

Further Enhancements for LTE-Advanced

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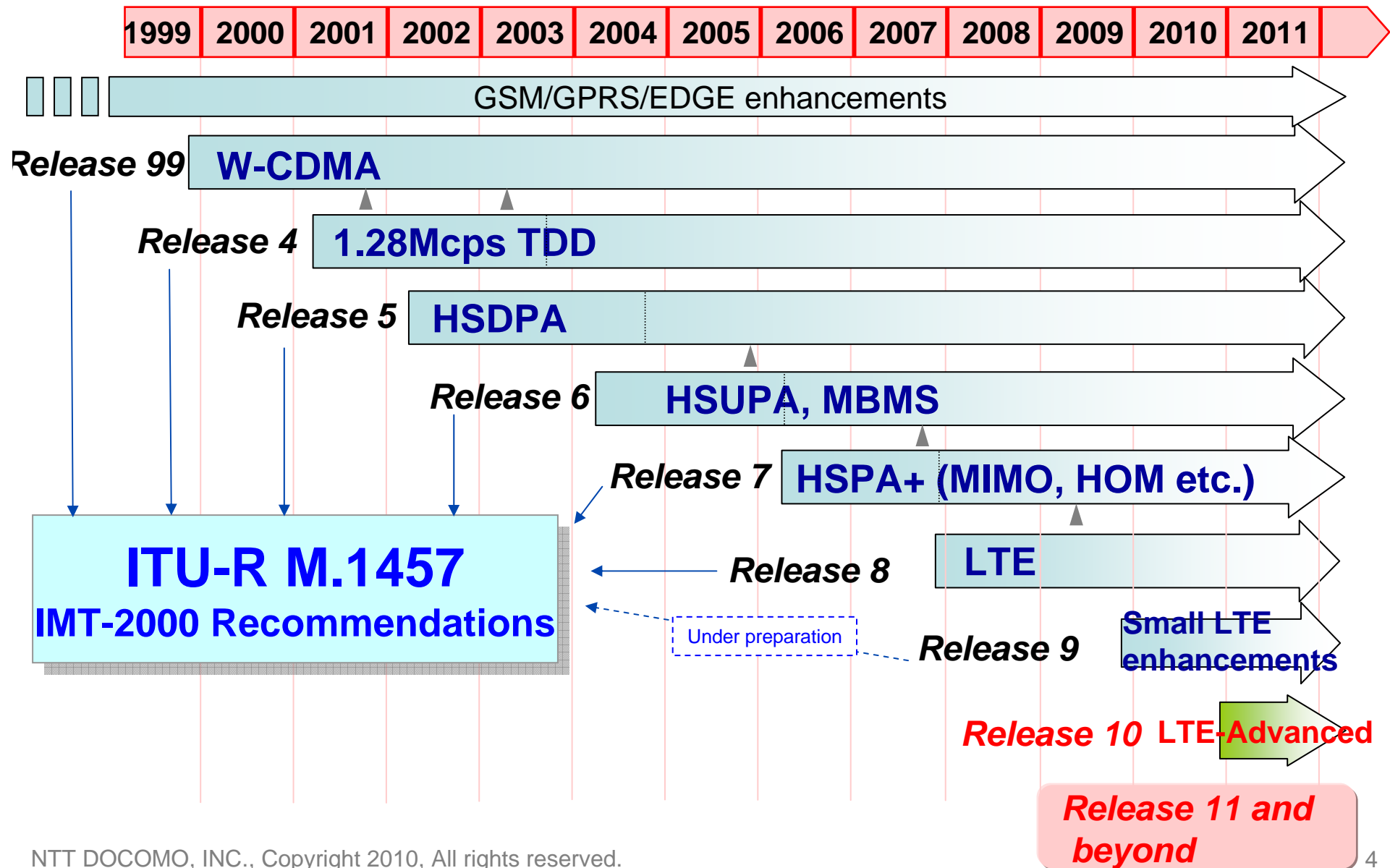
- Introduction
- LTE Rel-10
 - Requirements
 - Technical features
- LTE-enhancement
 - Targets
 - Rel-11 topics
- Summary

- **LTE Rel-10**
 - Rel-10 discussion on LTE-Advanced is actively on-going to approve the Rel-10 specs by December 2010.

- **LTE Rel-11 and Beyond**
 - Rel-11 discussion is expected to start from the beginning of 2011
 - LTE enhancements and beyond LTE/IMT are gaining interest across the world as standardisation fora and the industry progress toward IMT-Advanced.
 - ARTIST4G Project
 - ITU-R WP5D IMT.UPDATE toward WRC-12 and 16

- **Time has come to look at possible concept for Rel-11 and beyond**

Release of 3GPP RAN Specification



LTE Rel-10

System Performance Requirements for LTE-Advanced

- Peak data rate
 - 1 Gbps data rate will be achieved by 4-by-4 MIMO and transmission bandwidth wider than approximately 70 MHz
- Peak spectrum efficiency
 - DL: Rel. 8 LTE satisfies IMT-Advanced requirements
 - UL: Need to double from Release 8 to satisfy IMT-Advanced requirements

		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

***“100 Mbps for high mobility and 1 Gbps for low mobility” is one of the key features as written in Circular Letter (CL)**

System Performance Requirements for LTE-Advanced (Cont'd)

- Capacity and cell-edge user throughput
 - Targets for LTE-Advanced were set considering 1.4 to 1.6 times gain increase from Release 8 LTE performance

		Ant. Config.	Rel. 8 LTE*1	LTE-Advanced*2	IMT-Advanced*3
Capacity [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)

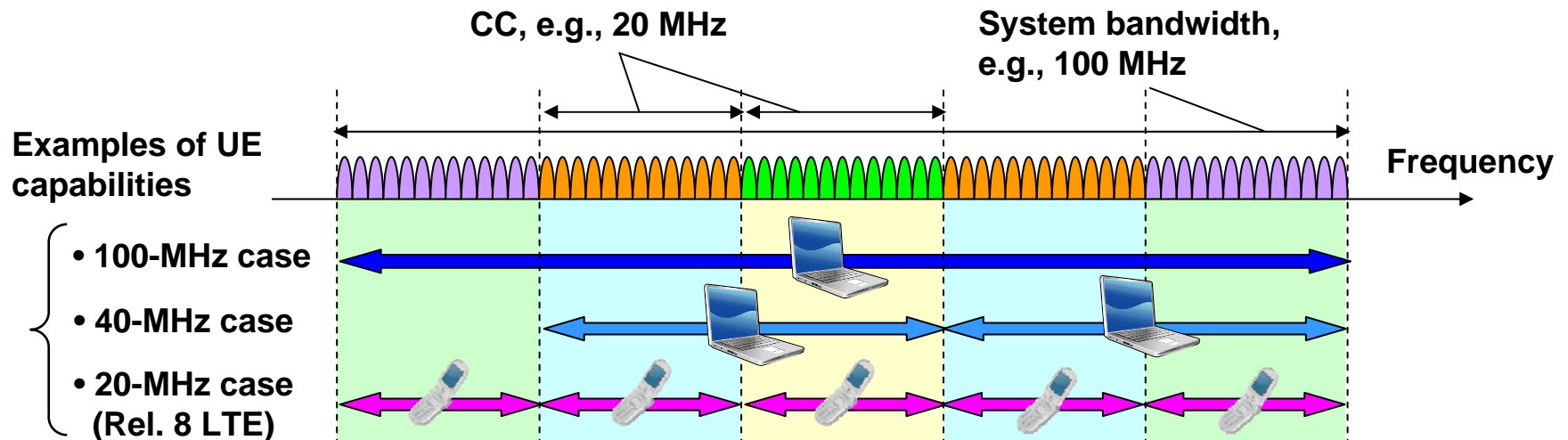
*3 See ITU-R M.2135(Base Coverage Urban scenario)

Rel-10 work items for LTE-Advanced:

- Carrier aggregation (CA)
- Enhanced downlink multiple antenna transmission
- Uplink multiple antenna transmission
- Relaying
- Enhanced ICIC for non-CA based deployments of heterogeneous networks for LTE (eICIC)

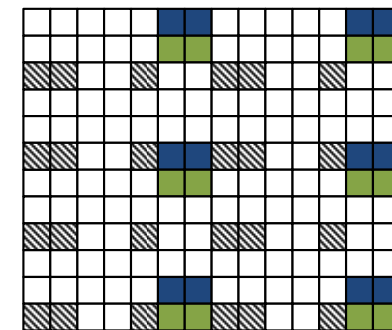
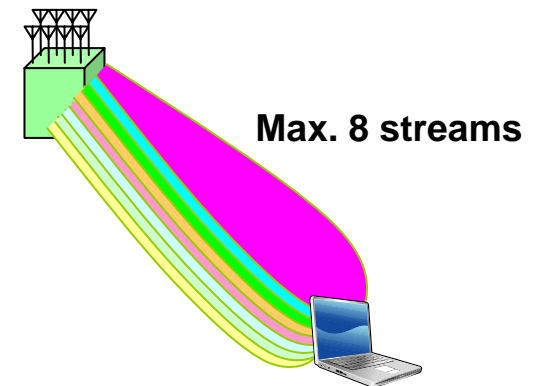
Carrier Aggregation (CA)

- Wider bandwidth transmission using carrier aggregation (CA) for both DL and UL
 - Entire system bandwidth up to, e.g., 100 MHz, comprises multiple basic frequency blocks called component carriers (CCs)
 - Satisfy requirements for peak data rate
 - Each CC can be configured in a backward compatible way with Rel-8 LTE
 - Maintain backward compatibility with Rel-8 LTE
- Carrier aggregation supports both contiguous and non-contiguous spectrum, and asymmetric bandwidth for FDD
 - Achieve flexible spectrum usage



Enhanced Downlink Multi-antenna Transmission

- Extension up to 8-layer transmission
 - Increased from 4 layers in Rel-8/9
 - Satisfy the requirement for peak spectrum efficiency, i.e., 30 bps/Hz
- Additional reference signals (RS) specified:
 - Channel state information RS (CSI-RS)
 - For downlink channel sounding
 - Sparse, low overhead (configurable)
 - Density: 1 resource element (RE) per antenna port per PRB
 - UE-specific demodulation RS (DM-RS)
 - UE-specific DM-RS can be precoded, supporting non-codebook-based precoding, → applied 1-8-layer transmission, and enhanced multi-user beamforming, such as zero forcing (ZF)
 - DM RS pattern for higher numbers of layers is extended from 2-layer format for transmission mode 8 in Rel-9

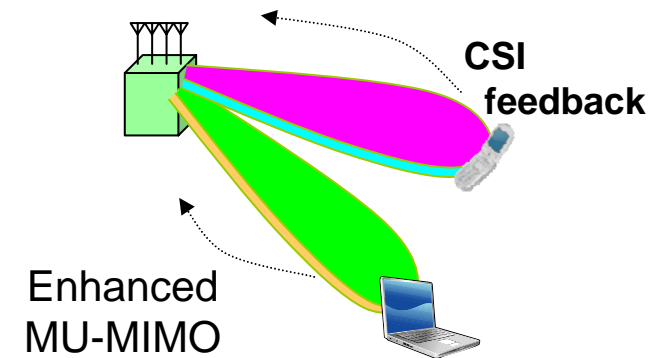


DMRS pattern

Enhanced Downlink Multi-antenna Transmission (Cont'd)

Enhanced Multi-user (MU) MIMO

- MU-MIMO dimensionality
 - Maximum spatial 4 layers
 - Maximum 2 layers per user
- CSI feedback enhancement using two matrix ($W1$, $W2$) feedback frame work
 - $W1$ targets wideband/long-term channel properties
 - $W2$ targets frequency-selective/short-term time channel properties
 - Matrix multiplication is used.
- Dynamic switching between SU/MU MIMO



Uplink Multi-antenna Transmission

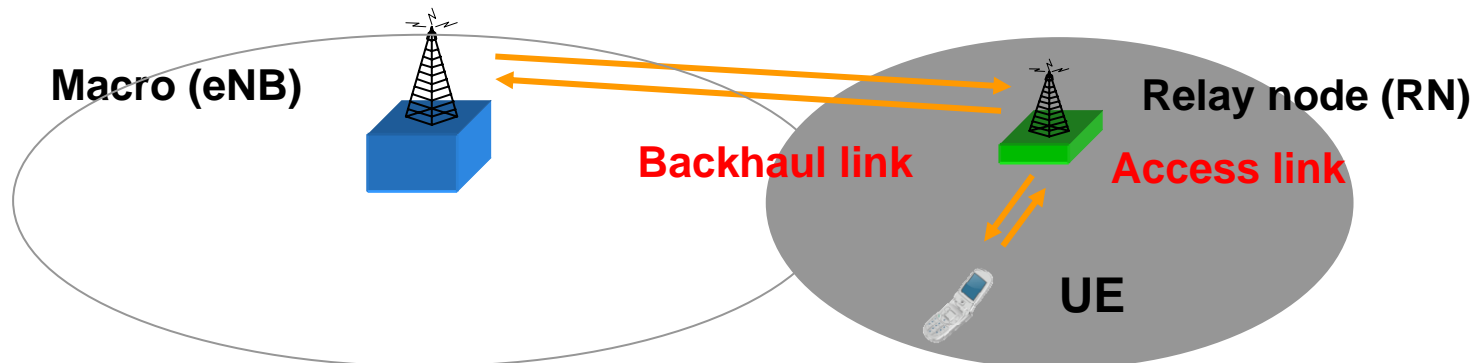
- UL transmit diversity for PUCCH to improve robustness in cell-edge
 - Orthogonal resource transmit diversity is supported for PUCCH format 1 (Scheduling request) 1a/1b (HARQ-Ack), and format 2 (CQI) 2a/2b (CQI+ HARQ-Ack) when UE has two Tx antennas
 - the same modulation symbol from the uplink channel is transmitted from two antenna ports, on two separate orthogonal resources.
- SU-MIMO up to 4-stream transmission to satisfy the requirement for peak spectrum efficiency, i.e., 15 bps/Hz
 - Closed-loop codebook based precoding supported



SU-MIMO up to 4 streams

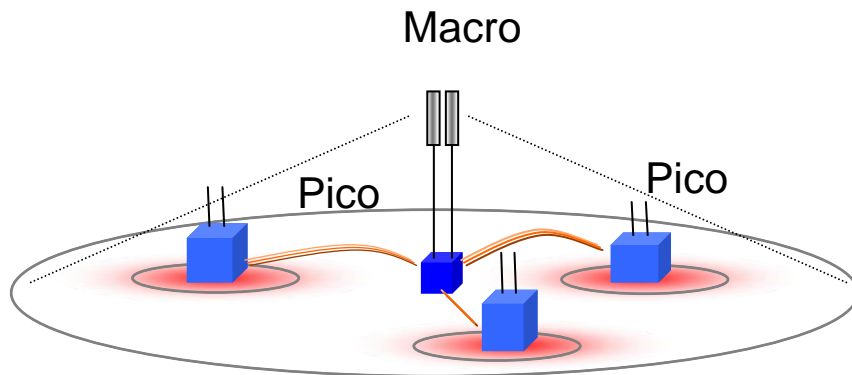
Relaying for LTE

- Relay design target for Rel-10 is coverage extension
 - Supports cell deployments in areas where wired backhaul is not available or very expensive
- “Type 1” relay
 - Inband relaying: same carrier frequency for backhaul and access links
 - Time division multiplexing of backhaul and access links
 - Relay node (RN) creates a separate cell distinct from the donor cell
 - UE receives/transmits control signals for scheduling and HARQ from/to RN
 - RN appears as a Rel-8 LTE eNB to Rel-8 LTE UEs
- “Type 1a” relay
 - Outband relaying: different carrier frequency for backhaul from access link

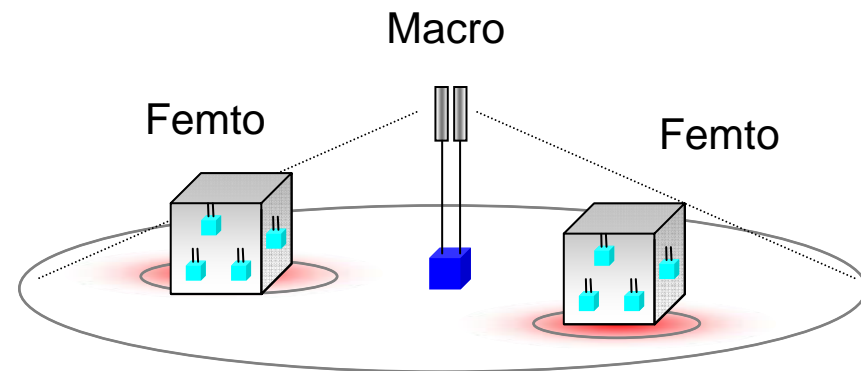


eICIC for non-CA based HetNets

- Interference coordination for non-CA based heterogeneous networks (HetNet)
 - Time domain coordination
 - Extend Rel-8/9 backhaul coordination for macro and pico deployments
 - Power control
 - Femto eNB power reduction to avoid interference to macro UE



HetNet with Macro and Pico



HetNet with Macro and Femto

LTE Rel-11 and Beyond

Future Requirements for Rel-11 and Beyond

Market trends

- Significant increase in data traffic
 - Driven mainly by video
 - Mobile Internet flat-rate tariffs
 - Spread of smart-phone, data-card for PCs
 - Requirement for high data rate comparable with that for fixed Internet
- Femto cell
 - Improve capacity and coverage
 - New services for home use (e.g., “My Area” in DOCOMO)
- Ecosystem, Openness
 - Radio interface, OS, application
- Energy saving
 - World wide interest and activities, e.g. EARTH project, activities in SDOs
- More diverse QoS
 - Increase in diverse data applications incl. Machine type communications, Sin Client
- Remote Radio Unit via optical fiber

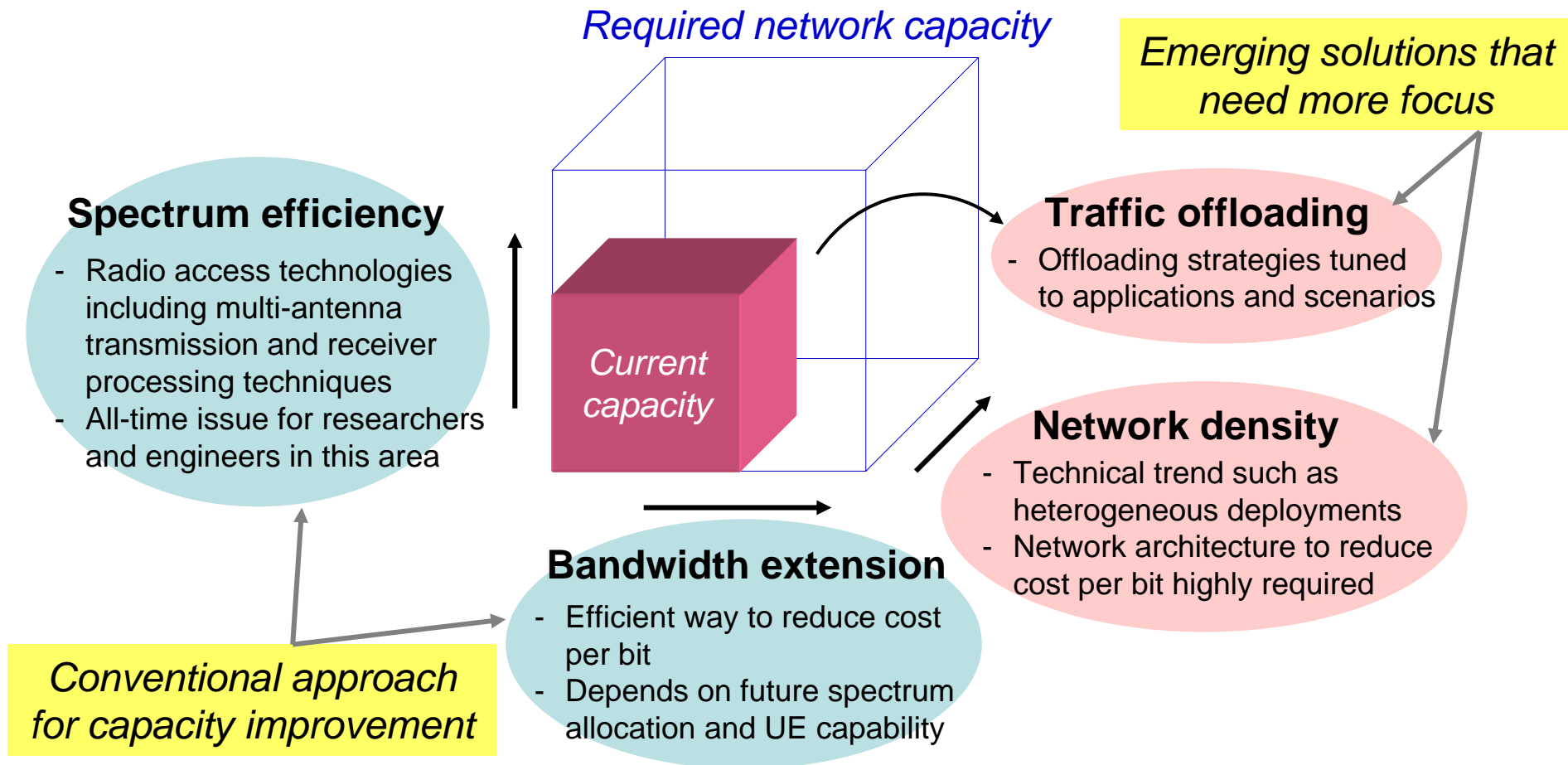


Technology requirements

- Very high network capacity
 - With significant reduction in cost per bit
- Higher spectrum efficiency and user-experienced throughput
- Fairness of user throughput
 - In a cell
 - Improve cell-edge throughput
 - Among cells
 - Urban to rural
 - Digital divide
 - Among users
 - Less system impact from few heavy users
- Low CAPEX and OPEX
- Energy saving
- Scalability and flexibility to optimize system for
 - Various environments
 - Various QoS
- Low end-to-end latency

Evolution Directions

- Evolution directions to further enhance network capacity



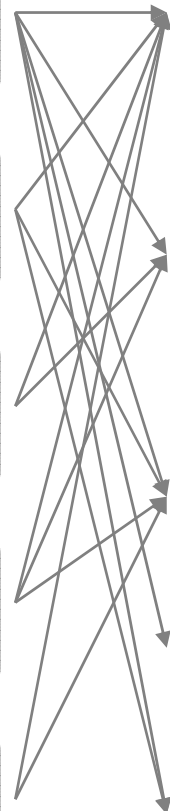
Requirements and Techniques

- Requirements

- Higher capacity and user-experienced throughput
- Fairness of user throughput
- Low CAPEX and OPEX
Energy saving
- Scalability and flexibility for various environments and QoS
- Low end-to-end latency

- Techniques

- Network density Traffic offloading
- New NW architectures/deployments and offloading techniques
- Bandwidth extension
- Techniques for bandwidth extension & enhanced utilization
- Spectrum efficiency
- Multiple access and efficient packet access mechanism
- MIMO (increase in number of Tx/Rx antennas)
- Advanced receiver techniques



LTE Rel-11: Possible Concept

- LTE enhancements after Rel-10
 - Backwards compatibility is essential
 - Non-backwards compatible features can be considered (only) if their gain justifies it
 - Gain-complexity tradeoff in actual commercial network and terminals must be considered
 - Main focus of LTE Rel-11:
 - Refinement of Rel-10 for further performance improvement
 - Features which have been studied but not supported in Rel-10 due to time limitation
- For brand new features targeting beyond Rel-11, e.g., non-backward compatible features, study items can be started during Rel-11 time frame.

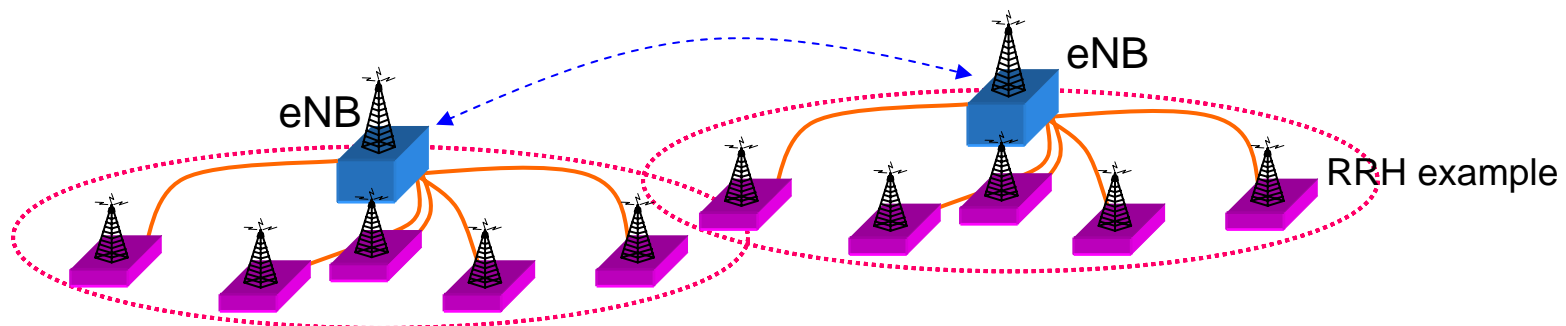
Candidate Topics for Rel-11

Initial candidates for Rel-11

- CoMP
- CA enhancements
- eICIC enhancements
- Advanced receiver
- Relay
- MDT enhancements
- MBMS enhancements
- SON enhancements
- MTC enhancements

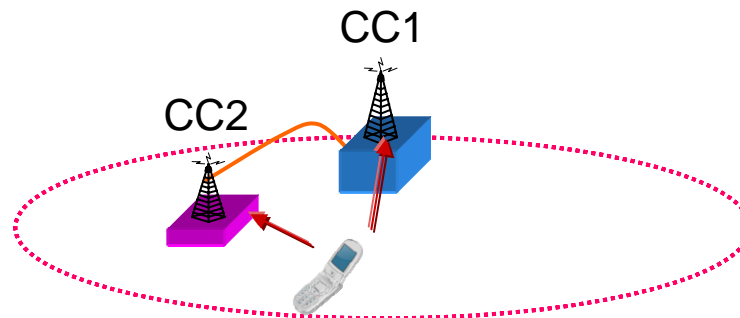
Coordinated Multiple Point Transmission and Reception (CoMP)

- Background
 - Standard transparent CoMP is supported for Rel-10
 - New Study Item (SI) for CoMP will be started.
 - Technical topics
 - Deployment scenarios
 - UE feedback enhancement
 - Multi-cell CQI measurement and feedback
 - Control signaling and measurement procedures
 - UL sounding (SRS) enhancement
 - (CSI-RS for Rel-10 will be designed to support inter-cell measurement for future CoMP)
- **Gain needs to be verified**



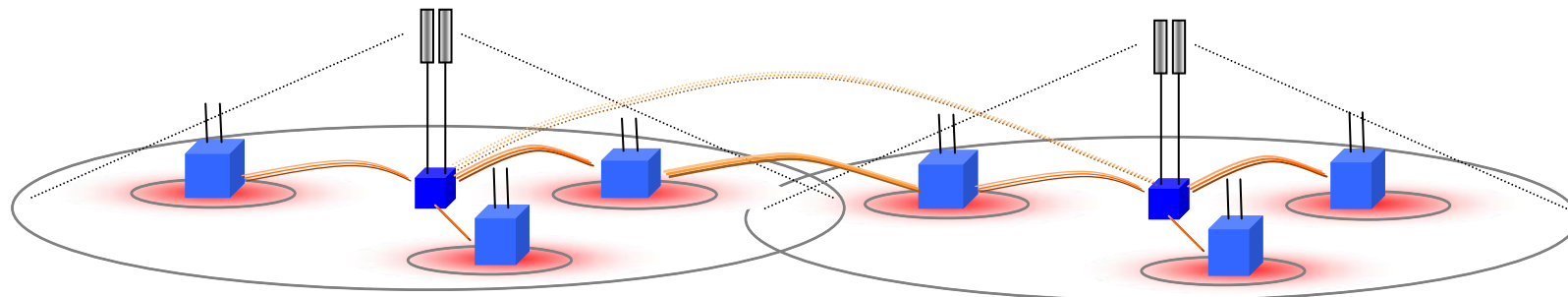
CA Enhancements

- Background
 - Rel-10 specification supports CA up to 5 CCs
 - Further refinements could be considered for Rel-11.
- Technical topics
 - Refinements of Rel-10 features, e.g.,
 - CQI feedback for 5 CC (or more)
 - Reduction of blind decoding at UE
 - Support for inter-band CA (definition of band combinations)
 - Support of various deployment scenarios, such as RRH
 - Support for multiple timing advance for UL CA



eICIC Enhancements

- **Background**
 - Rel-10 will support power control and time domain ICIC Macro
- **Technical topics to be studied**
 - Control channel enhancement
 - Capacity enhancement
 - Enhanced ICIC and flexibility
 - Backhaul support (X2) between macro and femto CSG cells
 - Information exchange between nodes for enhanced ICIC
 - New UE measurement support
 - Interference cancellation at UE
 - Extension of cell selection



- **Background**
 - Performance requirement for advanced receiver has been specified IRC for HSDPA
 - Advanced receiver (IRC) is necessary to meet the ITU-R requirements
 - Typical IRC is MMSE detection using covariance matrix of inter-cell interference
 - 30-40% gain can be expected by evaluation results
 - Advanced receiver is also beneficial in HetNet to improve the performance of both control and data
 - CRS cancellation receiver is a typical example

- **Topics for Rel-11**
 - Performance requirement for a simple multi-cell interference rejection receiver should be specified

- Relay
 - Mobile relays, flow control, coverage extension (include layer 1 issues)
- Minimization of Drive Test (MDT) enhancements
 - Additional measurement, tighter coupling with LCS
- Multimedia Broadcast/Multicast Service (MBMS) enhancements
 - Service continuity aspects
- Self-Optimizing Networks (SON) enhancements
 - LTE-A/HeNB specific aspects
- Machine-Type Communication (MTC) enhancements
 - RAN overload control

- Market demands and requirements for beyond LTE-A
 - Alignment with the market demand needs to be considered
- LTE-Rel-10 and possible extensions to Rel-11
 - CoMP
 - CA enhancements
 - eICIC enhancements (HetNet)
 - Advanced receiver
 - Relay
 - MDT enhancements
 - MBMS enhancements
 - SON enhancements
 - MTC enhancements
- For beyond Rel-11, brand new features with very big gain are needed to meet long-term requirements