3GPP 5G 無線インターフェース検討状況

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Disclaimers

• This presentation is based on the draft 3GPP specifications to be approved in RAN#78 meeting in Dec/2017.
• The Information may be subject to updates.
Based on the draft specifications and/or other agreements in 3GPP as of Dec. 2017

**3GPP 5G timeplan**

**IMT-2020**
- Requirements
- Proposals
- Specifications
- Evaluations

**Rel-14**
- NR Study Item
  - eMBB
  - Low latency

**Rel-15**
- NR WI Phase 1
  - High reliability

**Rel-16**
- NR SI(s) Phase 2
  - mMTC

**Rel-17**
- NR WI(s) Phase 2
  - Full IMT-2020

<table>
<thead>
<tr>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Non stand-alone Core. spec.</td>
<td>NR Stand-alone Core. spec.</td>
<td>NR Conformance spec.</td>
<td>Full IMT-2020</td>
<td></td>
</tr>
</tbody>
</table>
Based on the draft specifications and/or other agreements in 3GPP as of Dec. 2017

IMT-2020 submission timeplan

Source: RP-172098

3GPP RAN PLENARY

3GPP RAN WG4

New Generation Mobile Communication System Committee Technical Investigation Working Group documents

12/22/2017
3GPP NR overview

- Flexible, scalable, and future-proof design
  - Forward compatibility

- Spectrum range up to 100GHz
  - Frequency range 1 (FR1):
    - 450MHz – 6.0GHz
    - Channel bandwidth up to 100MHz
  - Frequency range 2 (FR2):
    - 24.25GHz – 52.6GHz
    - Channel bandwidth up to 400MHz

- Support NR carrier aggregation (CA) up to 16 component carriers

- Multi-antenna
  - Massive MIMO
  - Hybrid beam-forming
  - Active antenna system (AAS)

- Low latency
  - Shorter symbol time
  - Mini-slots

- Ultra-lean design
  - Minimize any transmissions not directly related to the user data transmission
  - No cell-specific reference signal
NR architecture options

• Option 3 and Option 7
  • Connectivity via EPC (option 3) or 5GC (option 7)
  • Initial access and mobility by LTE nodes

• Option 2 and Option 4

EPC: Evolved packet core (4G core network)
5GC: 5G core network
NR numerology and frequency/time structure

- Waveform: OFDM for UL and DL
  - UL also supports DFT-S-OFDM
- Subcarrier spacing (SCS)
  - Larger SCS
    - Shorter slot → Lower latency

<table>
<thead>
<tr>
<th>Subcarrier spacing</th>
<th>Freq range</th>
<th>Max CBW</th>
</tr>
</thead>
<tbody>
<tr>
<td>15kHz (Same as LTE)</td>
<td>FR1</td>
<td>50MHz</td>
</tr>
<tr>
<td>30kHz</td>
<td>FR1</td>
<td>100MHz</td>
</tr>
<tr>
<td>60kHz</td>
<td>FR1, FR2</td>
<td>200MHz</td>
</tr>
<tr>
<td>120kHz</td>
<td>FR2</td>
<td>400MHz</td>
</tr>
</tbody>
</table>

- Resource block - basic unit of resources consisting of 12 subcarriers and 1 slot (14 symbols)
UL/DL allocation for TDD carrier

- Network configures UL/DL allocation for transmission period (e.g., 5ms)
  - Cell-specific configuration
  - Possible to reconfigure UL/DL allocation for transmission period per UE
  - It is possible to configure the same UL/DL allocation as TD-LTE such as UL:DL=1:3 and special subframe configuration
Bandwidth part (BWP)

- A part of BS channel bandwidth configured by the network
  - Configuration per UE
  - Up to 4 BWPs for UL and DL carriers per UE
  - Each BWP may have different SCS, location, and bandwidth
  - UE transmit/receive signal on one of BWPs indicated by control channel
Physical layer uplink overview

- Waveform: CP-OFDM or DFT-S-OFDM (SC-FDM)
- Physical channels
  - PUSCH – Data channel
  - PUCCH – Control channel
    - HARQ-ACK, CSI, Scheduling Request
    - PRACH – Random access channel
- Physical signals
  - DM-RS – Demodulation for PUSCH/PUCCH
  - PT-RS – Phase-tracking RS for PUSCH
  - SRS – Sounding RS
- Modulation
  - PUSCH: \(\pi/2\)-BPSK, QPSK, 16QAM, 64QAM, 256QAM
  - PUCCH: \(\pi/2\)-BPSK, QPSK
- Channel coding
  - Polar code for PUCCH
  - LDPC for PUSCH
- Multi-antenna transmission
  - PUSCH support up to 4 layers with SU-MIMO
  - PUSCH support up to 12 layers with MU-MIMO using orthogonal DM-RS
Physical layer downlink overview

• Waveform: OFDM
• Physical channels
  • PDSCH – Data channel
  • PDCCH – Control channel
  • PBCH – Broadcast channel
• Physical signals
  • DM-RS – Demodulation for PDSCH/PDCCH/PBCH
  • PT-RS – Phase-tracking RS for PDSCH
  • CSI-RS – Channel state information
    • Also used for time/frequency tracking
  • PSS/SSS – Primary/Secondary Synchronization signals
• Modulation
  • PDSCH: QPSK, 16QAM, 64QAM, 256QAM
  • PDCCH/PBCH: QPSK
• Channel coding
  • Polar code for PDCCH/PBCH
  • LDPC for PDSCH
• Multi-antenna transmission
  • PDSCH support up to 8 layers with SU-MIMO
  • PDSCH support up to 12 layers with MU-MIMO using orthogonal DM-RS
NR operating bands

• New operating bands for NR (related to Japan)

<table>
<thead>
<tr>
<th>Operating band</th>
<th>UL frequency range</th>
<th>DL frequency range</th>
<th>Duplex mode</th>
<th>Frequency range</th>
</tr>
</thead>
<tbody>
<tr>
<td>n77</td>
<td>3300 – 4200 MHz</td>
<td>3300 – 4200 MHz</td>
<td>TDD</td>
<td>FR1</td>
</tr>
<tr>
<td>n78</td>
<td>3300 – 3800 MHz</td>
<td>3300 – 3800 MHz</td>
<td>TDD</td>
<td>FR1</td>
</tr>
<tr>
<td>n79</td>
<td>4400 – 5000 MHz</td>
<td>4400 – 5000 MHz</td>
<td>TDD</td>
<td>FR1</td>
</tr>
<tr>
<td>n257</td>
<td>26.5 – 29.5 GHz</td>
<td>26.5 – 29.5 GHz</td>
<td>TDD</td>
<td>FR2</td>
</tr>
</tbody>
</table>

Note: Existing LTE operating bands 1, 3, 8, 28, 41, and 74 (related to Japan) are also going to be introduced as NR operating bands as n1 (FDD), n3 (FDD), n8 (FDD), n28 (FDD), n41 (TDD), and n74 (FDD)
E-UTRA-NR-DC (EN-DC) band combination

• NSA is based on LTE dual connectivity and need LTE as an anchor carrier

• 3GPP are going to introduce the DC band combinations 1 NR band and one or more LTE bands
  • The table below summarizes the agreed EN-DC band combinations between the new NR bands and single LTE bands related to Japan as of Dec/2017

<table>
<thead>
<tr>
<th>New NR bands</th>
<th>LTE bands</th>
</tr>
</thead>
<tbody>
<tr>
<td>n77, n78, n79, n257</td>
<td>B1, B3, B8, B11, B18, B19, B21, B26, B28, B41, B42</td>
</tr>
</tbody>
</table>

• Note other combinations are going to be introduced in the future.
### BS channel bandwidth and SCS per NR band

- BS channel bandwidth depends on the subcarrier spacing

<table>
<thead>
<tr>
<th>NR band</th>
<th>SCS [kHz]</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>n77/n78</td>
<td>15</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td></td>
<td>60</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>n79</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
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<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NR band</th>
<th>SCS [kHz]</th>
<th>50</th>
<th>100</th>
<th>200</th>
<th>400</th>
</tr>
</thead>
<tbody>
<tr>
<td>n257</td>
<td>60</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>120</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>
Spectrum utilization

- 3GPP assume the spectrum utilization up to 98% (cf. 90% for LTE)
- Maximum numbers of resource blocks for FR1

<table>
<thead>
<tr>
<th>SCS [kHz]</th>
<th>BS channel bandwidth (MHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5</td>
</tr>
<tr>
<td>15</td>
<td>25</td>
</tr>
<tr>
<td>60</td>
<td>11</td>
</tr>
</tbody>
</table>

- Maximum numbers of resource blocks for FR2

<table>
<thead>
<tr>
<th>SCS [kHz]</th>
<th>BS channel bandwidth (MHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50</td>
</tr>
<tr>
<td>60</td>
<td>66</td>
</tr>
<tr>
<td>120</td>
<td>32</td>
</tr>
</tbody>
</table>

Note 1: 1 resource block consists of 12 subcarriers
Example: 12x30kHz=360kHz

Note 2: Values in [ ] mean under investigation in 3GPP
Channel raster and synchronization raster

- At the initial cell search, UE searches the synchronization signal and PBCH block (SS/PBCH block) consisting of PSS/SSS/PBCH
  - SCS for SS/PBCH block is fixed per operating band to reduce the UE complexity
  - SS/PBCH block raster is different from channel raster

<table>
<thead>
<tr>
<th>Channel</th>
<th>SS/PBCH block</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SCS [kHz]</td>
</tr>
<tr>
<td>n77/n78/n79</td>
<td>15/30/60</td>
</tr>
<tr>
<td>n257</td>
<td>60/120</td>
</tr>
</tbody>
</table>

Values in [ ] mean under investigation in 3GPP.
Conducted/OTA requirements for NR BS and UE

• For UE, apply conducted requirements to FR1 and OTA requirements to FR2
• For BS, 3GPP agreed to specify different sets of requirements depending on NR BS type

<table>
<thead>
<tr>
<th>NR BS type</th>
<th>Frequency range</th>
<th>BS Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1-C</td>
<td>FR1</td>
<td>Consisting only of conducted requirements defined at individual antenna connectors</td>
</tr>
<tr>
<td>Type 1-H</td>
<td></td>
<td>Consisting of conducted requirements defined at individual TAB connectors and OTA requirements defined at RIB</td>
</tr>
<tr>
<td>Type 1-O</td>
<td></td>
<td>Consisting only of OTA requirements defined at the RIB</td>
</tr>
<tr>
<td>Type 2-O</td>
<td>FR2</td>
<td>Consisting only of OTA requirements defined at the RIB</td>
</tr>
</tbody>
</table>

OTA: Over-the-air
TAB connector: Transceiver array boundary connector
RIB: Radiated interface boundary
BS type 1-C and 1-H

- Type 1-C (Conducted) is same as the existing LTE base station
  - Conducted test with antenna port
- TAB in type 1-H (Hybrid) is conducted interface between the TRXUA and the composite antenna
- RIB in type 1-H is radiated interface where the OTA requirements are defined

BBU: Base band unit
TRXUA: Transmitter/Receiver Unit Array
RDN: Radio Distribution Network
Based on the draft specifications and/or other agreements in 3GPP as of Dec. 2017

BS type 1-O/2-O

• Types 1-O/2-O (OTA) has no conducted interfaces
  • Implies that testing is performed over the air (OTA) in test chambers (e.g., anechoic chambers)
  • Only OTA requirements are specified especially for FR2
Discussion

• Regulations take into account the 3GPP requirements.

• Need to discuss how to capture three sets of BS requirements for FR1 into the regulations.

• For 1-O and 2-O, and in general for integrated AAS type products, there are significant challenges and limitations in relation to test ports (for on-site testing).