LTE Rel-9 and LTE-Advanced in 3GPP

September 8, 2009
Takehiro Nakamura
NTT DOCOMO, INC.
3GPP TSG-RAN Chairman

Copyright© 2009 NTT DOCOMO, INC. All rights reserved

Introduction

- In 3GPP
  - Rel-8 LTE/SAE core specification work has been completed.
  - Small improvements are being discussed for Rel-9 LTE/SAE, due to be finalized by end of 2009.
  - As LTE Release 10 and beyond, project on LTE-Advanced is on going
    - Study item: LTE-Advanced was approved in March 2008
    - Technology description on LTE-Advanced was submitted to ITU-R WP 5D in June 2009 as a candidate of IMT-Advanced
    - Detailed technical information and self-evaluation results will be provided to ITU-R WP 5D in October

- Rel-9 LTE/SAE topics
  - Home eNB
  - SON (self-organizing networks)
  - MBMS
  - LCS

- LTE-Advanced topics
  - Support for wider bandwidth
  - Extension of uplink multiple access
  - Extension of MIMO techniques
  - CoMP (coordinated multiple point transmission and reception)
  - Relaying
  - Self-evaluation results

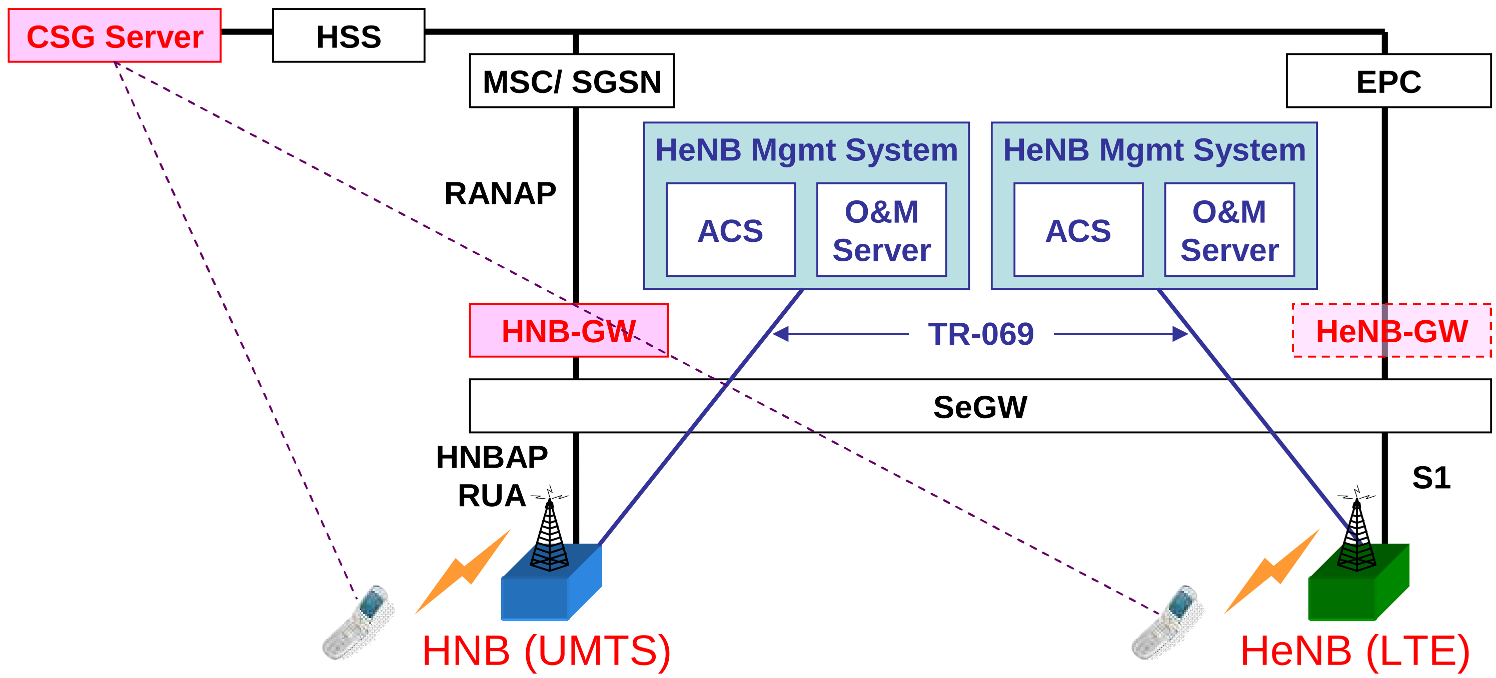
Copyright© 2009 NTT DOCOMO, INC. All rights reserved

LTE Rel-9

Copyright© 2009 NTT DOCOMO, INC. All rights reserved

Home eNB (HeNB)

- Basic functions for Home eNB are supported in Rel-8.
  - HeNB architecture



  - CSG (Closed Subscriber Group) control
    - CSG subscription info (allowed CSG ID list) concept in the UE and NW
    - Broadcasting of CSG ID
    - Implementation dependent UE autonomous search for CSG cells
    - No special inbound mobility procedure in Rel-8 to resolve potential PCI confusion

Copyright© 2009 NTT DOCOMO, INC. All rights reserved

HeNB enhancements in Rel-9

The following enhancements are under discussion:

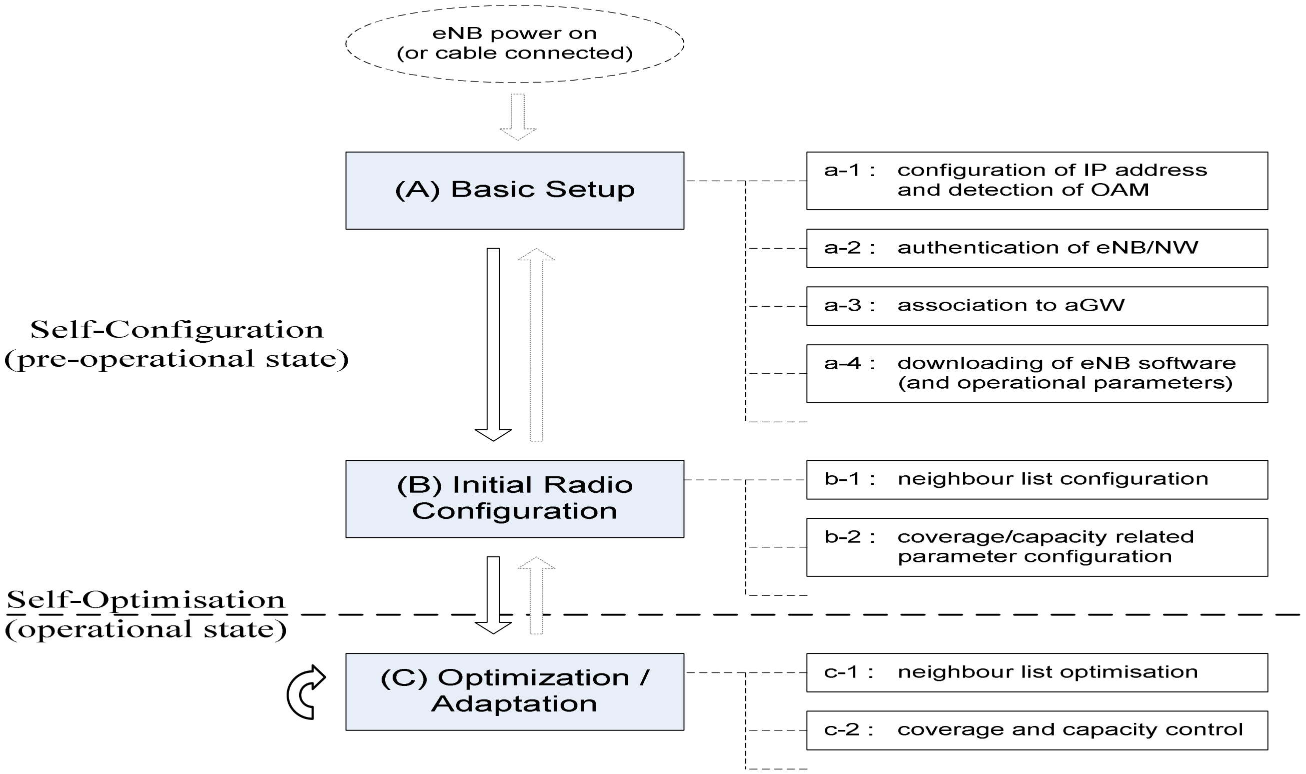
- Inbound mobility from macro eNB to HeNB
  - To resolve PCI confusion at handover (i.e., handover support when different HeNBs neighboring a macro cell are using the same PCI)
- Support for Hybrid Access modes
  - Closed access mode: Only UEs belonging to the CSG is entitled to access the cell
  - Hybrid access mode: All UEs are allowed to access the cell, but UEs belonging to the CSG is entitled to access with priority
- Support of accessibility check in the NW
  - To provide the support of a secondary access control in the NW in addition to UE's preliminary access check
- Local breakout
  - To reduce load on operator's core network
- SON for HeNB
  - Plug and play
  - Interference coordination
- Local IP access to home based NW
- Local IP access to the Internet
- IMS aspect for HeNB

Copyright© 2009 NTT DOCOMO, INC. All rights reserved

NTT docomo

SON (self-organizing network)

- SON is an integral part of LTE. A number of SON features are supported in Rel-8, and work is continuing for Rel-9.
- SON solutions can be divided into two categories:
  - Self-configuration: This function enables the network to automatically perform installation procedure (plug and play)
  - Self-optimisation: This function enables the network to auto-tune its operational parameters using UE, eNB and performance measurements.



Copyright© 2009 NTT DOCOMO, INC. All rights reserved

Rel-8 SON features

The following SON features are supported in Rel-8.

- Self-configuration:
  - S1 (eNB – core NW) interface dynamic configuration
  - X2 (inter-eNB) interface dynamic configuration
  - Framework for PCI (Physical Cell ID) selection
  - Automatic neighbor cell discovery
- Self-optimisation:
  - Basic intra-LTE mobility load balancing
    - Resource-related information exchange between eNBs over X2 I/F
  - Interference management
    - UL interference-related information exchange between eNBs over X2 I/F
- Other:
  - Standardized eNB measurements for multi-vendor SON interworking

Copyright© 2009 NTT DOCOMO, INC. All rights reserved

Rel-9 SON features

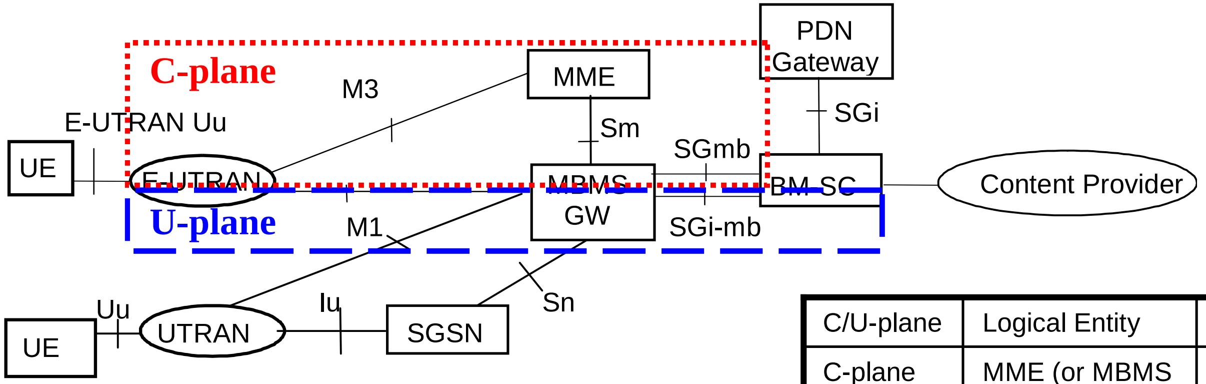
For Rel-9, the following self-optimisation features are being discussed.

- Mobility load balancing
  - Optimisation of cell reselection/ handover parameters to distribute traffic load across the network.
- Mobility robustness optimisation
  - Optimisation of cell reselection/ handover parameters to minimise radio link failures due to mobility.
- Common channel configuration optimisation
  - Optimisation of common channel configuration, e.g., random access channel configuration based on eNB measurements.
- Minimisation of drive tests
  - Logging and reporting of various measurement data (e.g., location information, radio link failure events, throughputs) by the UE and collection of data in a server to minimise drive tests run by operators.
- Coverage/ capacity optimisation
  - Optimisation of system parameters to maximise (adjust to the desired balance between) system coverage and capacity

Copyright© 2009 NTT DOCOMO, INC. All rights reserved

E-MBMS functionalities

- E-MBMS discussion was postponed in Rel-8 due to lack of time and is continued in Rel-9.
- Basic Rel-8 L2/L3 architecture is reused in Rel-9.
- E-MBMS in Rel-9 will support the following functionalities:
  - Broadcast mode and enhanced broadcast mode
  - Static MBSFN area (only)
  - One cell belongs to only one MBSFN area
  - Multiple non overlapping MBSFN areas in a PLMN
  - Broadcast transmission only in a shared carrier deployment (no dedicated carrier)
  - MBSFN without feedback (i.e. no ACK/ NACK or counting)
  - Signalling support, e.g. MCCH over LTE-Uu
- Note that the following functionalities are not supported:
  - MBMS in Home eNB
  - Mobility procedures to support MBMS continuity

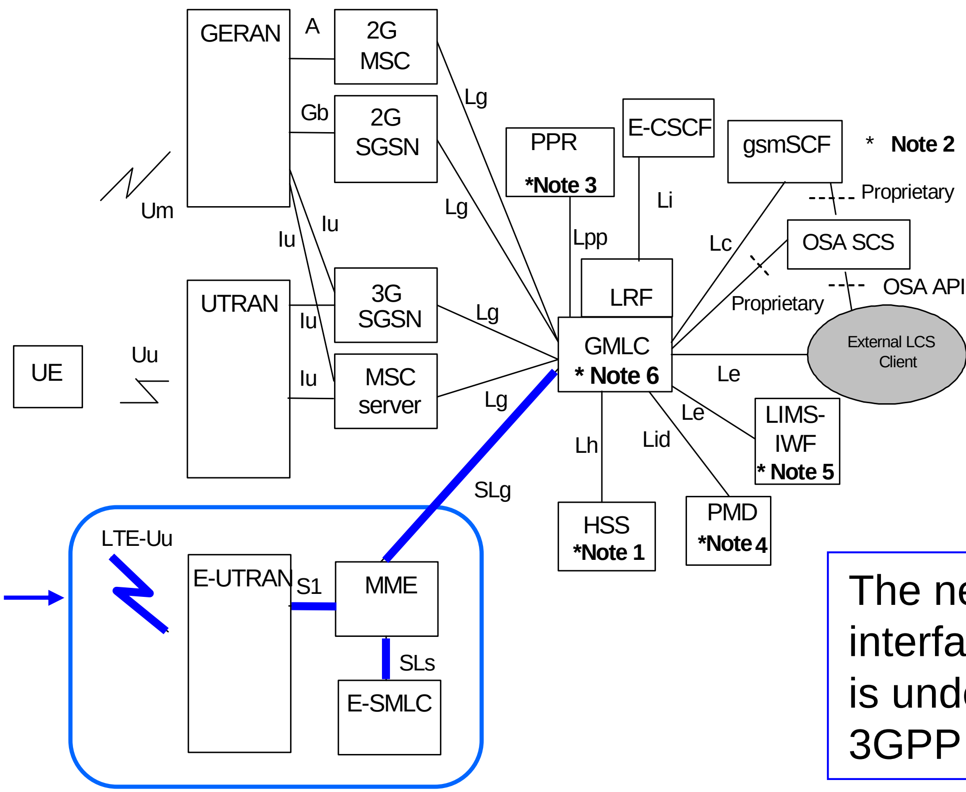


C/U-plane	Logical Entity	Function
C-plane	MME (or MBMS GW C-plane)	･Session control ･Session control message filtering for a certain service area (FFS)
U-plane	MBMS GW U-plane	･U-plane data IP Multicast transmission ･IP Multicast address allocation for each eNB

Copyright© 2009 NTT DOCOMO, INC. All rights reserved

Location service (LCS)

- Location method candidates in LTE:
  - Cell coverage based positioning method
  - OTDOA positioning method
  - A-GNSS based positioning methods
  - U-TDOA positioning method
  - ➔ Applicability of each method is being evaluated.
- General LCS architecture:



Newly defined architecture for LCS support in LTE →

The necessary support in each interface (LTE-Uu, S1, SLs, SLg) is under discussion in the relevant 3GPP WGs

Copyright© 2009 NTT DOCOMO, INC. All rights reserved

LCS protocol architecture

- Protocol architecture in the following figures are adopted for LCS in LTE.
  - LPP (LTE Positioning Protocol) is terminated between UE and E-SMLC
  - LPPa (LTE Positioning Protocol Annex) is terminated between eNB and E-SMLC

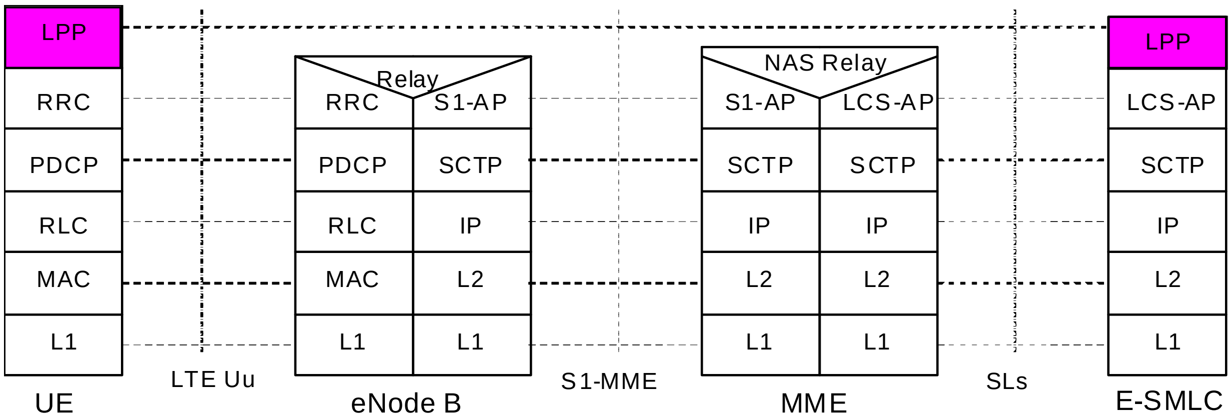


Fig.1: Protocol Stack for signaling between UE and E-SMLC

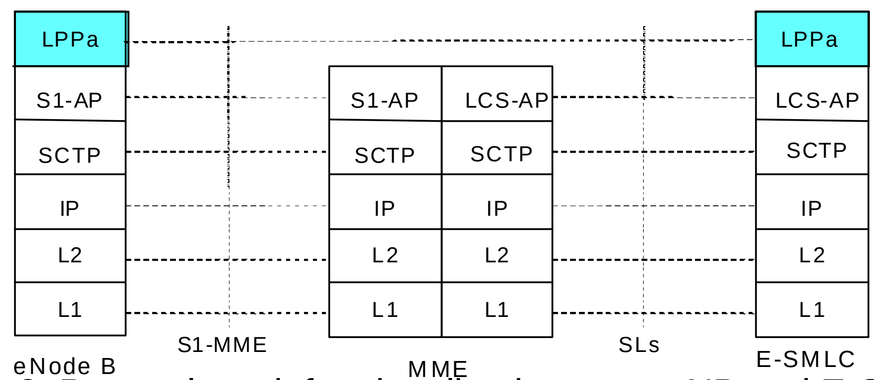


Fig.2: Protocol stack for signaling between eNB and E-SMLC

Copyright© 2009 NTT DOCOMO, INC. All rights reserved

Other Rel-9 enhancements

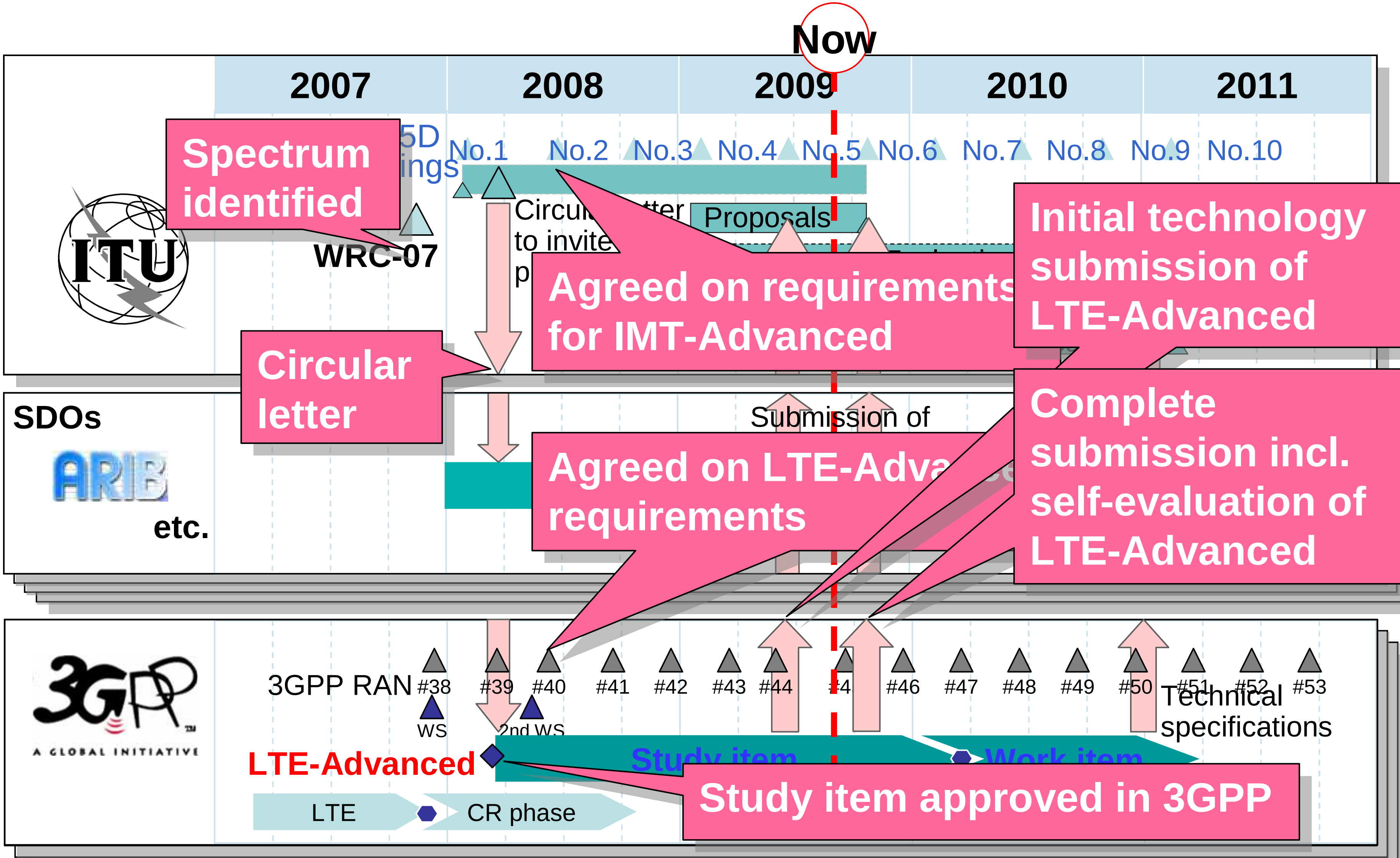
- IMS emergency call support
  - Including USIM-less UE support
- PWS (Public Warning System)/ CMAS (Commercial Mobile Alert System) support
  - New SIB to support up to 64 concurrent CMAS notifications
  - S1 procedure modifications to support CMAS transfer
- Vocoder adaptation
  - Based on ECN (RFC3168)
- RLF (Radio Link Failure) enhancements
  - Dedicated configuration of RLF timers
  - GBR bearer handling improvements
- SSAC (service specific access control)
  - Differentiated access control of MMTEL-voice/ video
- CS fallback enhancements
  - Measurement enhancements for faster procedure
  - Simultaneous fallback to CDMA 1xRTT + HRPD

Copyright© 2009 NTT DOCOMO, INC. All rights reserved

LTE-Advanced

Copyright© 2009 NTT DOCOMO, INC. All rights reserved

Schedule for IMT-Advanced

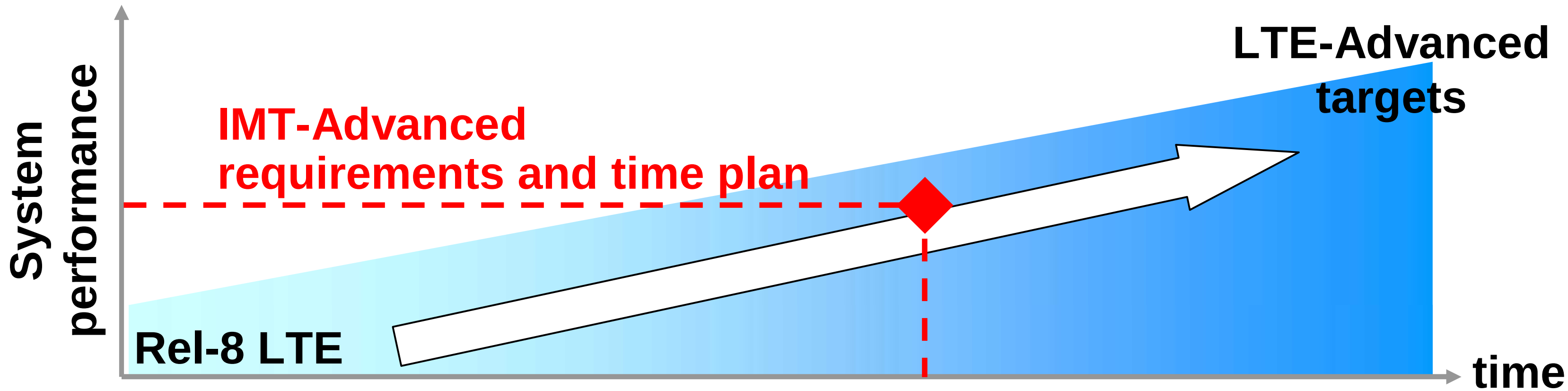


- **LTE-Advanced – candidate for IMT-Advanced in 3GPP (3rd Generation Partnership Project)**

Copyright© 2009 NTT DOCOMO, INC. All rights reserved

General Requirements

- LTE-Advanced is an evolution of LTE
- All relevant requirements of LTE are valid also for LTE-Advanced
- LTE-Advanced shall meet or exceed IMT-Advanced requirements within the ITU-R time plan
- Targets of LTE-Advanced are adopted as long term targets



Copyright© 2009 NTT DOCOMO, INC. All rights reserved

System Performance Requirements (1)

Peak data rate and peak spectrum efficiency

		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 and 1 Gbps for low mobility" is one of the key features as written in Circular Letter (CL)

Peak data rate

- 1 Gbps data rate will be achieved by 4-by-4 MIMO and transmission bandwidth wider than approximately 70 MHz

Peak frequency efficiency

- DL: Rel. 8 LTE satisfies IMT-Advanced requirement
- UL: Need to double to satisfy IMT-Advanced requirement

Copyright© 2009 NTT DOCOMO, INC. All rights reserved

System Performance Requirements (2)

■ Capacity and cell-edge user throughput

		Ant. Config.	Rel. 8 LTE	LTE-Advanced*	IMT-Advanced**
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

x1.4-1.6

* For Case 1 scenario in 3GPP

** For Base Coverage Urban scenario in IMT.EVAL

■ **DL/UL: Need further improvements to satisfy IMT-Advanced requirements on capacity and cell-edge user throughput**

Copyright© 2009 NTT DOCOMO, INC. All rights reserved

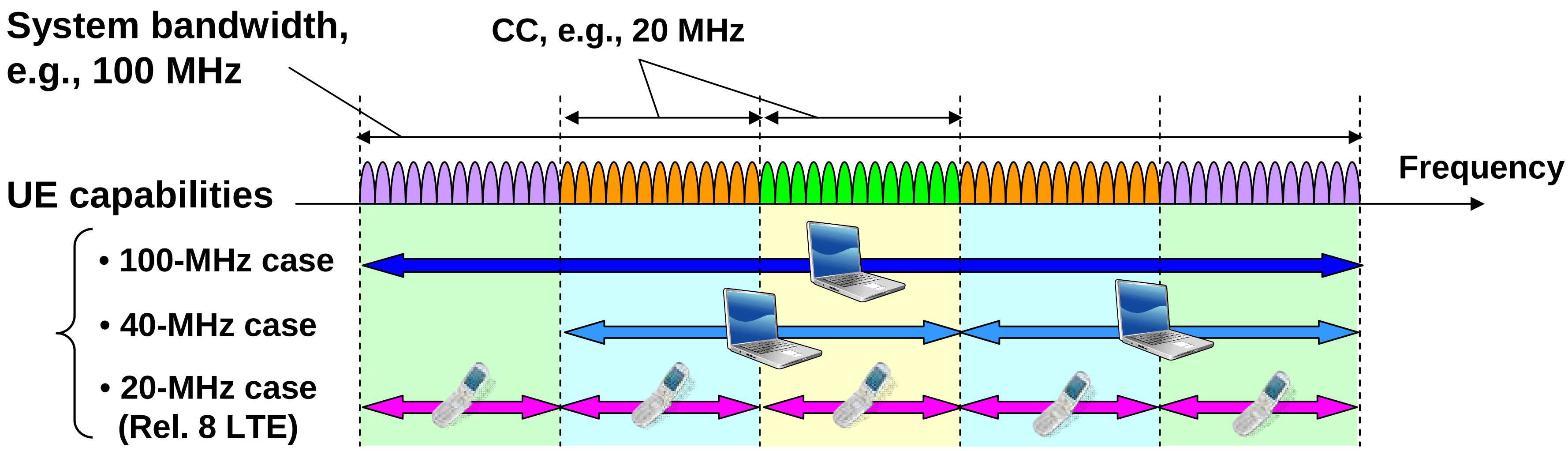
Radio Access Techniques for LTE-Advanced

- **Support of wider bandwidth**
  - Carrier aggregation to achieve wider bandwidth
  - Support of spectrum aggregation
  - ➔ Peak data rate, spectrum flexibility
- **Multiple access and radio parameters**
  - Rel. 8 LTE based multiple access per component carrier
  - Same radio parameters as those of Rel. 8 LTE
  - ➔ Backward compatibility
- **Advanced MIMO techniques**
  - Extension to up to 8-layer transmission in downlink
  - Introduction of single-user MIMO up to 4-layer transmission in uplink
  - ➔ Peak data rate, capacity, cell-edge user throughput
- **Coordinated multipoint transmission and reception (CoMP)**
  - CoMP transmission in downlink
  - CoMP reception in uplink
  - ➔ Cell-edge user throughput, coverage, deployment flexibility
- **Relaying**
  - Type 1 relays create a separate cell and appear as Rel. 8 LTE eNB to Rel. 8 LTE UEs
  - ➔ Coverage, cost effective deployment

Copyright© 2009 NTT DOCOMO, INC. All rights reserved

Carrier Aggregation for Wider Bandwidth

- **Wider bandwidth transmission using carrier aggregation**
- **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 is backward compatible 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**

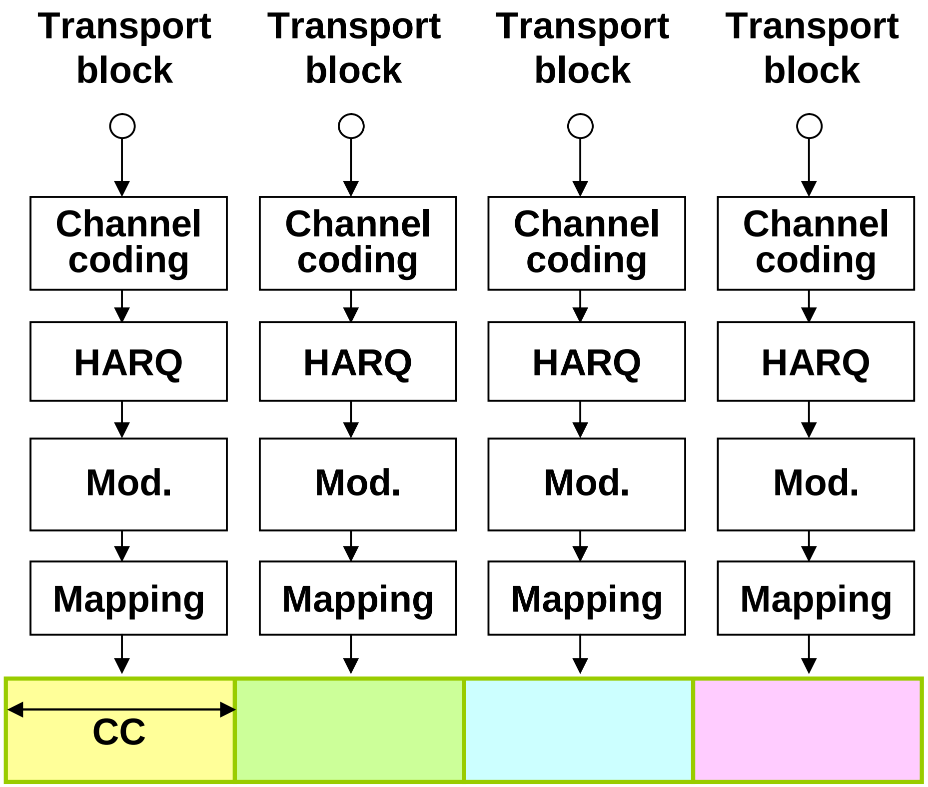


Copyright© 2009 NTT DOCOMO, INC. All rights reserved

Downlink Multiple Access Scheme

- **Downlink: OFDMA with component carrier (CC) based structure**
  - ➔ **Priority given to reusing Rel. 8 specification for low-cost and fast development**

- **One transport block (TB), which corresponds to channel coding block and retransmission unit, is mapped within one CC**
- **Parallel-type transmission for multi-CC transmission**



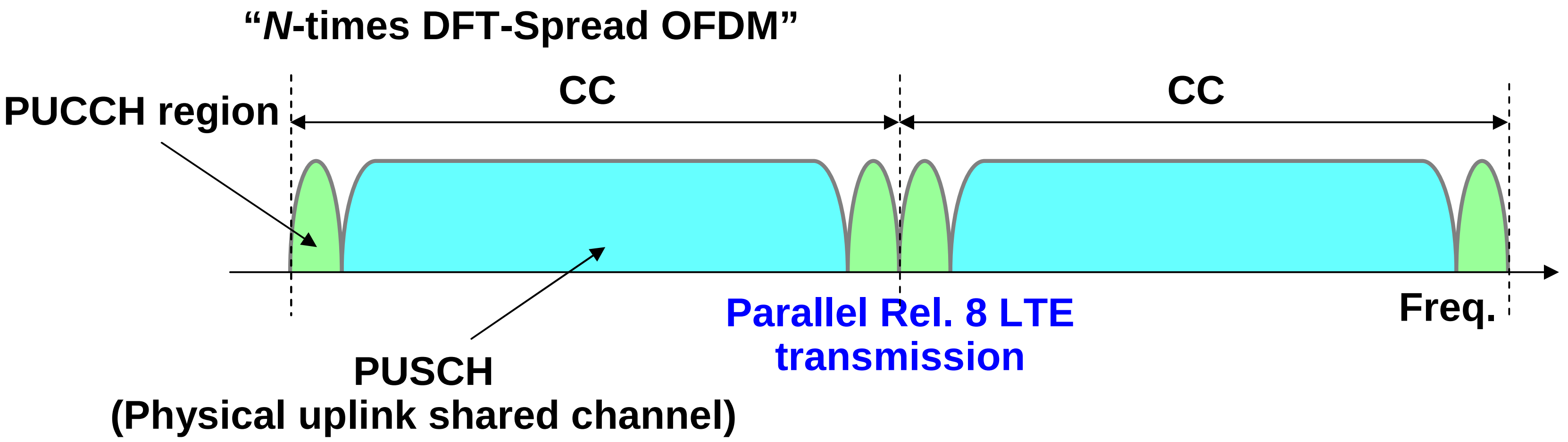
- **Good affinity to Rel. 8 LTE specifications**
- **No additional frequency diversity gain from Rel. 8 LTE**

Copyright© 2009 NTT DOCOMO, INC. All rights reserved

Uplink Multiple Access Scheme

■ Uplink: *N*-times DFT-Spread OFDM

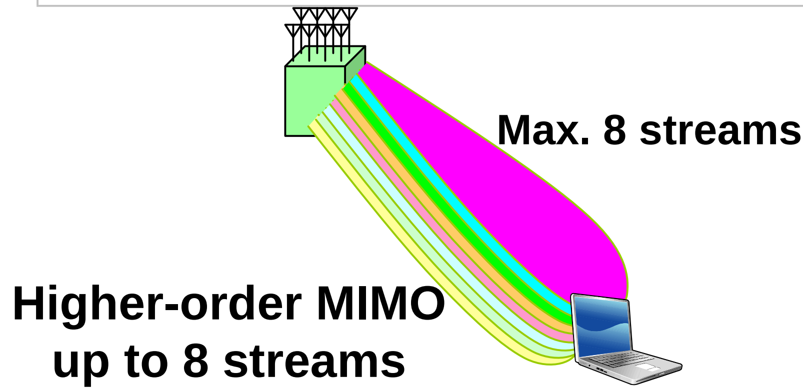
- Achieve wider band transmission by avoiding physical uplink control channel (PUCCH)
  ➔ Satisfy requirements for peak data rate while maintaining backward compatibility
- Adopt parallel-type transmission for multi-CC transmission allowing increase in peak-to-average power ratio (PAPR)
  ➔ Reuse Rel. 8 specification for low-cost and fast development

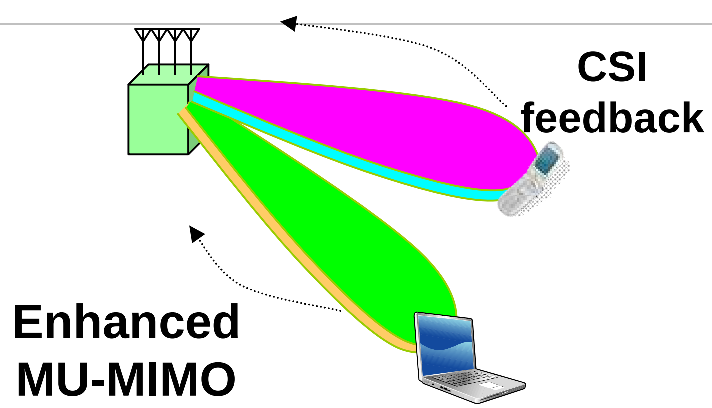


Copyright© 2009 NTT DOCOMO, INC. All rights reserved

Advanced MIMO techniques in Downlink

- **Extension up to 8-stream transmission**
- **Rel. 8 LTE supports up to 4-stream transmission, LTE-Advanced supports up to 8-stream transmission**
  ➔ **Satisfy requirement for peak spectrum efficiency, i.e., 30 bps/Hz**
- **Specify additional reference signals (RS)**
- **Two RSs are specified in addition to Rel. 8 common RS (CRS)**
  - **Channel state information RS (CSI-RS)**
  - **UE-specific demodulation RS (DM-RS)**
    - ✓ **UE-specific DM-RS, which is precoded, makes it possible to apply non-codebook based precoding**
    - ✓ **UE-specific DM-RS will enable application of enhanced multi-user beamforming such as zero forcing (ZF) for, e.g., 4-by-2 MIMO**

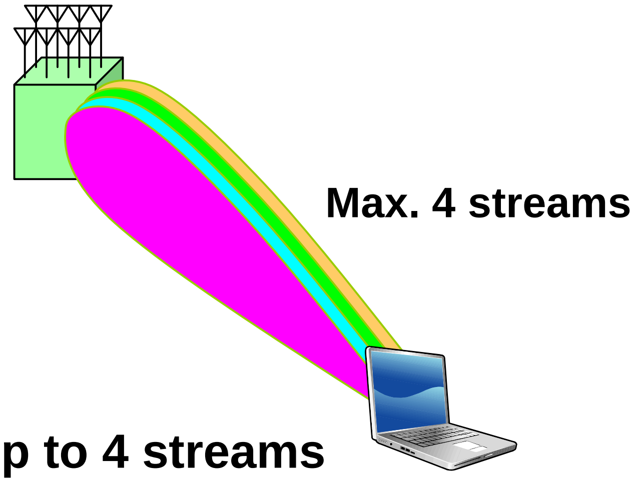




Copyright© 2009 NTT DOCOMO, INC. All rights reserved

Advanced MIMO techniques in Uplink

- **Introduction of single user (SU)-MIMO up to 4-stream transmission**
  - **Whereas Rel. 8 LTE does not support SU-MIMO, LTE-Advanced supports up to 4-stream transmission**
    ➔ Satisfy requirement for peak spectrum efficiency, i.e., 15 bps/Hz
- **Signal detection scheme with affinity to DFT-Spread OFDM for SU-MIMO**
  - **Turbo serial interference canceller (SIC) is assumed for eNB receiver to achieve higher throughput performance for DFT-Spread OFDM**
    ➔ Improve user throughput maintaining single-carrier based signal transmission



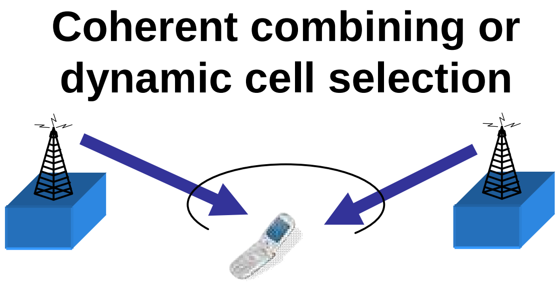
SU-MIMO up to 4 streams

Copyright© 2009 NTT DOCOMO, INC. All rights reserved

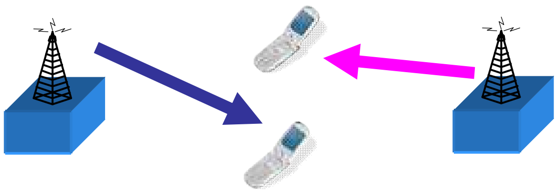
Downlink CoMP Transmission

- **CoMP transmission schemes in downlink**
- **Joint processing (JP)**
  - ✓ **Joint transmission (JT): Downlink physical shared channel (PDSCH) is transmitted from multiple cells with precoding using DM-RS among coordinated cells**
  - ✓ **Dynamic cell selection: PDSCH is transmitted from one cell, and the cell is dynamically selected**
- **Coordinated scheduling/beamforming (CS/CB)**

  PDSCH is transmitted only from one cell site, and scheduling/beamforming is coordinated among cells
- **CSI feedback (FB)**
- **Explicit CSI FB (direct channel FB) is investigated to conduct precise precoding, as well as implicit CSI FB (precoding matrix index FB) based on Rel. 8 LTE ➔ Tradeoff between gain and FB signaling overhead**



Joint transmission/dynamic cell selection



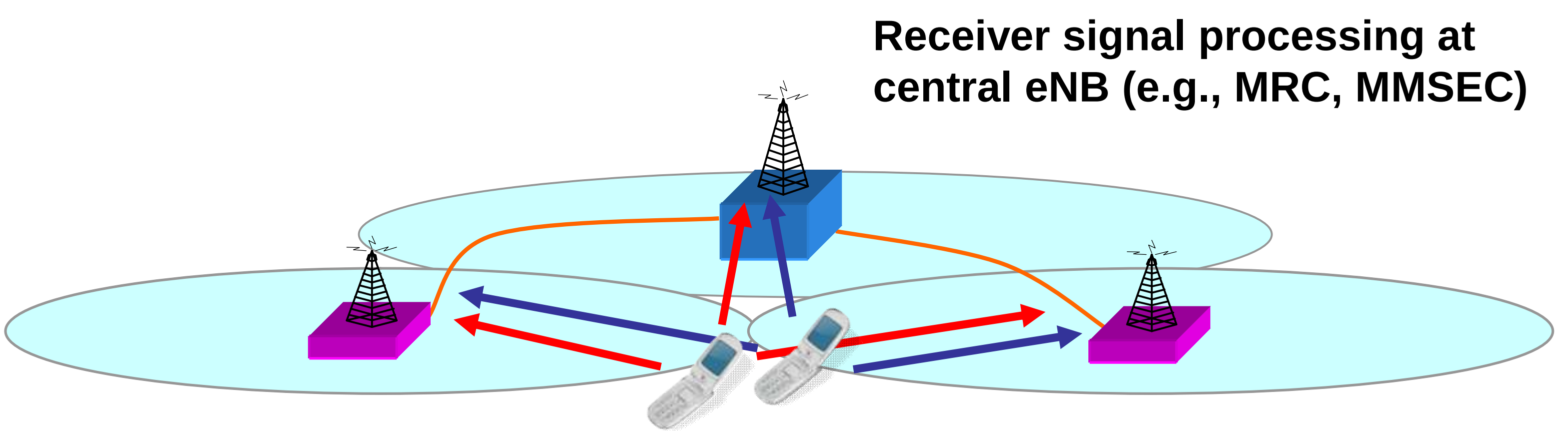
Coordinated scheduling/beamforming

Copyright© 2009 NTT DOCOMO, INC. All rights reserved

Uplink CoMP Reception

■ CoMP reception scheme in uplink

- **Physical uplink shared channel (PUSCH) is received at multiple cells**
- **Scheduling is coordinated among the cells**
  ➔ Improve especially cell-edge user throughput
- **Note that CoMP reception in uplink is implementation matter and does not require change of radio interface**



Multipoint reception

Copyright© 2009 NTT DOCOMO, INC. All rights reserved

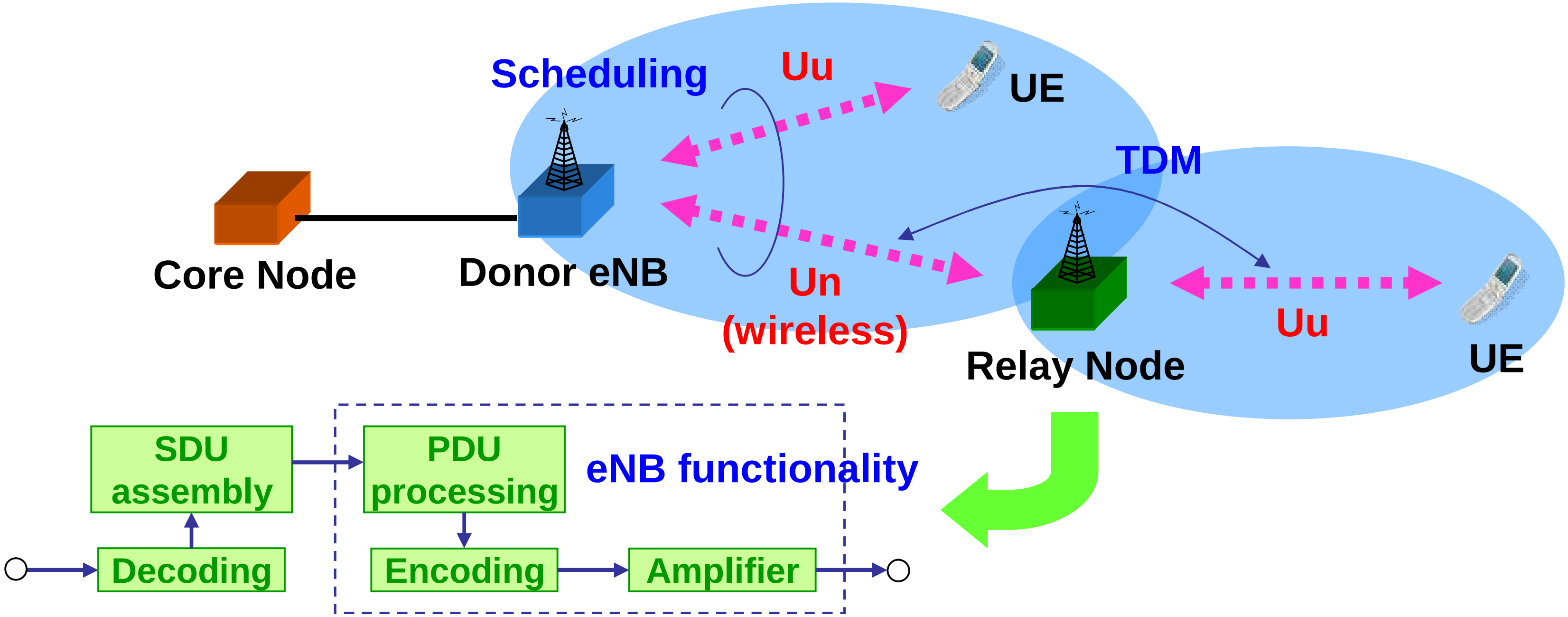
Relaying use cases

Scenario	Mobility	Hops	Targets
Urban Hot Spot	Fixed, Nomadic	Two hops	Coverage and Throughput
Dead Spot	Fixed	Two hops or Multi-hops	Coverage
Indoor Hot Spot	Fixed, Nomadic	Two hops	Throughput
Rural Area	Fixed	Two hops	Coverage and Throughput
Emergency or Temporary Coverage	Nomadic	Two hops or Multi-hops	Coverage and Throughput
Wireless Backhaul only	Fixed	Two hops or Multi-hops	Coverage or Throughput
Group Mobility	Mobile	Two hops	Throughput

Copyright© 2009 NTT DOCOMO, INC. All rights reserved

Type 1(Layer 3) relaying

- **Type 1 relaying** is assumed as one type of relaying (other types are FFS).
  - Layer 3 (RRC) is terminated in Relay Node for the Uu (Relay Node – UE) interface.
  - L1/L2 signaling (CQI, HARQ, etc) is performed between Relay Node and UE.
  - Un (Donor eNB – Relay Node) transmission is time multiplexed with Uu for UEs connected to the Relay Node.
  - Relay Node has their own PCI (physical cell identity).
  - ➔ **From a Rel-8 UE, a Relay Node is seen as Rel-8 eNB.**



Copyright© 2009 NTT DOCOMO, INC. All rights reserved

Self-evaluation results

- Self-evaluation for LTE-Advanced was conducted in 3GPP
- The self-evaluation results shows:

  Baseline configuration exceeding ITU-R requirements with minimum extension

  - LTE release 8 fulfills the requirements in most cases (no extensions needed)
  - Minor extensions in some scenarios (Urban Macro/Micro DL)

  More advanced configurations with further enhanced performance

- Many (18) companies perticipated in simulations
  ⇨ **High reliability**
- Self evaluation results will be captured in Technical Report TR 36.912 and provided to ITU-R WP 5D meeting in October

Copyright© 2009 NTT DOCOMO, INC. All rights reserved