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Ultra Dense Network: Key Solution for Future Capacity Explosion

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Outline

- Introduction
- Scenarios
- Requirements
- Key Technologies
- Roadmap

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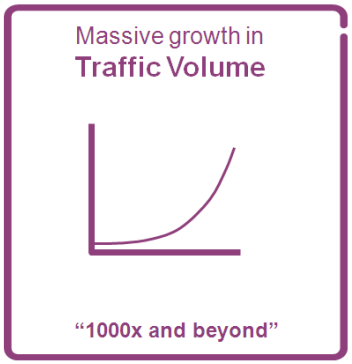
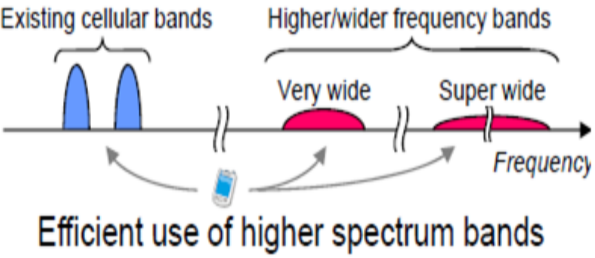
Why we need ultra dense network?

- The overall traffic volume in wireless communication systems has grown tremendously - by 2020, 1,000 times traffic volume increasing.

- To achieve the capacity requirement, there are three main directions.

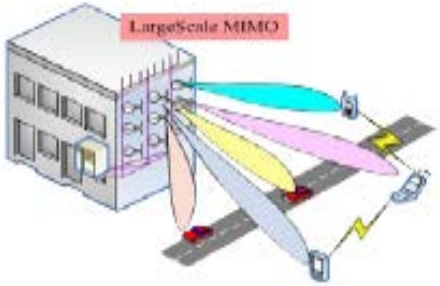


■ Spectrum extension

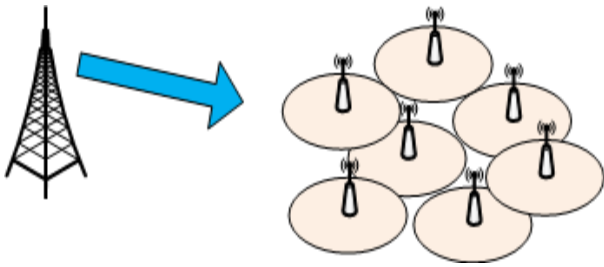


■ increasing spectrum efficiency

e.g. Massive MIMO



■ Network densification



Advantages of Ultra Dense Network

- Network densification by deployment of ultra large numbers of access nodes is a powerful means to increase spectral efficiency by exploiting spatial reuse, In extreme cases
  - indoor access nodes deployed in every room
  - outdoor access nodes deployed at lamppost distance apart

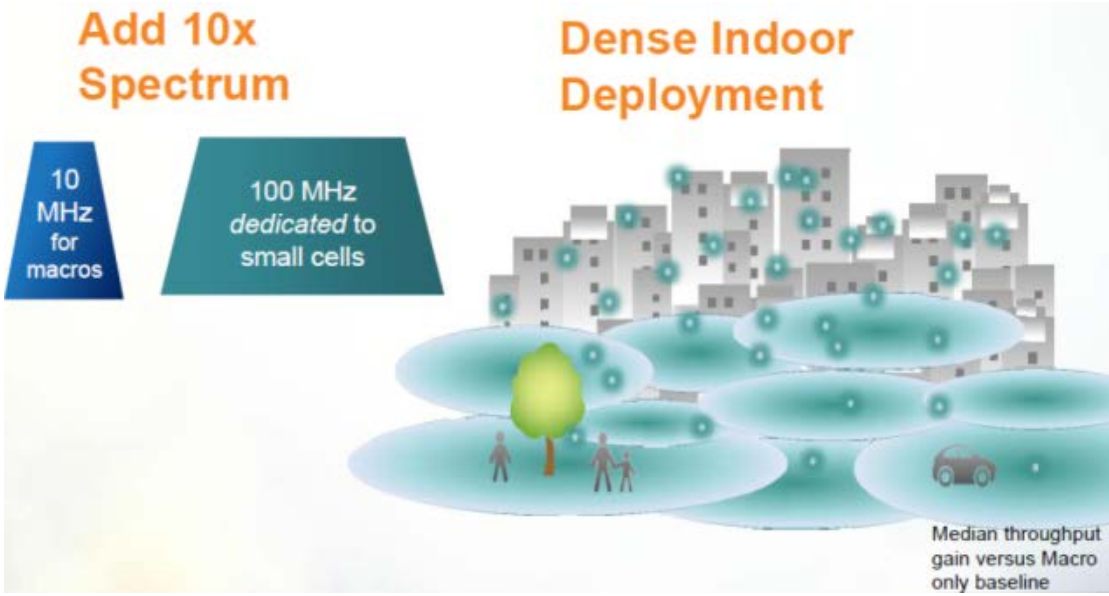
- For ultra dense deployment, access technologies include:
  - 2G, 3G, 4G, Future New RAT or Non-3GPP RAT

Scenarios for Ultra Dense Network

Method1:Traffic volume increasing 1,000 times

- Assumption
  - Current cell: 10MHz bandwidth @2GHz
  - Small cell: 100MHz bandwidth @3.5GHz
  - Dense indoor deployment

144 small cells get 1,000 times gain versus macro only

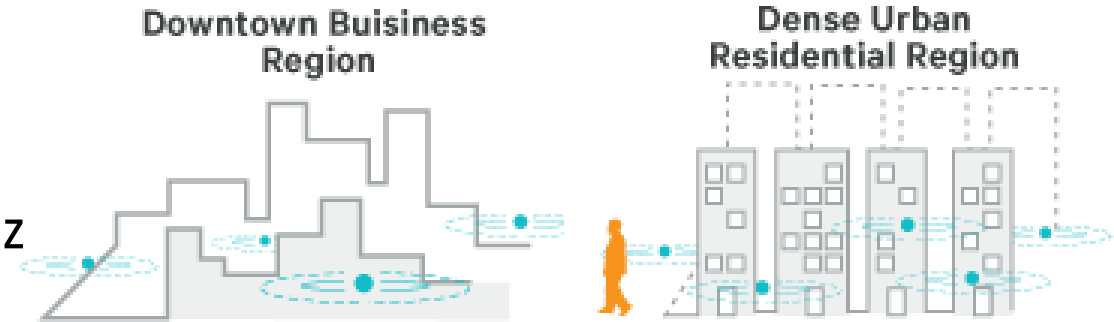


Scenarios for Ultra Dense Network

Method2:Extreme capacity requirements

- Case1: Central Hong Kong/Shanghai
  - User density in the densest region: 130,000users/ km^2
  - Traffic volume: 5GByte/user/day
  - Tidal effect of traffic: centralized in 2.4hours
  - Small cell: 9bit/s/Hz 100MHz bandwidth

670 small cells/ km^2 meets this capacity requirement
= 146 small cells in the macro (ISD 500) scope

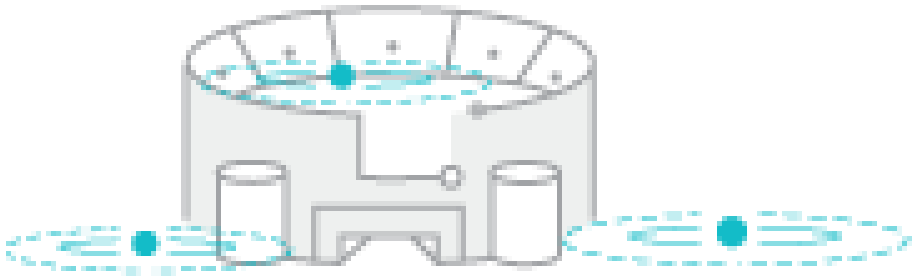


Scenarios for Ultra Dense Network

Method2:Extreme capacity requirements

- Case2: Stadium
  - User density: 200,000 users/0.25 km^2
  - Traffic volume: 10Mbps/user simultaneously
  - Small cell: 9bit/s/Hz 100MHz bandwidth

9,000 small cells/ km^2 meets this capacity requirement
= 2,000 small cells in the macro (ISD 500) scope



Stadium

Scenarios for Ultra Dense Network

Category	Density (versus Macro of ISD500)	Examples
Low dense scenarios	<100	3GPP TR36.872
Medium dense scenarios	100-1000	Above Method1 Above Method2 Case1
High dense scenarios	>1000	Above Method2 Case2

Ultra dense network

- Higher frequency
- Wider bandwidth
- Deployment density from several decuples to several thousand times versus the current macro cell

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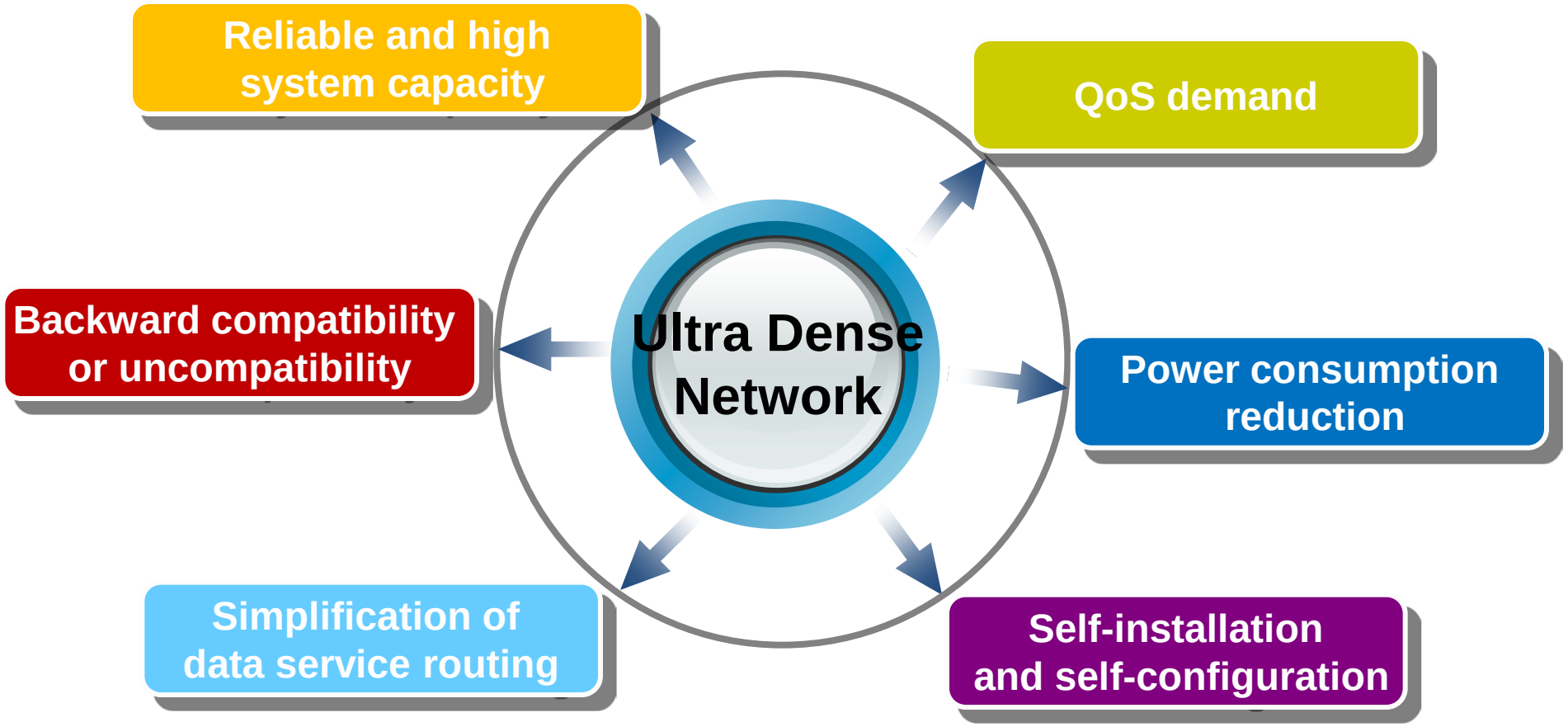
Requirements for Ultra Dense Network



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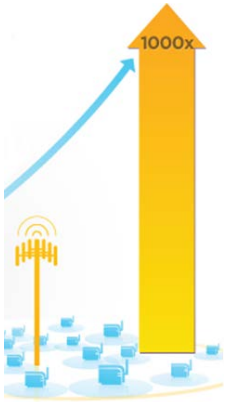
Requirements for Ultra Dense Network

Reliable and high system capacity

- Aiming at the characteristics of high user density and heavy traffic in future, ultra dense network should
  - support several decuples to several thousand times number of cells
  - improve the throughput per unit area



Backward compatibility or uncompatibility

- Ultra-dense network will try to maintain the existing LTE/SAE design, to let existing LTE terminals has the ability to access.
- Ultra-dense network can also be designed to be uncompatable with existing LTE/SAE design, to satisfy special scenarios and frequency bands.

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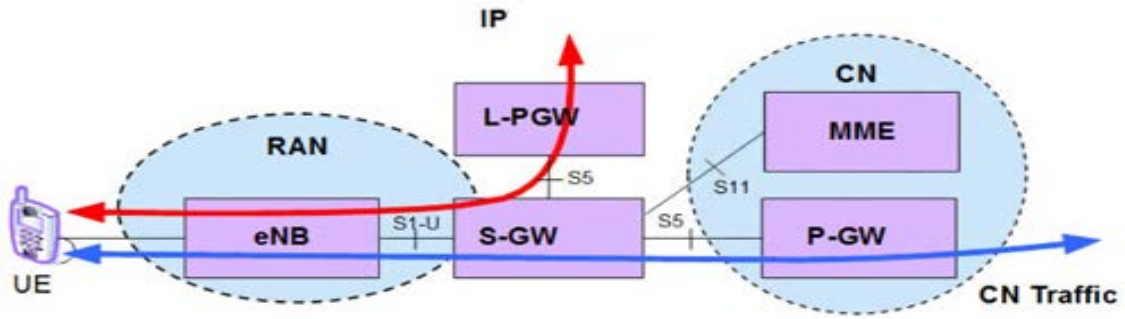
Requirements for Ultra Dense Network

simplification of data service routing

- In ultra dense network, traffic volume will be very huge after converged by each level of backhaul.
- Legacy path will cause the capacity pressure on wired network and result in long end-to-end delay.
- The local data traffic can access to the internet directly without going through the CN.
- Cloud storage and smart content delivery can be considered.



self-installation and self-configuration

- The number of eNBs is huge, so the installation and configuration process should be simplified to reduce CAPEX and OPEX.
- Self-installation and self-configuration should be used, including
  - certification and authentification
  - download from operator
  - frequency, PCI, ANR

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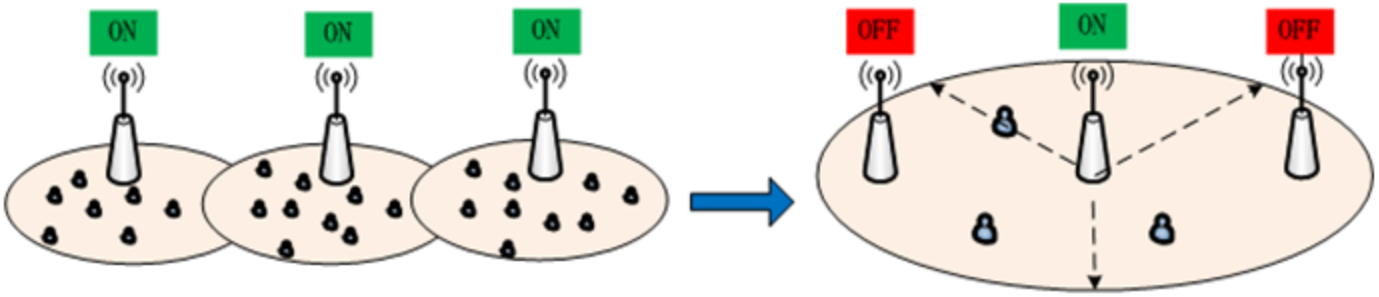
Requirements for Ultra Dense Network

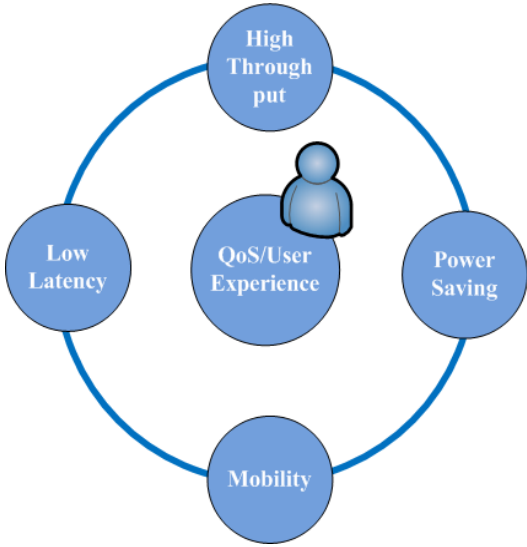
Power consumption reduction

- The power consumption of eNB/UE should be reduced.



QoS demand

- The QoS demand should be in accordance with that of LTE, or even higher than LTE.
- Related QoS includes high user throughput, low end-to-end latency, good experience for mobility, power saving, etc.



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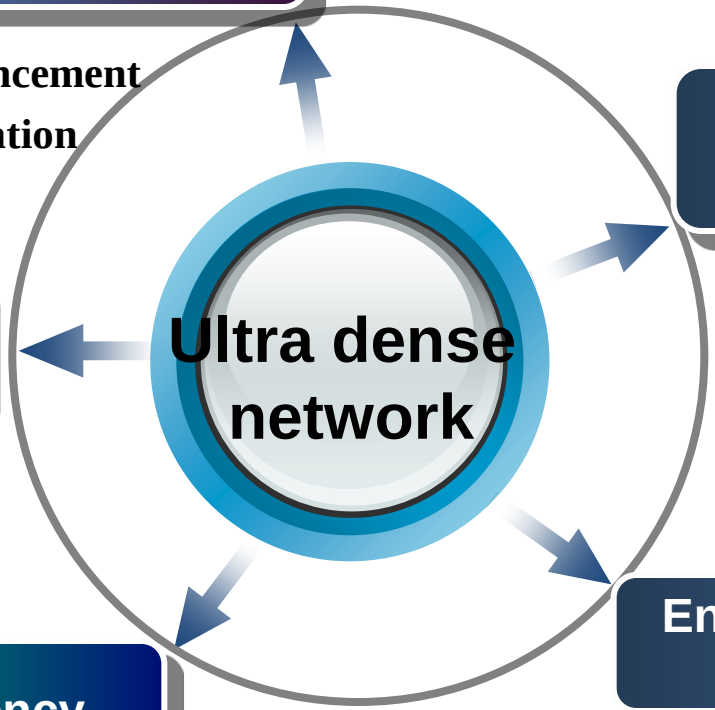
Key Technologies for Ultra Dense Network



Network architecture and procedure enhancements

- Architecture enhancement
- Procedure optimization

Super SON

- Self-configuration
- Self- optimization
- Self-healing

Inter-cell coordination/ cooperation

- Interference reduction
- Inter-cell cooperation

Enhanced physical technology

- higher order modulation
- overhead reduction
- synchronization

Energy efficiency

- Network energy saving
- UE energy saving

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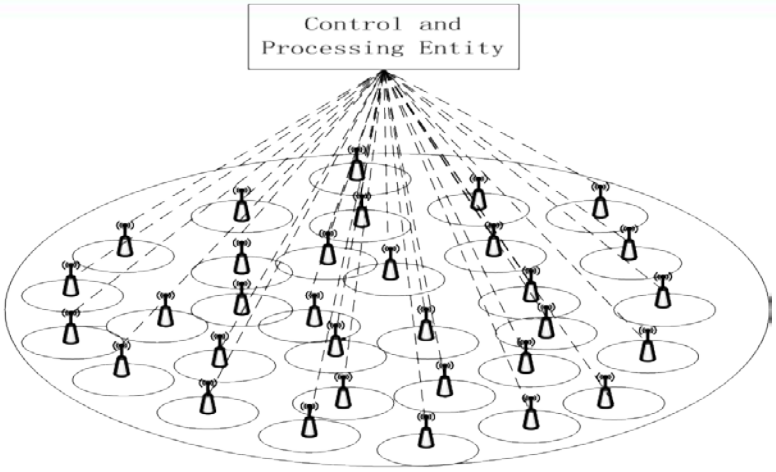
Key Technologies for Ultra Dense Network

Network architecture and procedure enhancements

Background

- Density increasing, mobility problem and interference
- Signaling overhead, performance and user experience



Potential alternative

- Dual connectivity
- Control/user plane splitting
- Hyper-cellular/centralized control
- Further flat network architecture
- Efficient node change procedure

Small cell control

Localized

- Compatible
- Simpler, lower latency
- Interaction between cells

Centralized

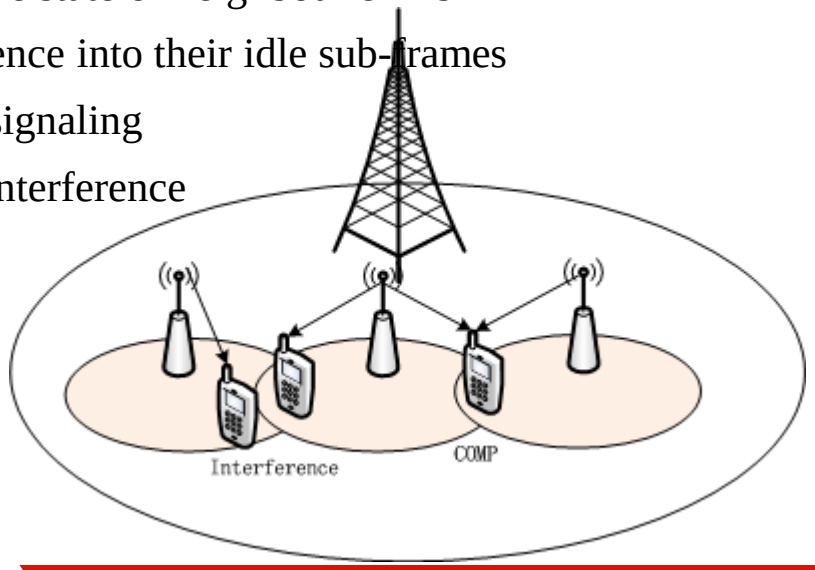
- Standardization efforts
- Data path choice and resources aggregation more easily
- Inter-node interference will be controlled well by centralized algorithms of allocation and scheduling

Key Technologies for Ultra Dense Network

Inter-cell coordination/ cooperation

Interference avoidance methods

- Frequency: different frequency for neighbor cells or the edge
  - Far-interval frequency for neighbour cells
  - Using cognitive radio technology to achieve optimal unoccupied frequency for each cell
- Time: interference divided by different sub-frame
  - Using idle sub-frame or MBSFN to let eNB know the state of neighbour eNBs
  - Allocate those neighbours cells with strong interference into their idle sub-frames
- Power : power control or code compression for control signaling
- Synchronization: synchronization technology to reduce interference



Study/work areas

- Super ICIC
- Enhanced inter-cell coordination/cooperation

Key Technologies for Ultra Dense Network

Energy efficiency

Energy Saving

Network

- In case no UE or no traffic, nodes shut up or enter low-power mode.
- Traffic load is low or medium, part of small cells are turned off and the other ones can adjust the coverage adaptively to cover the blank area.
- Centralized on/off control

UE

- Cell search, measurement and cell selection/reselection will be enhanced.
- According to UE's movement
  - high speed UE connect to macro cell
  - static or low speed UE connect to small cell
- According to the state of UE
  - idle UE or UE with low power consumption preference or UE with infrequent small data connect to macro cell
  - other UE with measurement and cell reconfiguration connect to small cell

Key Technologies for Ultra Dense Network

Super SON

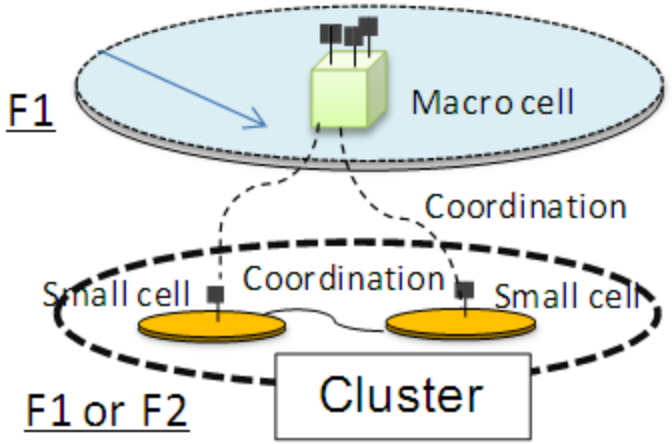
Study/Work areas

- ANR, PCI
- MLB
- Mobility
- RLF
- Self-healing

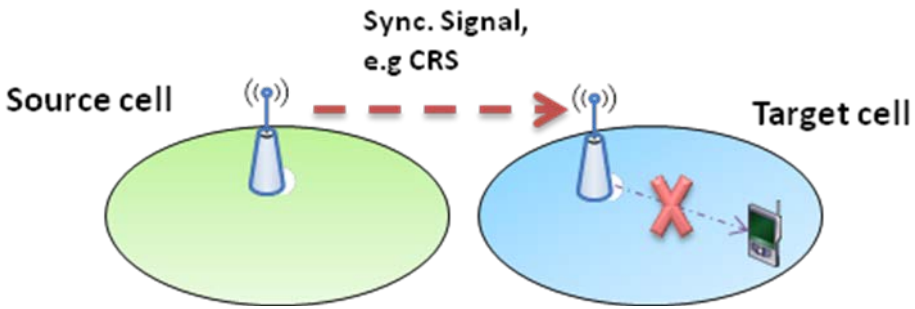
Key Technologies for Ultra Dense Network

Enhanced physical technology

- **Improve spectrum efficiency**
  - Higher order modulation scheme
  - Overhead reduction for UE-specific reference signals
  - Enhancements of control signaling



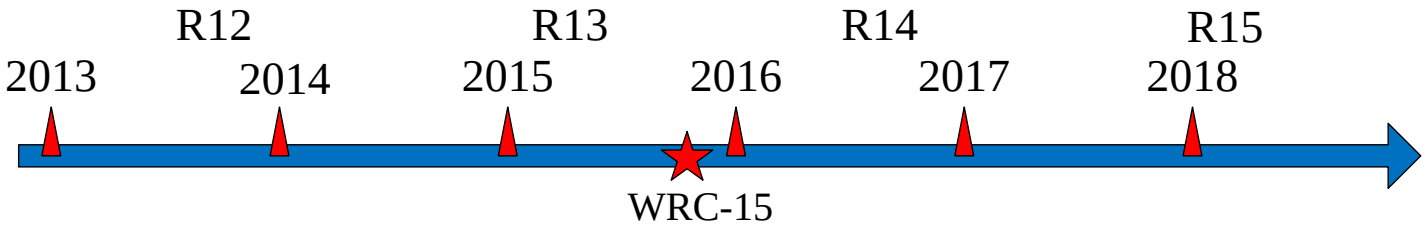
- **Ensure efficient operation**
  - Efficient discovery of small cells
  - Synchronization mechanisms



Network listening synchronization mechanism

Roadmap for Ultra Dense Network

- The standard work for ultra-dense network has been done in 3GPP R12 and is expected to continue in R13 and beyond.
  - features with small cell enhancement will be studied in the short-term, covering the period of 2013 to 2014.
  - features with ultra-dense network will studied in the mid-term and long-term



SCE PHY layer	SI	WI:256QAM, RS and control signalling...
SCE high layer	SI	WI: U-plane architecture, Dual-connectivity...
Ultra-dense	SI	WI: architecture enhancement, inter-cell enhancement, SON, energy saving...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Thank you