Toward 5G Deployment in 2020 and Beyond

NTT DOCOMO, INC.
Takehiro Nakamura

Outline

- 5G Concept
- Timeline for 5G development
- 5G technologies and deployment
- 5G experimental trials

5G CONCEPT

5G Global Trend

Future IMT Vision in ITU-R WP5D

National/international projects on 5G

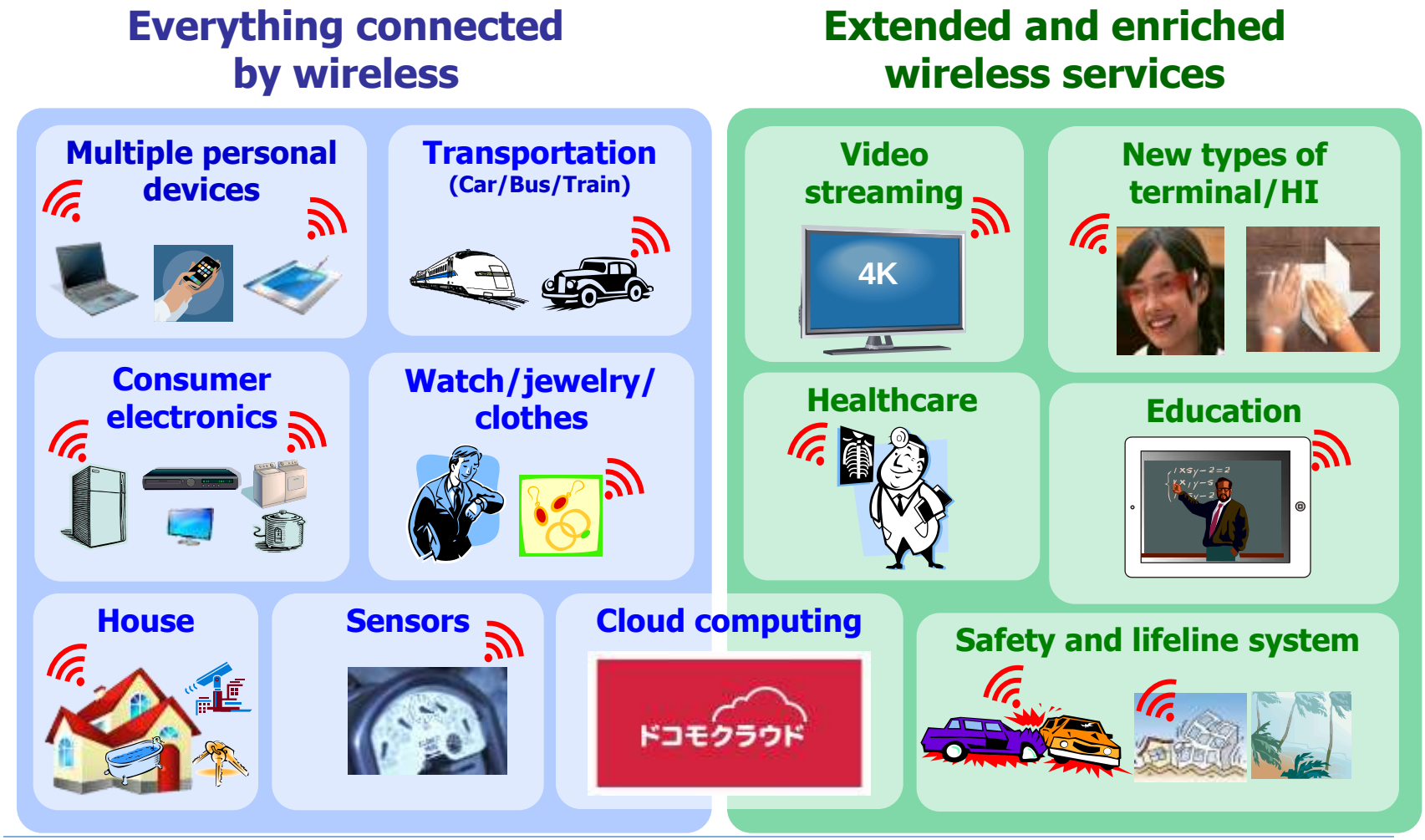
Special sessions on 5G in international conferences

Global initiative to define operator requirements for 5G

Vision2020/ Network2020

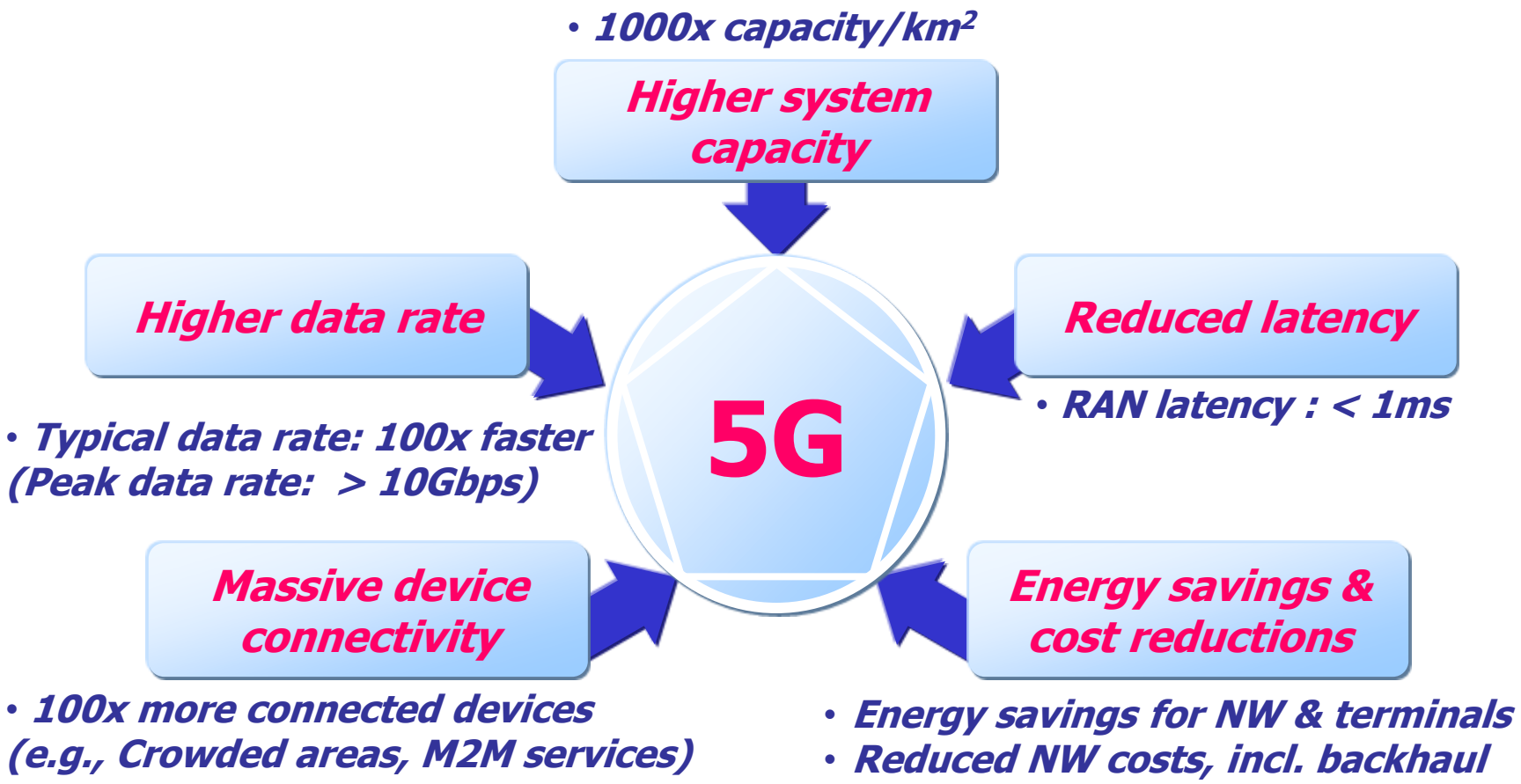
5G Workshop in Sep. 2015

Mobile Communications in 2020 and Beyond



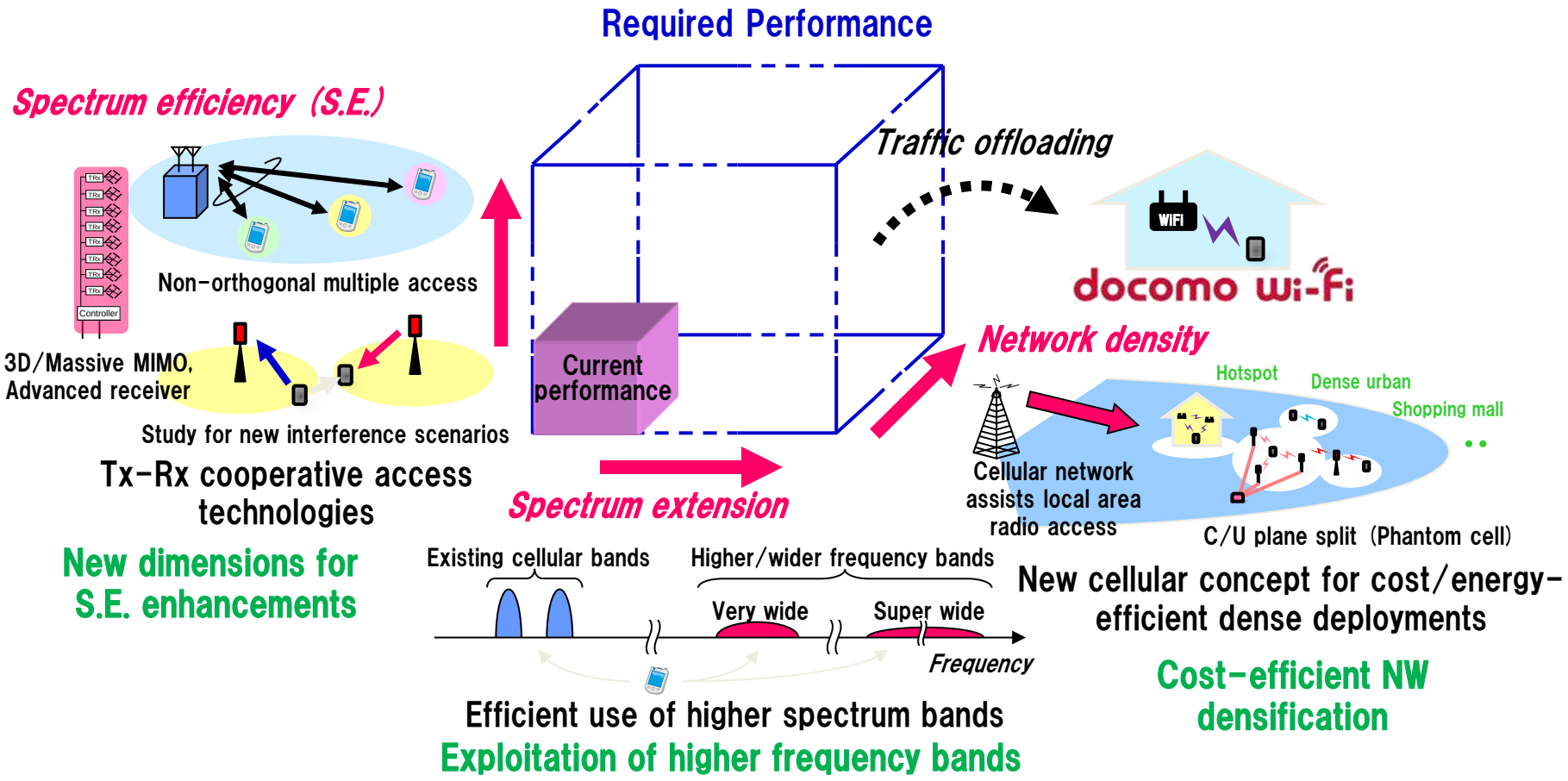
5G Target Performance

5G radio access will provide a total solution for a *wider range of requirements* in 2020 and beyond



Directions of Evolution: "The Cube"

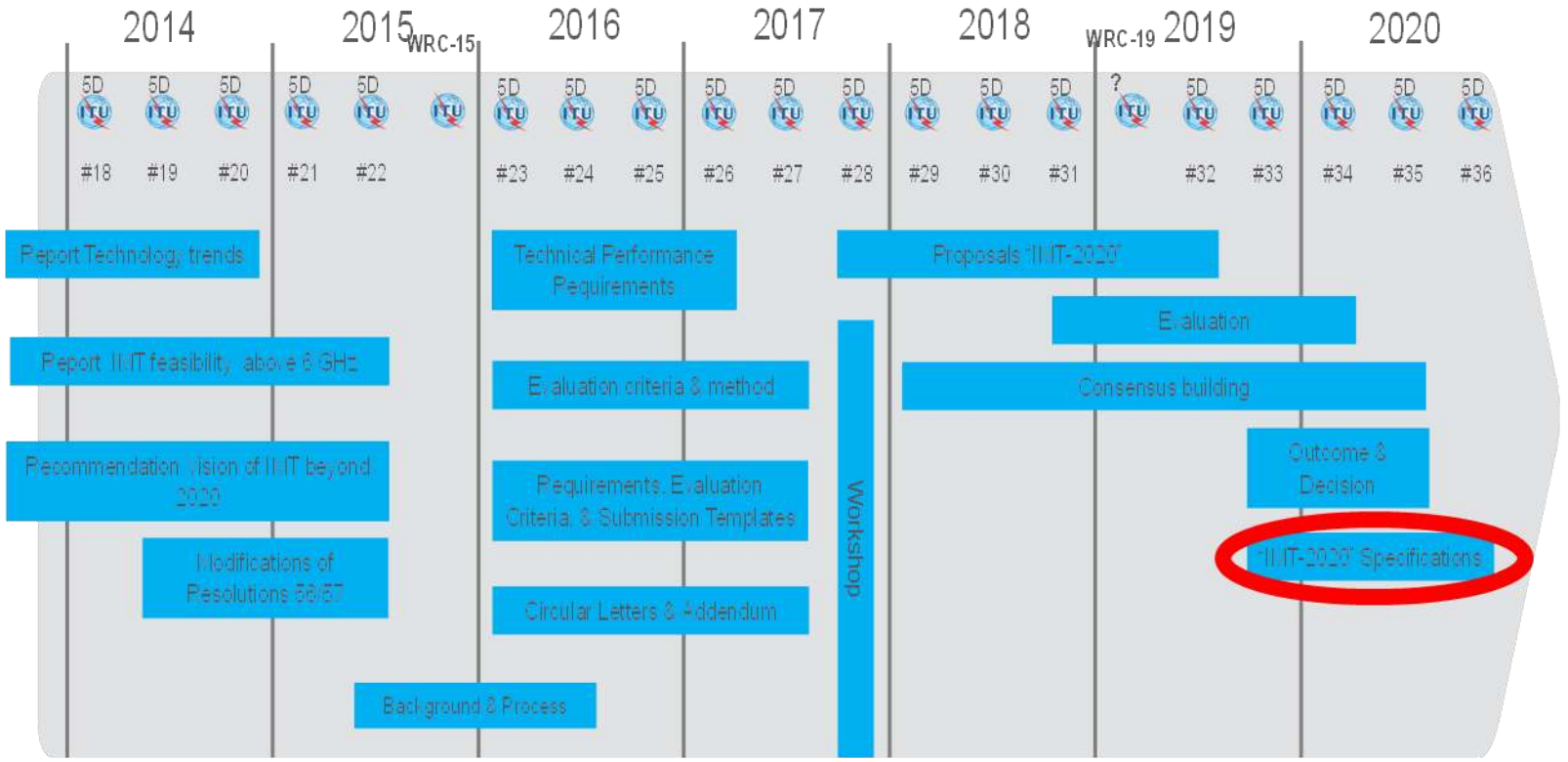
A set of radio access technologies is required to satisfy future requirements



TIME LINE FOR 5G DEVELOPMENT

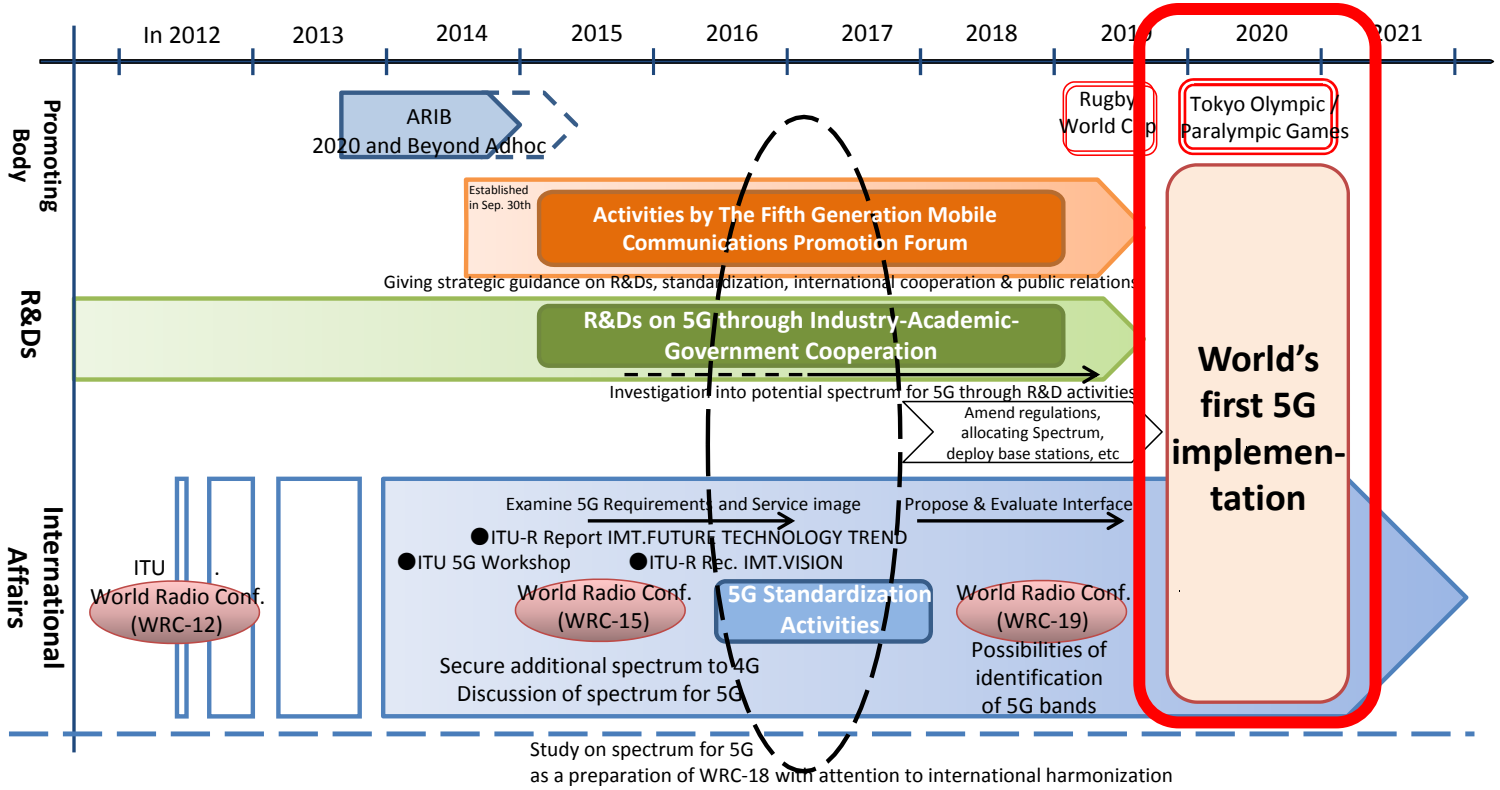
5G Work Plan in ITU-R

ITU-R is targeting completion of 5G specification development in 2020



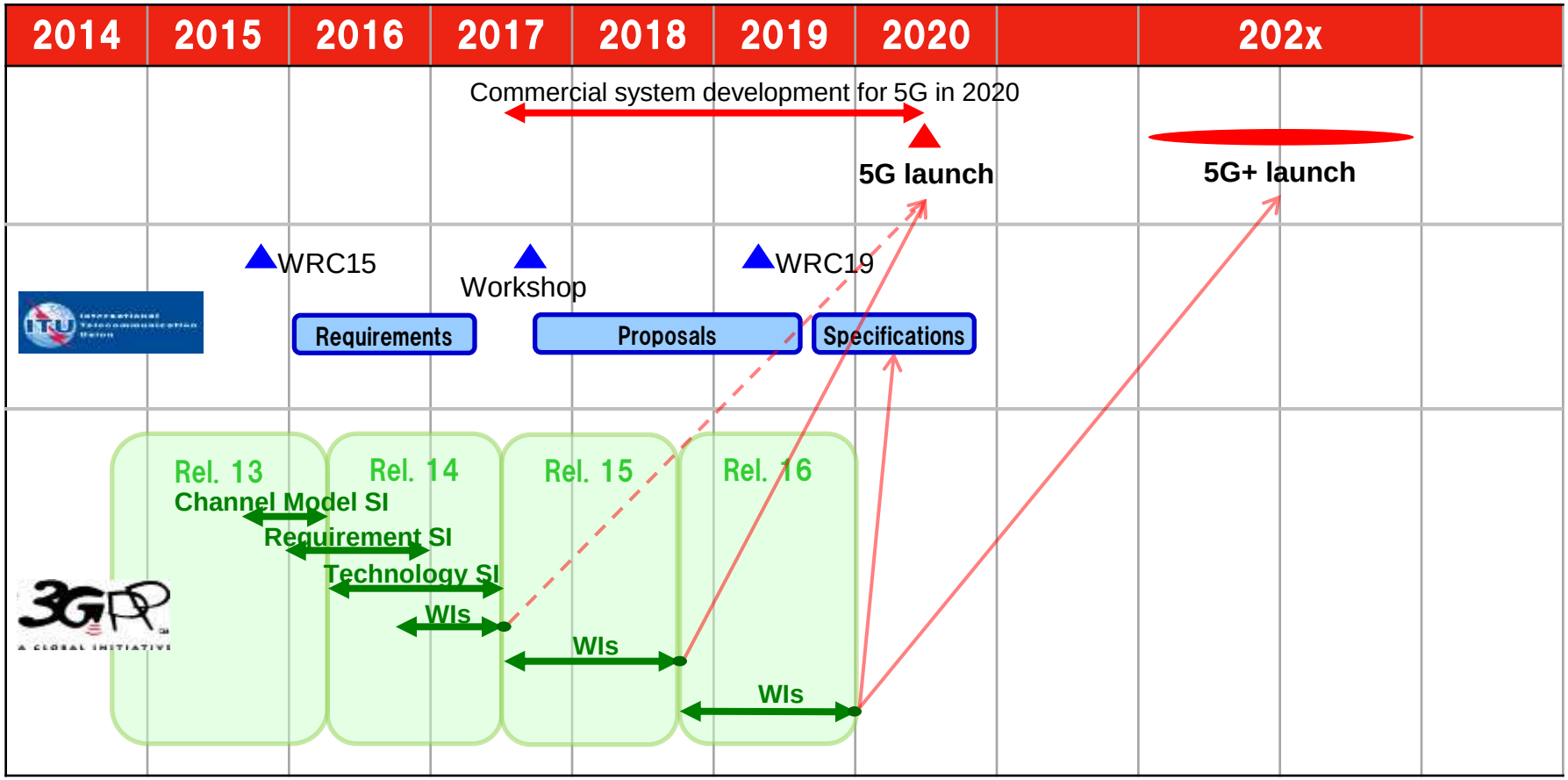
5G Commercial Requirements

Japan is targeting 5G commercial launch in 2020



Translated from "Final Report from the Radio Policy Vision Council", Ministry of Internal Affairs and Communications, Japan, December 2014.

Time Plan for 5G and 5G+



3GPP RAN Workshop on 5G in Sep. 2015

Phasing

- Emerging consensus that there should be two phases for the normative work
  - Phase 1 to be completed by H2 2018 to address a more urgent subset of the commercial needs (to be agreed)
  - Phase 2 to be completed by Dec 2019 for the IMT 2020 submission and to address all identified usecases & requirements
- The above implies the following, tentative, release timing

* NOTE: Dates above refer to "stage-3 functional freeze" of specs. ASN.1 freeze is typically one quarter after that.

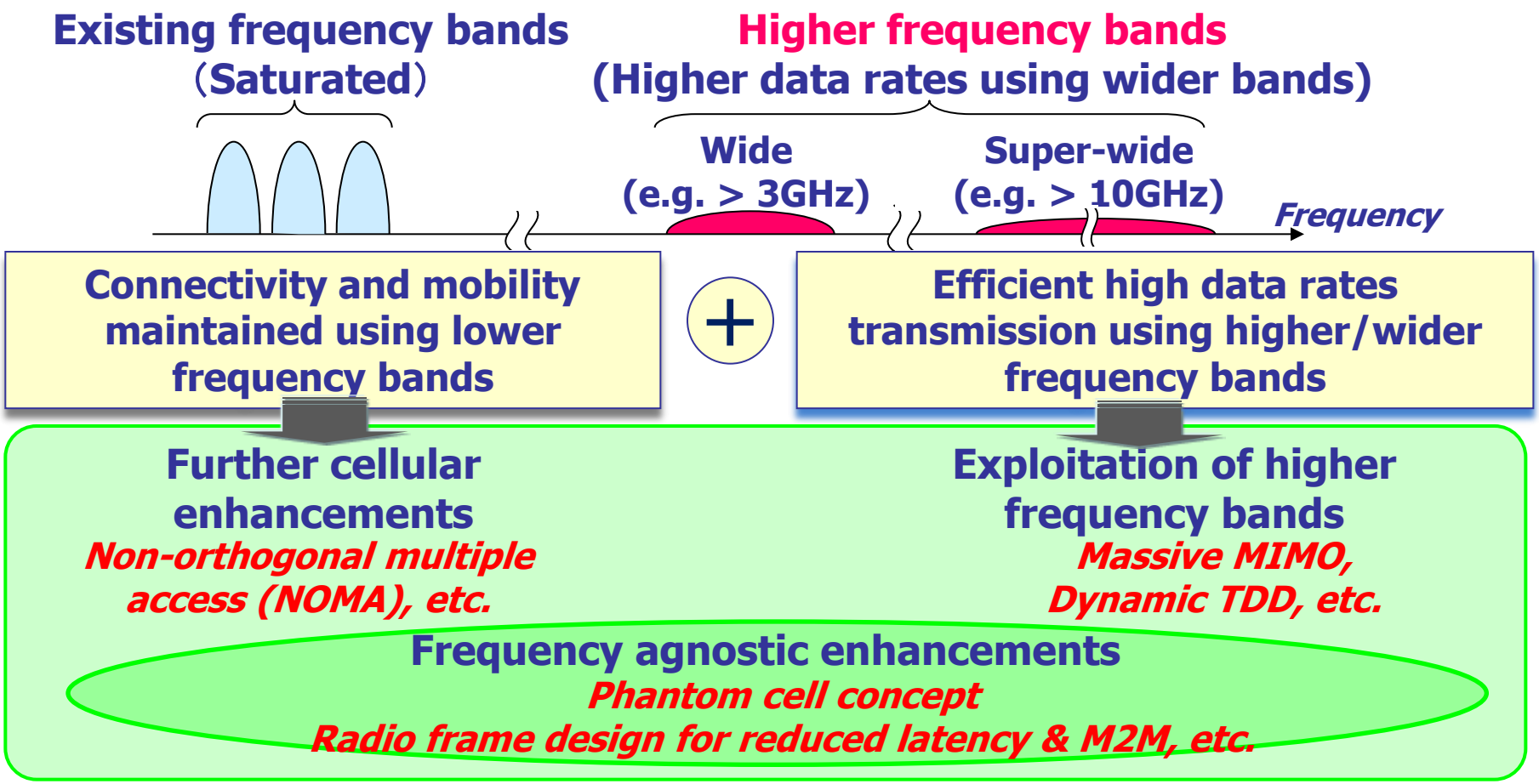
RAN workshop on 5G, Sep. 2015

 7

RWS-150073: RAN chairman's Summary of 3GPP RAN Workshop on 5G

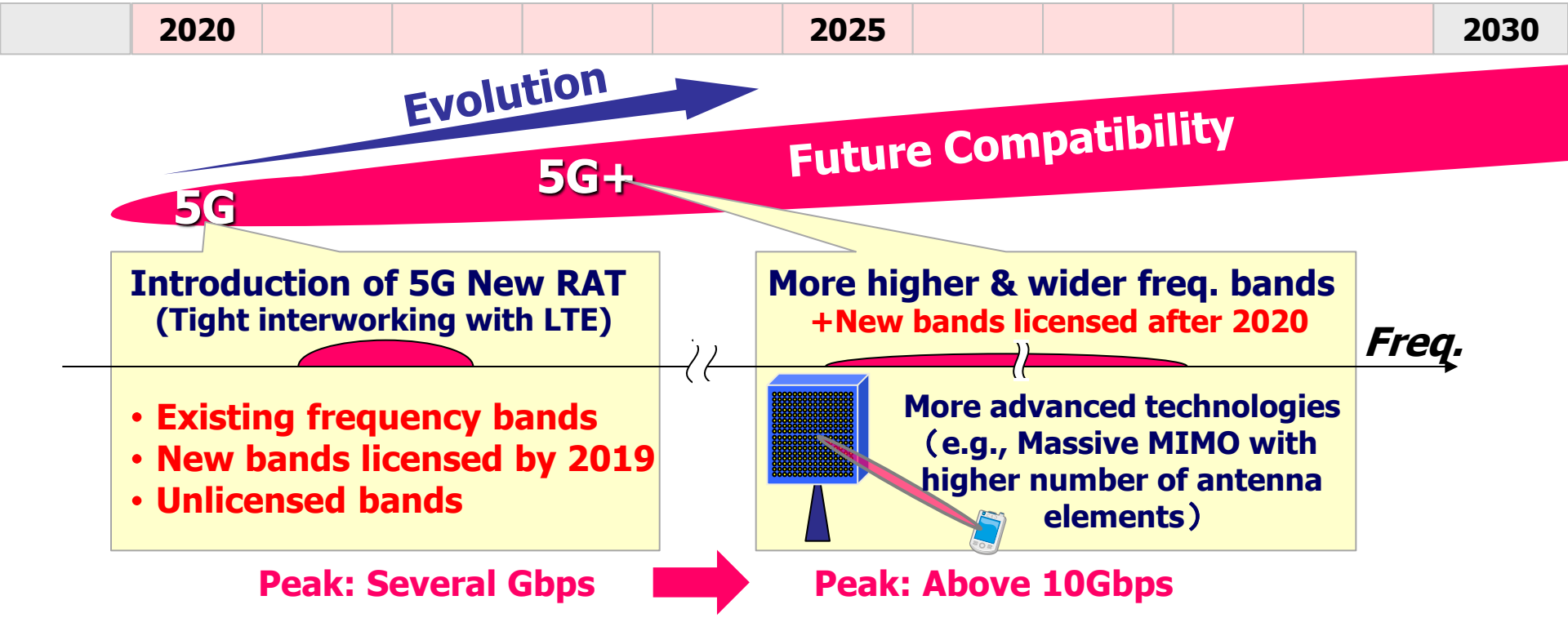
5G TECHNOLOGIES AND DEPLOYMENT

DOCOMO 5G Technical Concept



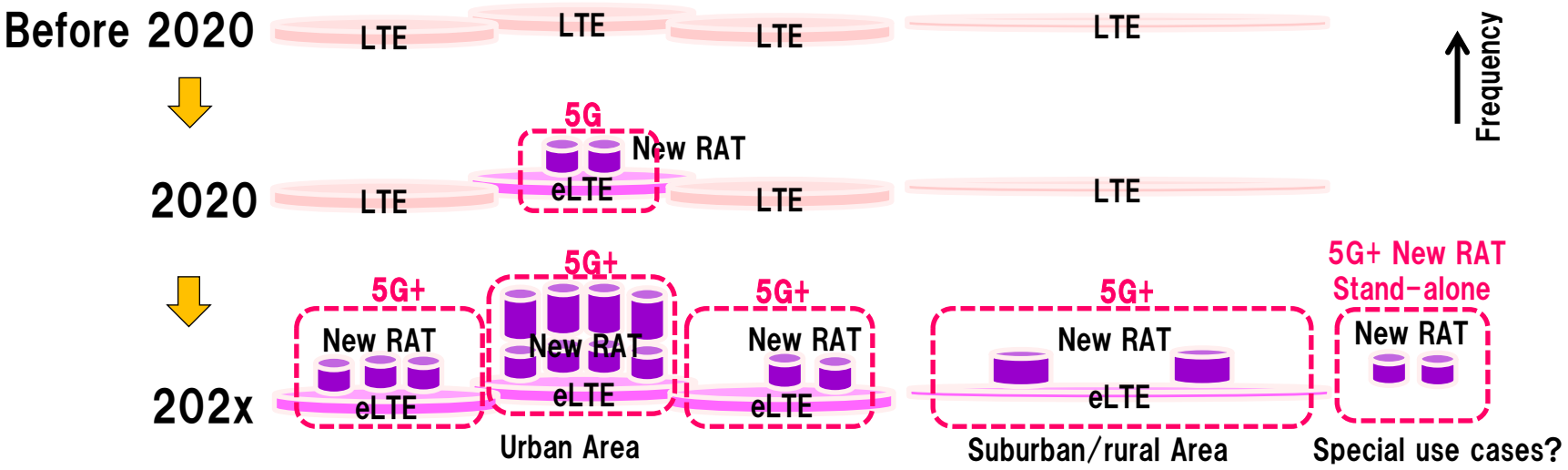
5G Phased Realization

5G will evolve by incorporating new freq. bands and technologies
➔ Future compatibility is key for system design to continue evolution



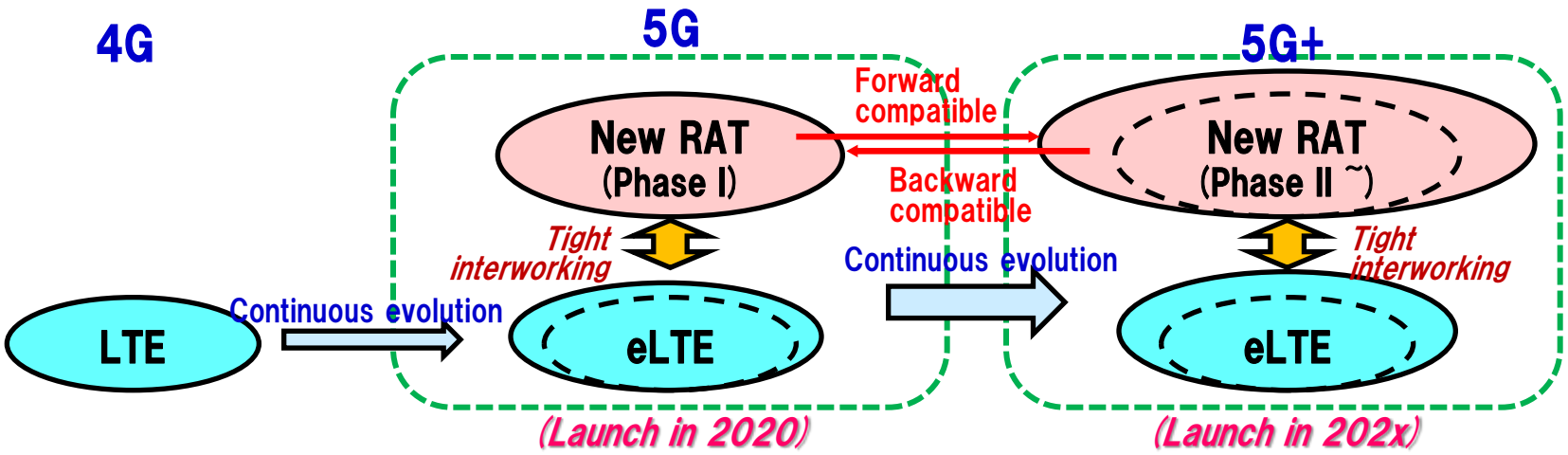
Deployment/Migration Scenarios

- In 2020, 5G will be launched initially from areas, where higher performance is required, e.g., dense urban area
- In beyond 2020, deployment areas for 5G are gradually expanded while introducing additional technologies and frequency bands (= 5G+)



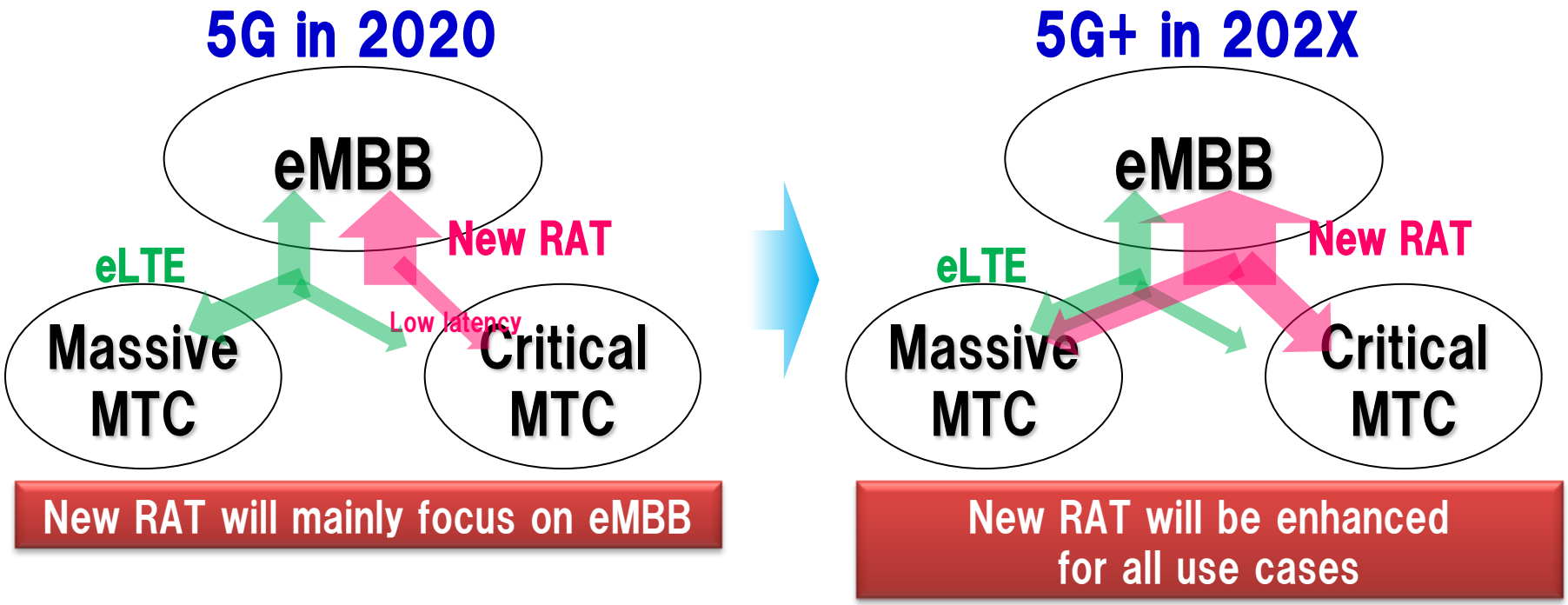
5G Forward/Backward Compatibility

- **It is important to make sure 5G continuous evolutions and 5G forward/backward compatibility considering:**
  - **Unclear spectrum allocation plan especially for mmW**
  - **Difference in 5G launch timing between countries/regions**



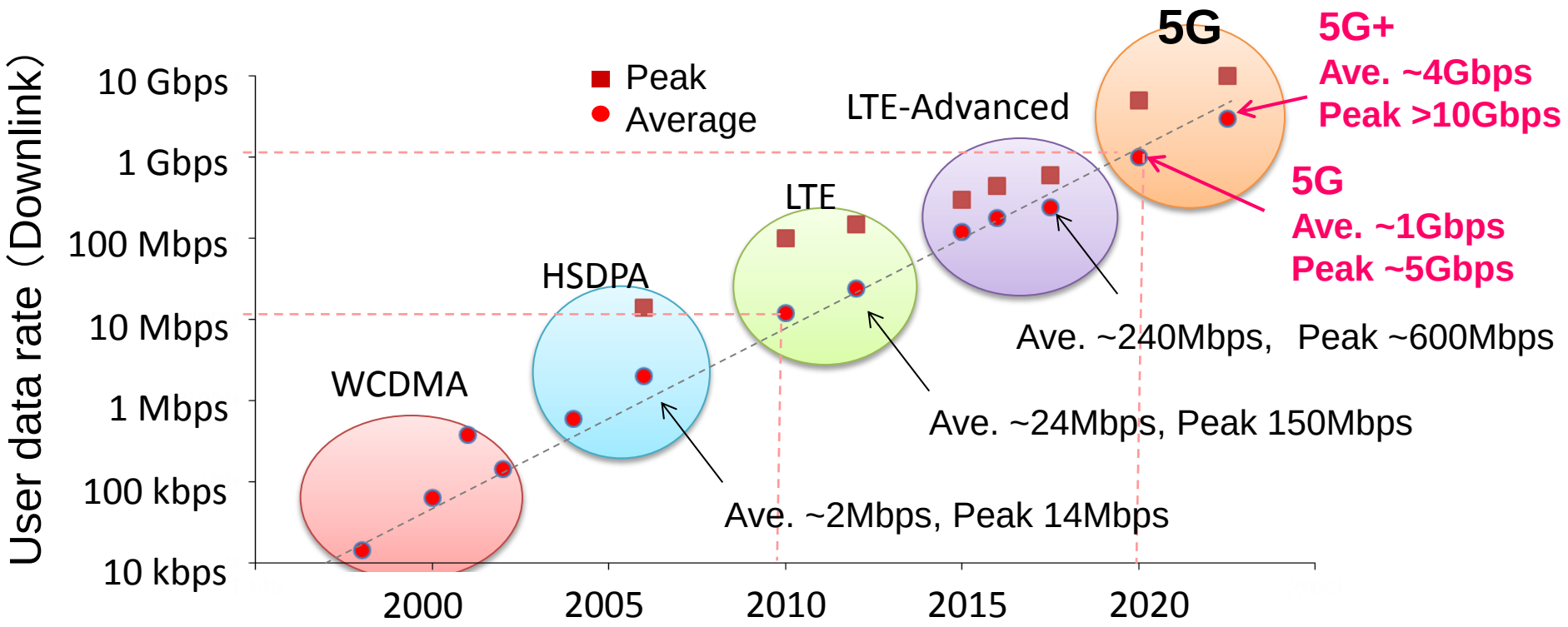
5G Use Cases

5G will support both use cases for enhanced Mobile Broadnand(eMBB) and Machine-Type Communications(MTC) together with LTE evolution



Data Rate Improvements Toward 2020 and Beyond

Continuous improvement of user experienced throughput toward 5G/5G+



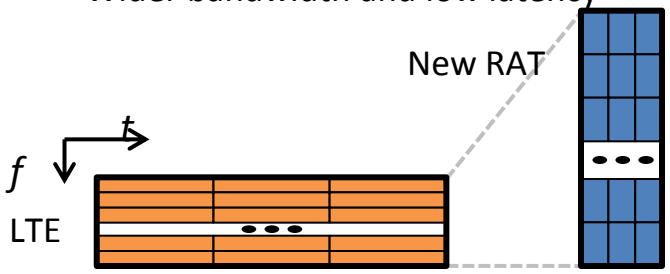
✓ Data rate increase will continue (approx. 100x per 10 years) (quasi-Moore law)

5G Key Technologies for 2020 Deployment

New RAT

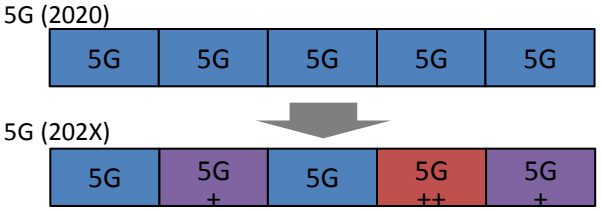
New numerology with shorter TTI

Wider bandwidth and low latency

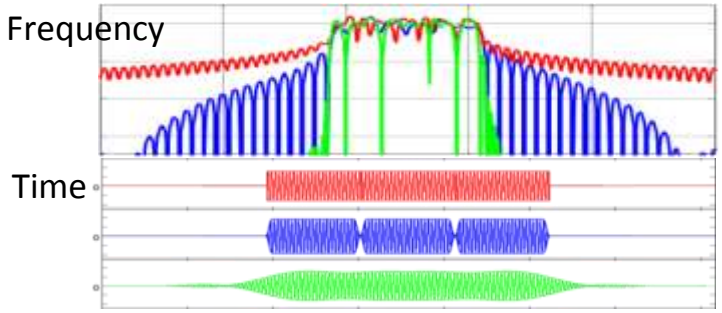


Lean radio frame

Less inter-cell interference, energy saving, good forward compatibility



Well localized waveform



Massive MIMO/ beamforming

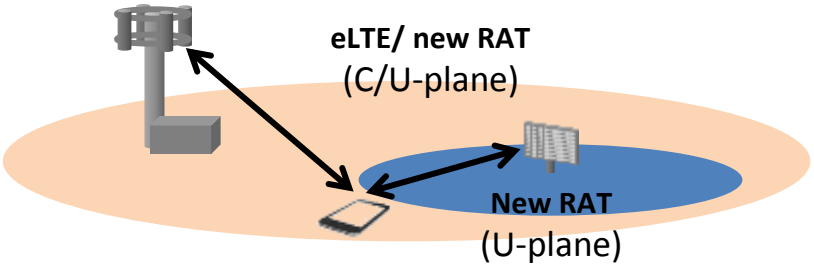
Cell range extension

Improved spectral efficiency

5G Key Technologies for 2020 Deployment

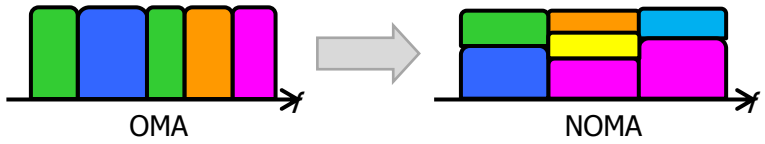
Tight LTE integration

C/U-plane split (dual connectivity, CA)



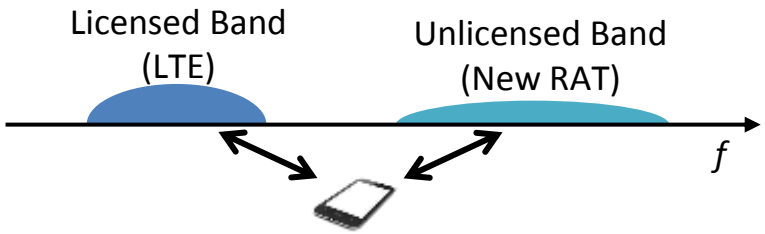
NOMA on LTE

Further cellular enhancement with massive connectivity



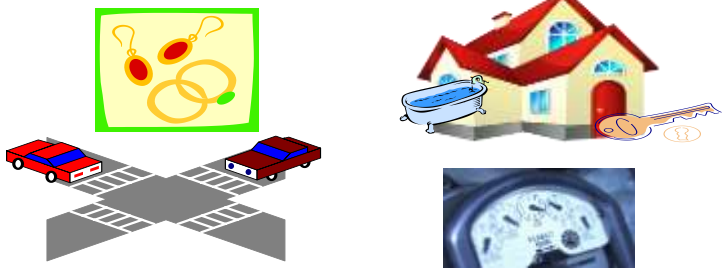
Intentional non-orthogonality

Flexible duplex with unlicensed spectrum (e.g. LTE-assisted access)



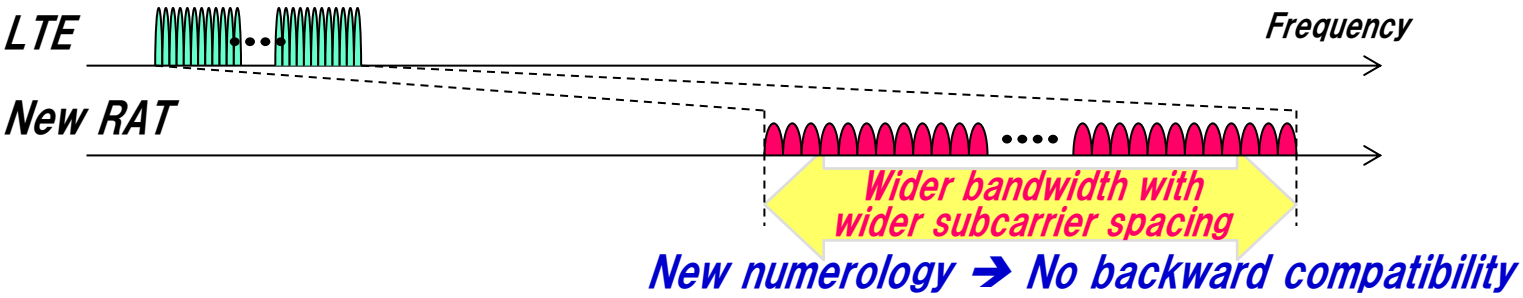
IoT related LTE enhancements

Low cost / Long battery life devices



New numerology and lean radio frame

- **New numerology (radio parameter set)** to support higher frequency bands and lower latency
  - Desired *scalability from LTE numerology*
    - Low complexity implementation for LTE/new RAT dual-mode terminals
    - Easy support of dual connectivity between LTE and new RAT

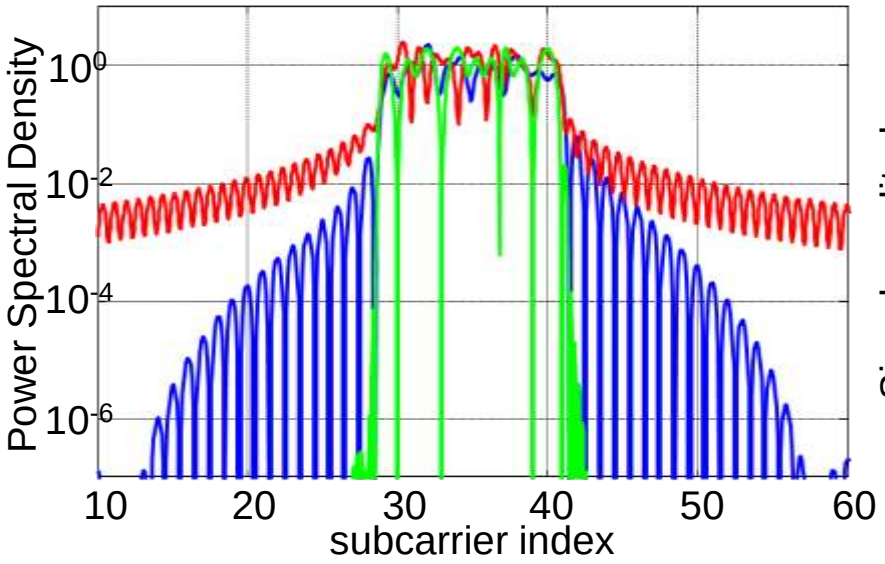


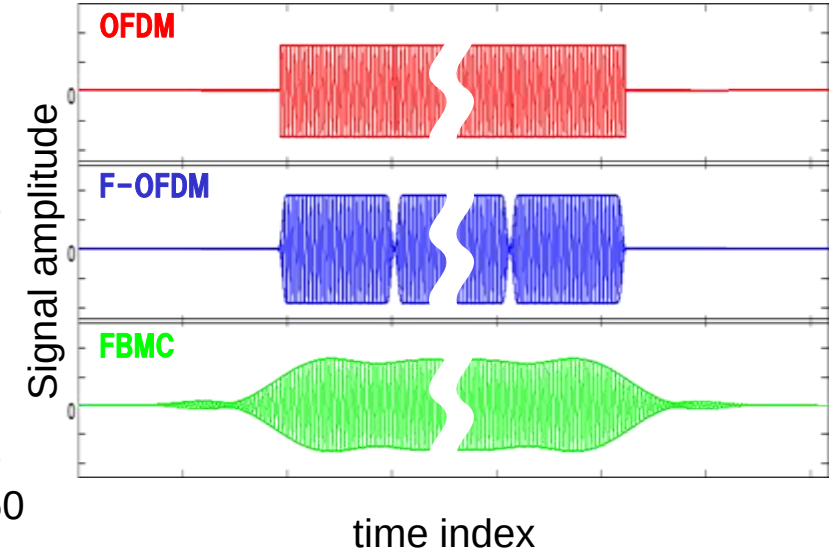
  - Shorter TTI for low latency (< 1ms)
- **Lean radio frame** with Good forward compatibility
  - Removal of "always-on" signals such as cell-specific reference signal

Waveform

- Flexible waveform design to support both mobile broadband and IoT
- New waveform designs allow for a limited amount of in-band distortion in order to significantly reduce out-of-band leakage
- Trade-off between time and frequency localization of filter response

Waveform

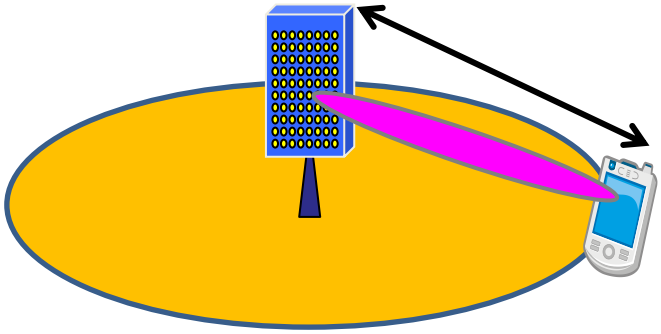




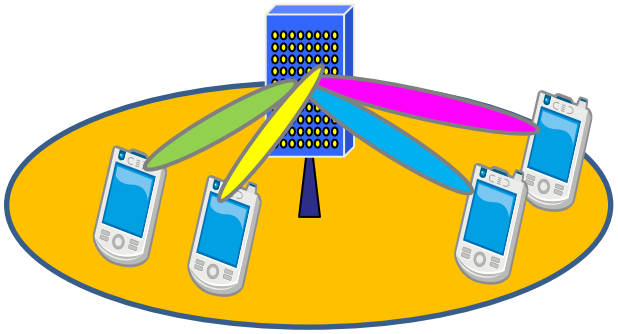
FBMC (Filter Bank Multi-Carrier) and Filtered-OFDM are studied as alternative waveforms of CP-OFDM

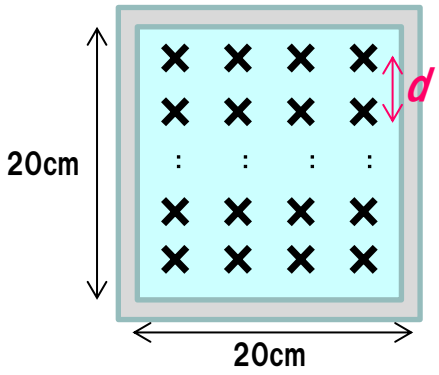
Massive MIMO

Compensation for path-loss
➔ Range extension of small cells

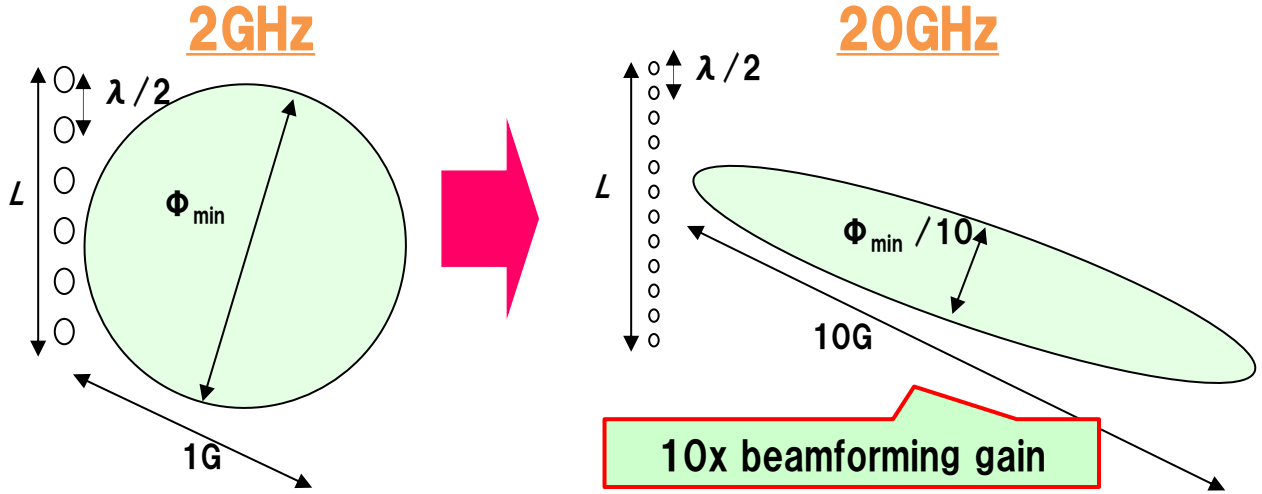


Large number of simultaneously connected users
➔ Smooth connectivity even in crowded areas

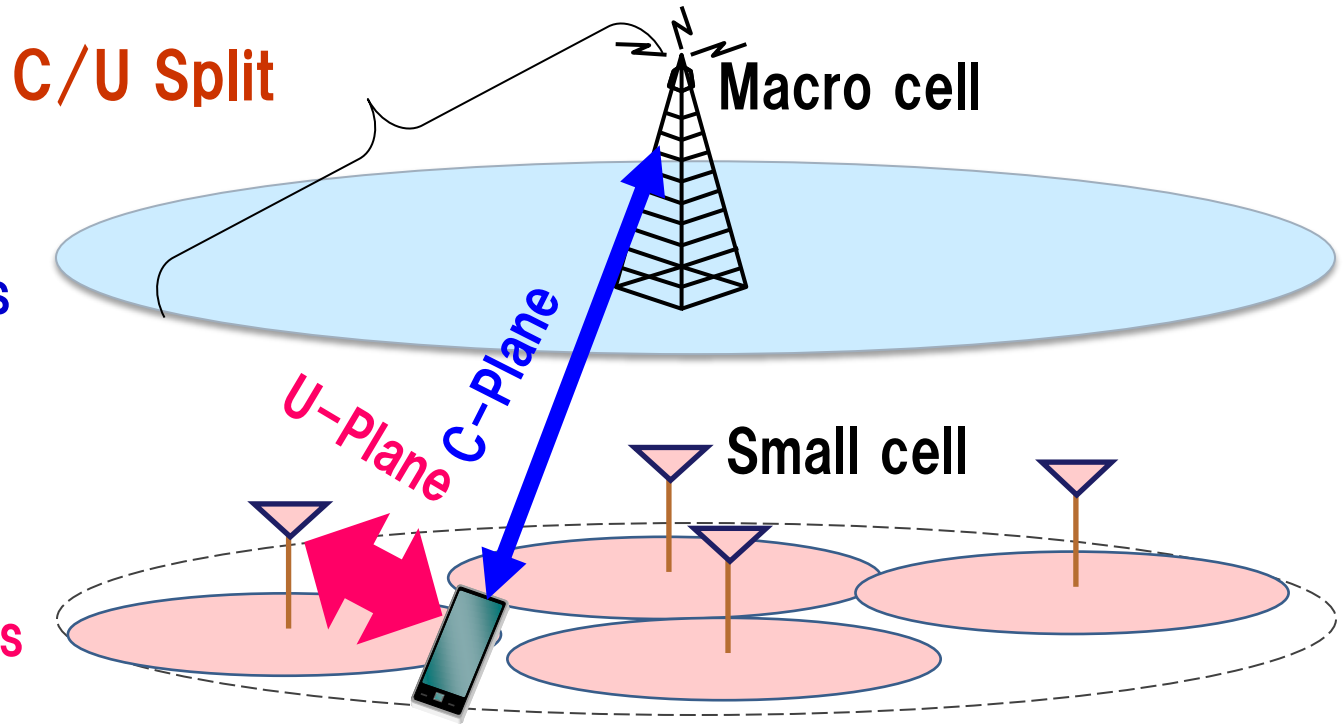




More than 100 antenna elements per small cell



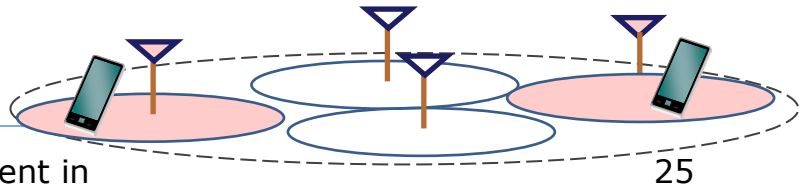
C/U-Plane Split (Phantom Cell)



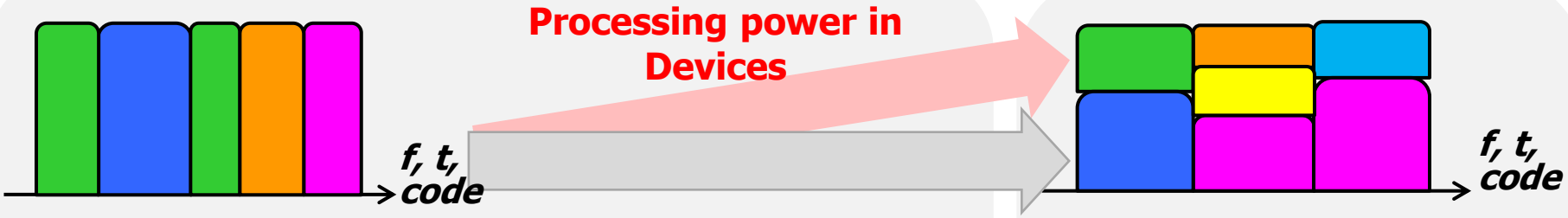
U-plane: Small cell provides higher data rate and more flexible & cost-energy efficient operations

C-plane: Macro cell maintains good connectivity and mobility

Cell ON/OFF: Small cell are put on only when there is traffic



NOMA



Effort for Orthogonality

OFDMA (LTE)
(or FDMA, TDMA, CDMA)

Effort for Interference Mitigation

Equalizer, Canceller

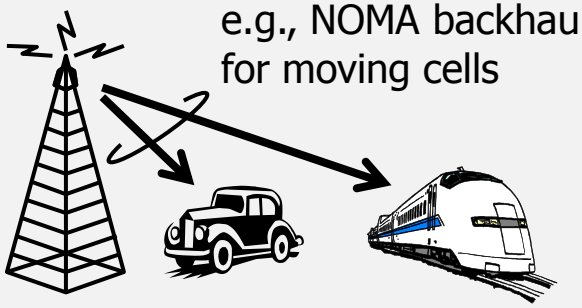
MIMO

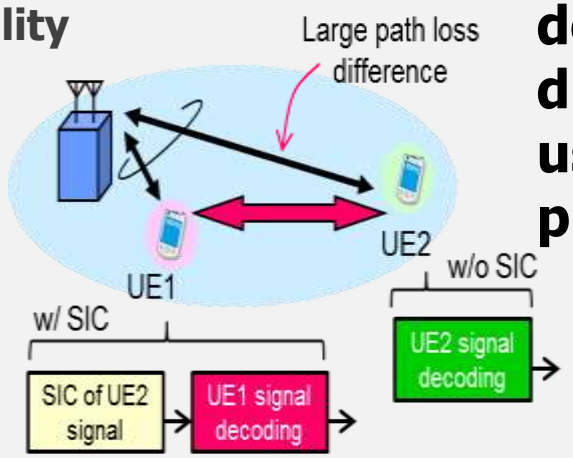
Intentional Non-orthogonality

NOMA

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

Robust gain against user mobility





Under study in LTE Release 13

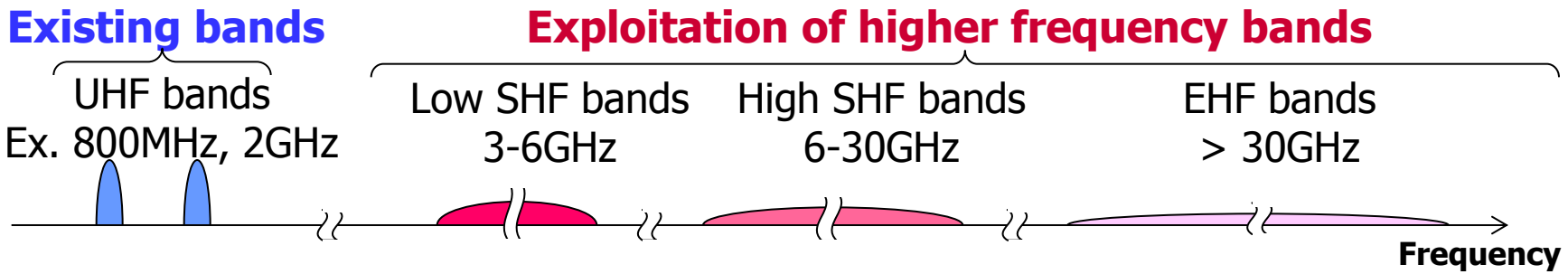
Radio Technology Components for Phase 1 and Phase 2

Technology components	Phase I of new RAT	Phase II of new RAT
Target spectrum	Up to 30 (or 40) GHz	Up to 100 GHz
Target deployments	eMBB (Hotspot, UMi, UMa) Dense urban scenario	All scenarios
Waveform	OFDM-based	Single carrier (or alternative waveform) ?
Numerology	Flexible numerology Minimized number of options for target spectrum and target deployments	Optimizations to higher frequency bands and all use cases
Radio frame design	Low latency (short TTI) Minimized overhead channels Flexible radio frame structure	Extension to support all use cases
Massive MIMO	Supported ・Coverage extension and MU-MIMO gain	Possible extensions for higher order array, UE beamforming, etc.
Initial access	Prioritize LTE assisted access	Standalone to be supported

5G EXPERIMENTAL TRIALS

5G Experimental Trials

5G experimental trials are being started since Q4 of 2014



Alcatel·Lucent HUAWEI FUJITSU NEC ERICSSON SAMSUNG MITSUBISHI ELECTRIC NOKIA

Key devices/Chip sets vendors

intel QUALCOMM

System solution vendors

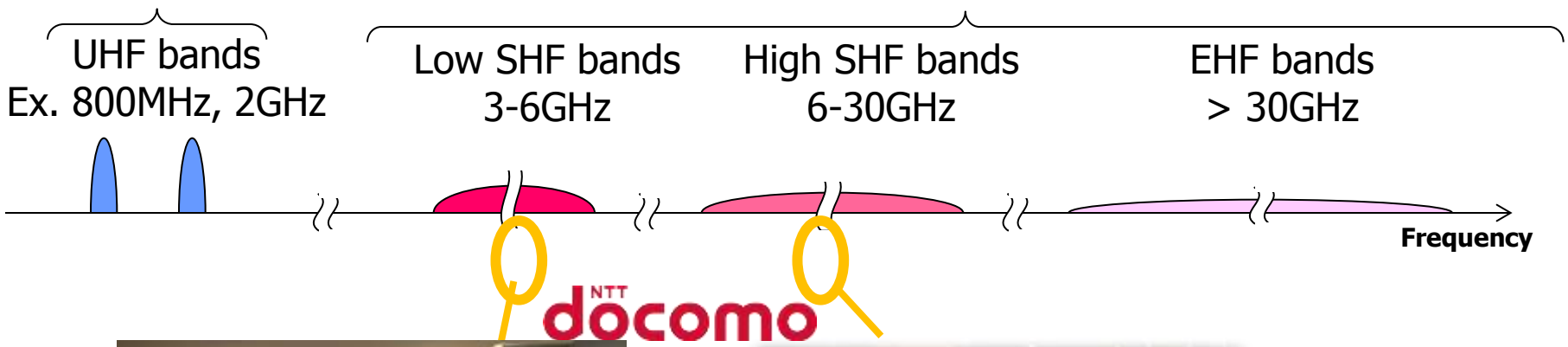
Panasonic

Measuring instruments vendors

KEYSIGHT TECHNOLOGIES ROHDE&SCHWARZ

5G Experimental Trials

Experimental trials on DOCOMO proposed NOMA and channel sounder to explore higher frequency bands are also conducted



Conclusion

- Diverse requirements to be considered for 5G (including MBB and IoT)
- 5G will be about an innovative combination of several technical components
- Now 5G is about to enter standardization phase (3GPP and ITU-R)
- Phased approach is important to introduce 5G technologies considering market needs and realistic spectrum allocation time plan


NTT
docomo