10

Thank You

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