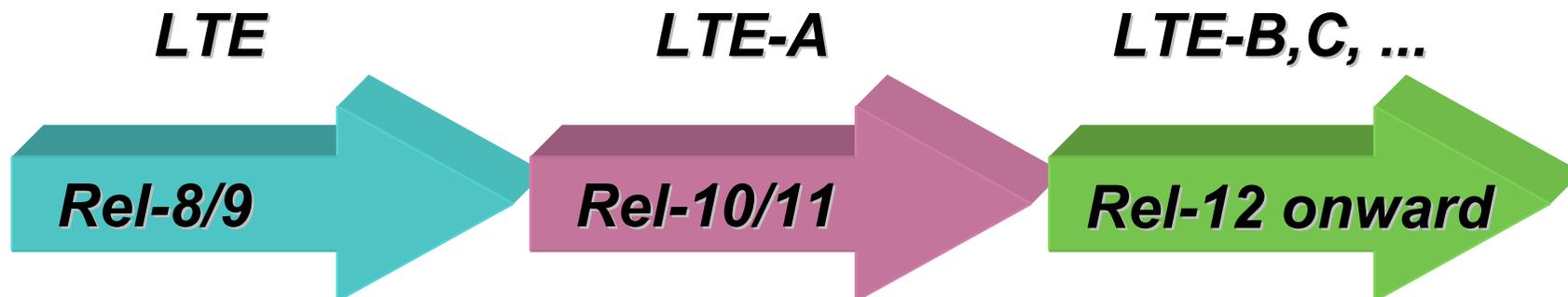


Requirements, Candidate Solutions & Technology Roadmap for LTE Rel-12 Onward

NTT DOCOMO, INC.

Outline

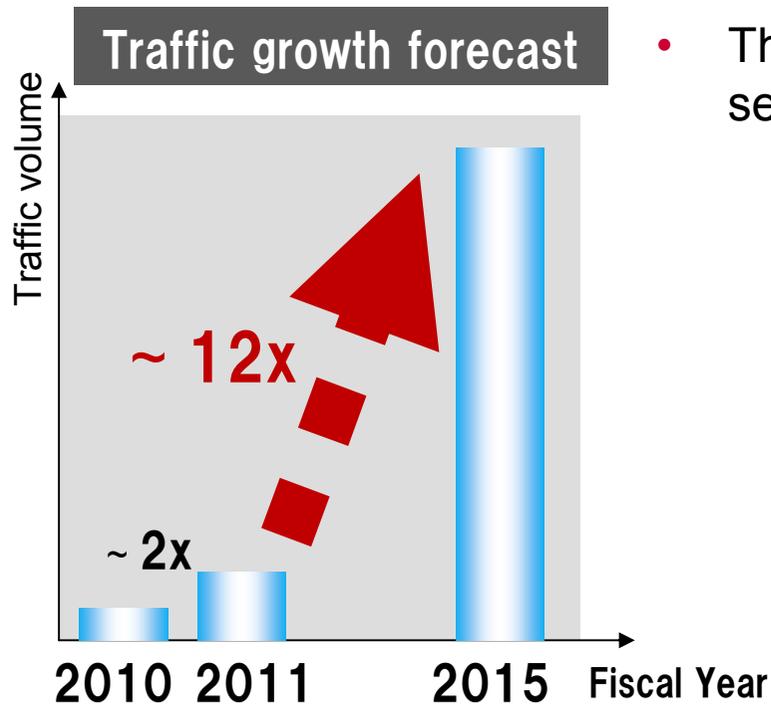
- Future Requirements
- Conceptual Views on Solutions
- Candidate Solutions
- Technology Roadmap



Future Requirements

Requirements (1)

- **Higher system capacity:**
 - Report ITU-R M.2243 (IMT.UPDATE): **15~30 times traffic growth is envisioned between 2010 and 2015**
 - Mobile data traffic is continuously growing over DOCOMO network
 - Approx. 1.6 times per year (2004 – 2009)
 - **Approx. 2 times per year (2010 – 2011)**
 - **Approx. 12 times traffic growth is envisioned between 2011 and 2015**



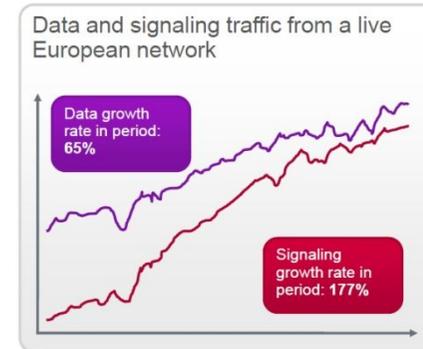
- The main drivers are smartphones, video services and high-speed data access

Mobile data traffic is expected to grow beyond 500x in 10 years (2010 – 2020)

Requirements (2)

- **Efficient support for variety of traffic types**

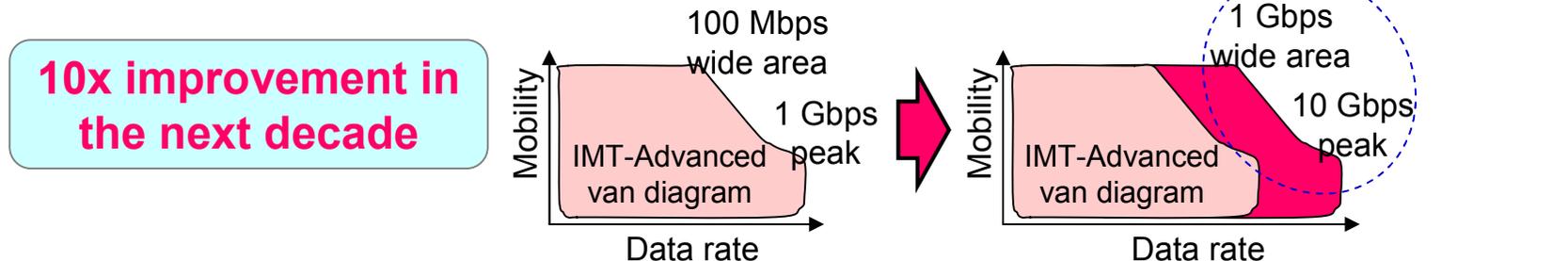
- Signaling traffic from smartphones
- Low latency traffic for cloud applications
- Large number of small data packets for M2M
- etc.



Source: Nokia Siemens Networks, 2011

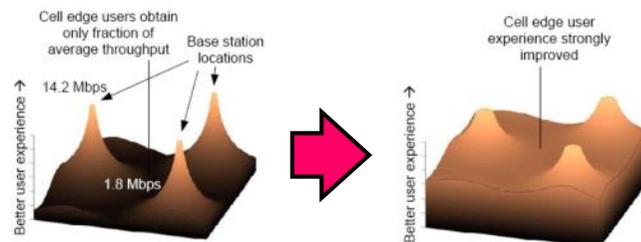
- **Higher data rate and user-experienced throughput**

- Gbps-order experienced throughput
- Low latency for improving user experience



- **Fairness of user throughput**

- Improve cell-edge throughput
- Lower system impact from few heavy users

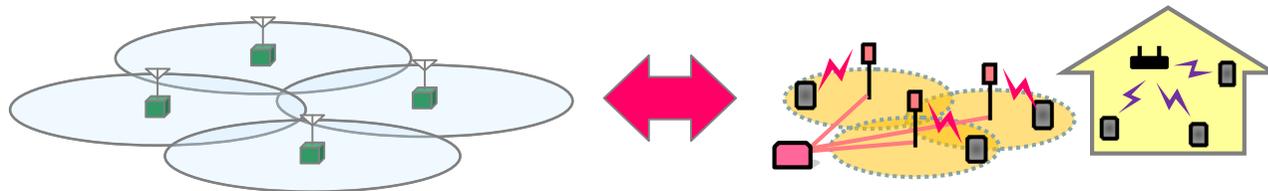


Source: Artist4G (FP7 ICT), 2010

Requirements (3)

- **Flexible and cost-efficient NW deployments**

- Increased capacity per NW cost
- Efficient utilization of higher and wider frequency spectrum bands
- Efficient support for diverse environments
e.g., wide area and local area



- **Energy/battery saving**

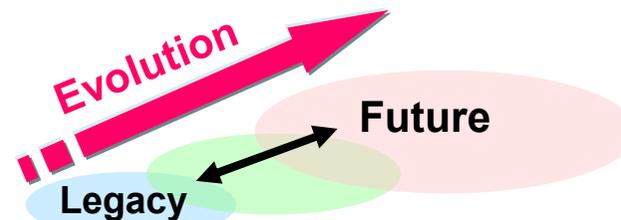
- NW energy saving & UE battery saving



- **System robustness against emergencies**

- Earthquake, Tsunami, etc.

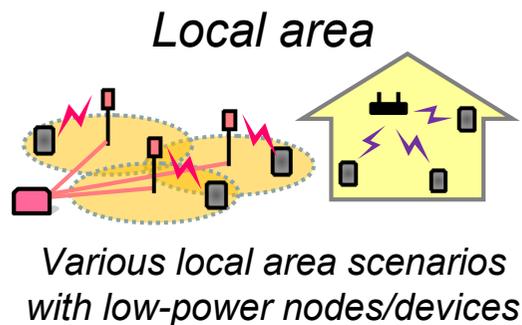
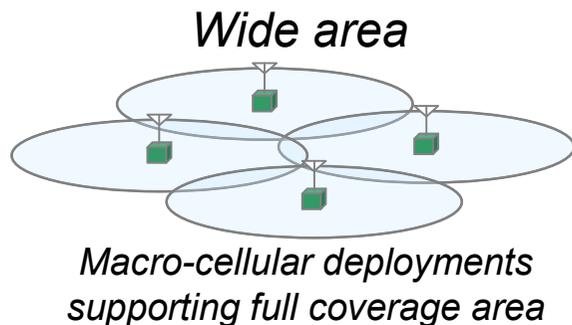
- **Balancing between backward compatibility & future enhancements**



Conceptual Views on Solutions

Wide & Local area enhancements

- Wide area enhancement will continue to be important
- Local area enhancement is **becoming more important**. Small cells are required
 - To support huge traffic in future
 - To allow for efficient utilization of higher spectrum bands
 - To provide better user experience throughput



Local area supported by low power nodes for:

- *Outdoor dense deployments*
- *Outdoor/Indoor hotspot*
- *Indoor home/offices*

- Difference in requirements between wide area and local area needs to be considered

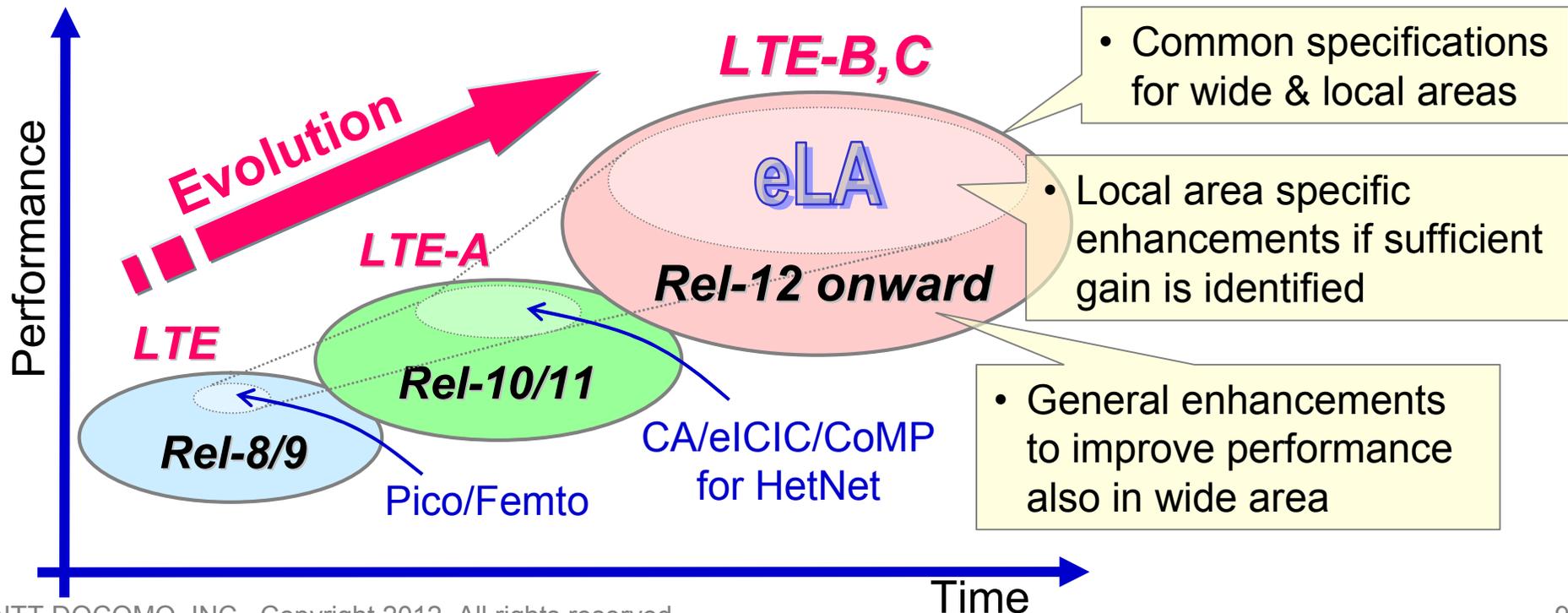
	Wide Area	Local Area
Mobility	Medium-to-High	Low-to-Medium
Coverage	Essential	Wider is better
DL/UL radio link (Tx power & antenna gain)	Asymmetric	More symmetric
Traffic load	More uniform	More fluctuated
Cell planning	Essential	To be simplified

Concept of Rel-12 onward evolution **docomo**^{NTT}

LTE Rel-12 onward should integrate technologies for enhanced Local Area (eLA) with general LTE enhancements

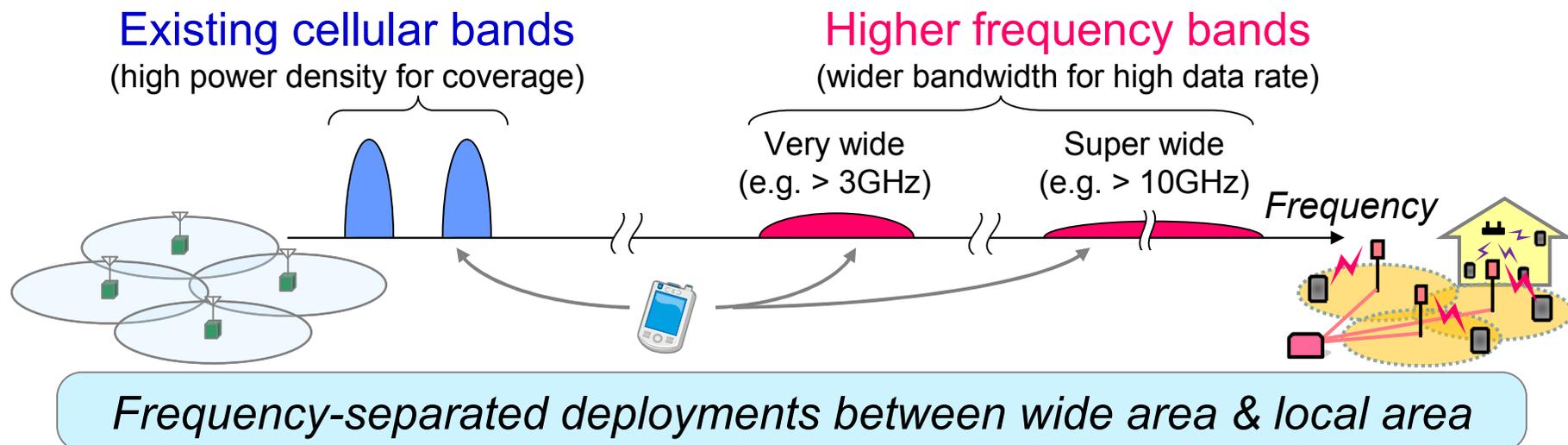
eLA with efficient utilization of higher frequency bands

- Support huge traffic in the future
- Provide better user experienced throughput



Spectrum utilization for eLA concept **docomo**

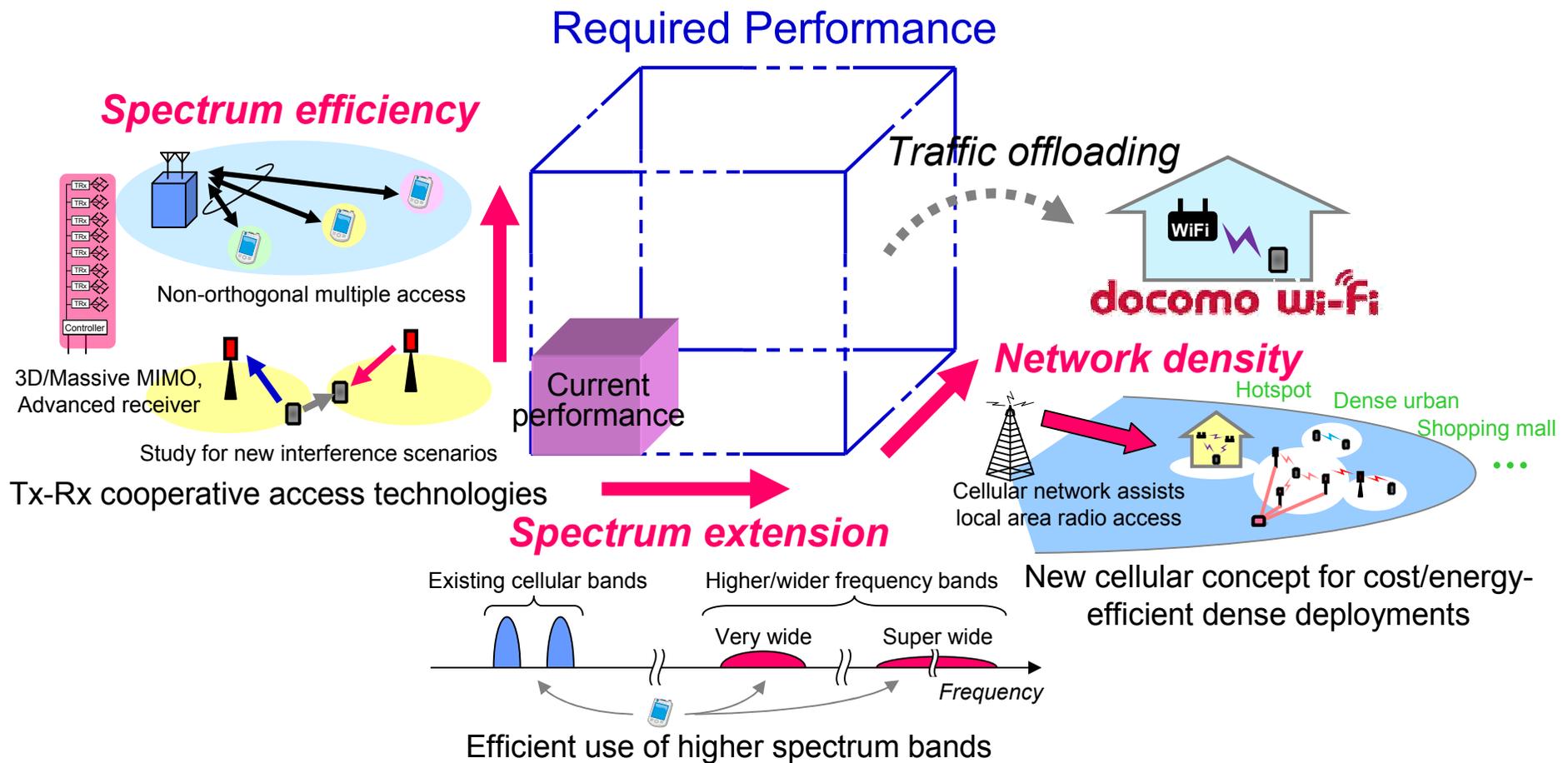
- **Wide area:**
 - **Basic coverage/mobility supported in lower frequency bands, e.g., existing cellular bands**
 - Current service quality in terms of connectivity & mobility can be maintained
 - Support control signaling, e.g., for efficient small-cell discovery
- **Local area:**
 - **High speed data transmission supported on separate frequency band from that of wide area, e.g., higher frequency bands**
 - Wider spectrum bandwidth in higher frequency bands
 - Local area specific technologies for smaller/denser cell deployments



Candidate Solutions

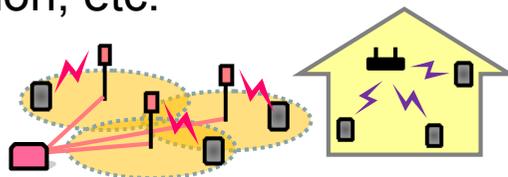
Directions of evolution: "The Cube" ^{NTT} docomo

A set of radio access technologies is required to satisfy future requirements



Candidate technologies for enhanced spectrum efficiency

- ◆ General enhancements – Interference is the main bottleneck against enhanced spectrum efficiency
 - **Continuing challenges for MU-MIMO/CoMP technologies from Rel-10/11**
 - e.g. CSI feedback enhancement, MU-MIMO enhancements, etc.
 - **Further advanced radio access technologies with further interference mitigation and avoidance**
 - **Approach 1: Advanced transmitter beamforming**
 - Active beamforming with more antenna elements
 - **Approach 2: Advanced receiver cancellation**
 - Further advanced receiver for inter-cell interference
 - Non-orthogonal multiple access
- ◆ Local area specific technologies for spectrum efficiency & traffic adaptation
 - Flexible radio resource control, dynamic TDD (eIMTA), enhancement for higher SINR region, etc.

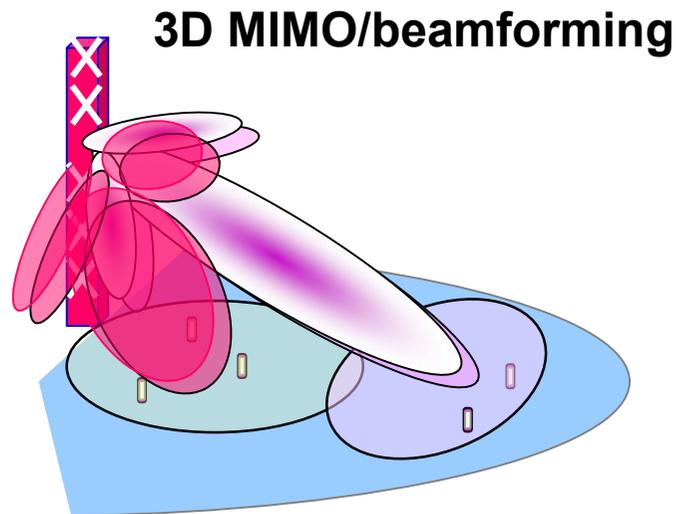


- ✓ More power efficiency
- ✓ More fluctuated traffic load
- ✓ More symmetric DL/UL radio links

Advanced transmitter beamforming **docomo**

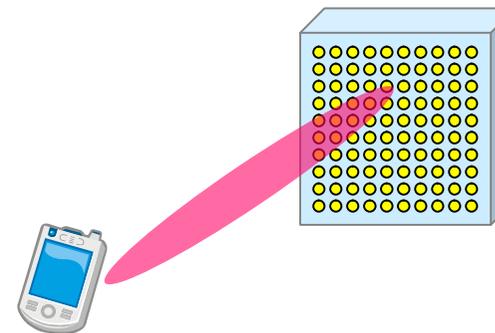
➤ Active beamforming with more antenna elements

- **3D MIMO/beamforming with Active Antenna System (AAS)**
 - More than 8 antenna elements
- **Massive-antenna technology for higher frequency bands**
 - e.g. Massive-antenna MIMO/beamforming (e.g. more than 100 antenna elements)



- 3D beamforming can allow beam control in both horizontal and vertical directions
- Vector sectorization can create additional inner-cell besides to the outer-cell

Massive-antenna MIMO/beamforming
(for higher frequency beyond Rel-13)



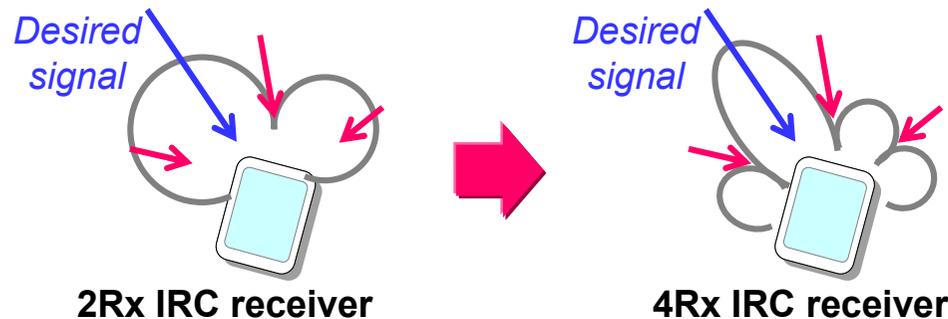
Very narrow beamforming
➔ *Compensate for path loss in higher frequency*

- In higher frequency, antenna elements can be miniaturized and their number can be increased
 - Path-loss can be compensated for via larger beam-forming gain
 - Trivial MU-MIMO pre-coding via single-user beam-forming

Advanced receiver cancellation

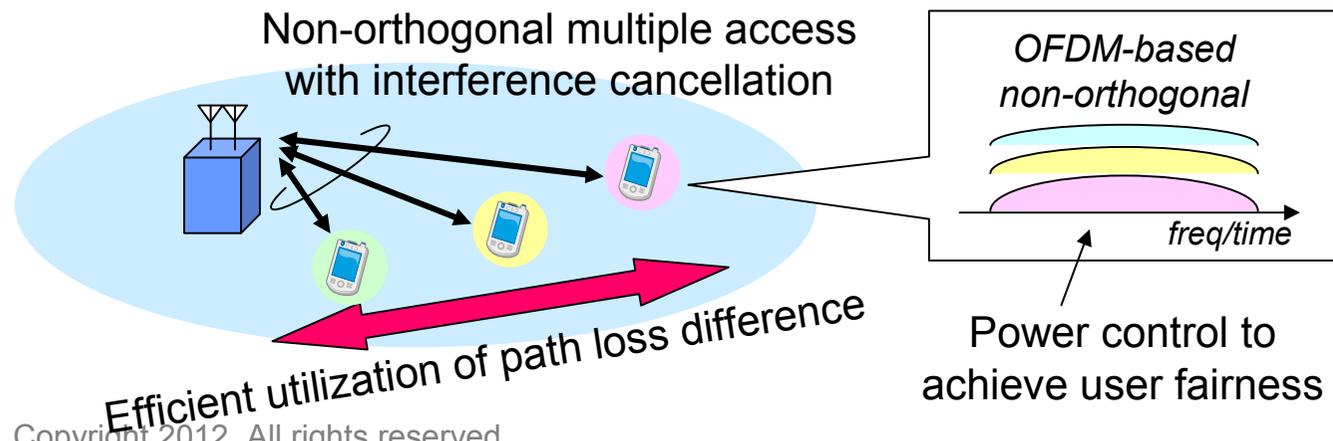
➤ Further advanced receiver for inter-cell interference

- **Linear interference cancellation, e.g., 4Rx/8Rx advanced receiver**
 - Continue enhancement from Rel-11 2Rx IRC receiver



➤ Non-orthogonal multiple access (*Beyond Rel-12*)

- **Advanced non-orthogonal multiple access based on non-linear cancellation (OFDM signal-based)**
 - Efficient utilization of path loss difference among users in wide area

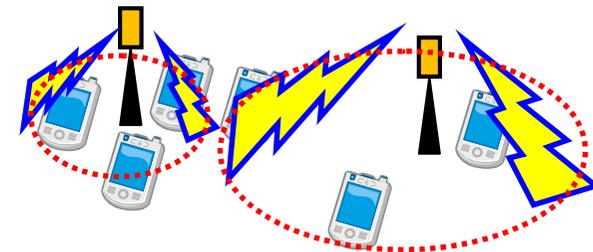


Spectrum efficiency: eLA topics

- Flexible radio resource control for local area access

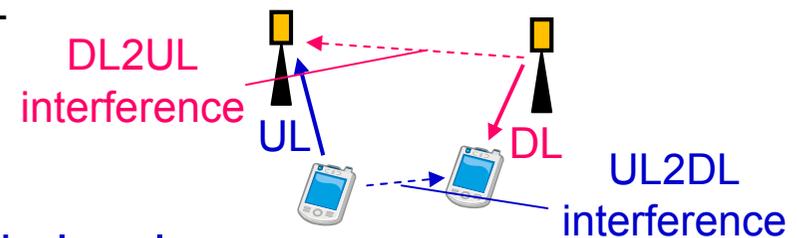
- Support for flexible DL power control with removal of Rel-8 CRS
 - DL/UL coverage symmetry
 - Interference control & load balancing
 - Power-efficient data transmission
 - » No interference when no traffic

Flexible DL power control



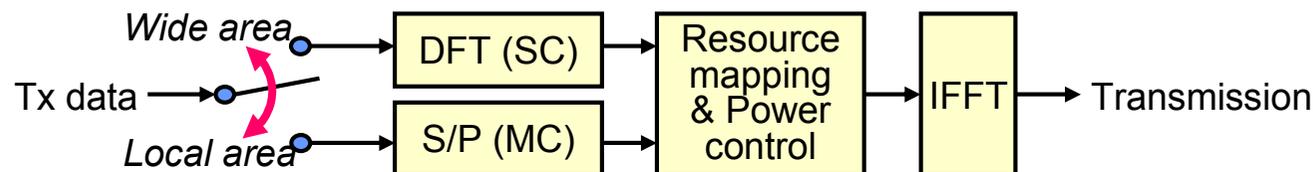
- Dynamic TDD & interference solutions (eIMTA)

- Spectrum sharing between DL and UL (continued from Rel-11 SI)



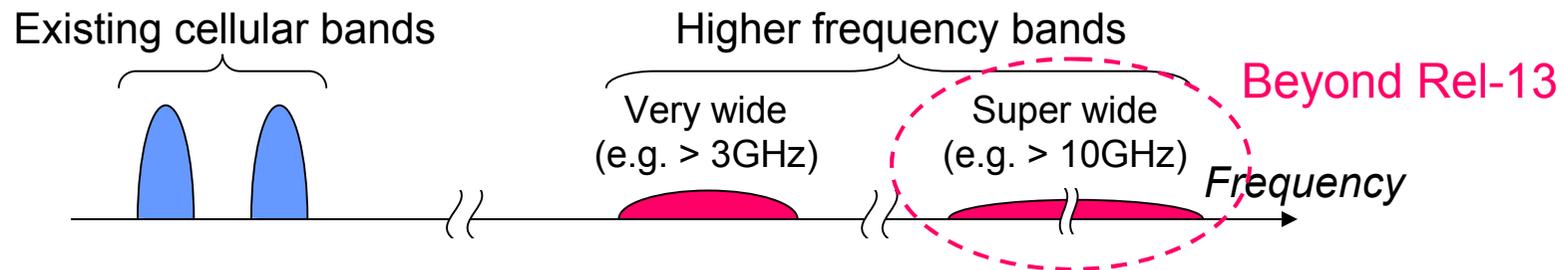
- Enhancement for higher SINR region in local area

- UL OFDMA, 256QAM, etc.

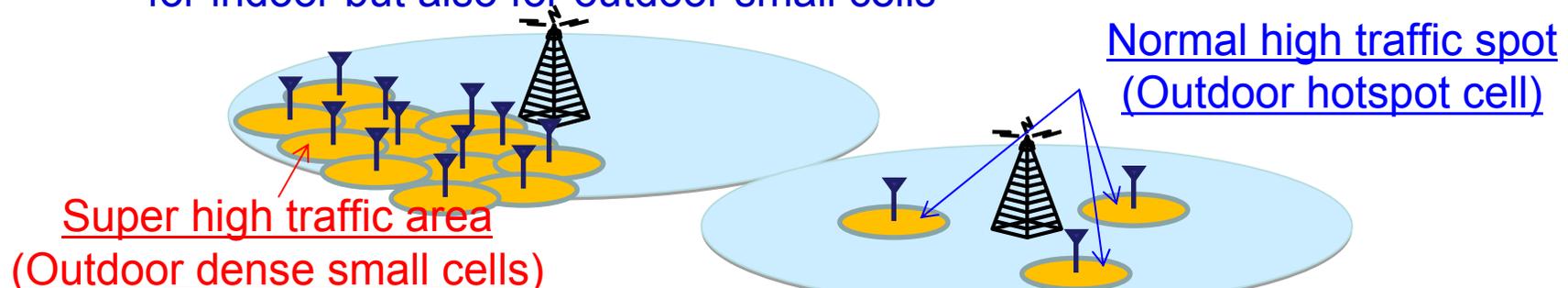


Scenarios for spectrum extension

- Future spectrum extension & utilization
 - **Focus on operator licensed bands below 5GHz at least for Rel-12/13**
 - Future spectrum extension to beyond 10GHz (maybe up to 60GHz) can be a long-term evolution target
 - New requirements and radio interface design maybe required



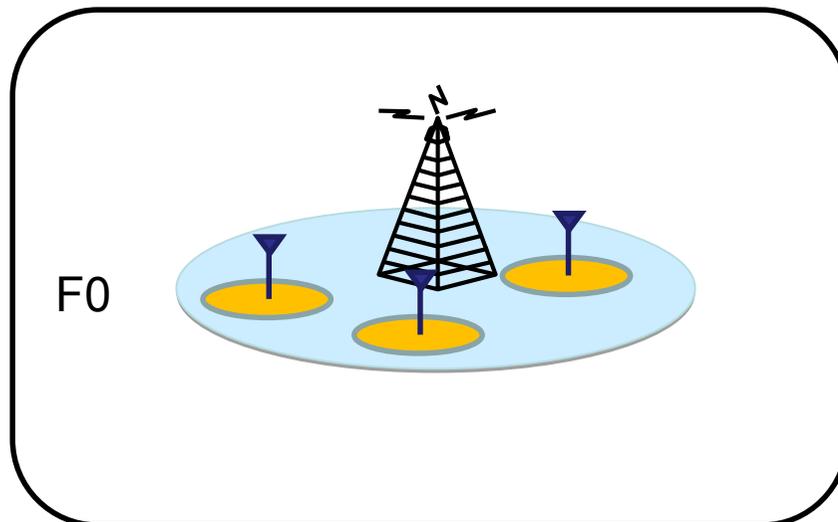
- Market for utilizing higher frequency bands needs to be large from a commercial service point of view
 - Higher frequency bands need to be utilized in **various deployments not only for indoor but also for outdoor small cells**



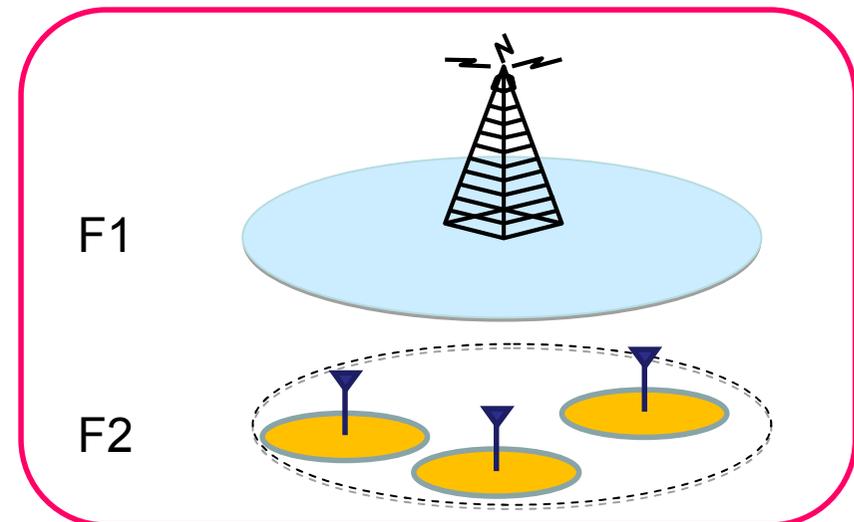
Network density: Scenarios

- Two deployment scenarios are identified towards harmonizing wide area and local area:
 - Scenario 1 (Mixed deployment scenario):
 - Small cell and Macro cell co-exist on a single carrier.
 - Scenario 2 (Small-cell dedicated carrier scenario):
 - Small cell utilizes a dedicated carrier, where no Macro cell exists.
- ➔ Scenario 1 was studied in Rel-11. Scenario 2 with higher frequency bands used for small cells should be the focus in Rel-12 onward

Scenario 1: Mixed deployment scenario

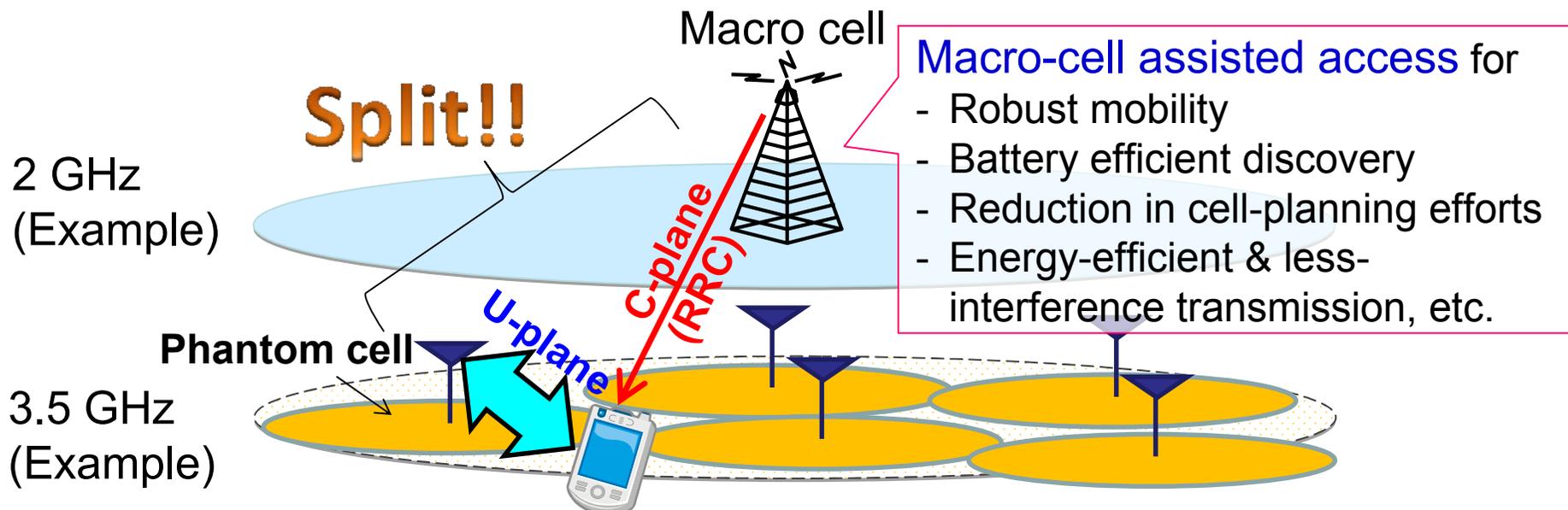


Scenario 2: Small-cell dedicated carrier scenario



C/U plane split & Phantom cell

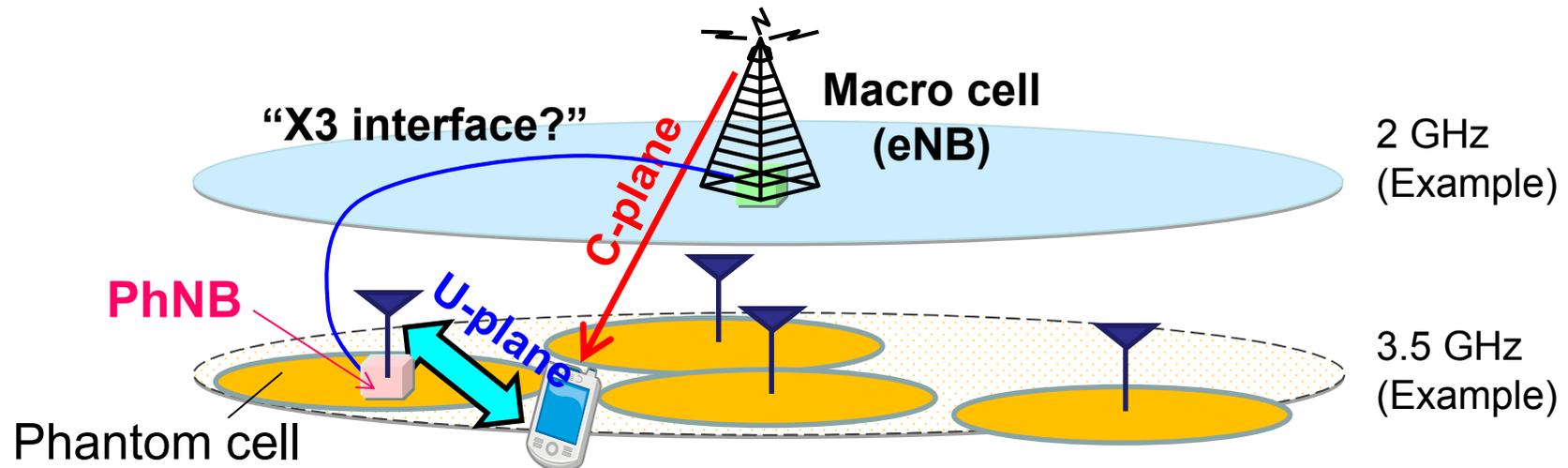
- Split of C-plane and U-plane between macro & small cells
 - **C-plane**: Macro cell maintains good connectivity and mobility using lower existing frequency bands
 - **U-plane**: Small cell provides higher throughput and more flexible / cost-energy efficient operations using higher/wider frequency bands
- Small cell with new carrier type becomes “Phantom cell”
 - The phantom cell is not a conventional “cell” because of removing conventional cell-specific signals/channels, i.e., PSS/SSS, CRS, MIB/SIB, etc.



Phantom cell by single/separate nodes

- Phantom cell by single node (Carrier aggregation using RRHs)
 - Macro cell for C-plane and RRH (Phantom cell) for U-plane

- Phantom cell by separate nodes is also required for:
 - Support for non-optical fiber deployments as well
 - System extensibility
 - Flexible cooperation between Phantom cell and different macro eNBs
- ➔ New architecture with C/U plane split using separate nodes for LTE Rel-12
 - Phantom eNodeB (PhNB) for Phantom cell
 - Interface between eNB for C-plane & PhNB for U-plane



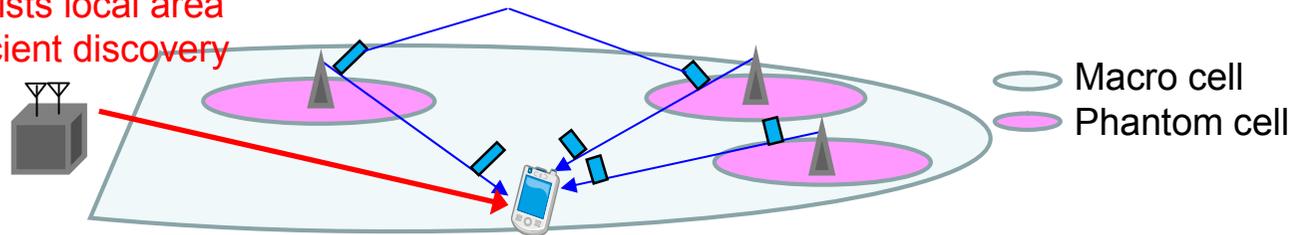
Phantom cell: Other topics

- Phantom cell discovery

- UE battery saving while achieving good discovery coverage

Discovery signal transmissions (ref. R1-120398)

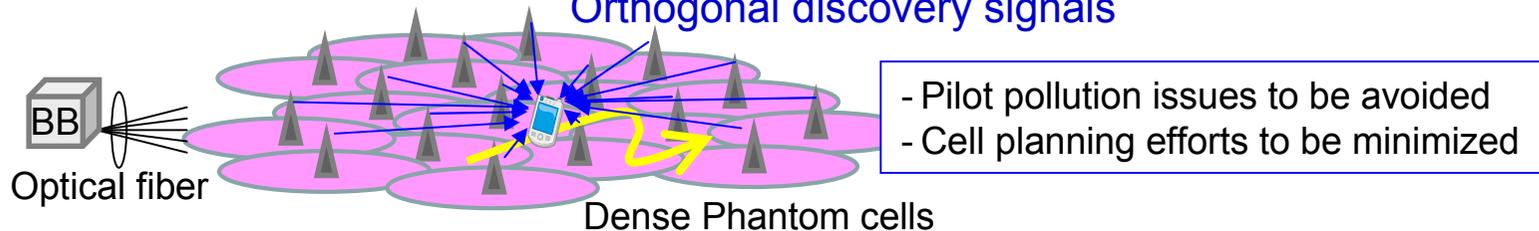
Macro cell assists local area for battery-efficient discovery



- Efficient L1/L2 mobility among Phantom cells

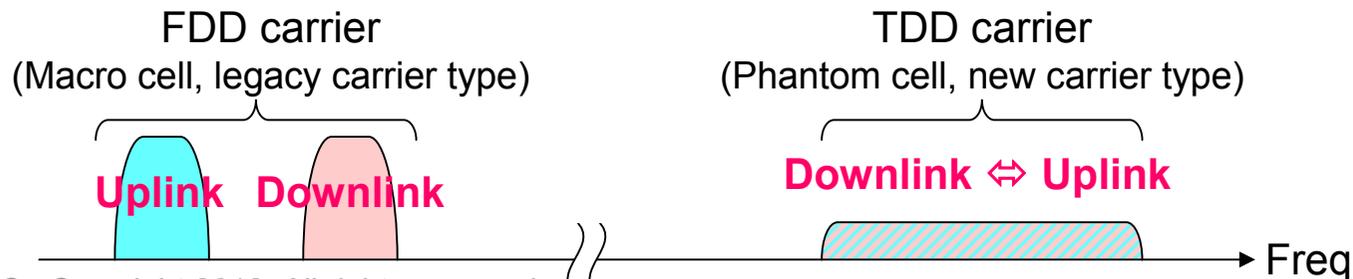
- Efficient point association based on measurement using *Discovery signal*

Orthogonal discovery signals



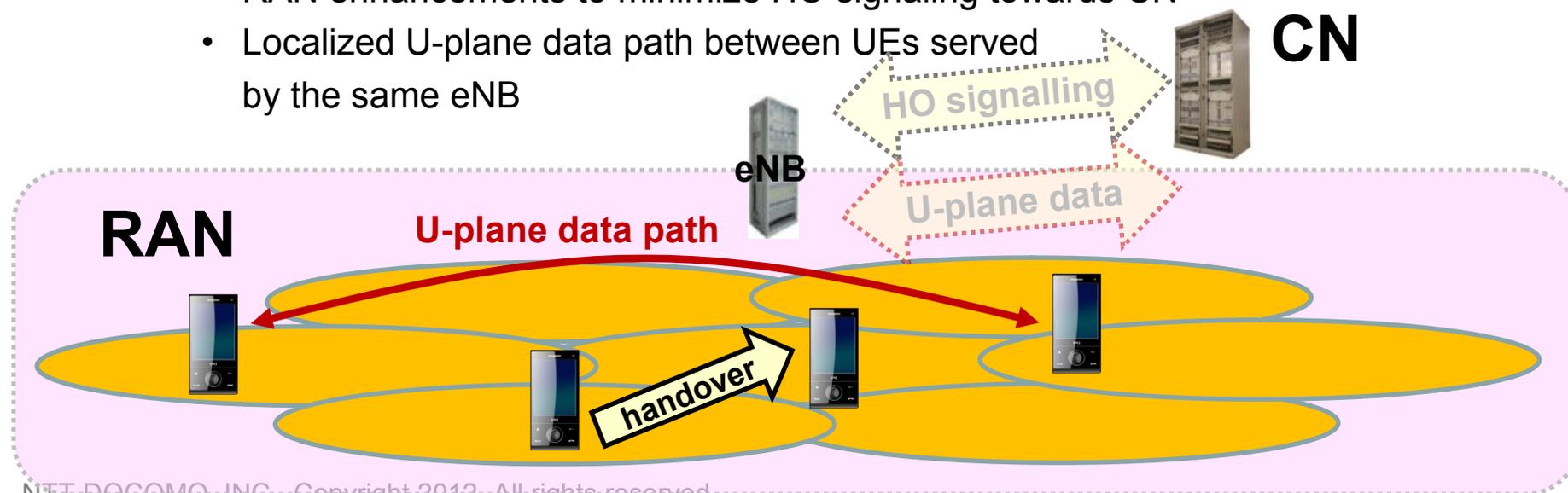
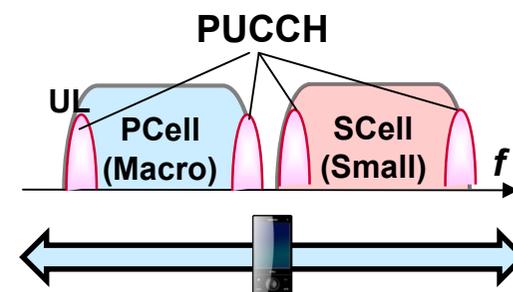
- Flexible duplex support for Phantom cells

- Support for different duplex schemes (e.g. FDD/TDD) in macro and Phantom cell spectrum bands



Enhancements for variety of traffic types **docomo**

- Accommodation of massive signaling traffic via “always-on” connectivity
 - By keeping UEs in RRC_CONNECTED with DRX, the signaling for connection setup can be reduced and "always-on" connectivity can be provided.
- Accommodation of many RRC_CONNECTED UEs via NW enhancements
 - L1/L2 enhancements:
 - PUCCH capacity enhancements (e.g., PUCCH on SCell) to resolve resource overhead in macro cells (PCell)
 - Higher layer enhancements to minimize CN overload:
 - RAN enhancements to minimize HO signaling towards CN
 - Localized U-plane data path between UEs served by the same eNB



Technology Roadmap

Views on standardization roadmap **docomo**

LTE-B

- Release 12
 - eLA technologies along with Phantom cell concept
 - General enhancements for spectrum efficiency such as 3D MIMO/beamforming, further advanced receiver, etc.
 - Enhancements for variety of traffic types
 - Potential topics continued from Rel-11
 - DL MIMO, eDDA, and other leftover topics
- Release 13
 - Further eLA technology enhancements
 - Further general enhancements such as non-orthogonal access with interference cancellation (feasibility study is needed)

LTE-C (?)

- Release 14~
 - Potential new radio interface and technologies (e.g. massive-antenna MIMO/beamforming) for future new spectrum bands (to be identified in WRC 15)

Standardization roadmap

LTE-B Release 12

Release 13

Release 14~

NW-level aspects for eLA

Radio protocols for Phantom cell

NW architecture for Phantom cell

Requirements and radio interface design for new spectrum (WRC15)

Radio access technologies for eLA

NCT design for Phantom cell

Other eLA optimizations (UL OFDMA, 256QAM, etc.)

Discovery & L1/L2 mobility for Phantom cell

Dynamic TDD & interference solutions (eIMTA)

Flexible duplex support

General enhancements for spectrum efficiency

4Rx/8Rx advanced receiver

MIMO enhancements (e.g. 3D beamforming with AAS)

Non-orthogonal multiple access using non-linear cancellation

Massive-antenna technology for higher frequency bands

Enhancements for variety of traffic types

Advanced always-on connectivity, etc.

Summary

- LTE Rel-12 onward should integrate technologies for enhanced Local Area (eLA) with general LTE enhancements
- Frequency-separated deployments between wide area & local area
 - To allow efficient utilization of higher/wider frequency bands while keeping basic mobility and connectivity
- A set of radio access technologies is required to satisfy future requirements
 - Enhanced spectrum efficiency via:
 - Advanced receiver cancellation and transmitter beamforming
 - eLA technologies, e.g., flexible power control and dynamic TDD
 - Small cells with new carrier type, **“Phantom cell”**, for efficient use of higher frequency bands
 - C/U plane split – Macro-cell assisted access for efficient discovery, mobility, etc.
 - Supported by both single eNB with RRH and separate nodes with PhNB
 - Enhancements to support a variety of traffic types

Should identify use cases and deployment scenarios that really matter before starting specification work for the identified ones only

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