



## LTE evolution

Asbjörn Grövlen  
Ericsson

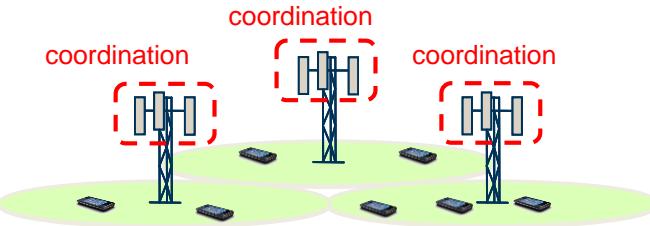
# Overview

- LTE is submitted as part of the SRIT to IMT-2020
- What has happened in LTE since the IMT-Advanced submission?
  - Lots!

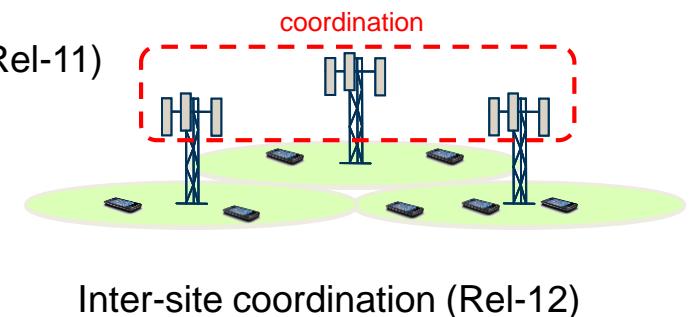


# Coordinated Multi-Point Operation

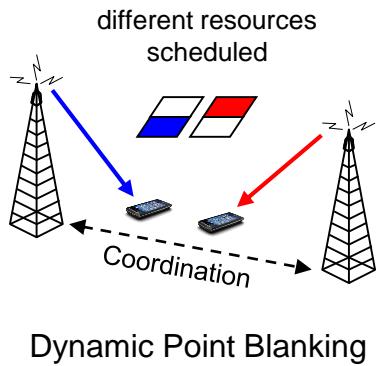
- Introduced coordination across antenna points
  - Reducing inter-cell interference, improving coverage
- Many coordination schemes require fast backhaul



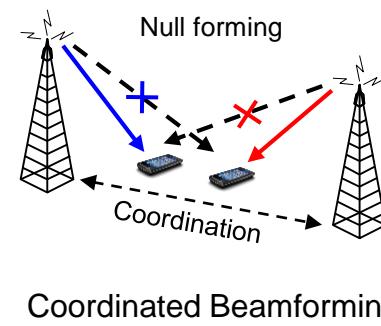
Intra-site coordination only (Rel-11)



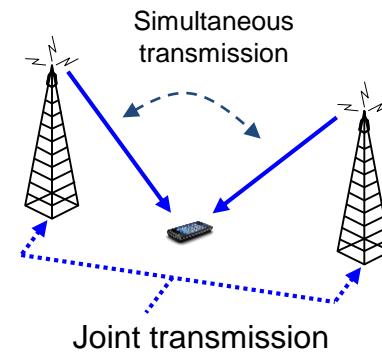
Inter-site coordination (Rel-12)



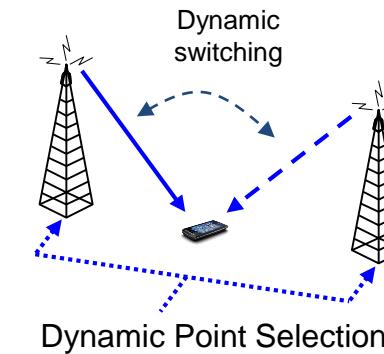
Dynamic Point Blanking



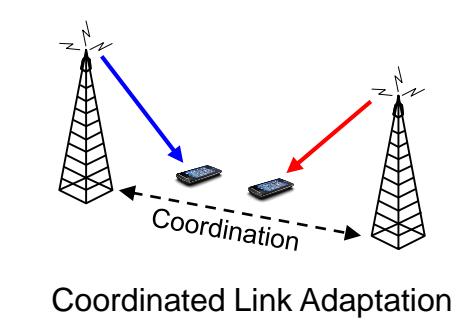
Coordinated Beamforming



Joint transmission



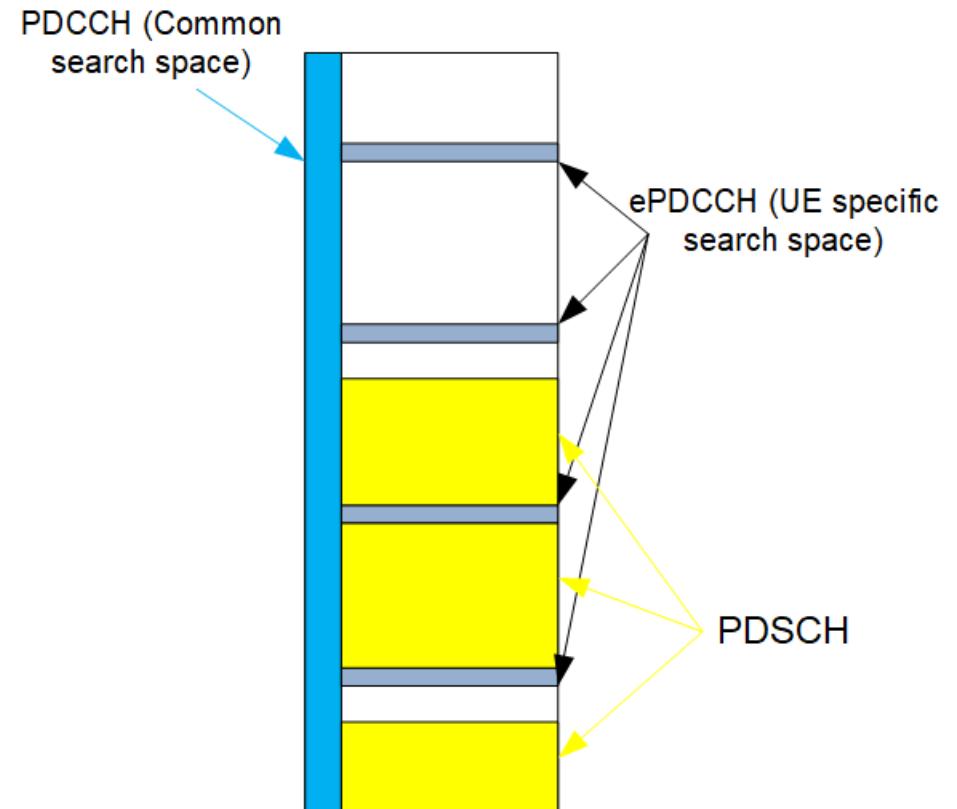
Dynamic Point Selection



Coordinated Link Adaptation

# Enhanced downlink control channel

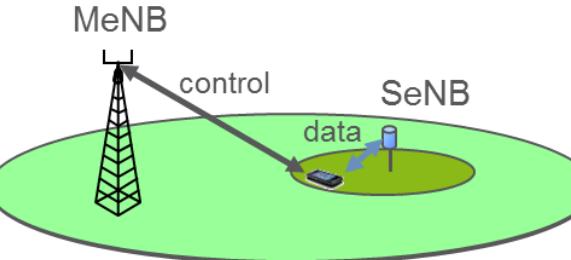
- » PDCCH is
  - » always full bandwidth
  - » using common reference signal (CRS)
- » EPDCCH introduced to support
  - » increased control channel capacity
  - » frequency-domain ICIC
  - » improved spatial reuse of control channel resource
  - » beamforming and/or diversity
- » The EPDCCH can
  - » be transmitted multiplexed with PDSCH
  - » coexist with legacy UEs on the same carrier
- » DMRS are used for demodulation



# Dual connectivity

## Control and user plane separation

- DL (Rel-12)
- UL (Rel-13)

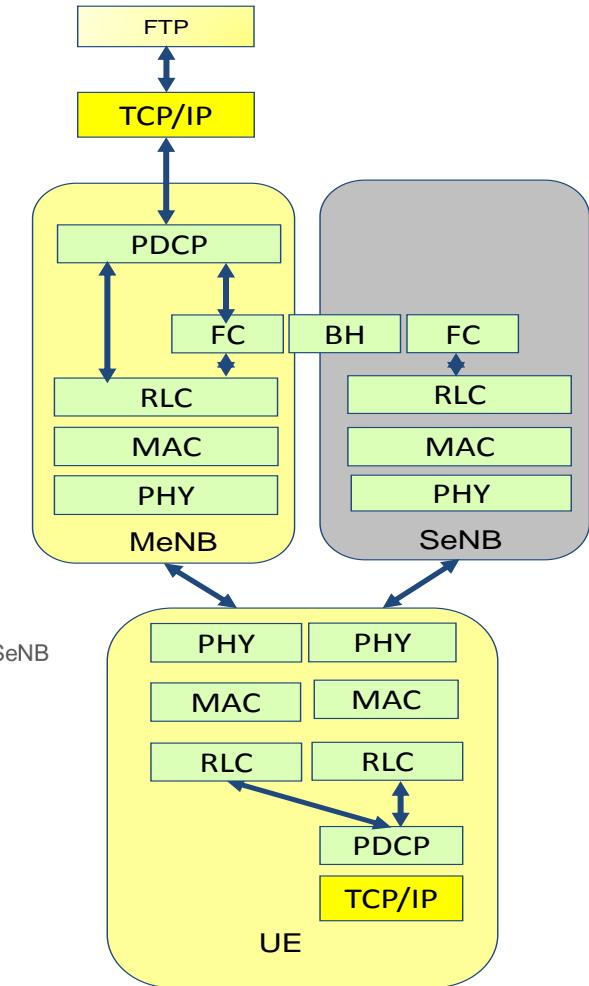
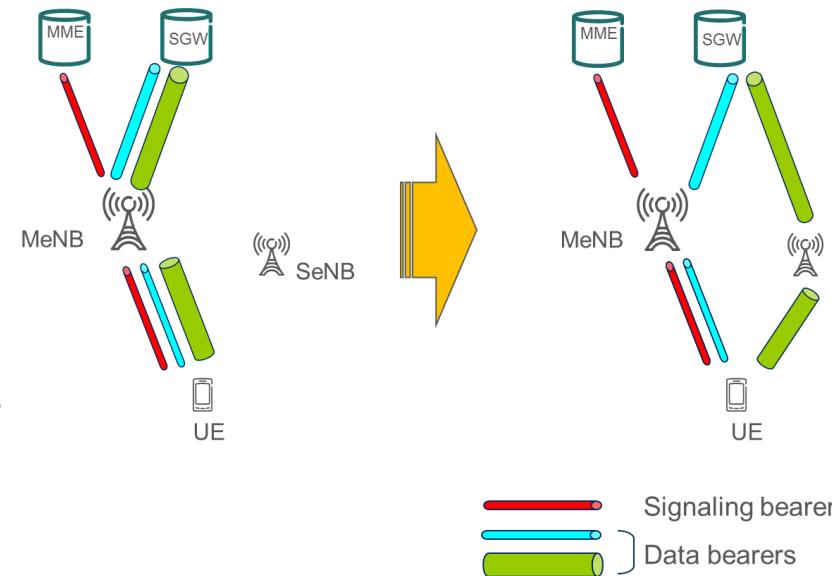


## Benefits

- Increased mobility robustness
- Minimize UE context transfer
- Minimize re-establishment failures

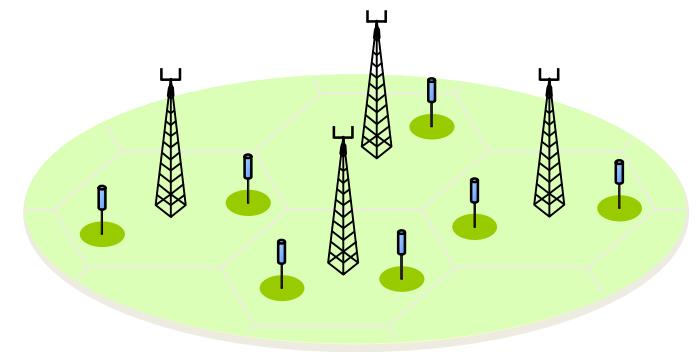
## Split bearer

- Data is split on the PDCP layer
- Transparent to higher layer protocols
- Service specific offloading



# Small cells

- » Dynamic TDD (eIMTA)
  - » Certain subframes within the radio frame can be dynamically switch between UL and DL
- » 256QAM
  - » 1024 QAM also supported in DL
- » Allow small cells to be turned on/off with low latency
  - » Discovery signal
- » Radio interface based inter-cell synchronization



# Proximity services (ProSe) and vehicle-to-everything (V2X)

Rel-12→



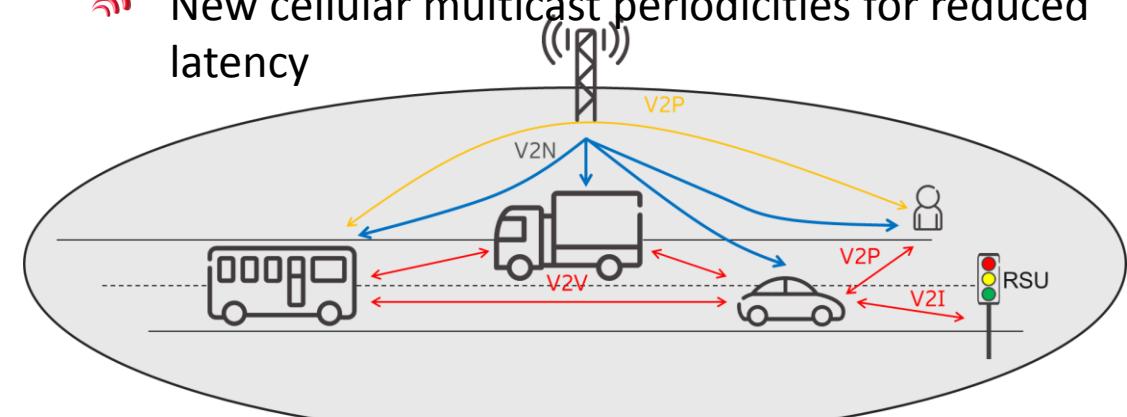
- The introduction of the sidelink interface enables direct UE-to-UE communications
- The cellular interface was enhanced to handle efficiently unicast and broadcast traffic

## Use cases

- Mission critical push-to-talk for first responders (ProSe, Rels. 12-13)
- Discovery (ProSe, Rels. 12-13)
- Vehicular day-1 safety services such as CAM and DENM (V2X, Rel. 14)
- Truck platooning, advanced driving, vehicle sensor sharing (V2X, Rel. 15)

## Features

- UE-autonomous resource allocation and NW-managed resource allocation for sidelink
- Distributed synchronization for operation outside network coverage
- New physical layer format for high mobility scenarios (V2X)
- Aggregation of multiple sidelink carriers
- New cellular multicast periodicities for reduced latency



# Licensed-Assisted Access

## Rel-13 Licensed assisted access

- Enable gigabit throughput LTE via carrier aggregation framework
- Downlink only access to 5 GHz unlicensed bands

**Primary Carrier**  
Licensed Spectrum



**Secondary Carrier**  
Unlicensed Spectrum

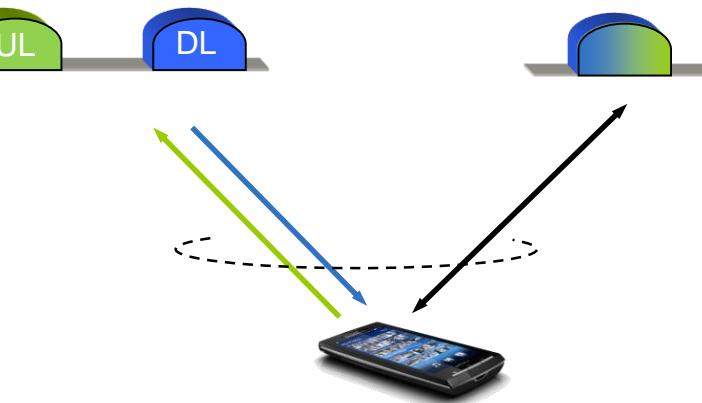


## Rel-14 Enhanced LAA

- Introduce scheduled uplink access to unlicensed bands

## Rel-15 Further enhanced LAA

- Enhance uplink access throughput and latency with configured grants (aka “autonomous UL”)

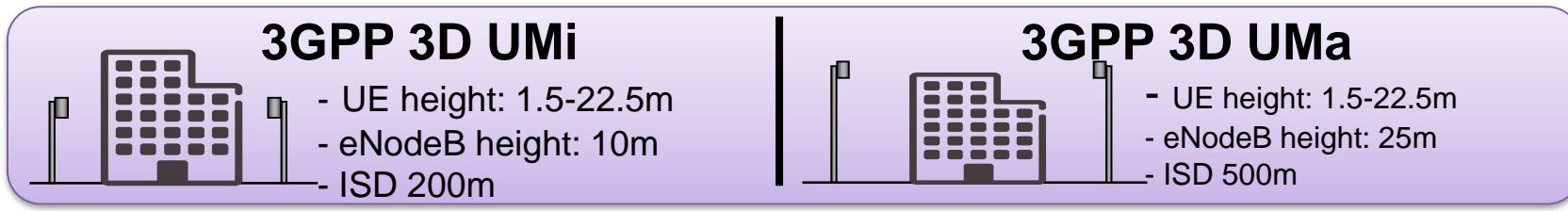
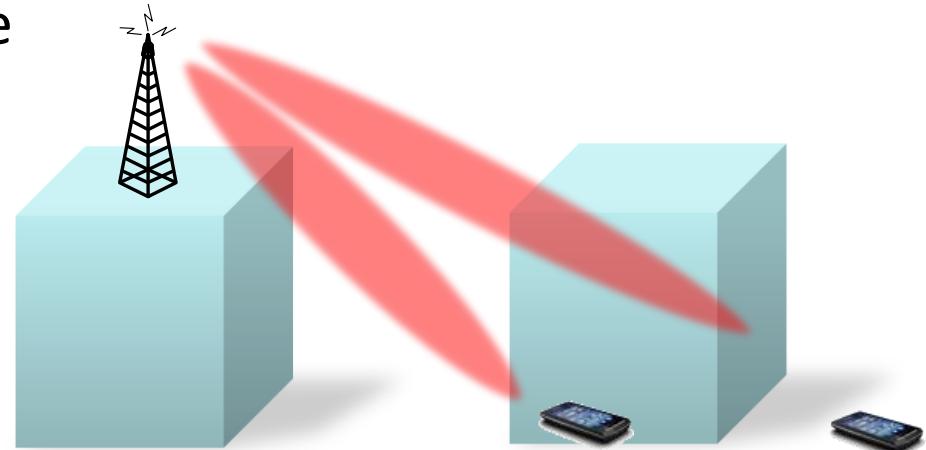


# Elevation Beamforming/ Full-Dimension MIMO

Rel-13→

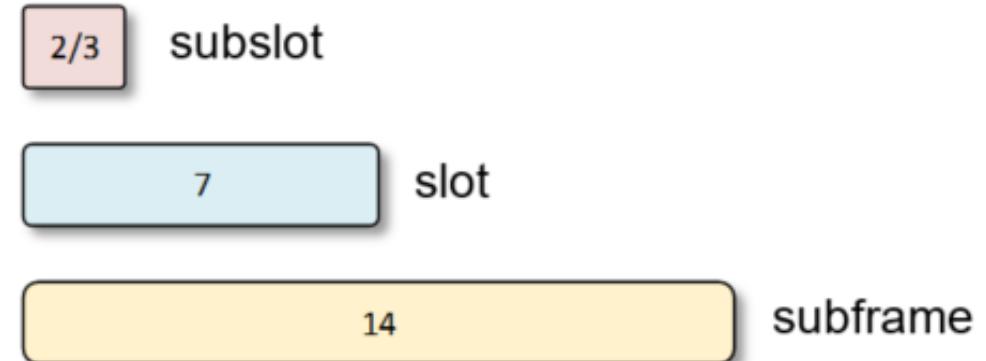


- With the introduction of advanced antenna systems with more antenna elements, exploiting all three dimensions for MIMO becomes possible
- A 3D channel model was developed
- Feature components
  - Increased number CSI-RS ports to 12 and 16
  - Beam selection
  - SRS enhancements for low delay spread channels
  - DMRS enhancements to increase the number of co-scheduled UEs



# Shortened TTI and processing time

- Shortened TTI and processing time for LTE introduces the possibility for subslot- (2 or 3 symbols long) and slot-based transmission, each associated with a short processing time.
- A shortened processing time of  $n+3$  (compared to  $n+4$ ) has also been introduced for subframe-based transmissions
- DL and UL control channels have been redesigned (SPDCCH and SPUCC for UL and DL respectively) ensuring backwards compatibility with existing LTE operation
- Higher layer improvements to latency have also been introduced



# Summary



- Continuous enhancements have improved LTE meeting the IMT-2020 requirements of a component RIT