EE6143: Advanced Topics in Communications
Assignment 6
5G NR Overview

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1 Introduction to 5G

5G NR *Fifth Generation: New Radio* is the technology standard for broadband cellular networks and is the successor to 4G [1]. Similar to 4G, 5G is also instituted by 3GPP (Third-generation partnership project). 5G primarily consists of three use cases:

- eMBB: enhanced Mobile Broadband Communication

- mMTC: massive Machine-Type Communication

- URLLC: Ultra-Reliable and Low-Latency Communication

The initial releases of NR support up to 52.6 GHz, a significant upgrade from the 6GHz limit of LTE.

2 NR Evolution

NR was first introduced in Release 15 of 5G and was further improved upon in Release 16.

2.1 Integrated Access and Backhaul

Integrated Access and Backhaul is an important feature of NR. This has primary applications in pico-base stations in macro cells, as the macro gNB can communicate to all other pico-base stations inside the cell. IAB is likely to use the FR2 band (mmWave) [2].

Initially, the backhaul link was made using optical fibres. However, the evolved 5G has capabilities to support *wireless* backhaul links also.

The backhaul consists of a donor node, connected using conventional backhaul. This connects wirelessly to an IAB node. This IAB node in turn may connect to further IAB nodes to form a chain.

From the UE point of you, these backhaul nodes appear as conventional gNB, so there is no special upgradation required from the user side.

2.2 Usage of unlicensed spectra

The scenario in 4G: The usage of unlicensed spectra has its origins in LTE. However, licensed spectrum is limited and expensive. LTE attempts to use unlicensed spectrum to complement licensed spectrum. *License-assisted access* is an important feature of LTE

where the primary carrier is in the licensed spectrum while there is a secondary carrier using a large amount of data in the other higher frequencies.

`NR` has features for license-assisted access and mostly reuses the standards of 4G. This is crucial for NR-LTE coexistence. However, `NR` (Rel 16) also supports standalone unlicensed operation in the DL, which does not require a primary carrier in the licensed spectrum. The primary policy for unlicensed spectrum is *listen-before-talk.*

2.3   Intelligent Transport

In `NR`, URLLC is a fundamental ideology. The main need for this is device-to-device communication. With the advent of autonomous (self-driving cars), this is essential.

There are many types in this:

- V2V: Vehicle-to-Vehicle: Inter-vehicular communication for safety.

- V2D: Vehicle-to-Device

- V2I: Vehicle-to-Infrastructure

- V2C: Vehicle-to-cloud

- V2P: Vehicle-to-Pedestrian

Platooning: Platooning uses 5G to enable vehicles to travel in close coordination, which can improve road efficiency and capacity (basically drag is reduced due to platooning). 5G is needed for platooning because it can provide ultra-low latency and high reliability to prevent clashing.

2.4   Improved GPS (positioning)

For various applications, we might need accurate positioning. In LTE, we had cellular-assisted satellite positioning. In 5G, we might also desire to have accurate positing of the `UE`indoors, and 5G Rel 16 takes care of this also.

There is a new reference signal emitted by `gNB`, called the positioning reference signal. For positioning, the device measures the time taken for messages from different base-stations to arrive there and calculated position based on that.

3   Release 17 and 18 updates

The following section is from 5G_ref1 (Ericcson Technology).

3.1   Beamforming and MIMO

The following enhancements of MIMO are noted:

- Beam management: greater mobility in FR2

- Multiple TRPs (transmission and reception points) for eMBB and URLLC: PDCCH, PUCCH are more robust

- TDD and FDD reciprocity: Better channel sounding

3.2 Power efficiency (RedCap)

Rel-17 includes power-saving enhancements for UEs. RedCap (reduced capability) devices are a major part of this. The major features are:

- Relaxed radio resource monitoring

- Extended discontinuous reception (eDRX) for latency-tolerant devices

- Reduced PDCCH monitoring during active time

- Power-efficient paging reception

The operation of RedCap `UE` are less complex than regular `UE` and the operation is half-duplex.

3.3 NR beyond 52 GHz

In Rel-17, FR2 is augmented from 52.6GHz-71GHz. This will provide greater bandwidth both in the licensed and the unlicensed spectrum.

References

[1] Erik Dahlman, Stefan Parkvall, and Johan Sköld. Chapter 5 - nr overview. In Erik Dahlman, Stefan Parkvall, and Johan Sköld, editors, *5G NR: the Next Generation Wireless Access Technology*, pages 57–71. Academic Press, 2018.

[2] Ericsson. Integrated access and backhaul.