LTE Enhancements and Future Radio Access

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Future Radio Access (FRA) will provide a total solution to satisfy the requirements by future drivers.

FRA concept

- Support for traffic explosion
  - Beyond 500x in 10 years

- Massive device connectivity
  - Reduced control signaling, More simultaneous pipes

- QoE for various applications
  - Gbps-experience data rate, Reduced latency, Battery saving

- Intelligent network with low cost & high robustness
  - Support of diverse environments (small cells & higher frequency bands), Energy saving
Evolution paths for FRA

- **Further LTE enhancements**
  - Macro-assisted small cell enhancement (Phantom cell)
  - Further general LTE enhancements
- **Potential new RAT**
  - Should prioritize the achievement of more big gains over backward compatibility
  - Consider new spectrum allocations of WRC-15 and beyond
  - Some technical components may be applied to further LTE enhancements

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**Future Radio Access**

**Potential New RAT**

**Big gain**

- **Future LTE enhancements**
  - CA/eICIC/CoMP for HetNet
  - Macro-assisted small cell enhancement (Phantom cell)

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**WRC-15**

~2015

**Rel-12/13**

~2020

**Rel-14/15,…**

**Rel-10/11**

**LTE-Advanced**

**LTE-B**

**LTE**

**Rel-8/9**

**Pico/Femto**
Directions of evolution: “The Cube”

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

Required performance

Spectrum efficiency

Current capacity

Traffic offloading

Network densification

Spectrum extension

Efficient use of higher spectrum bands

New cellular concept for cost/energy-efficient dense deployments

- Non-orthogonal multiple access
- Study for new interference scenarios
- 3D/Massive MIMO, Advanced receiver
- Tx-Rx cooperative access technologies

Existing cellular bands

Higher/wider frequency bands

- Very wide
- Super wide

Frequency

Controller

TRx

Controller

TRx

TRx

TRx

TRx

TRx

TRx

Cellular network assists local area radio access

Dense urban

Shopping mall

Hotspot

WiFi

Traffic offloading

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Combined usage of lower and higher frequency bands

→ Higher frequency bands become useful and beneficial!

**Existing cellular bands**
(high power density for coverage)

**Higher frequency bands**
(wider bandwidth for high data rate)

- Very wide (e.g. > 3GHz)
- Super wide (e.g. > 10GHz)

- No coverage issue any more
- Can provide very high throughput using wider bandwidth
- Big offloading gain from existing cellular bands

**FRA technical concept**

Future cellular enhancements

New RAT for higher frequencies

Non-orthogonal multiple access (NOMA), etc.

Phantom cell concept

Massive MIMO, etc.
Phantom cell concept

- Proposed macro-assisted small cell – “Phantom cell”
  - Split of C-plane and U-plane between macro & small cells in different bands

**C-plane**: Macro cell maintains good connectivity and mobility using lower frequency bands

(RRC: Radio Resource Control)

**U-plane**: Small cell provides higher throughput and more flexible/cost-efficient operations using higher/wider frequency bands
Massive MIMO – BF gain

 Beamforming (BF) gain with massive antenna elements

Increasing number of antenna elements by X
1) Increase of BF gain by X
2) Decrease of BF width by 1/X

Massive MIMO in higher frequency bands
→ Compensation of increased path loss & Improved spectrum efficiency

Improved coverage and spectrum efficiency for super dense small cells in higher frequency bands
Non-orthogonal multiple access (NOMA)

- More efficient multiple access scheme
  - Non-Orthogonal Multiple Access (NOMA)

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<td>Non-orthogonal (CDMA)</td>
<td>Orthogonal (OFDMA)</td>
<td>Orthogonal (OFDMA) + Superposition/Cancellation (NOMA)</td>
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<td>Non-orthogonal assisted by power control</td>
<td>Orthogonal between users</td>
<td>Superposition &amp; interference cancellation</td>
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- Why NOMA? – Multiple access using interference cancellation itself is very old technology (for uplink in particular)
  - Evolution of device processing capabilities for interference cancellation
    - Moore’s law: 100x processing power after 10 years
    - In OFDMA, frequency-domain signal processing becomes possible
  - Exploitation of path loss difference among users
    - Multi-path fading was exploited by OFDMA, but path loss still needs to be further exploited

※More details on NOMA concept and initial results are presented in this WS.
FRA Real-time Simulator

The potential performance gains of applying key FRA technologies are demonstrated using FRA real-time simulator.

Demo Scenario

- Spectrum extension x NW densification
  - Efficient exploitation of higher frequency bands using small cells
- Key technology for small cells
  - Massive MIMO
- Key technology for macro cells
  - Non-orthogonal Multiple Access (NOMA)
FRA Real-time Simulator
Cell Configurations

3 cells per macro site
12 small cells per sector
FRA Real-time Simulator
Spectrum Allocations

Macro cell: 20 MHz BW @ 2 GHz
Small cell: 100 MHz BW @ 3.5 GHz
FRA Real-time Simulator
System Thoughut Gain

More than x60 gain compared with macro only
FRA Real-time Simulator
Gain by Massive MIMO

More than x350 gain with 600 MHz BW@20 GHz and Massive MIMO compared with macro only
Summary

• We presented our views on requirements and potential key technologies for *Future Radio Access (FRA)*:
  – Macro-assisted small cell, i.e., Phantom cell, and Massive MIMO are promising approaches for higher/wider frequency bands towards the long-term future
  – Non-orthogonal multiple access (NOMA) is a promising technology for future cellular enhancements