



Standard of 4G LTE

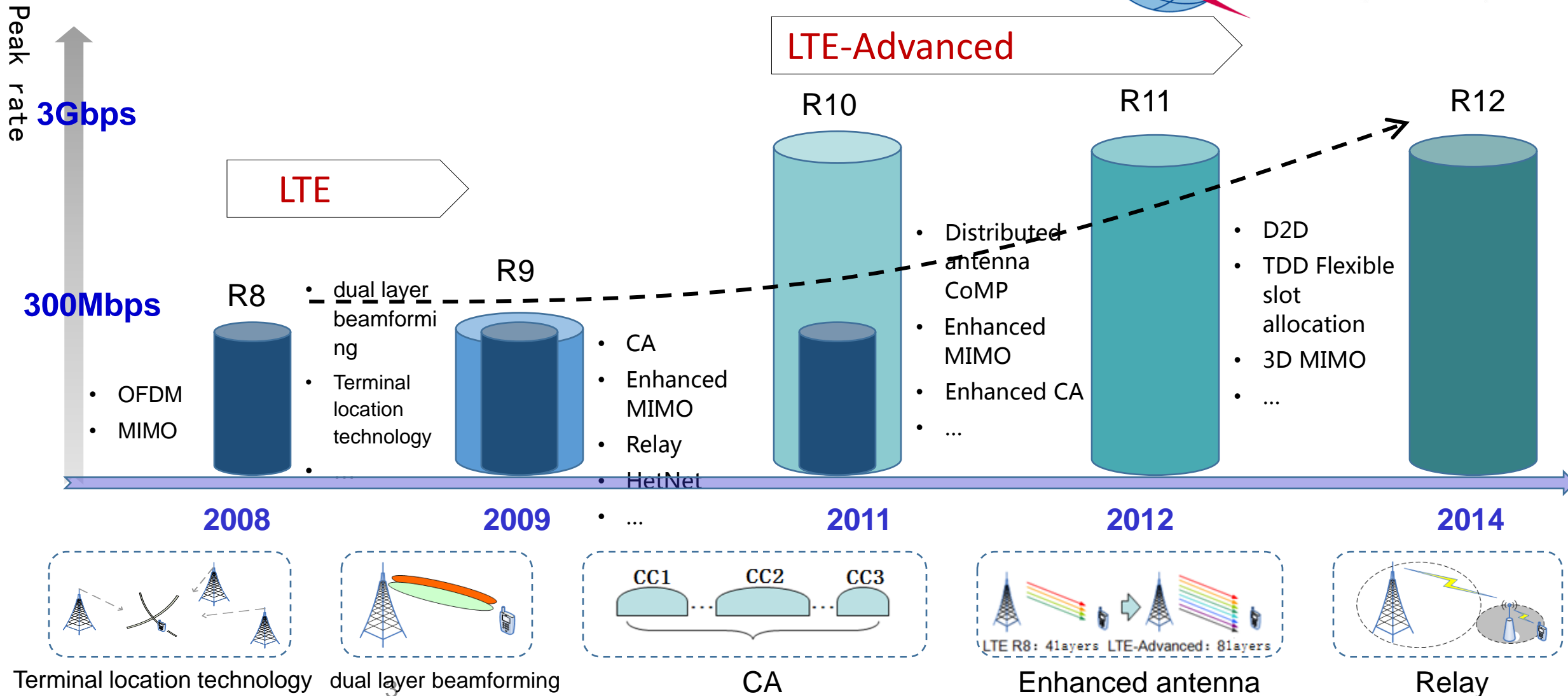
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CAICT



Course Objectives:

- **Evolution of LTE-Advanced**
- **LTE-Advanced pro**

Evolution of LTE/LTE-A technology standard



Course Objectives:



- **Evolution of LTE-Advanced**
 - **CA**
 - **Enhanced MIMO**
 - **CoMP**
 - **eICIC**
 - **Relay**
- **LTE-Advanced pro**

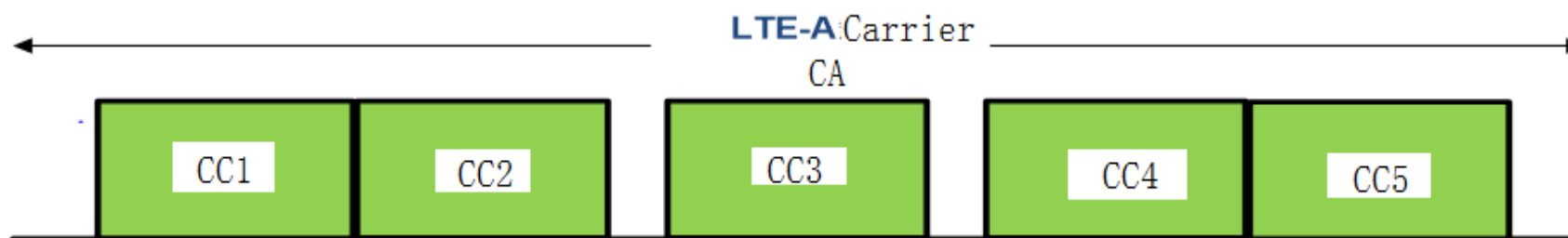
Principle of carrier aggregation (CA)



Carrier aggregation

- In order to satisfy the design of LTE-A system with the maximum bandwidth of 100MHz, and to maintain the backward compatibility , 3GPP proposed carrier aggregation.

In the LTE-A system, the maximum bandwidth of a single carrier is **20MHz**



Participate in the aggregation of the various LTE carrier is known as the LTE-A member carrier (Component Carrier, CC)

Standard

Considering the backward compatibility of LTE system, the maximum bandwidth of a single carrier unit is 20MHz in the LTE-A system.

All carrier units will be designed to be compatible with LTE, but at this stage it does not exclude the consideration of non - backward compatible carriers.

In the LTE-A FDD system, the terminal can be configured to aggregate different bandwidth, different number of carriers. For TDD LTE-A systems, the number of uplink and downlink carriers is the same in a typical scene.

In the LTE-A system, CA supports up to 5 DL carriers.

Classification of CA



contiguous CA

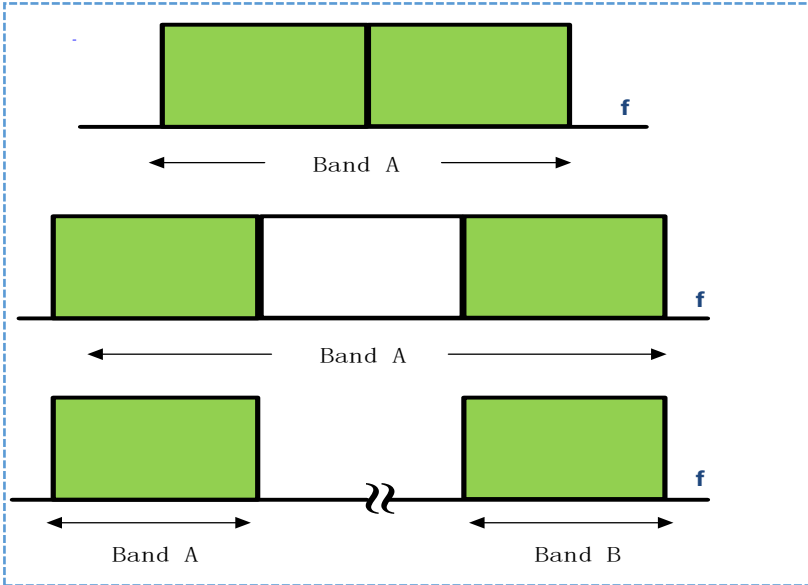
Component carriers are successive adjacent LTE carriers .

- Good Compatibility, simplify the configuration of the base station and terminal, can be used in the frequency distribution, such as 3.4GHz~3.8GHz high frequency section

Non-contiguous CA

Component carriers are composed of non continuous LTE carrier.(Intra or Inter band)

- More flexible .



Symmetric CA

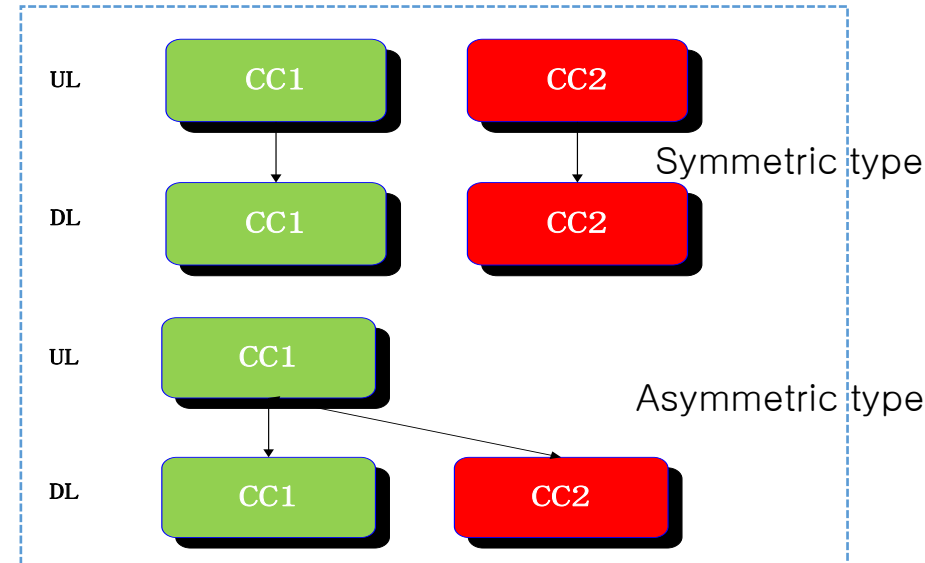
There are same number of carriers in Uplink and downlink .

- Can follow the LTE system standards, good compatibility, support FDD, TDD

Asymmetric CA

There are different number of carriers in Uplink and downlink .

- higher peak rate, lower peak to average ratio, reduce control channel and satisfy user's diversity



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Technology principle of TM9



- **TM9 is a kind of multi beam forming technology with the advantages of TM4 and TM7/8.**

- **Tm9 supports 8 antenna port configuration** , so it could further improving the throughput and spectrum efficiency of downlink transmission.
- TM9 uses new public reference signal CSI-RS, for the channel information (CQI, PMI, RI) measurement.
- **Channel state information (CSI)** and New codebook , TM9 supports two kinds of CSI feedback mode:the "code book" and "non code based"

- **Technical difficulties of TM9 :**

- Selections of code book and pre coding scheme
- Effect of codebook TM9 on LTE R8 terminal
- Contradictions between non codebook TM9 and CA/CoMP
- Promotion of performance gain



Two pre coding schemes for TM9



	TM9 Based on codebook	TM9 Based on non-codebook
Whether need Codebook or not	Yes	No
Whether need UE feedback PMI or not	Yes	No
Whether need CSI-RS or not	Yes	No
Whether need SRS or not	No	Yes

TM9 Based on codebook

Advantages

- Does not sensitive to environment and mobile speed.
- Better support for asymmetric CA and COMP.
- Suitable for user intensive scences.
- Better support for uplink single antenna.

Disadvantages

- Need UE' s feedback, the complexity of the pre coding selection is at the UE side.
- Because CSI-RS will seriously affect the performance of the R8&R9 terminal, so the base station needs to avoid scheduling.
- Make no use of the interaction of TDD system.

TM9 Based on non-codebook

Advantages

- Pre coding schemes determined by BS.
- Same implementation leads good Forward compatibility .
- Make full use of the interaction of TDD system
- When UE moves in low speed, it can bring significant gain .

Disadvantages

- Sensitive to environment and movement speed, the performance of NLOS and high speed scene decreased obviously.
- Asymmetric CA, uplink COMP, large user amount caused by SRS resource constraints can not be very good support.

Course Objectives:

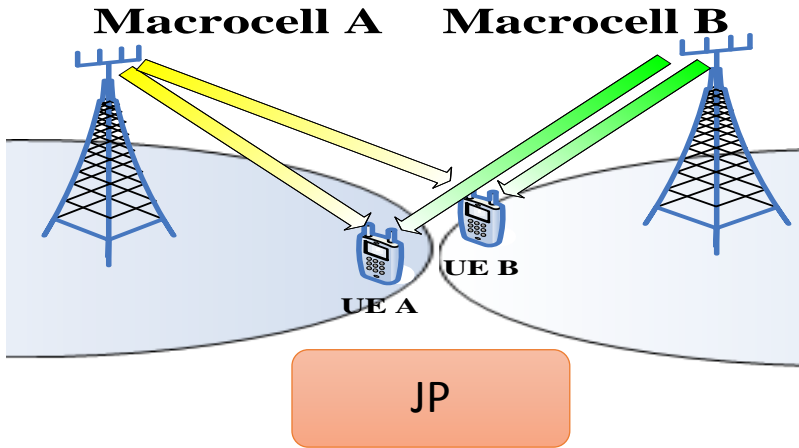


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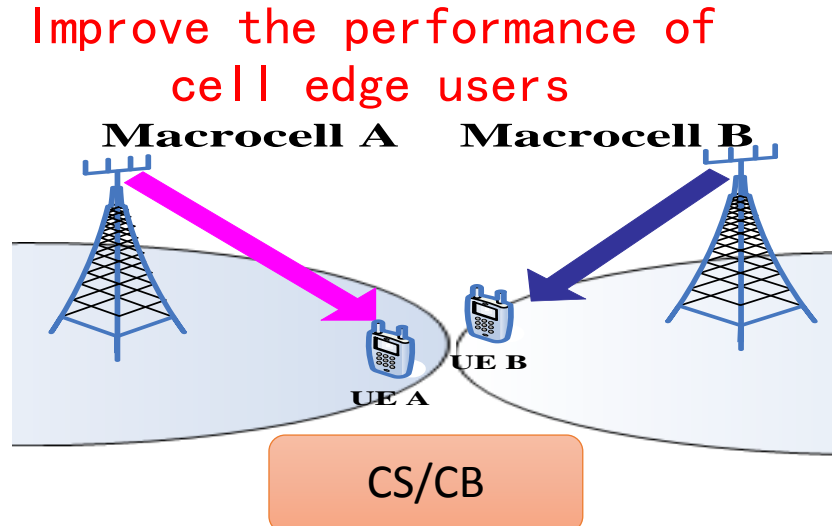
What is CoMP ?



CoMP (Coordinated Multi-Point) is a kind of distributed antenna technology, it could improve system capacity and coverage through the coordination of neighboring base stations .



By sharing CSI /Data, CoMP provides multi-point service for users, which is divided into DL multi-point and UL multi-point.



CoMP

JP(joint processing): Cooperative set share channel information and data information .

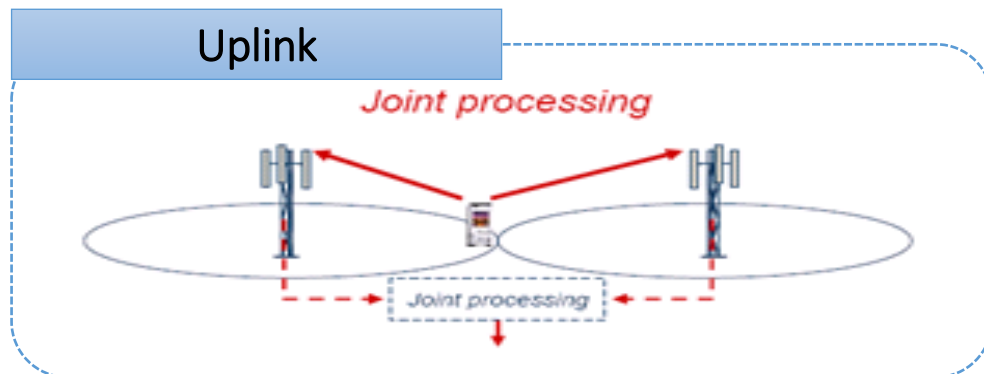
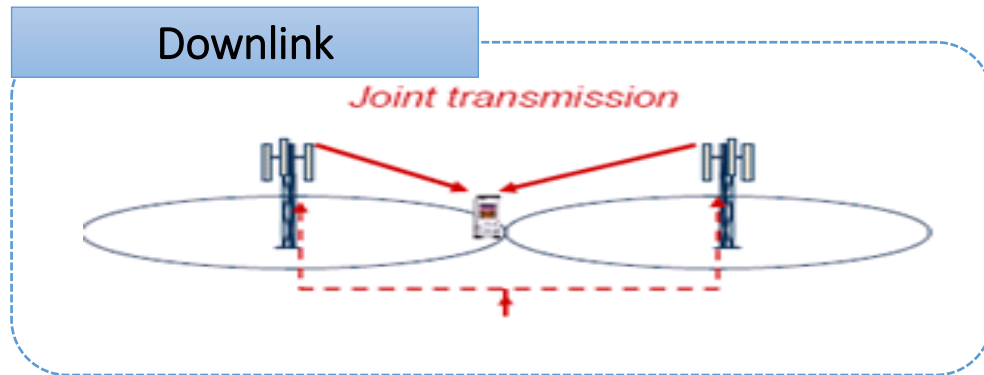
CS/CB(Coordinated scheduling/beamforming): Service data obtained from a service cell

Technical principle of CoMP I

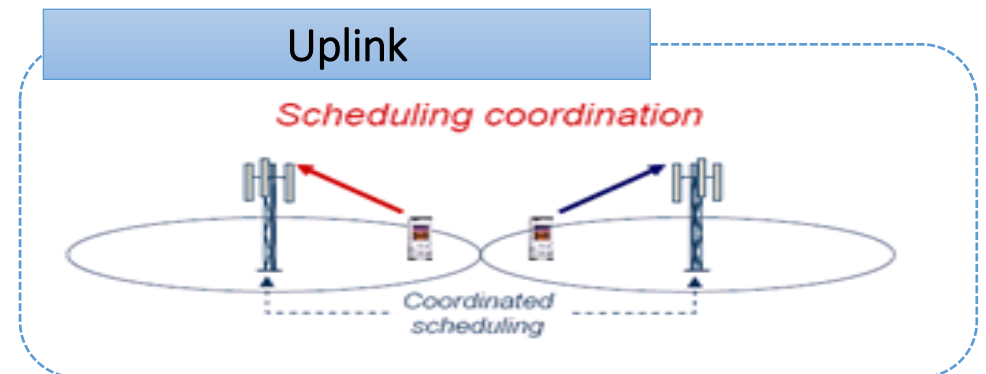
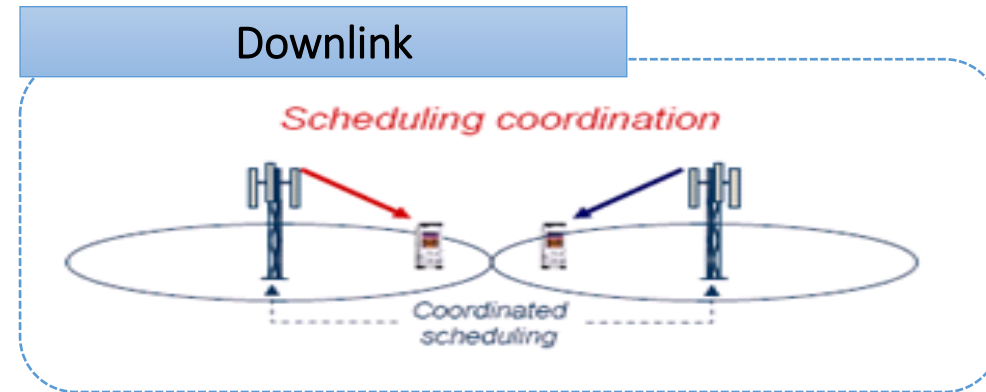


By using dynamic coordination between a plurality of geographically separated transmission points (a base station or a cell), CoMP enhanced coverage of high data rates. CoMP reduce the intra-frequency interference, improve the throughput of the cell edge UE, improve the system throughput.

JP



CS/CB



Technical principle of CoMP II



JP

• Through the sharing information, base station take the inter cell interference as useful signal to conduct joint processing

CS/CB

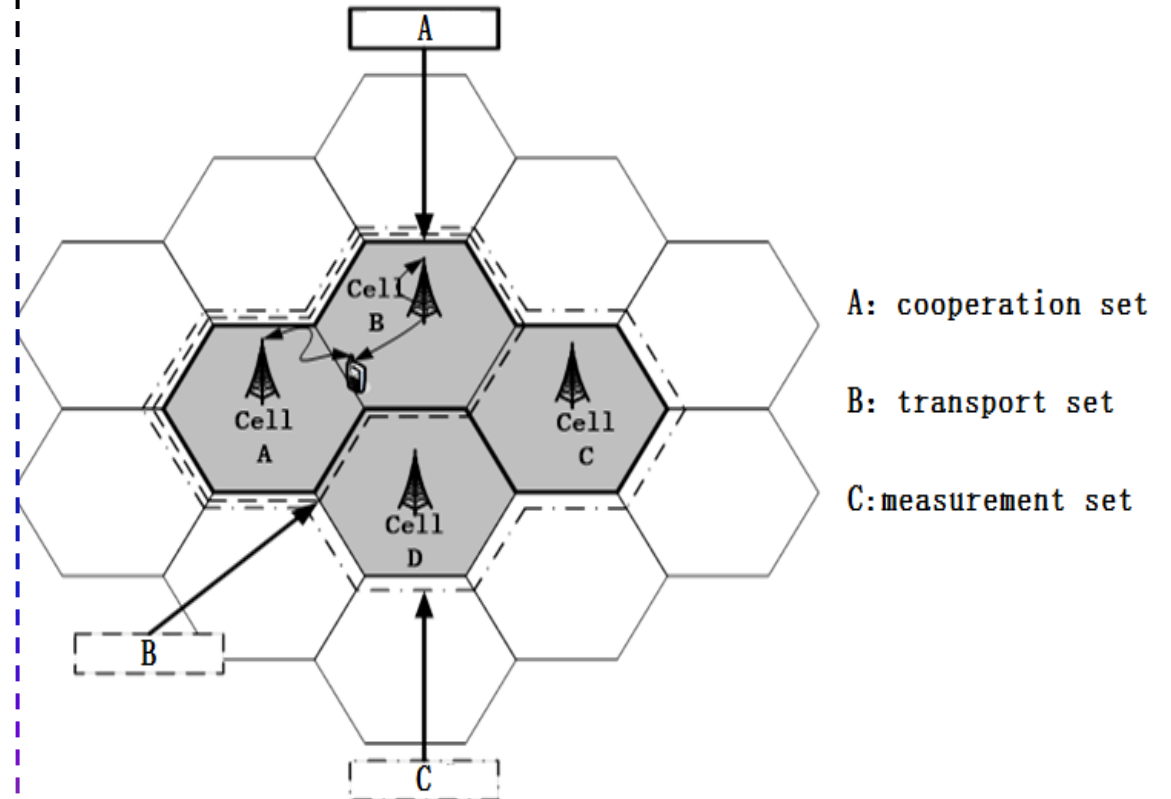
• The cooperative scheduling or beam forming is carried out among the transmission points to reduce the interference between the overlapping regions of each transmission point.

CoMP
分簇

CoMP cooperation set: A set of transmission points directly or indirectly involved in the downlink data transmission

CoMP transport set: A collection of transmission points that transmit data directly to the UE

CoMP measurement sets: A collection of cells need to report the UE link related to the channel state information or the channel statistical information.



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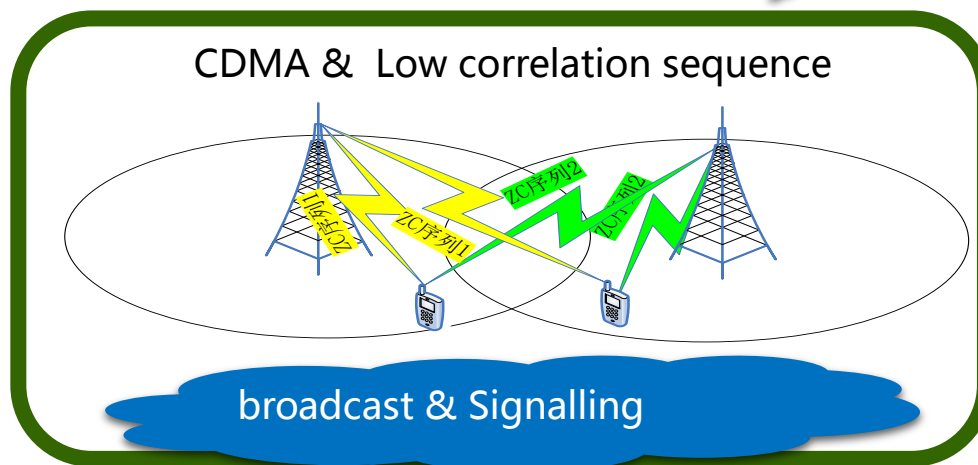
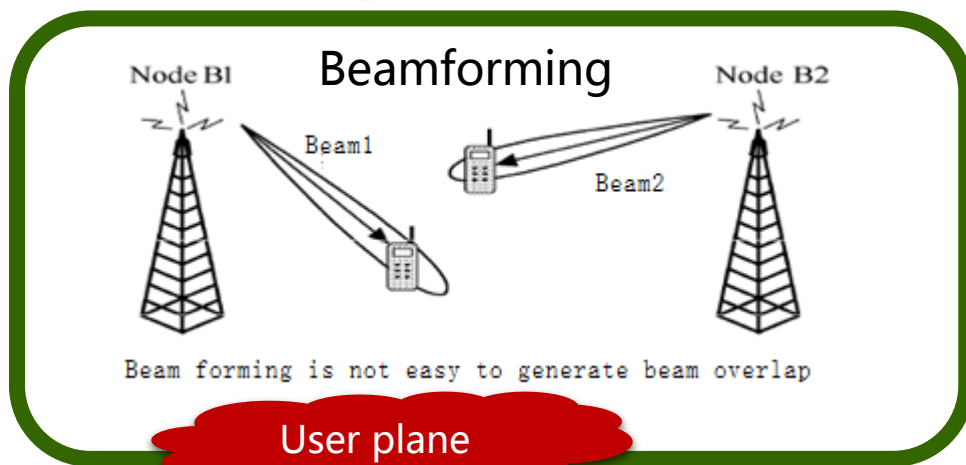
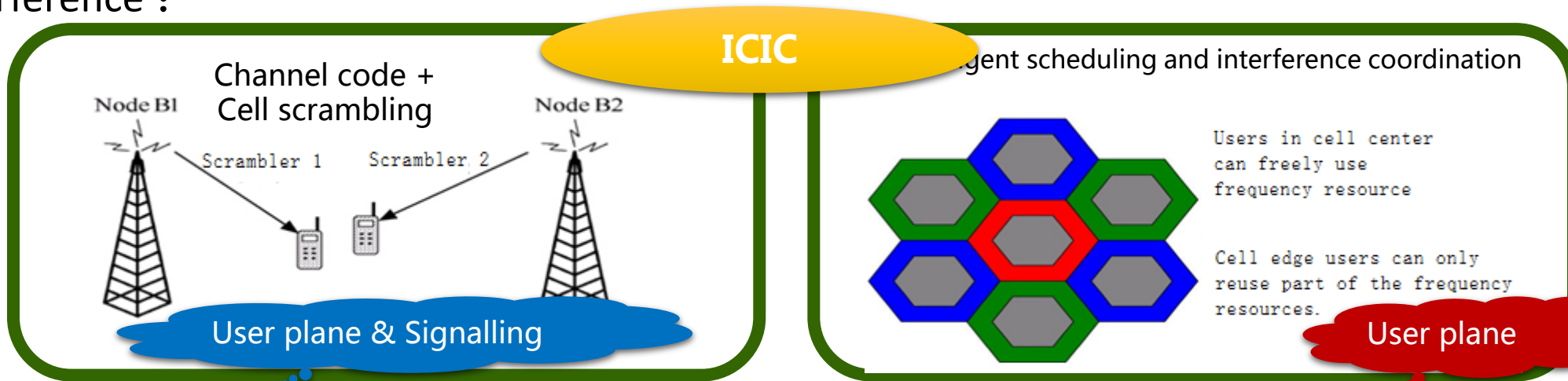


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ICIC in LTE



- Besides the OFDMA networking mechanism, LTE system can also use a series of enhanced technology to suppress the intra-frequency interference :



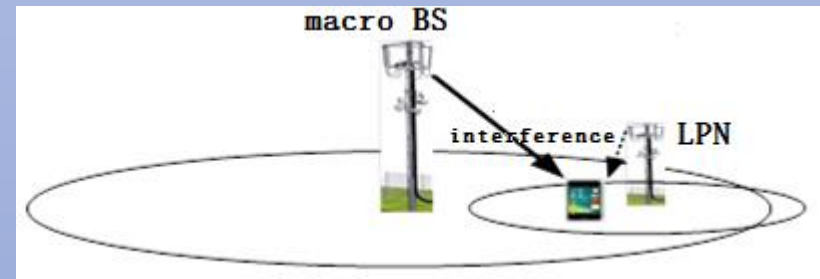
Introduction of eICIC Technology



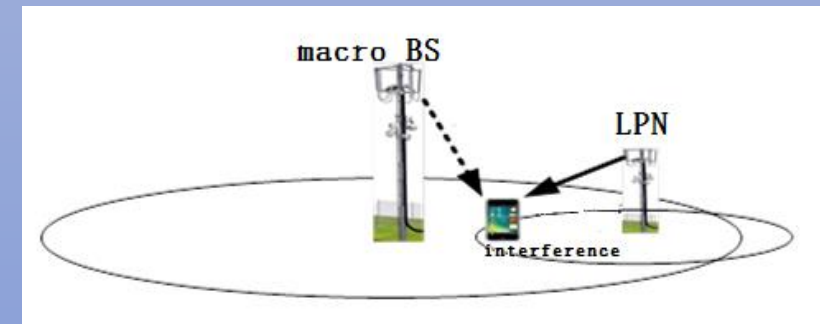
- The above mentioned techniques are used for horizontal interference suppression.
- eICIC technology is the "vertical interference" suppression of heterogeneous networks (HetNet) between different layers.

- Heterogeneous network is a network with low power nodes(LPN) added in the original cellular coverage area , used in indoor and hot scenes coverage enhancement and optimization problems.
- LPN includes Pico (Pico with cell), HeNB (Femtocell) and a relay node.

Vertical interference of macro cell and micro station



LPN cell interfered with macro cell



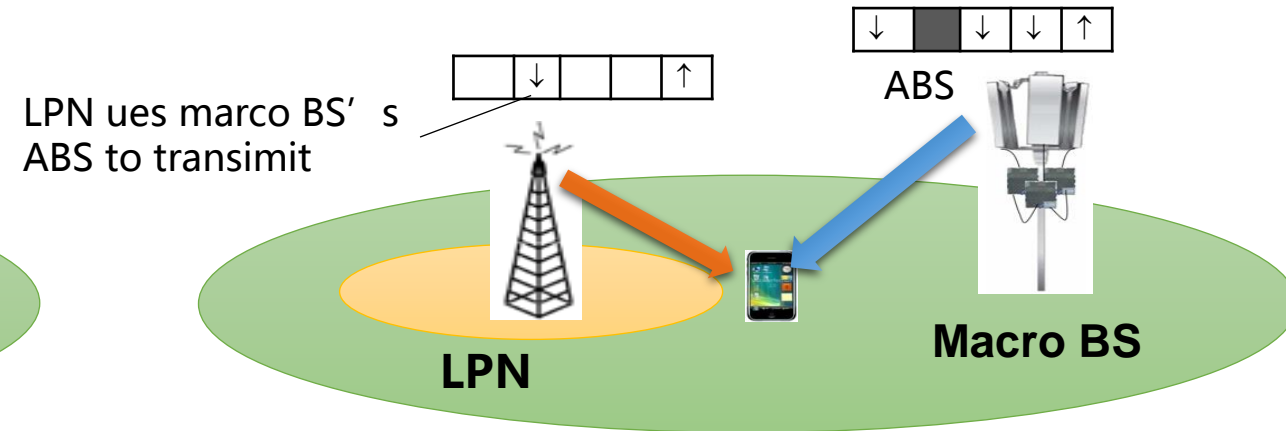
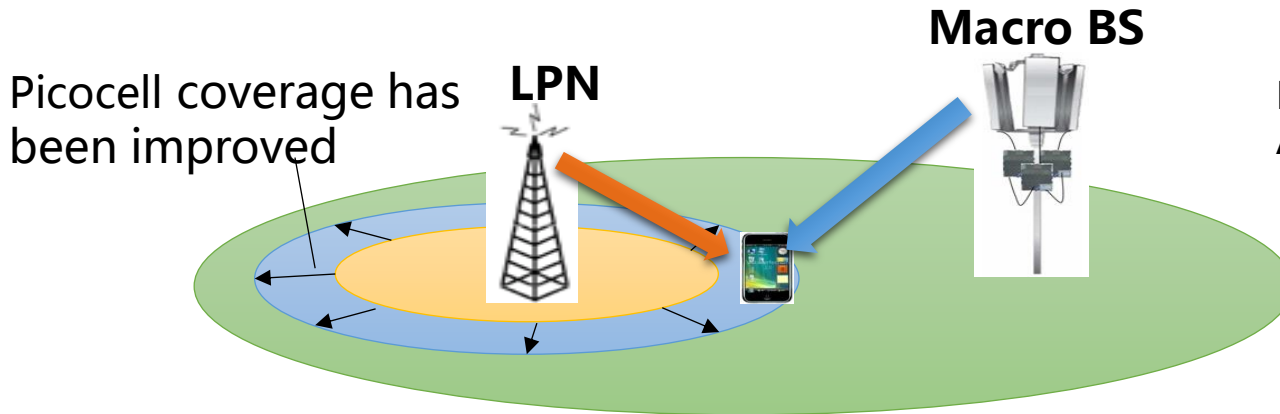
Macro cell interfered with LPN cell



Implementation scheme of eICIC Technology

- **CRE (Cell Range Extension)** : Using RSRP configuration, CRE can expand the area coverage of Picocell, increase the number of users access Picocell, thereby reducing the interference of edge users, and achieve the purpose of sharing the macro cell load.

- **ABS** : only transmits CRS signal in macro cells, while transmit data&control info in Picocell. By using ABS subframes,,the inter-cell interference is reduced.



CRE is actually a tilt type of scheduling-To access users who should not be accessed into Picocell. Equivalent to enhance the coverage of the Picocell.

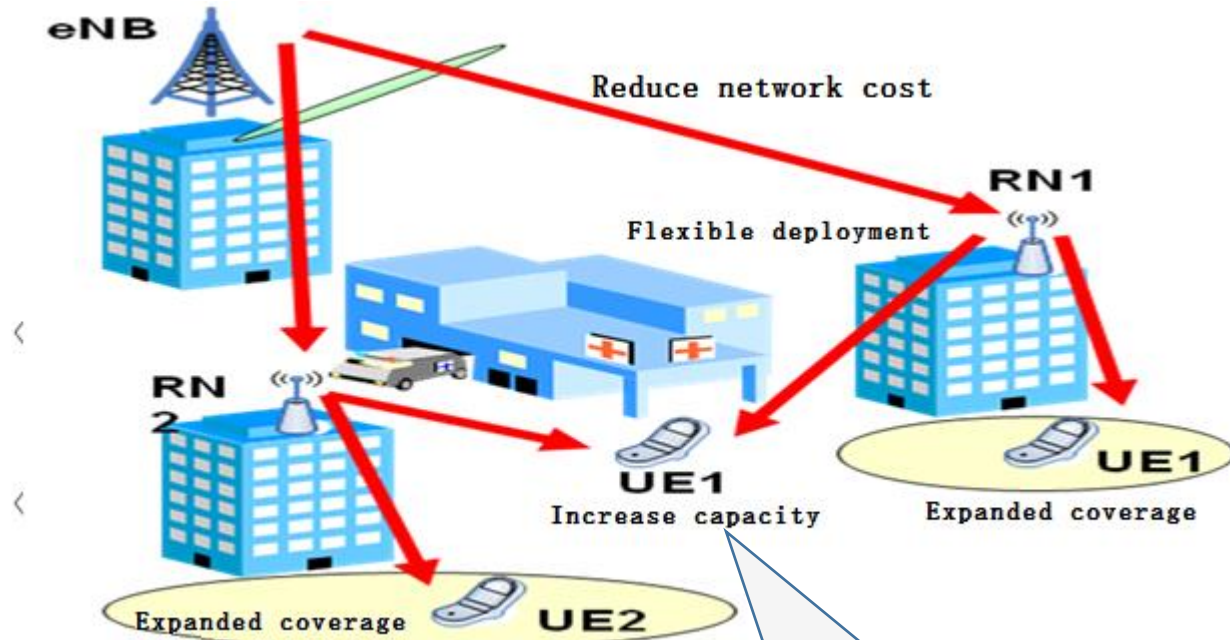
ABS requires coordination between Macro BS and LPN.

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Introduction of Relay



Reduce network cost • Don't need Fiber backhaul link and equipment room .

Flexible deployment • Small volume , wireless backhaul

Improve network capacity • Distributed antenna, resource reuse, cooperative communication

Expand coverage Placed at the edge of the cell to expand coverage

Placed at the edge of the cell to expand coverage

Place in hot spots or indoor to improve system capacity



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Evolution trend of "4.5G"



R11 (2011-2012)

LTE-A Basic version

- CA
- Enhanced MIMO
- Relay
- eICIC

R12 (2011-2012)

LTE-A Enhanced version

- CoMP
- FeICIC
- New carrier type
- Enhanced control channel

R13 (2012-2014)

- Small cell enhancement
- Dynamic TDD
- 3D-MIMO
- D2D

LTE-A pro
4.5G

Vertical deepening

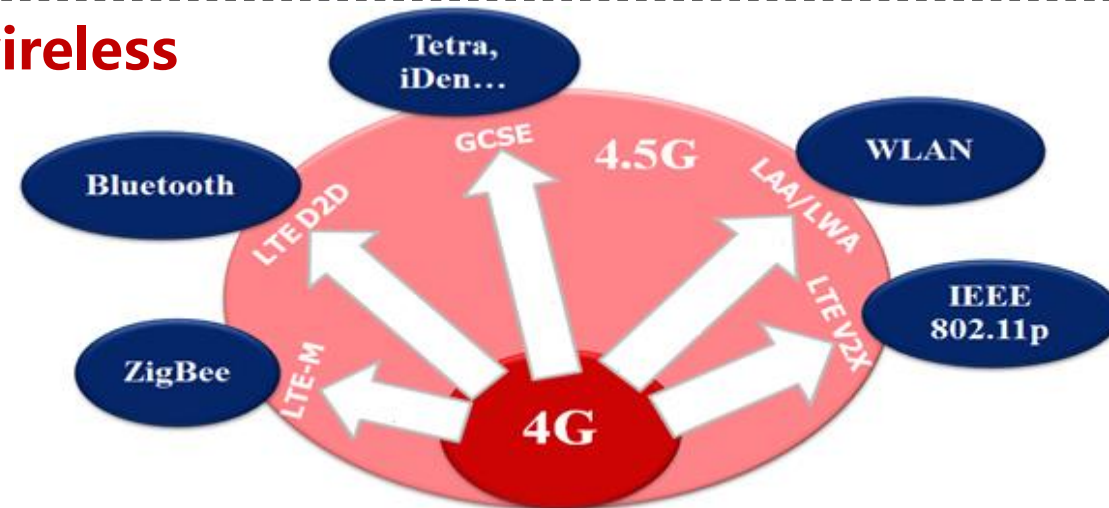
Spectral efficiency and throughput improvement

- 3D MIMO
- D2D enhancement
- Multiple user overlay transmission
- CA enhancement

Horizontal expansion

Penetration in other wireless communications

- ◆ LTE D2D vs bluetooth
- ◆ LAA/LWA vs WLAN
- ◆ LTE V2X vs 802.11p
- ◆ LTE-M vs ZigBee
- ◆ GCSE vs Tetra...



Evolution trend of 4.5G:Internet of things



According to MTC demand, 4.5G has produced several versions of LTE-M for different markets :

- In 2015Q1, Sequans released Cat1 chip which would reduce UE cost less than 3G.
- The latest version of the two LTE-M technology is being standardized work : coverage > 10km , 10 years Battery , Lower cost
 - 1.4MHz LTE-M : Simplified version of LTE technology, the mid-market of M2M, such as intelligent home appliances
 - 200kHz LTE-M : The new design, ultra low cost and power consumption of the LPWA market, such as meter reading

Lower rate, smaller bandwidth, fewer antennas, larger coverage, more simplified design, lower power consumption, lower cost

	Common LTE UE (R8 Cat4)	Low category LTE UE (R8 Cat1)	Low category LTE UE (R12 Cat0)	LTE-M UE (R13 1.4MHz)	Narrowband LTE-M UE (R13 200kHz)
Downlink peak rate	150Mbps	10Mbps	1Mbps	1Mbps	200kbps
Uplink peak rate	50Mbps	5Mbps	1Mbps	1Mbps	144kbps
Antenna number	2	2	1	1	1
Duplex mode	全双工	全双工	半双工	半双工	半双工
Receiving bandwidth	20MHz	20MHz	20MHz	1.4MHz	200kHz
Transmit power	23dBm	23dBm	23dBm	20dBm	20dBm
Terminal complexity	100%	80%	40%	20%	<15%

Source : Nokia

Evolution trend of "4.5G:unlicensed spectrum"



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Coexistence and integration with WiFi

LTE-U

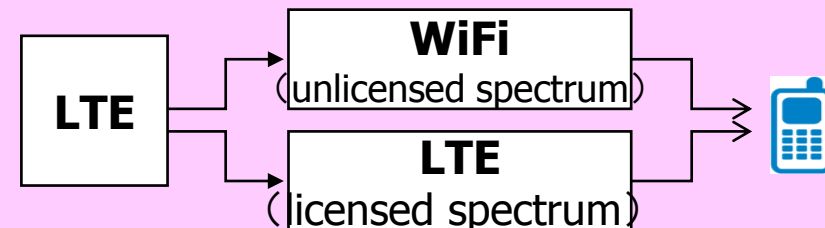
- **Direct deployment of LTE in the unlicensed spectrum**
 - Can be used in countries that do not require listen-before-talk (LBT) ,USA/CHINA/KOREA/INDIA etc..
- Operators in U.S. began trial, but there is a lot of controversy
 - WiFi operators (Cable Tv Co) and WiFi union protest to carry out LTE-U trial.

LAA

- **Deployment of LTE in the unlicensed spectrum, but avoid interference with WiFi, and WiFi harmonious coexistence.**
 - The deployment of LTE-A scc in the unlicensed spectrum.
 - Pcc is still deployed in the licensed spectrum(controls scc) , avoiding interference with WiFi
 - Can be used in countries that require listen-before-talk (LBT),Japan/ Europe etc..

LWA

- **In the unlicensed spectrum is still deployed WiFi, LTE and WiFi depth integration in the base station and network level**
 - LTE/WiFi integration Basestation
 - LTE/WiFi integration Network

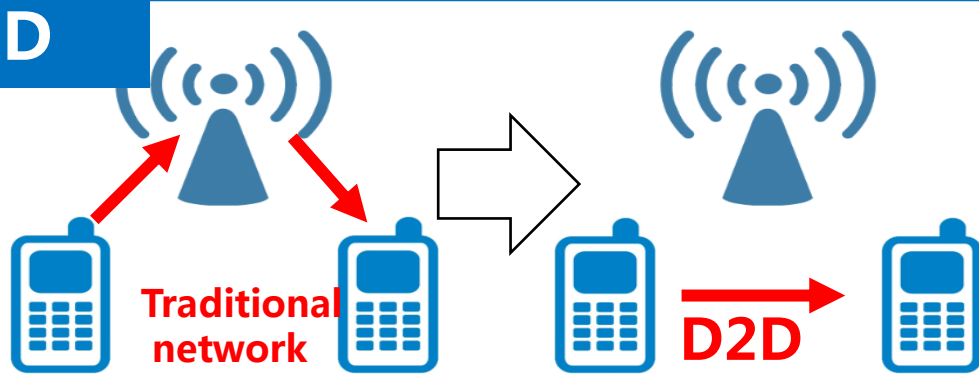


Evolution trend of "4.5G:LTE D2D & LTE V2X



LTE D2D can greatly improve the efficiency of network transmission in specific scenarios, and will become an effective complement to the LTE cellular network.

LTE D2D

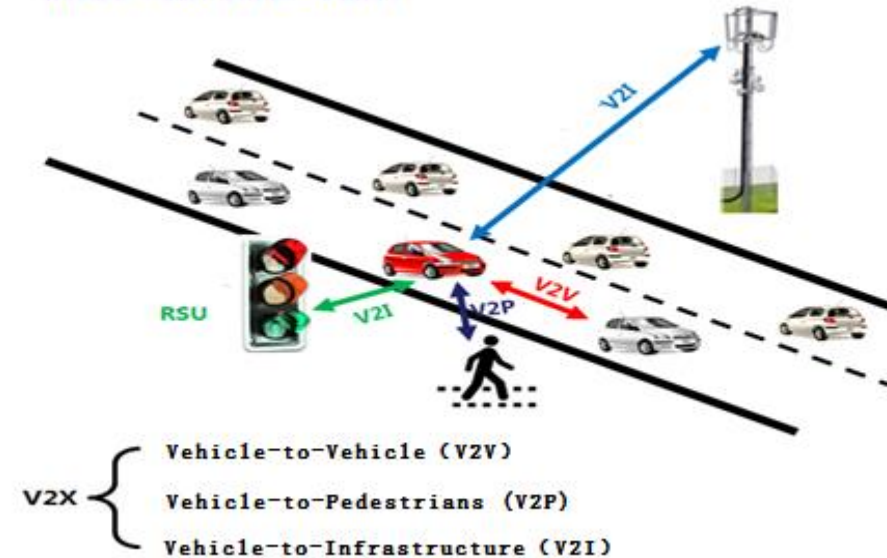


- ◆ Direct communication between mobile phones, data transmission is not through the operator base station: high efficiency, low cost
- ◆ R12: the first version of the standard, R13: enhanced
- ◆ "Communication" mode : Enhanced Bluetooth
 - Transmission distance = 10 times of Bluetooth
 - Thousands of devices can be used at the same time
 - Better security than bluetooth
- ◆ "Discover" mode :
 - ◆ social networks : discover friends
 - ◆ Shopping entertainment : discover goods
 - ◆ Rescue and relief : discover Patient / person in distress

LTE V2X

- ◆ Vehicle networking technology based on LTE
- ◆ Reference D2D design, to achieve through the car
- ◆ R13:Research ; R14 : Complete standardization

What is LTE V2X?





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• THANKS.

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