Future Radio Access 5G Toward 2020 and Beyond

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Network/Communication Society in 2020 and Beyond

Everything Connected by Wireless

Monitor/collect information & control devices

Multiple personal devices

Interaction across multiple devices

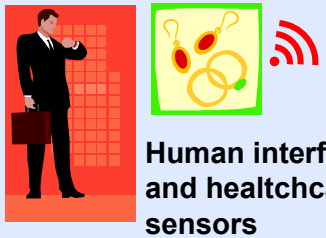
Transportation (Car/Bus/Train)

Entertainment, Navigation
Traffic information

Consumer electronics

Remote operation using personal terminal

Watch/jewelry/cloth



Human interface and healtchcare sensors

House

Remote control of facilities
House security

Sensors

Smart power grid
Agriculture and farming
Factory automation
Weather/Environment

Cloud computing

ドコモクラウド

All kinds of services supported by the mobile personal cloud

Extension/enrichment of wireless services

Deliver rich contents in real-time & ensure safety

Video streaming

4K/8K video resolutions
Video on newspapers
Background video

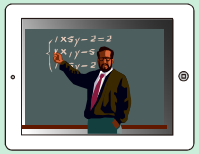
New types of terminal/HI

Glasses/Touch internet

Healthcare

Remote health check & counseling

Education



Distance (remote) learning
Any lesson anywhere/anytime

Safety and lifeline system

Prevention of accidents
Robustness to disasters

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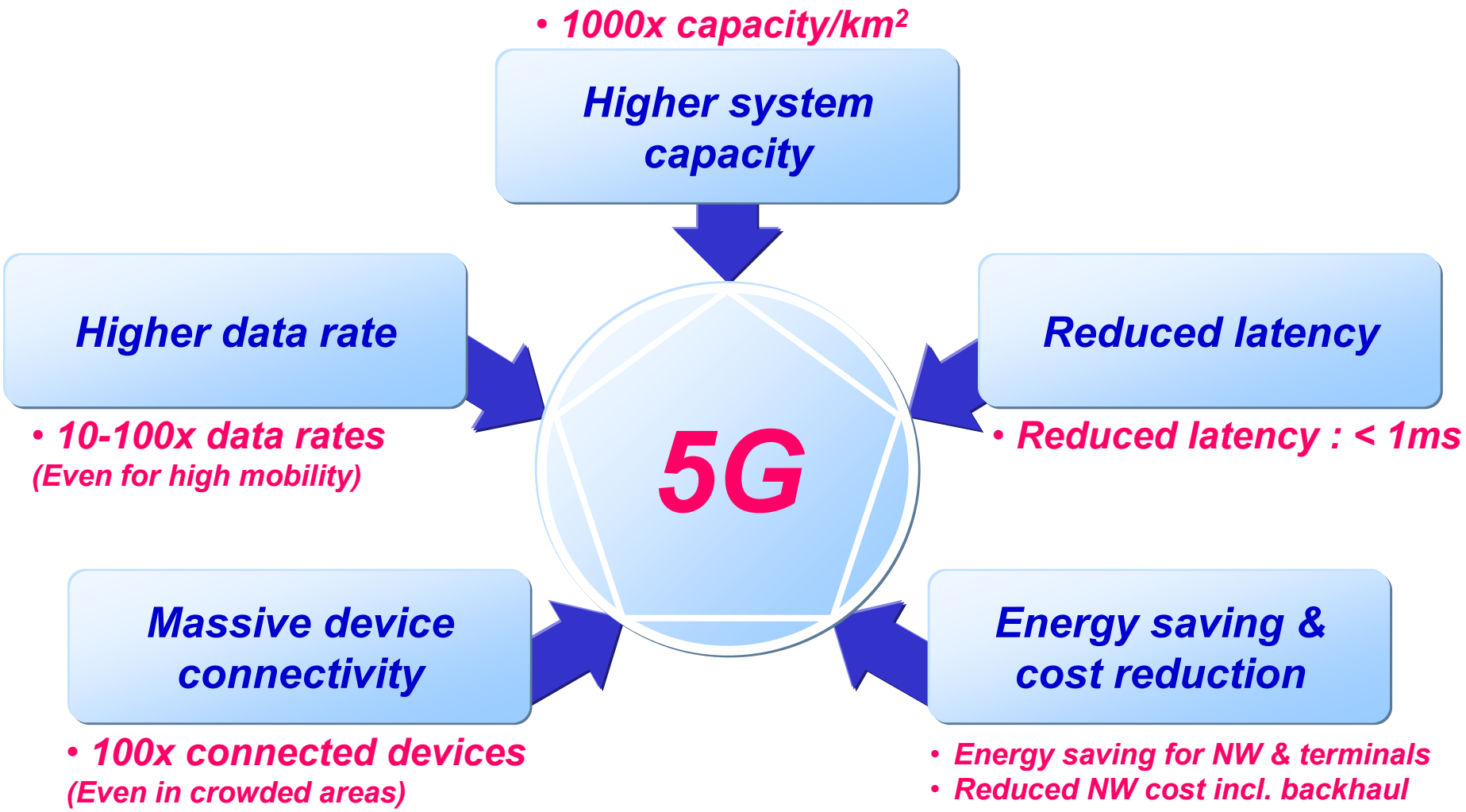
Future Radio Access for 5G

Future radio access (FRA) to provide a total solution to satisfy the requirements of 5G era (2020s)



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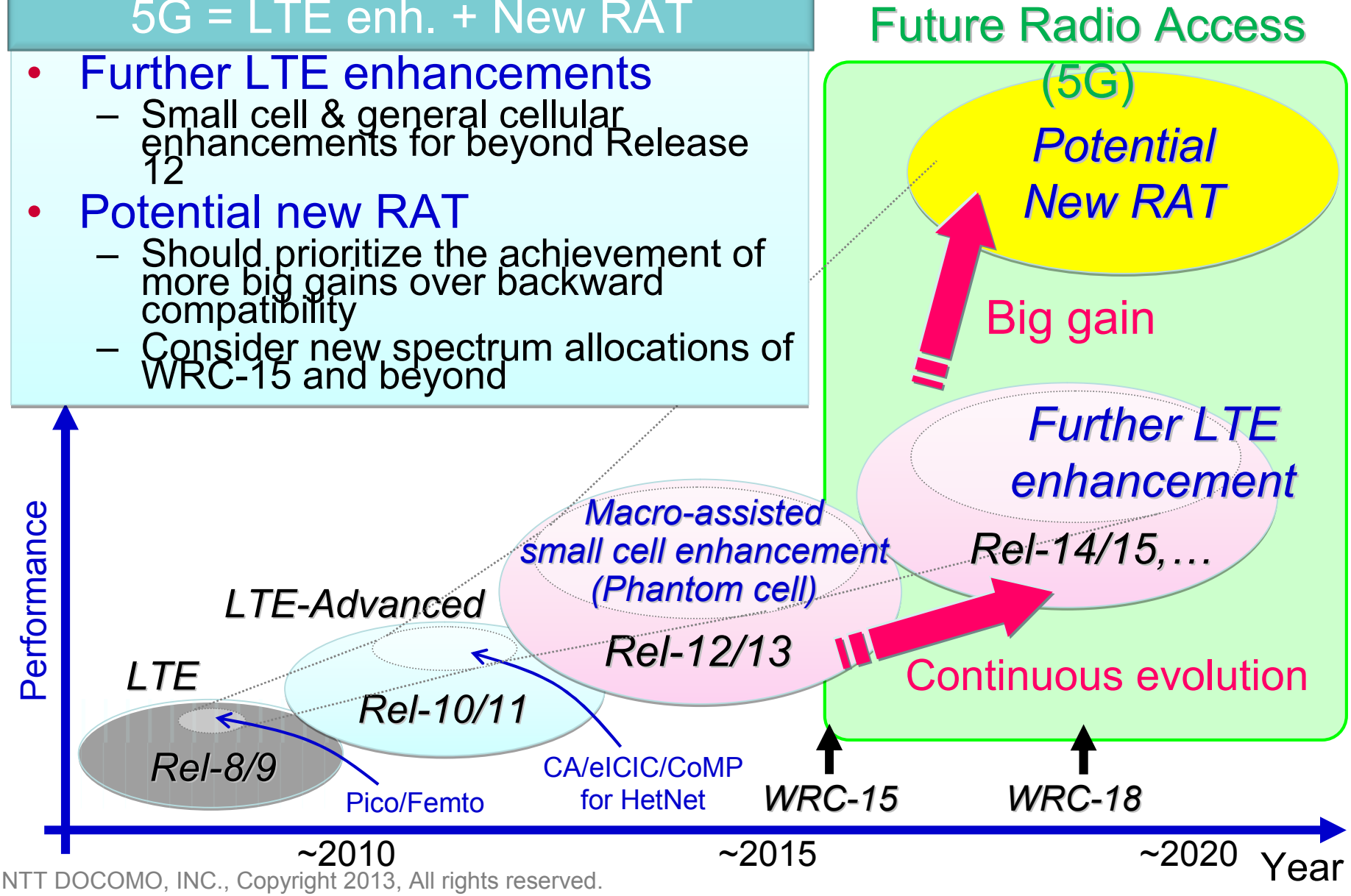
Evolution Paths for 5G

5G = LTE enh. + New RAT

- Further LTE enhancements
  - Small cell & general cellular enhancements for beyond Release 12
- Potential new RAT
  - Should prioritize the achievement of more big gains over backward compatibility
  - Consider new spectrum allocations of WRC-15 and beyond



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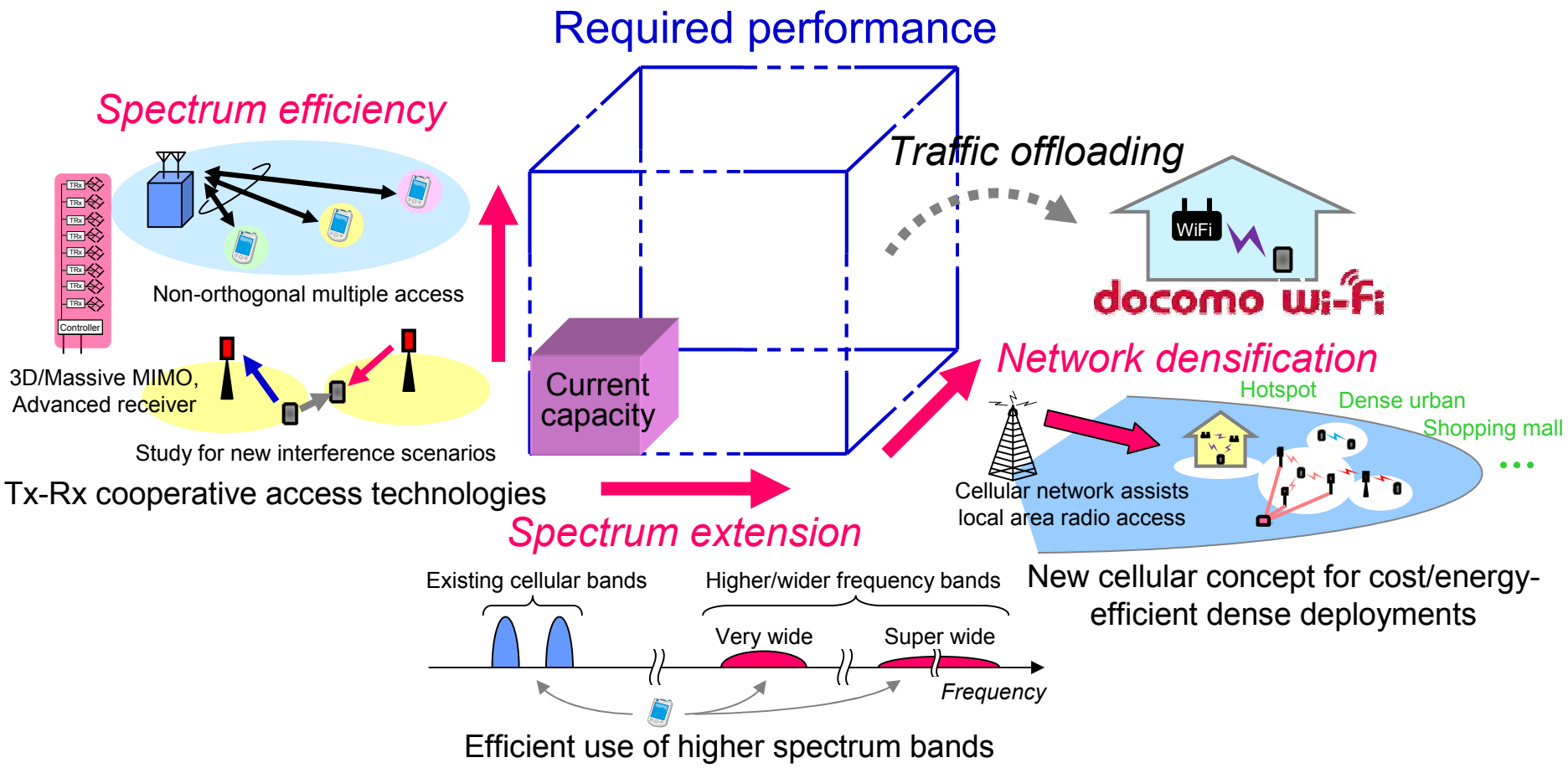
Directions of evolution: “The Cube”

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



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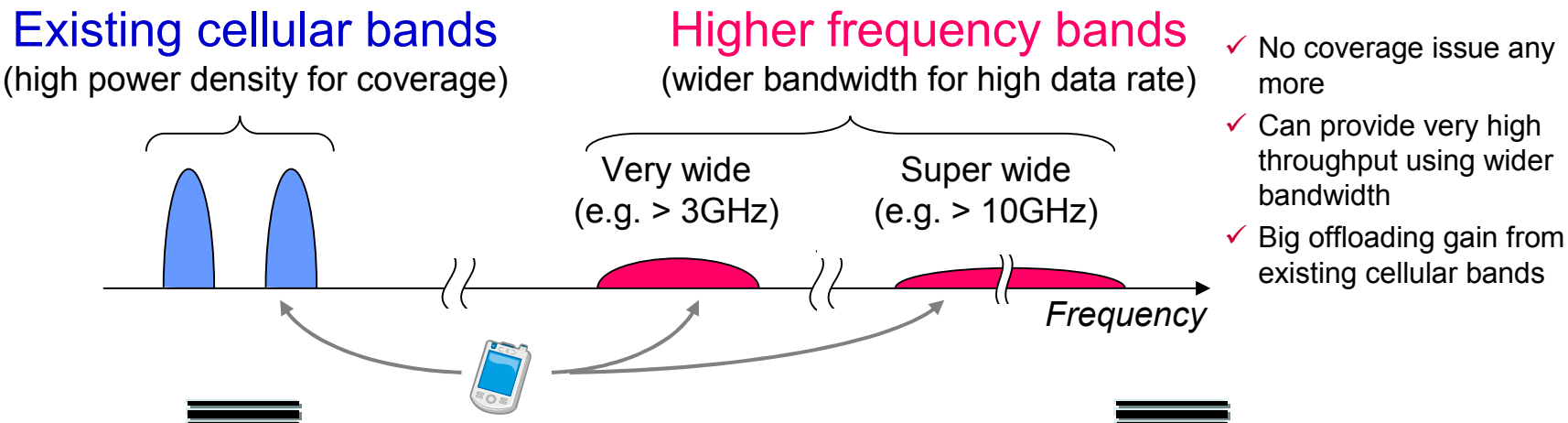
FRA technical concept

Combined usage of lower and higher frequency bands

→ ***Higher frequency bands become useful and beneficial!***



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

FRA technical concept

Further cellular enhancements

Non-orthogonal multiple access (NOMA), etc.

Phantom cell concept (C/U plane split)

Exploitation of higher frequency bands

Massive MIMO, Numerology/frame design, etc.

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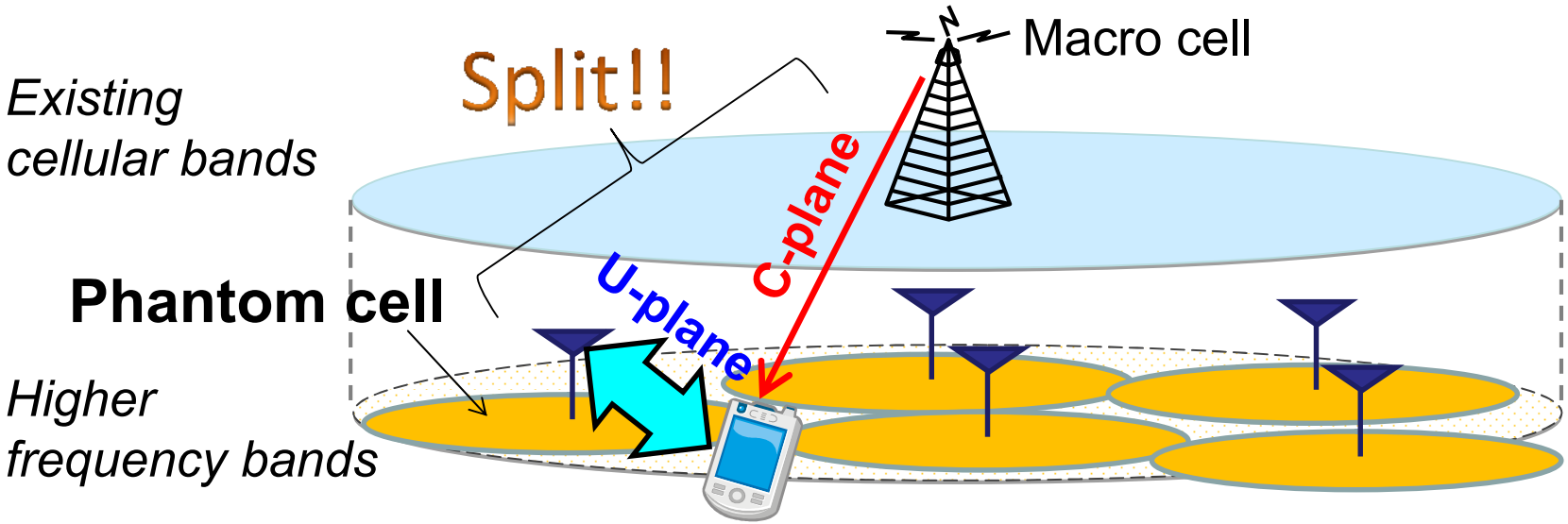
Phantom Cell

- *Proposed architecture to utilize higher frequency bands*
  "Phantom cell" – **Split of C-plane & U-plane** between macro and small cells in different frequency bands [1, 2]



[1] NTT DOCOMO, 3GPP RWS-120010, June 2012.
[2] H. Ishii et al., IEEE Globecom 2012 Workshop, Dec. 2012.

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

U-plane: Small cell provides higher throughput and more flexible/cost-energy efficient operations using higher/wider frequency bands

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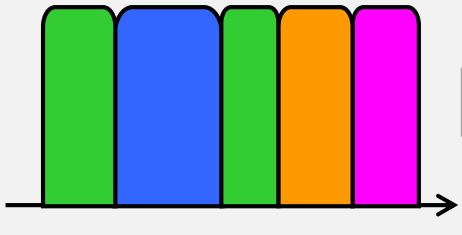
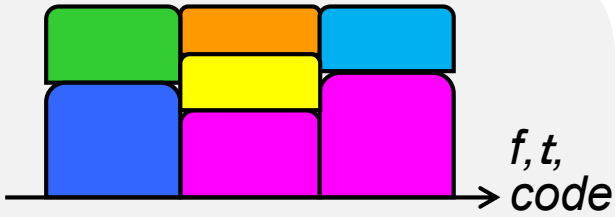
Non-Orthogonal Multiple Access (NOMA)



Processing power in Devices



Effort for Orthogonality

FDMA,TDMA, CDMA, OFDMA

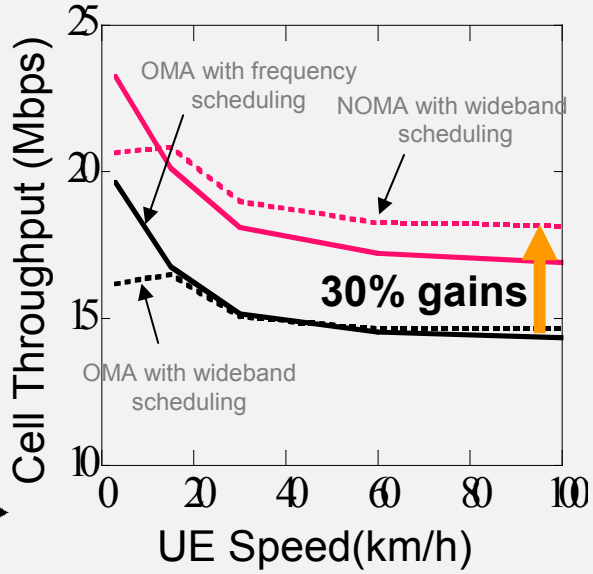
Effort for Interference Mitigation

Equalizer, Canceller

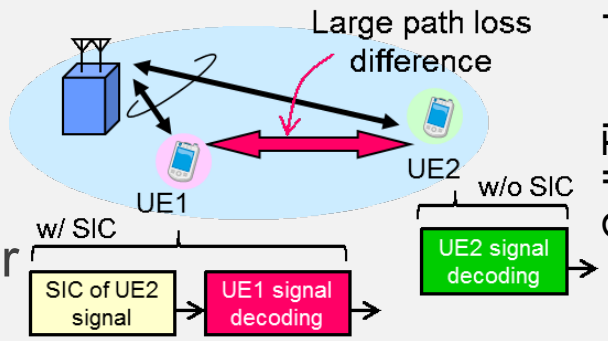
MIMO

Intentional Non-orthogonality

NOMA



Exploitation of power-domain, path loss difference among users, and UE processing power



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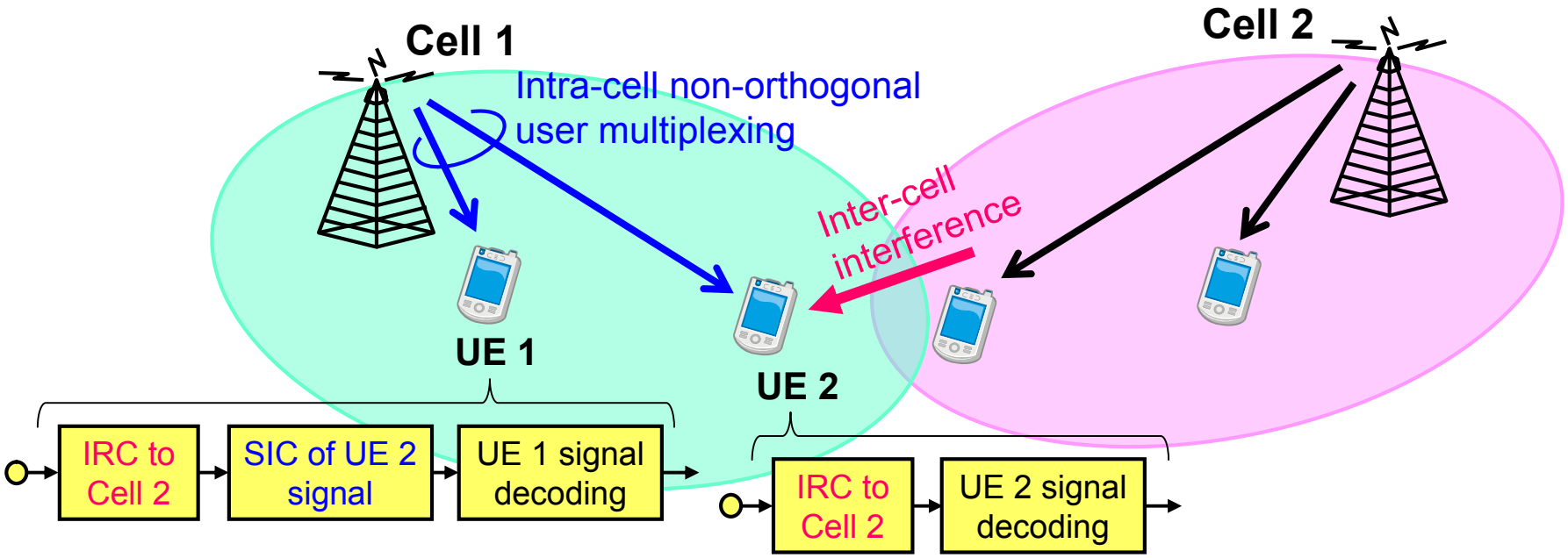
NOMA with Advanced Receiver

- Proposed NOMA with multi-antenna advanced receiver
  - Successive interference cancellation (SIC) for intra-cell/beam user multiplexing
  - Interference rejection combining (IRC) for inter-cell/beam interference suppression

➔ Enhance both capacity and cell-edge user throughput



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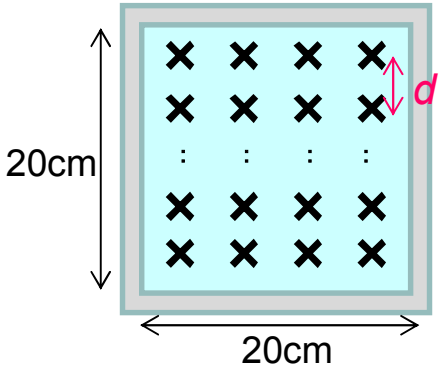
Massive MIMO in higher frequency

- **Massive MIMO** – Beamforming using massive antenna elements in higher frequency bands
  - *Essential technology to extend effective cell range*

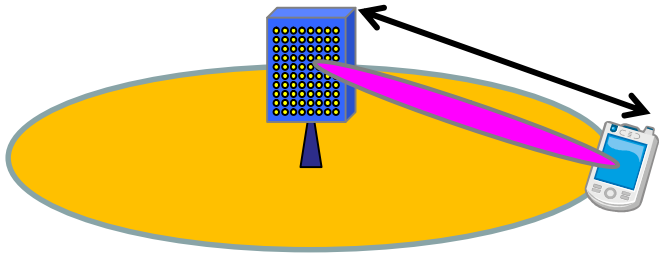
Example 2D antenna configuration



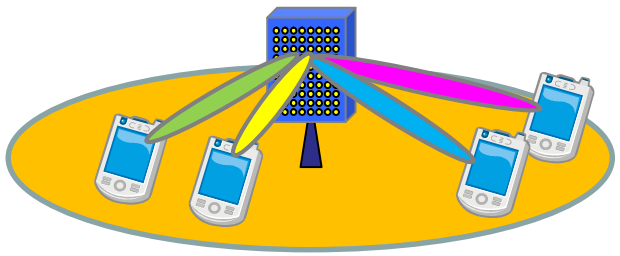
	LTE 3D-MIMO	Massive MIMO	
Antenna element spacing (d)	3.5 GHz (λ = 8.6 cm)	10 GHz (λ = 3 cm)	20 GHz (λ = 1.5 cm)
0.5 λ	16	169	676
0.7 λ	9	81	361

→ Compensation of increased path loss & Improved spectrum efficiency

Cell range extension by beamforming gain



Improved spectrum efficiency with (multi-user) spatial multiplexing



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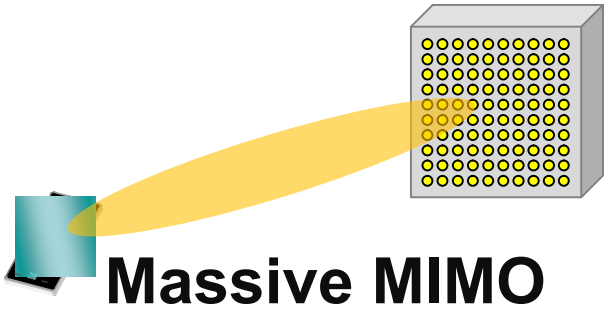
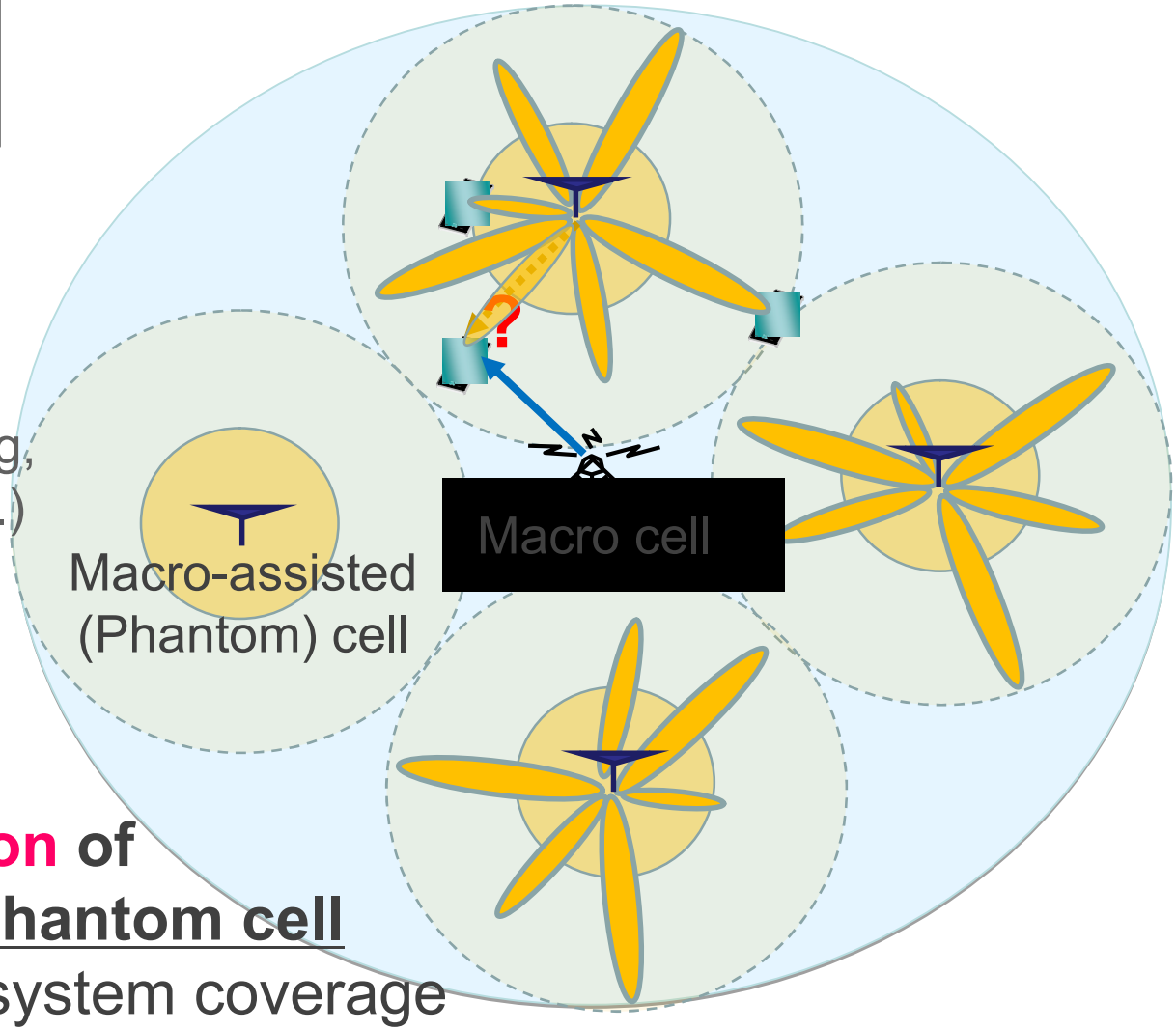
Macro-assisted Massive MIMO



Massive MIMO

Key issue – Coverage for common channels (system information, paging, synchronization signal, etc.)



Proposed combination of Massive MIMO and Phantom cell will provide adequate system coverage even with higher frequency bands

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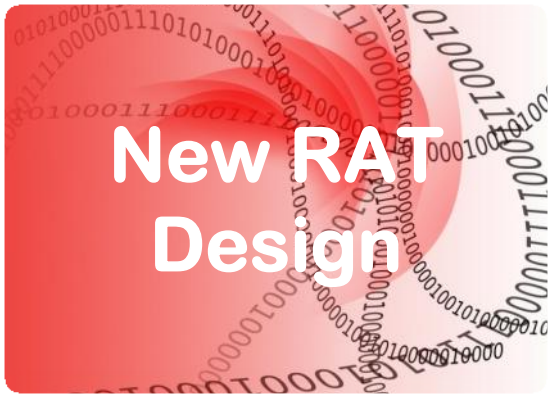
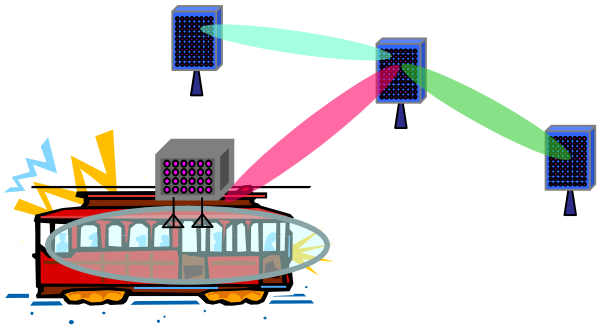
Other Technical Areas

- ***New numerology and frame structure*** for:
  - Higher frequency bands
  - Wider frequency bandwidths
  - Small cells
  - Reduced latency
  - etc.
- ***New waveforms***
  - UL OFDM
  - FBMC, FTN, etc.
- ***Enhanced contention based access*** for:
  - Lower overhead, reduced latency, and large capacity for small packets from, e.g. M2M terminals
- ***Flexible NW*** for:
  - NW cost reduction
  - Coverage enhancement
  - Mitigation of fronthaul/backhaul bottlenecks
  - QoE improvement
  - Moving NW/mobile relay
  - D2D
  - Caching at base station/mobile terminal
  - etc.





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