Empowered by Innovation NEC

LTEの実現とさらなる飛躍に向けて
LTE: Today's Implement and Tomorrow's Advancement

NEC

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Contents

- Introduction
- LTE Architecture
- Physical Channel Structure and Procedure
- Signal Processing
  - Algorithm (eNB)
  - Architecture
- Radio Resource Management (eNB)
- LTE Advanced
- Conclusion

Introduction

- Trend for Mobile Wireless Broadband

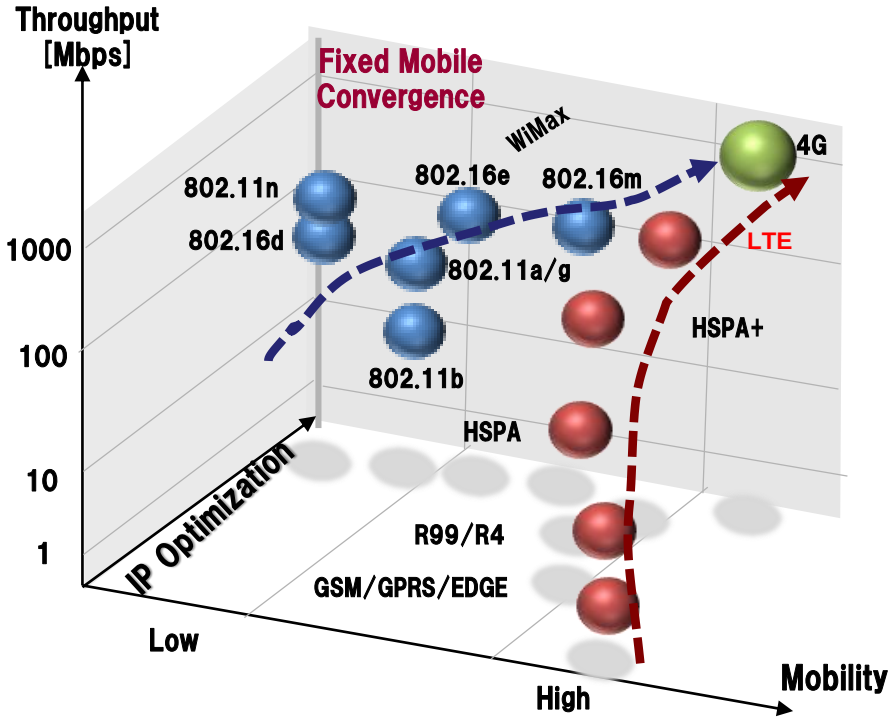
Two Streams for Mobile Broadband

ITU Family

- W-CDMA, HSPA, **LTE** etc.
- CDMA2000, EV-DO, UMB etc.

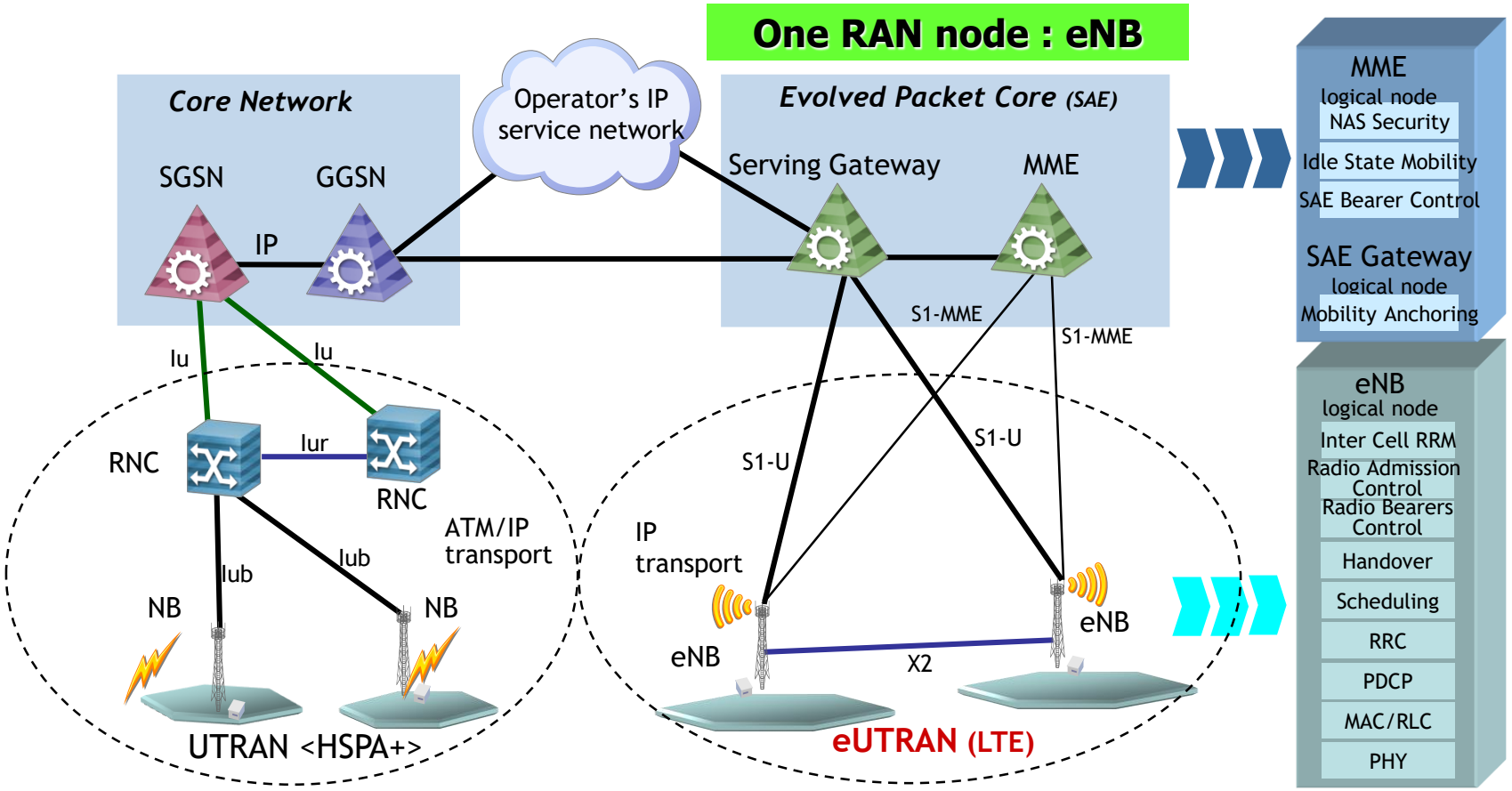
IEEE Family

- Wi-Fi, **WiMAX** etc.



Realization of Mobile Broadband Services

LTE Architecture (SAE)



MME: Mobility Management Entity
S-GW: Serving Gateway
EPC: Evolved Packet Core
eNB: evolved NodeB

- Functions in 3G RNC are moved to eNB in LTE
- Call Processing related functions are moved to eNB.
- C-plane latency and U-plane latency can be minimized due to reduction of layer of network elements and optimization of signalling.

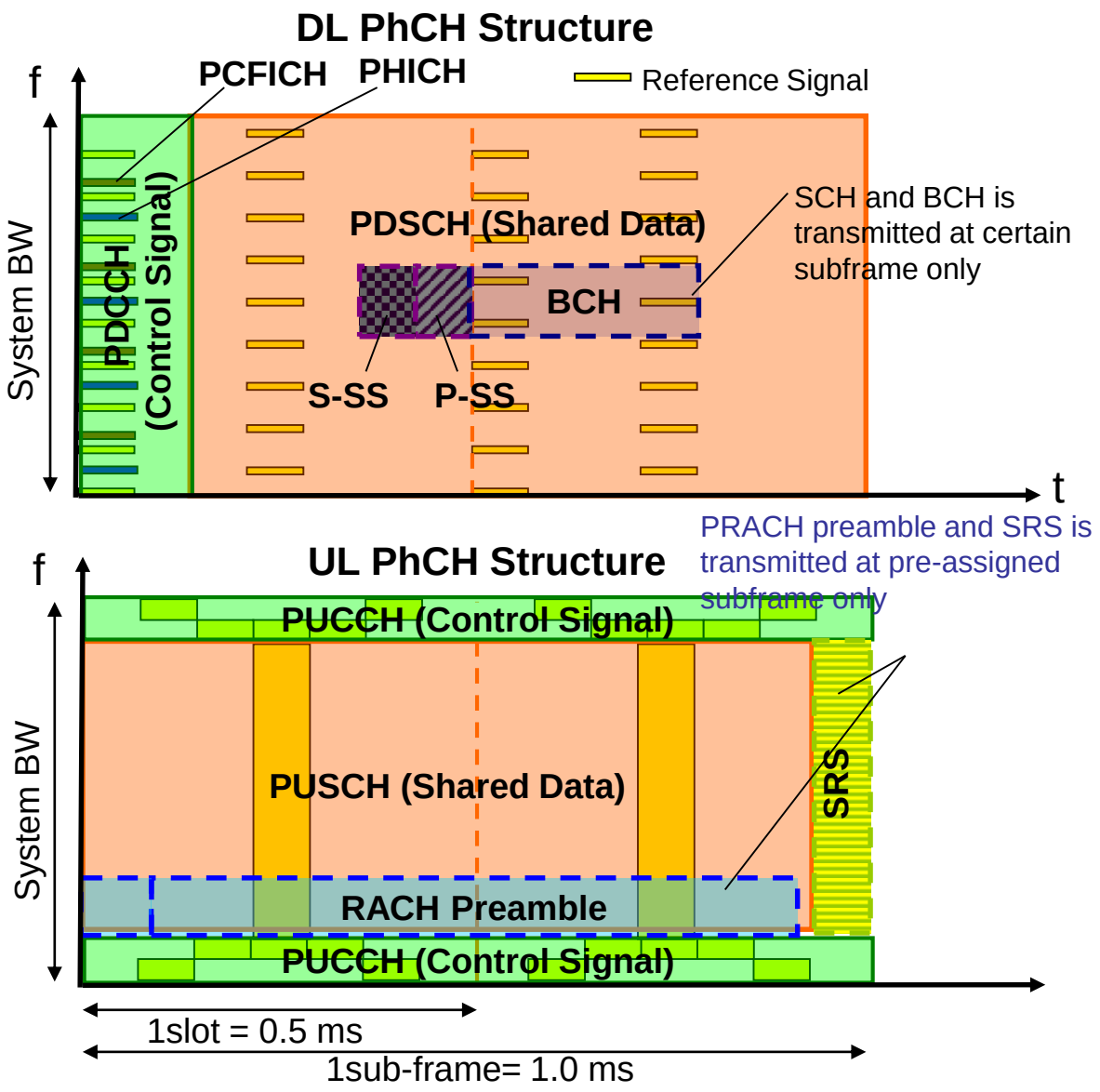
Physical Channel Structure

<Downlink>

- PDSCH
  - Transmit Data
- PDCCH
  - Assign PDSCH/PUSCH
- PHICH
  - Indicate HARQ-ACK for UL
- PCFICH
  - Indicate PDCCH symbol
- BCH
  - Transmit Broadcast channel
- Synchronization Signal
  - For UE synchronization

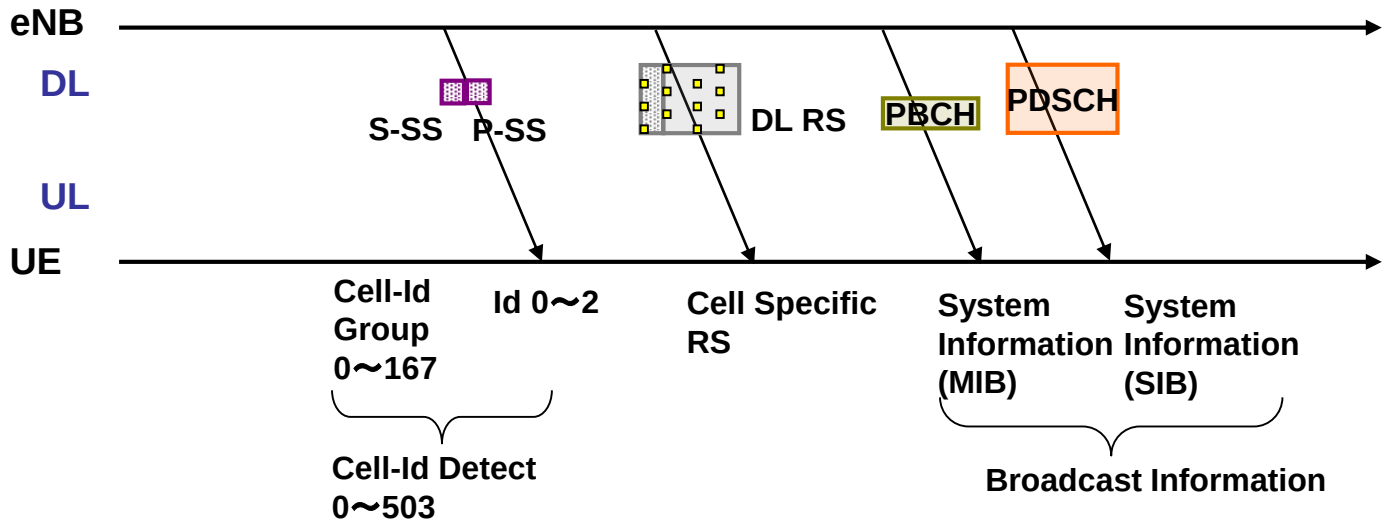
<Uplink>

- PUSCH
  - Transmit Data
- PUCCH
  - Transmit ACK/NACK, CQI, SR
- PRACH
  - Transmit Random Access Preamble
- SRS
  - For UL CQI measurement

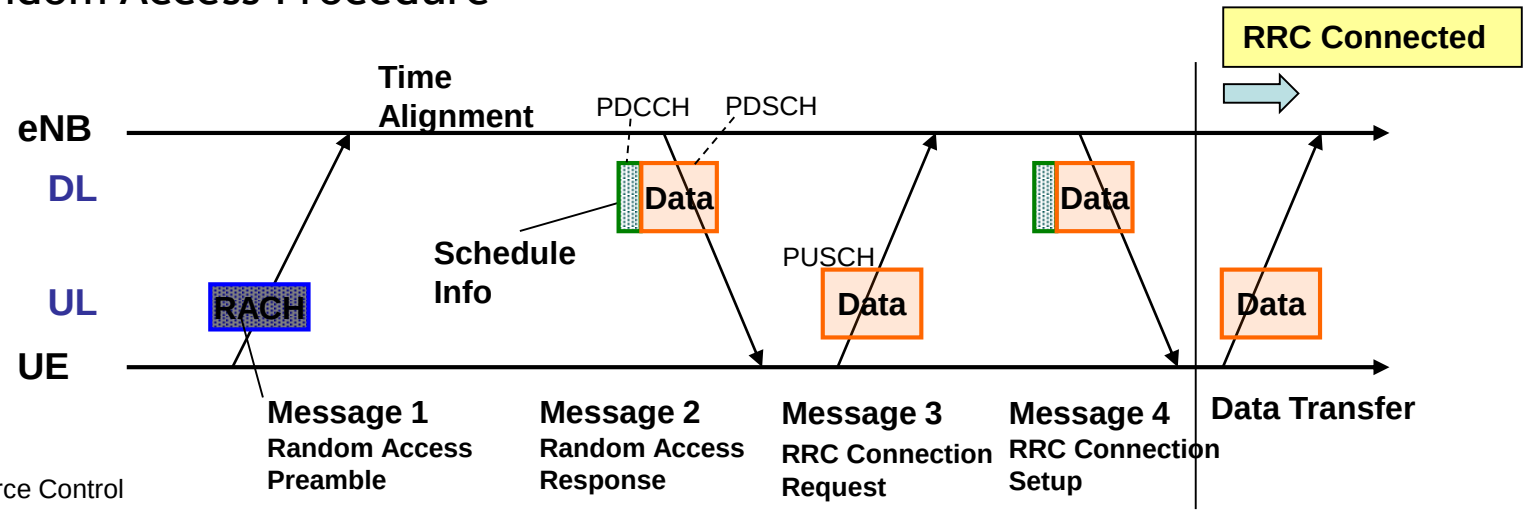


Physical Channel Procedure

- Synchronization Procedure



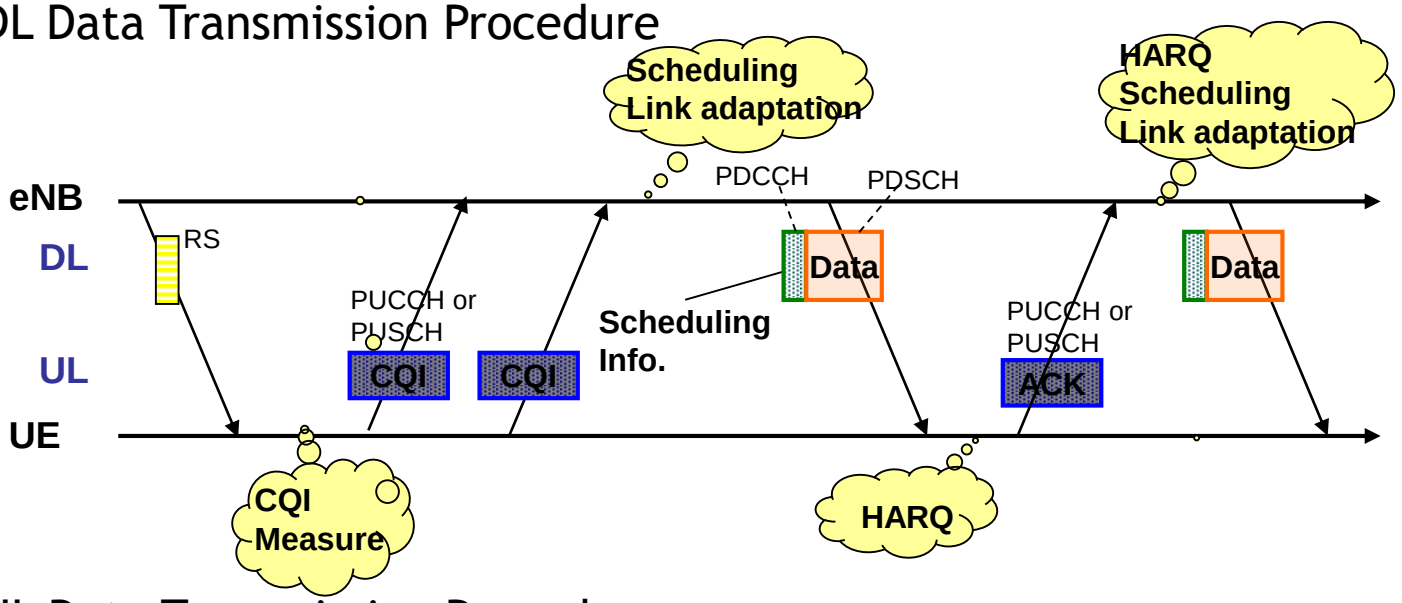
- Random Access Procedure



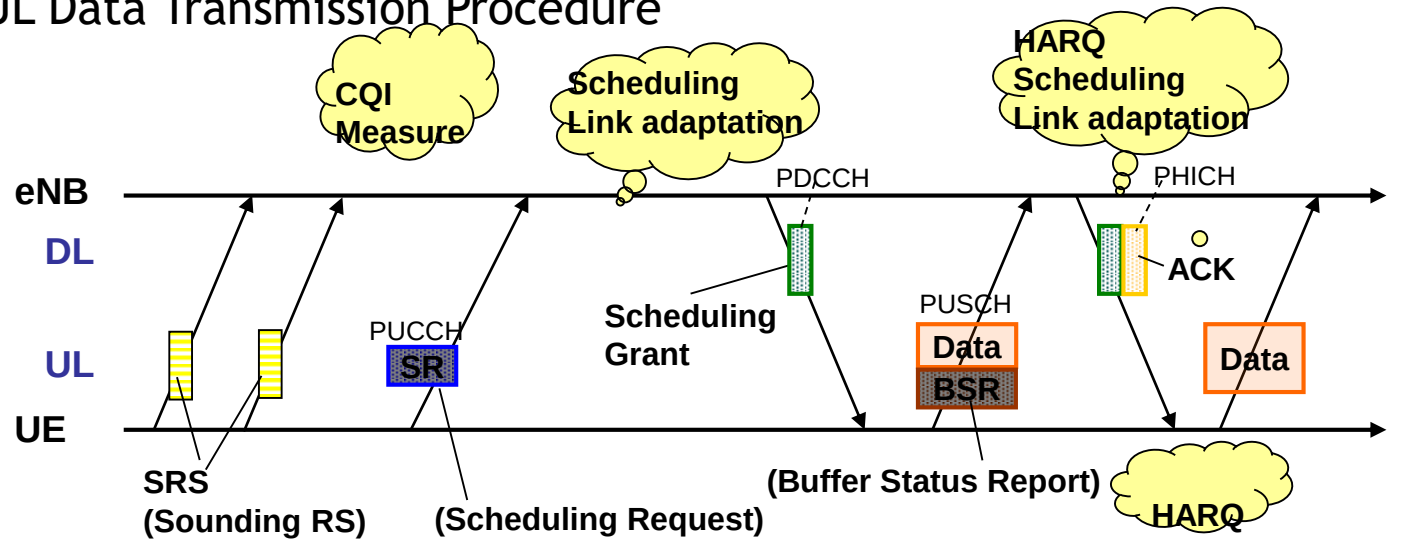
RRC: Radio Resource Control

Physical Channel Procedure

- DL Data Transmission Procedure

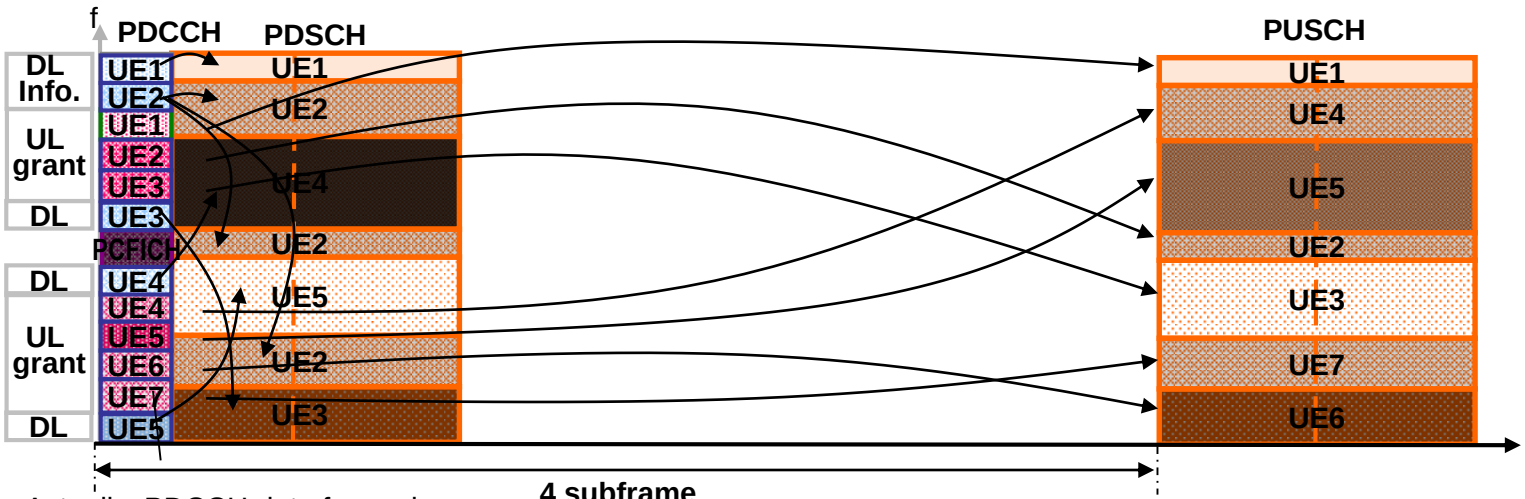


- UL Data Transmission Procedure



Physical Channel Procedure - Resource Assignment

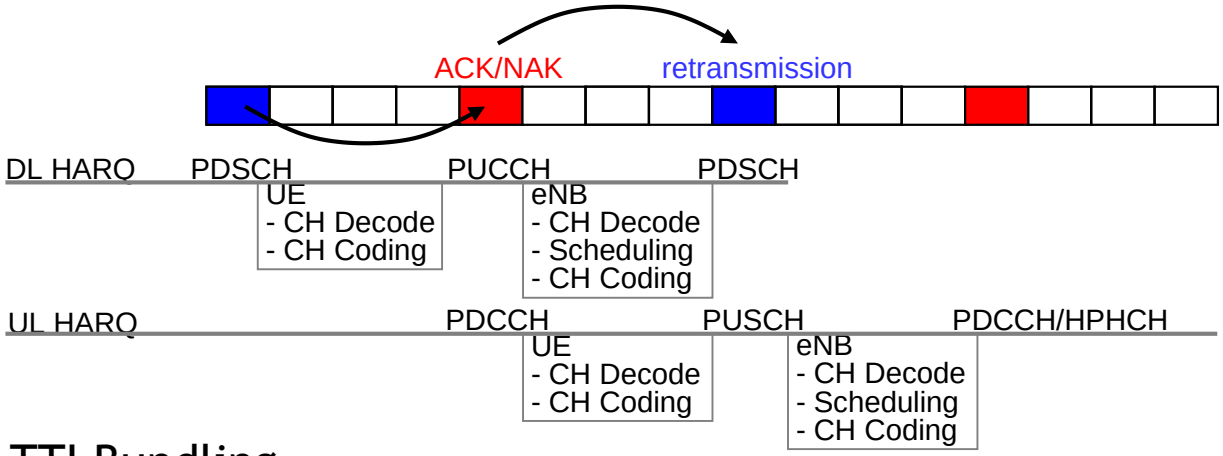
- Resource Allocation
  - PDCCH assigns PDSCH of the same subframe
  - PDCCH assigns PUSCH of 4 subframe later
- Dynamic scheduling
  - Resource is allocated by PDCCH subframe by subframe
- Semi-persistent scheduling
  - Period is pre-assigned by RRC
  - Initial transmission is assigned by PDCCH
  - Transmission continues periodically.



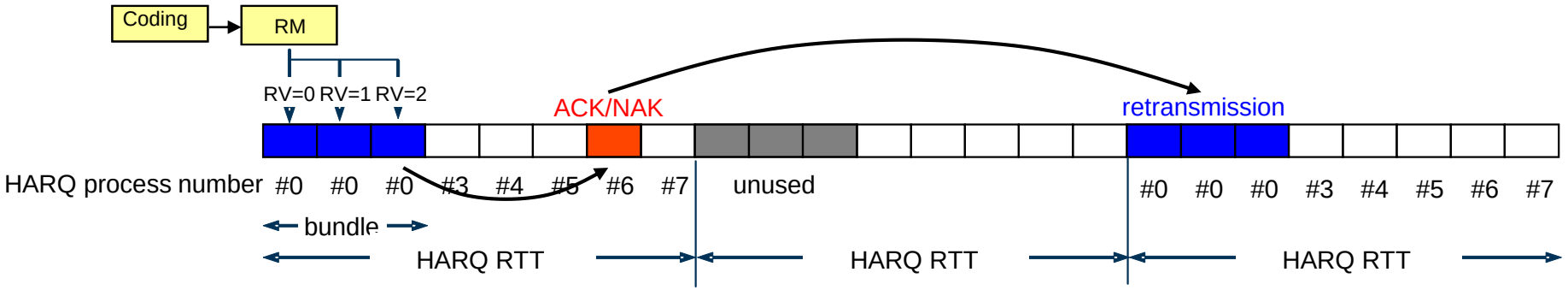
Actually, PDCCH data for each user is interleaved each other.

Physical Channel Procedure

- HARQ

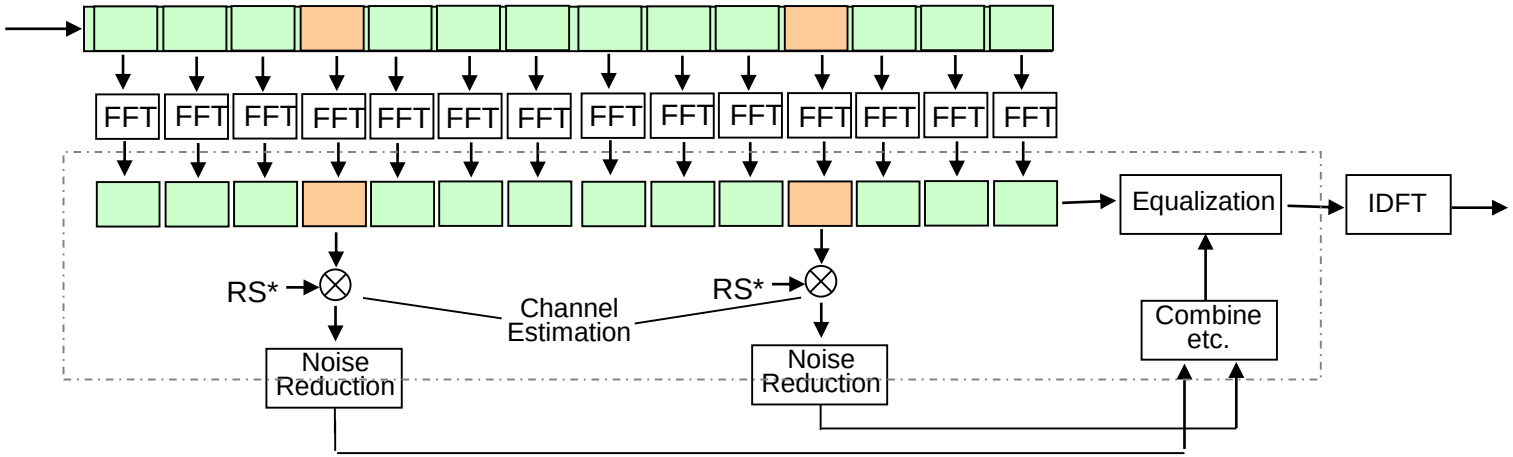


- TTI Bundling
  - Single transport block is coded and transmitted in Consecutive subframes.
  - The same hybrid ARQ process number is used in each of the bundled subframes
  - No change in HARQ timing relation



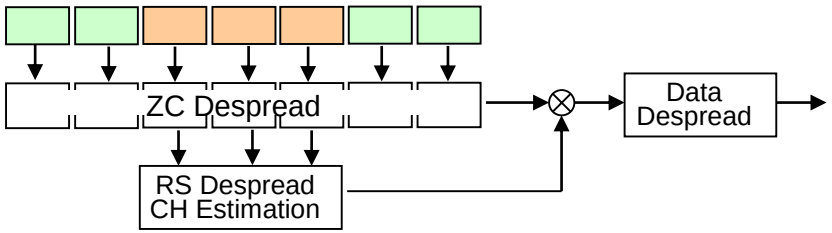
Signal Processing (UL)

- PUSCH Demodulation
  - Channel estimation & Equalization on Frequency domain
  - Both RS in subframe is used to improve performance.

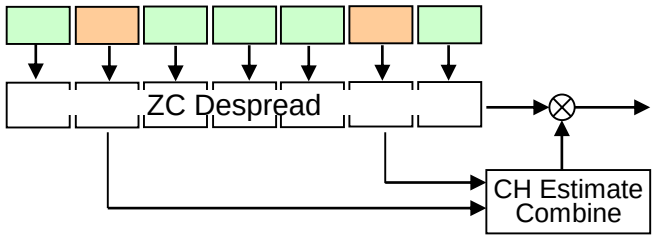


- PUCCH Demodulation
  - Similar to PUSCH

Format 1/1a/1b

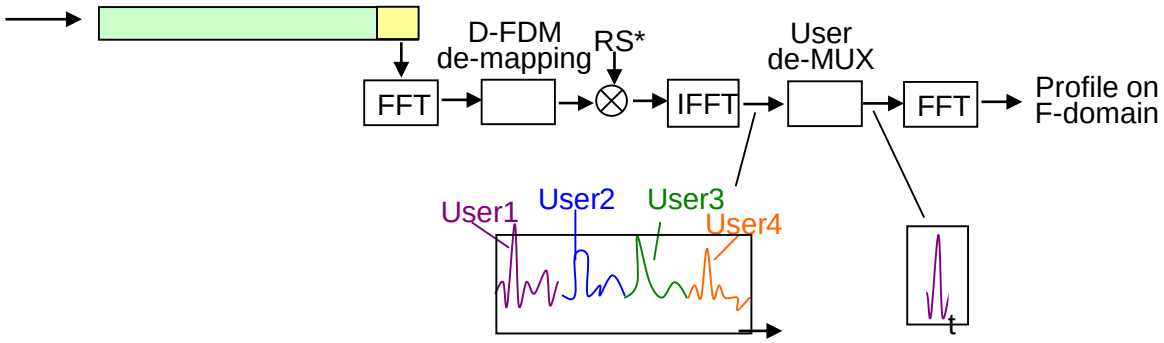


Format 2/2a/2b

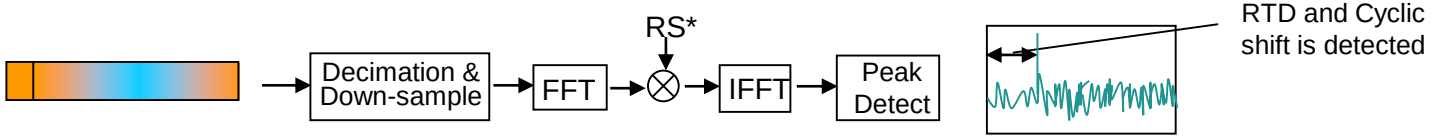


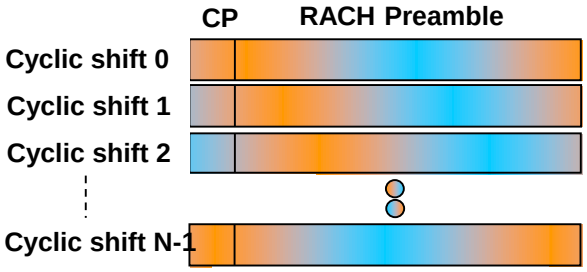
Signal Processing (UL)

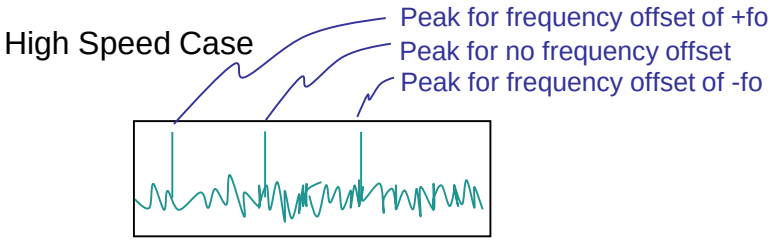
- SRS (Sounding RS) Detection
  - Users are multiplexed by Distributed-FDM and cyclic shift based CDM
  - Frequency domain CQI is measured



- PRACH Detection
  - 6bit information is expressed by Cyclic shift and Root sequence

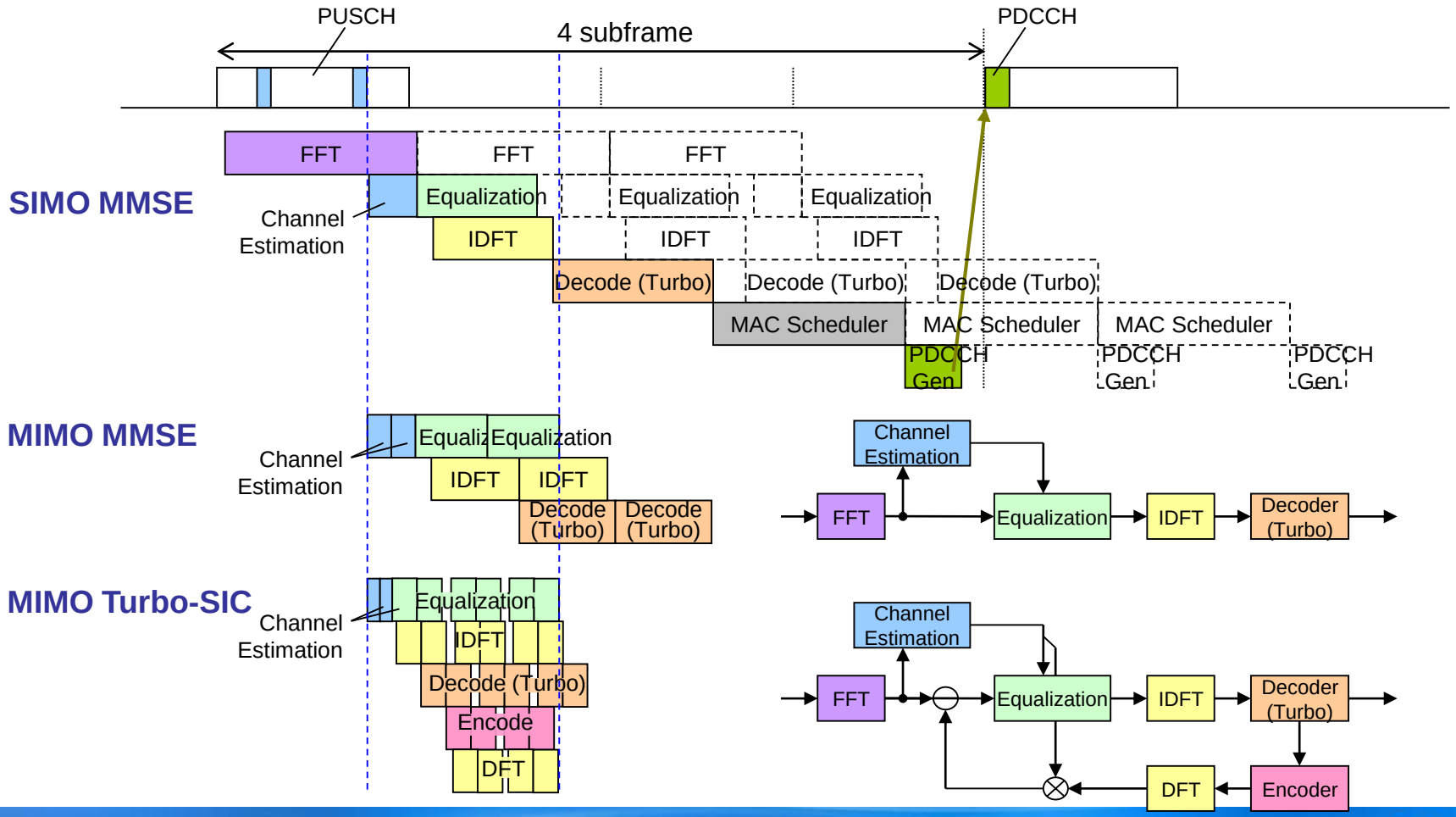






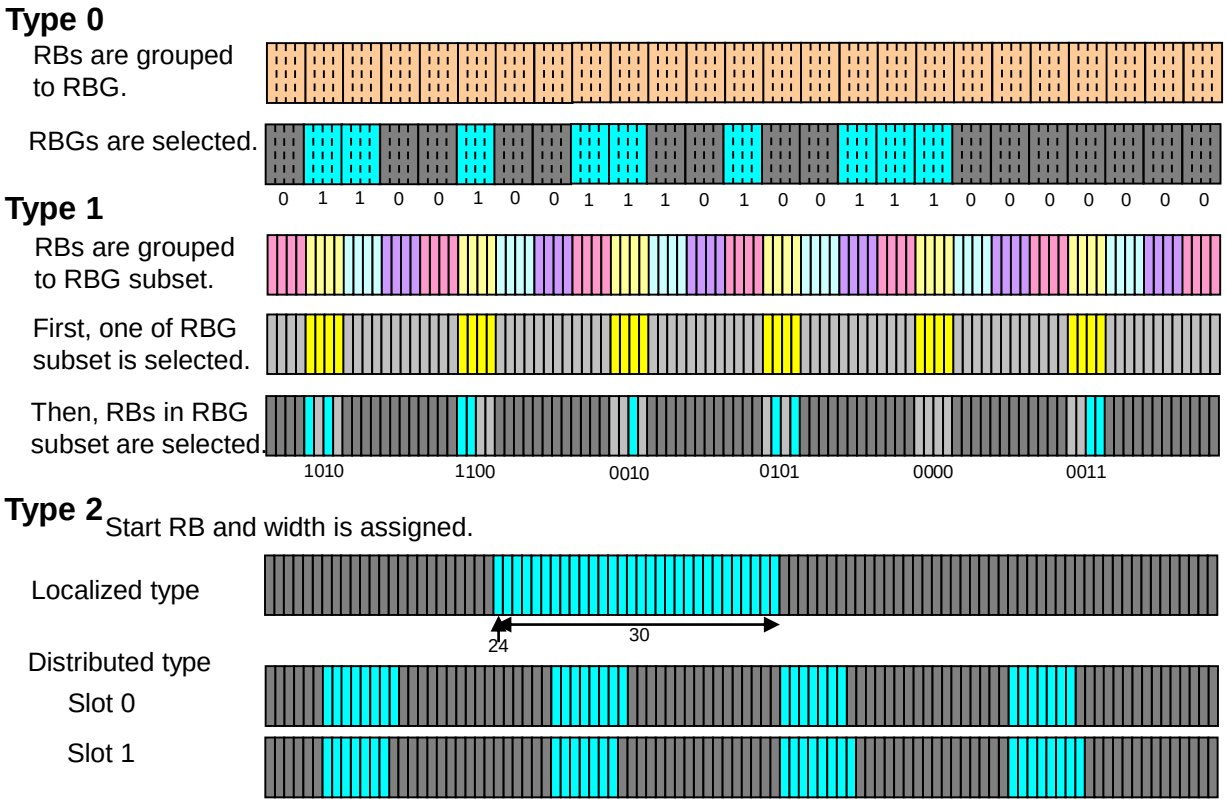
Signal Processing (UL)

- MIMO Receiver
  - MLD : For DL only (Can not be applied to DFT-spread-OFDM (SC-FDMA))
  - MMSE : Rather poor performance
  - Turbo-SIC : 2~3 heavier processing load



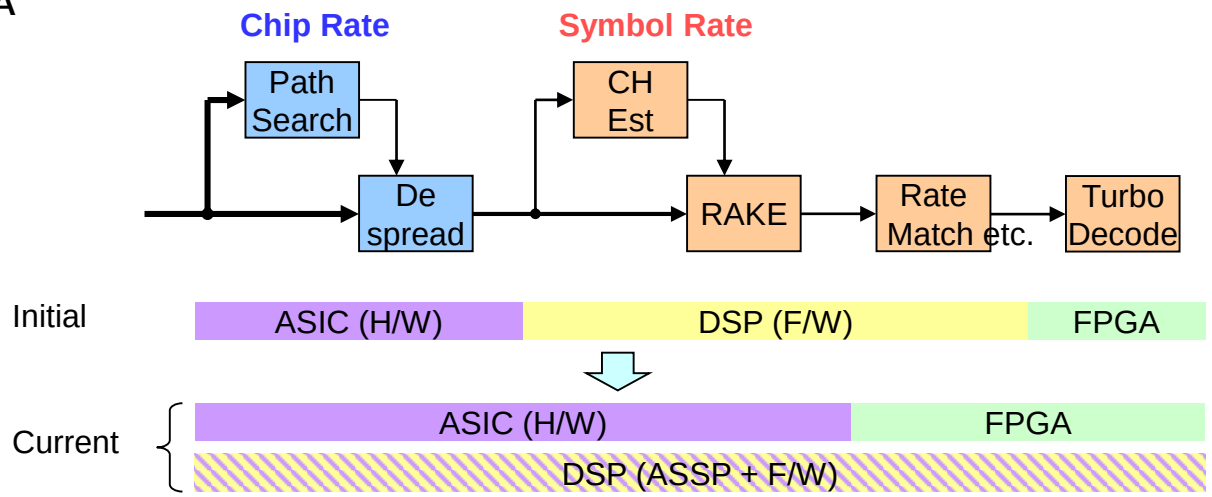
Signal Processing (DL)

- DL Demodulation
  - OFDM demodulation based on RS signals
- PDSCH Resource Allocation
  - Type 0: RB groups are allocated by Bit Map.
  - Type 1: RBs in selected 'Distributed" RBG subset are allocated by Bit Map.
  - Type 2: Start position and Width is assigned.
    Localized type and Distributed type

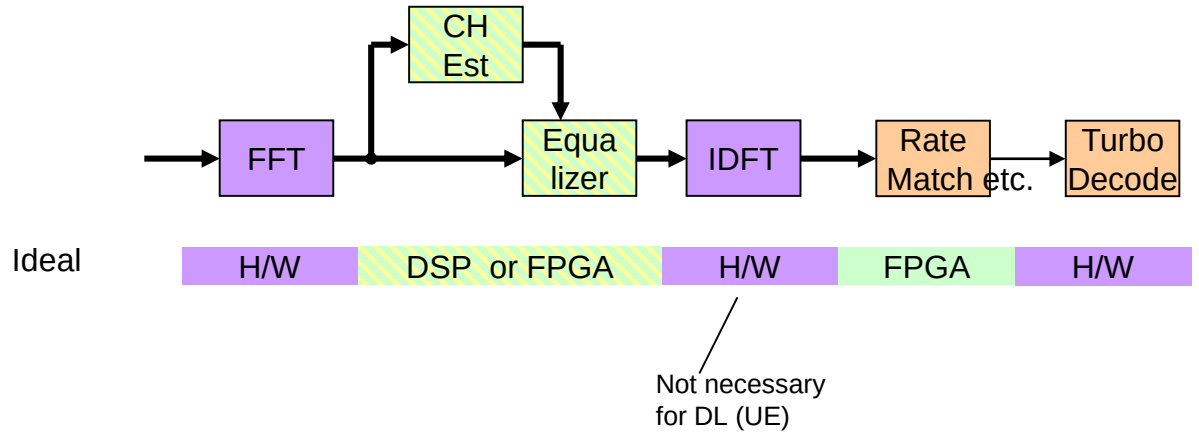


Signal Processing

- Hardware Architecture (Implementation)
  - WCDMA

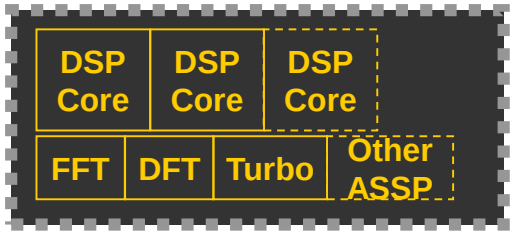


  - LTE

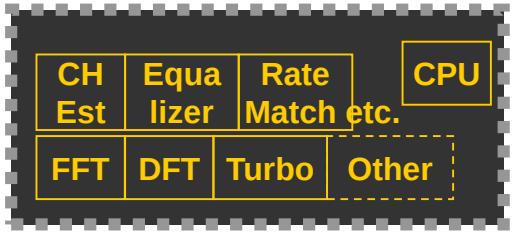


Signal Processing

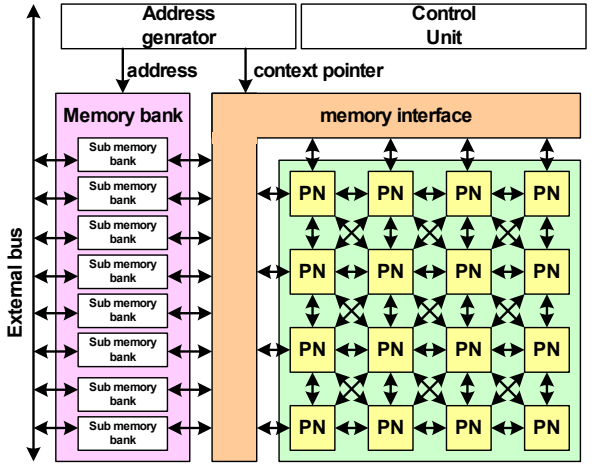
- Hardware Architecture Trend (eNB)
  - DSP w/ ASSP



  - FPGA



- Others
  - Flexible & High performance Processor

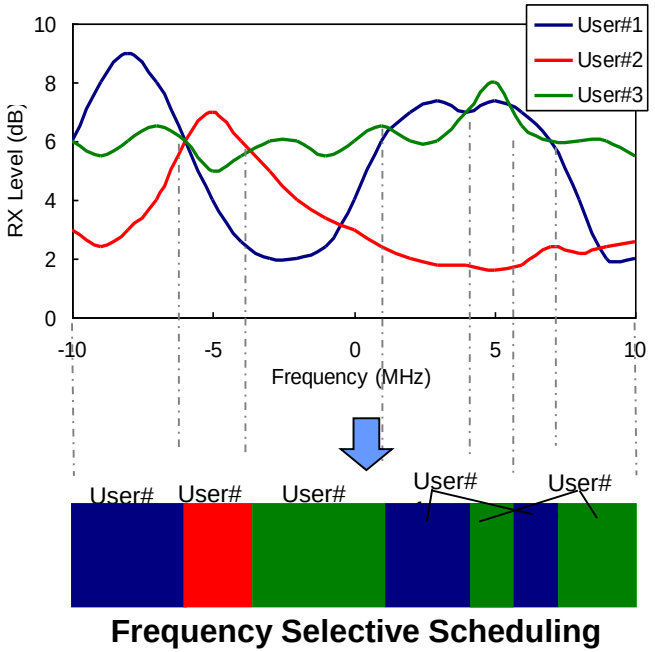


NEC Laboratories

- eNB equipment example
  - 20MHz x 3sector

RRM (Radio Resource Management)

- Scheduling
  - Trigger for UL Scheduling
    - Buffer Status report (BSR) :PUSCH scheduled user
    - Scheduling request (SR) : Synchronous user (PUCCH allocated)
    - PRACH : Asynchronous users
  - Frequency Selective Scheduling
    - DL: Based on CQI (Channel Quality Indicator) reported by UE
    - UL: Based on CQI measured by eNB using SR

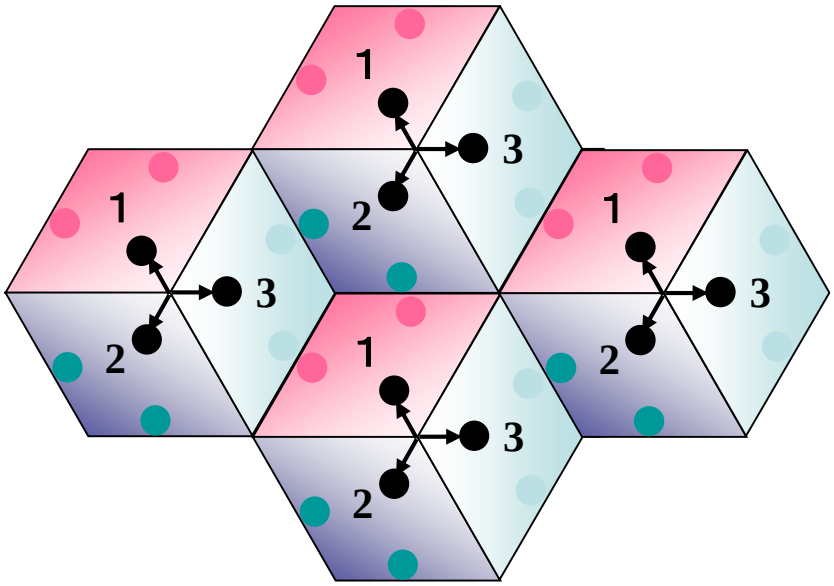


Frequency Selective Scheduling

  - MIMO
    - DL: Based on PMI (Pre-coding Matrix Indicator) and RI (Rank Indicator) reported by UE
    - UL: Based on Channel Estimates measured by eNB using SRS
  - Inter Cell Interference
    - FFR
    - ICIC

RRM (Radio Resource Management)

- FFR (Fractional Frequency Reuse)
  - To improve Throughput of User at Cell Edge
  - Edge users is restricted to fraction of transmission bandwidth (i.e. reuse 1/3 for edge users)
  - Center users can use entire bandwidth (reuse=1)



- For all users
- For users in Sector 1
- For users in Sector 2
- For users in Sector 3

eNodeB

Sector 1

Sector 2

Sector 3

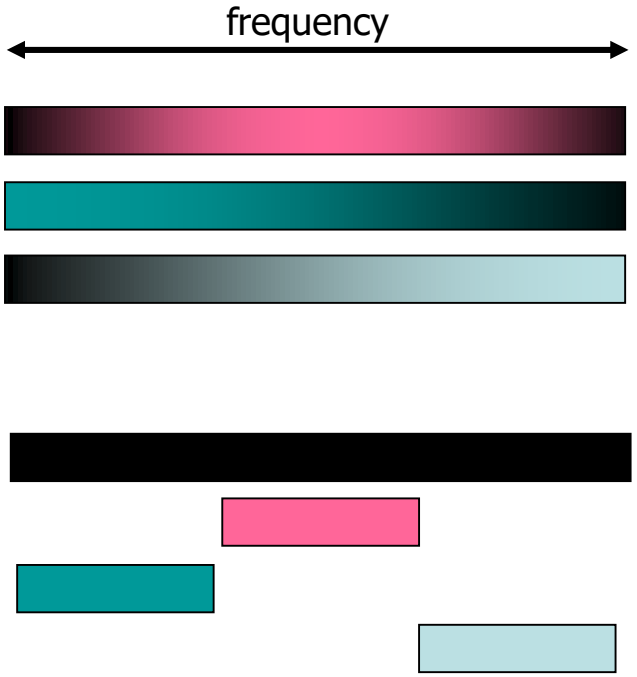
UE

Reuse set

Reuse set

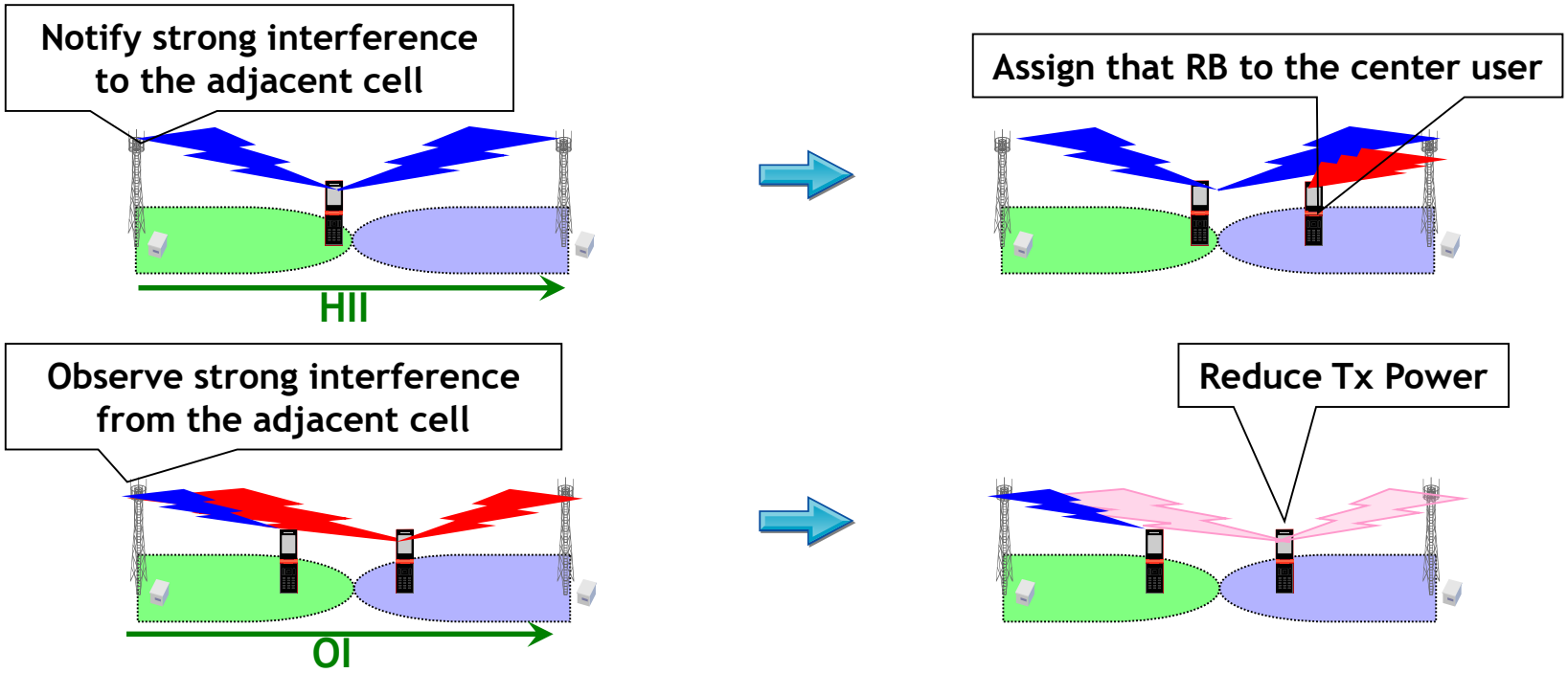
Reuse set

Reuse set



RRM (Radio Resource Management)

- ICIC (Inter-Cell Interference Coordination)
  - Use X2 Interface (btw eNB) to exchange following information for UL
    - HII (High Interference Indicator)
    - OI (Overload Indicator)

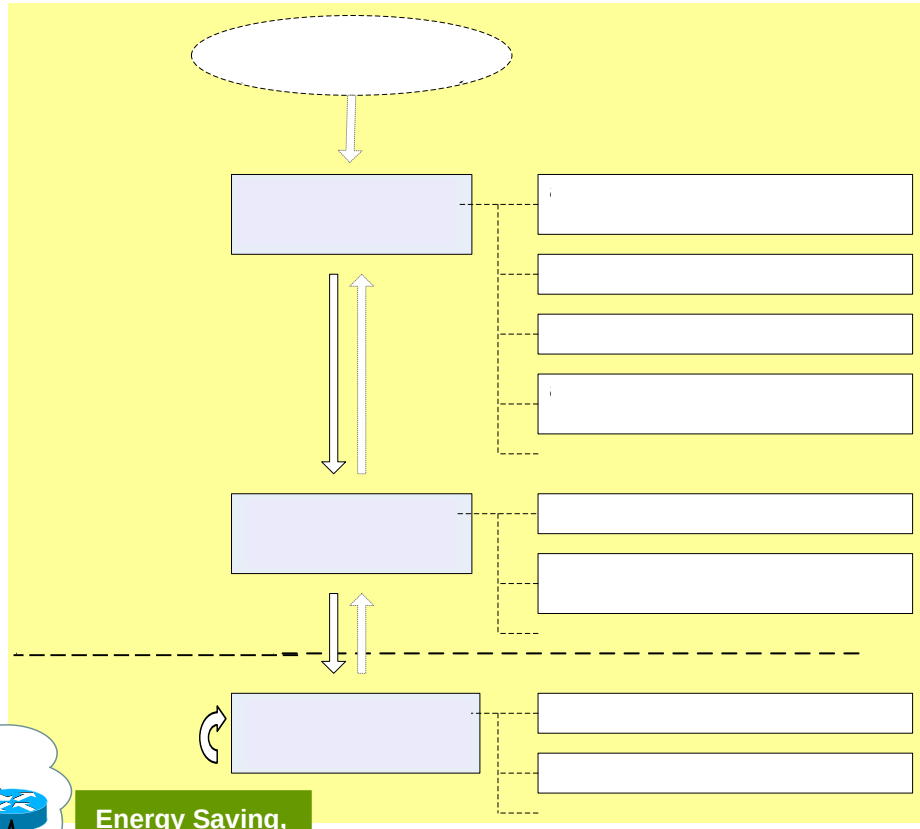


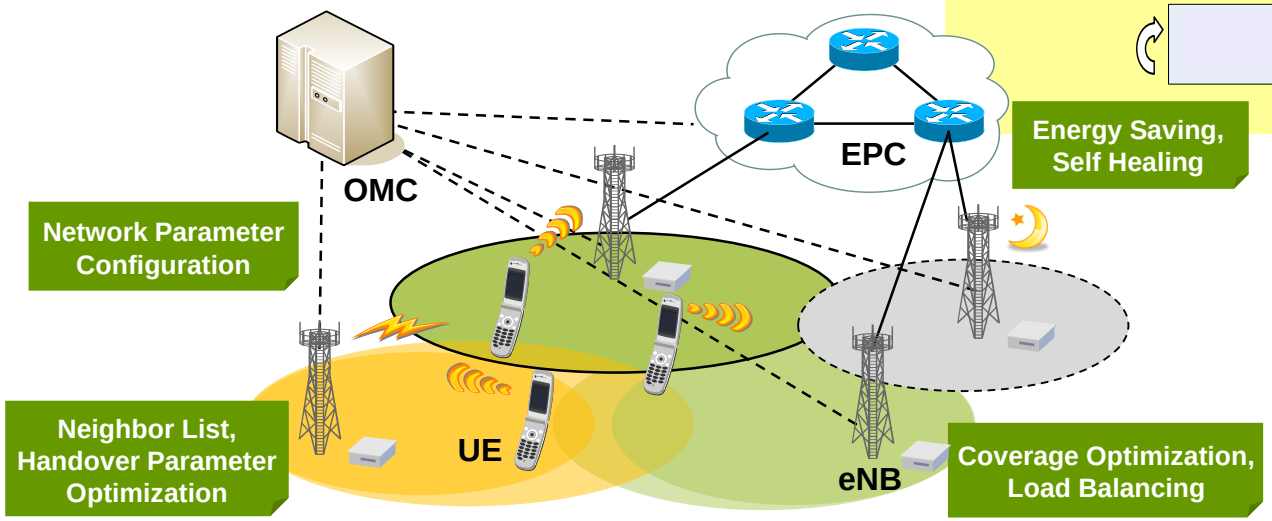
  - If receive HII, assign that RB to center user to minimize interference.
  - If receive OI, reduce transmission power of "suspect" user.

SON (Self Organizing/Optimizing Network)

- Motivation for SON
  - Cell size will decrease for future generation
  - Radio network control is quite complicated (Handover, Interference coordination etc.)
  - TCO (Total Cost of Ownership) need to reduced

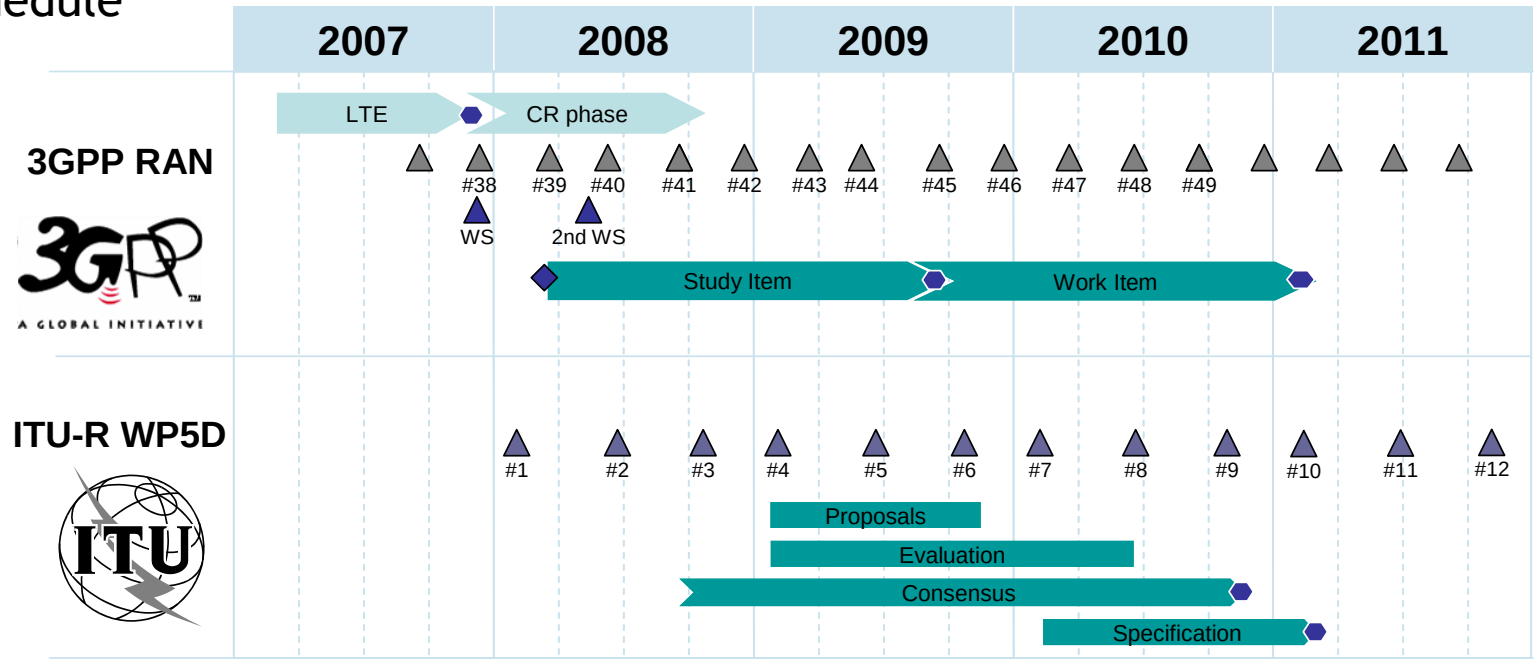
  →Mechanism to control network automatically is demanded to reduce CAPEX /OPEX.





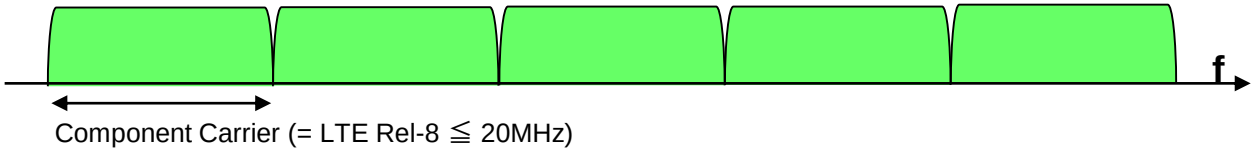
LTE Advanced

- Measure Items now being studied
  - Bandwidth extension 20MHz~100MHz
  - Uplink access scheme
  - MIMO
    - DL 8x8, Multi user MIMO
    - UL 4x4, Single user MIMO
  - CoMP (Coordinated Multipoint Transmission/Reception)
    - UL (no impact on Uu)/DL, Intra-eNB/Inter-eNB
    - Joint-processing/transmission, Coordinated scheduling and/or beamforming
  - Relay
    - (Layer-1 Relay=Repeater), Layer-2,3 Relay
- Schedule

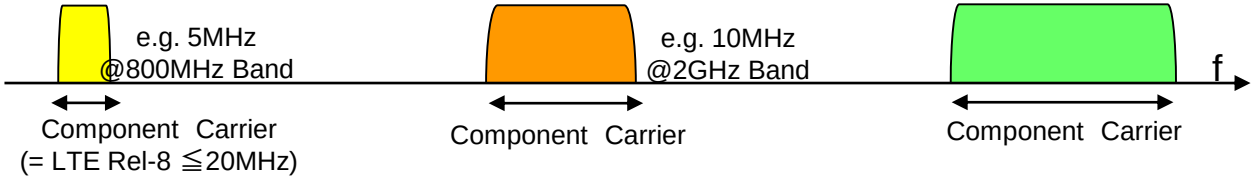


LTE Advanced

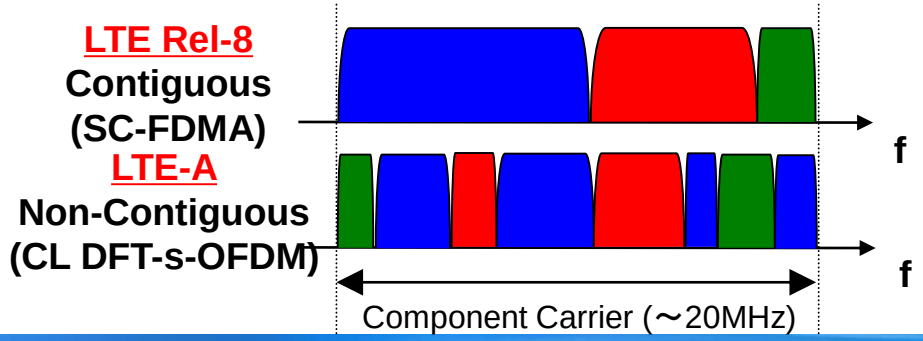
- Bandwidth Extension
  - Use continuous Component Carriers if continuous frequency available



  - Use distributed Component Carriers if continuous frequency not available

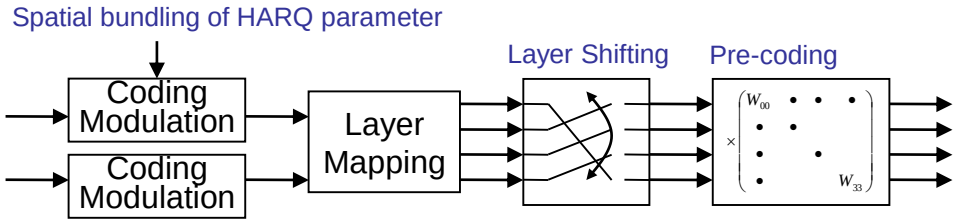


- UL Access Scheme
  - More flexible Scheduling
    - Assign only preferred frequency for the UE
  - PAPR of UE transmission degraded



LTE Advanced

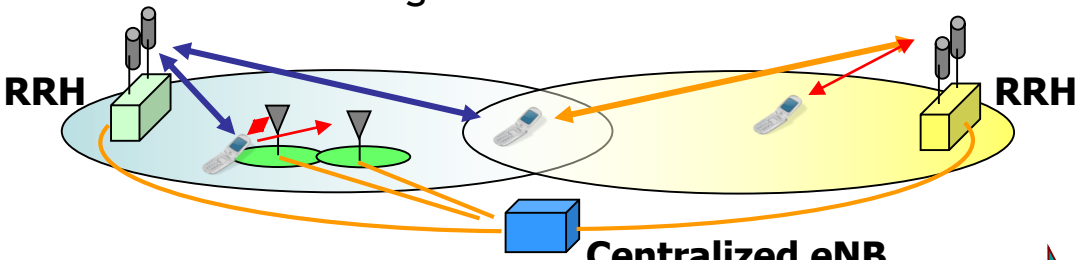
- UL MIMO Extension
  - Multi User MIMO : Already covered by LTE (Rel-8)
  - Single User MIMO
    - Spatial bundling of HARQ parameter (ACK, RV etc.)
    - Layer shifting in time domain
    - Pre-coding
  - TX Diversity



- DL MIMO Extension
  - Pre-coding Code Book
    - Extended for 8x8
  - Multi User MIMO
    - Improvement from Rel-8
- Downlink RS
  - Extended for 8 antenna transmission
  - Cell Specific RS for Measurement and UE Specific RS for demodulation

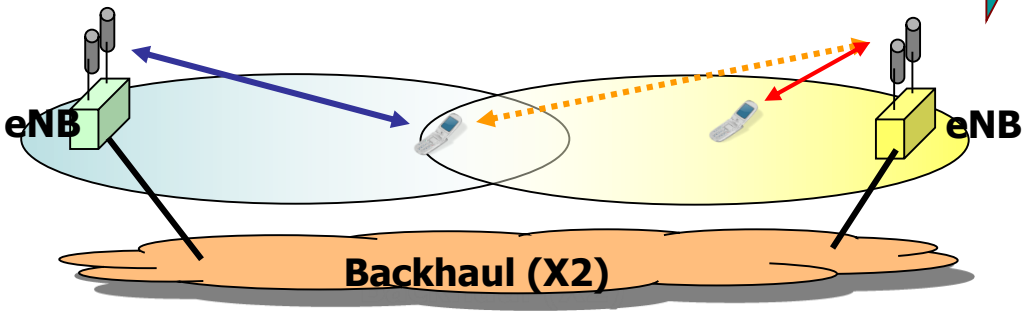
LTE Advanced

- Coordinated Multipoint Transmission/Reception (CoMP)
  - Intra-eNB -Joint-scheduling



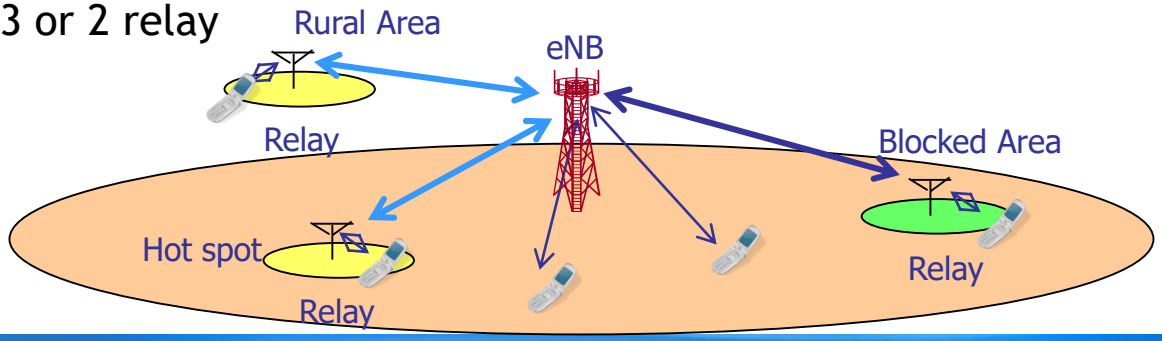
RRH: Remote RF Head

  - Inter-eNB - Coordinated scheduling



Improve Cell Edge Throughput

- Relaying
  - Layer 3 or 2 relay



Conclusion

- Signal Processing
  - Effective Algorithm and Architecture is desired for
    - Performance Improvement (Throughput, MIMO scheme)
    - Power Consumption Reduction (Of course for UE, also for eNB)
    - Cost Reduction
    - Flexibility (Standard and Environment is changing)
- Radio Resource Management (eNB)
  - It is key technology to increase cell capacity
    - There may be much room for improvement
- LTE Advanced
  - Further Standard improvement is being studied.

    → Further improvement for Algorithm and Architecture needed..

Thank you!