

Wireless Networks - SSY145

Research Project Progress Report

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1 Title

5G New Radio (NR): Next Generation Radio Access Network

2 Background

This is a research work in partial fulfillment of the requirements for completing the Wireless Network Course, SSY145. The project is built on 5G New Radio (NR) as an innovation in Wireless Access Networks. This is to acquire the needed knowledge of the 5G network, the driving forces, and other related specifications by 3GPP.

3 Introduction

5G new radio (NR) is the access air interface into the 5G network. 5G NR offers a unified, and high capacity use of the air interface. It has been designed with an extended capability to enable next-generation user experiences, empower new deployment models, and deliver newer services. This is to be achieved with very high data rates in the wireless space, with superior reliability and very low latency. 5G NR covers higher data modulation, channel coding, waveform generation, network slicing, massive MIMO, frame structures, flexible numerology, hybrid automatic repeat request (HARQ), and duplexing. 5G will expand the mobile ecosystem into new realms of services, and use cases. It will improve every industry, from safer transportation, remote healthcare, precision to agriculture, to digitized logistics, and much more. Incisively, 1G, 2G, 3G, and 4G all led to 5G, which is designed to provide more connectivity than was ever available before now.

Going forward, 5G will serve as the foundation for other newer technologies. It will focus on the breakthroughs to support the expansion and enhancement of mobile internet and Internet of Things (IoT). The future 5G mobile applications defined by the International Telecommunication Union (ITU) in June 2015 are categorized into three types. They are Enhanced Mobile Broadband (eMBB), Massive Machine Type Communication and Ultra-Reliable and Low-Latency Communication.

Enhanced Mobile Broadband (eMBB) is to facilitate people-to-people exchange as a fundamental requirement set out for mobile communications. eMBB focuses on larger bandwidth and shorter, leading to a tremendous improvement of a user's perceived experience, quality of experience (QoE). Massive Machine Type Communication (mMTC) promotes the increasingly interconnected, Internet of Things (IoT) and other vertical industries, that will bring about a large number of wireless sensor networks, putting a new demand network access quantities and power consumption efficiency. Then, Ultra-Reliable and Low-Latency Communication (URLLC) revolves around Industry automation, telemedicine, smart grid, and other vertical industries that require high reliability and low latency. Consequently, the key features of the 5G NR encompass ultra-lean carrier design, Scalable OFDM based air-interface, UE Massive MIMO and beamforming, Usage of sub 6GHz and mmWave spectrum, and scalable numerology. A couple of technological solutions released and standardized over the years have actually made this a reality.

In order to meet the requirements of massive connections and ultra-high data rates, 5G networks are designed to be deployed in high-frequency bands, such as 28 GHz and 39 GHz, (attracting industrywide attention) in addition to sub-6 GHz bands. There is also room to use other higher frequencies, licensed or unlicensed. Compared with the radio propagation features of low-frequency bands, the signals in high-frequency bands are more susceptible to issues such as architecture materials, vegetation, rain attenuation, atmospheric absorption, and oxygen attenuation. Empirically, to increase data rate is to increase the bandwidth used for communication and use a better modulation technique. The wireless channel is unique as it is unguided and hence, other concerns have to be catered for the efficient use of the wireless space. It is designed to scale up to 1000MHz of bandwidth and 20Gbps data rate over the air interface.

Furthermore, 5G offers both forward and backward compatibility. It can co-exist with a 4G LTE network, using the same frequency band, and sharing physical infrastructure. This has led to 5G networking modes denoted as standalone (SA) and non-standalone (NSA).

4 Progress

A general review of the 1G,2G,3G, and 4G LTE has been done. The received lectures have also helped to clarify and buttress some points. Also, the need for a better, more efficient, and versatile mobile network has been highlighted. The architecture of the 5G network has been covered, with regards to the network elements, functionalities, the basic structure, and some technical considerations for deployment. The frame structure of the system has been covered. Others are the concepts of numerology and its importance, network slicing as related to software-defined networking (SDN) and network function virtualization (NFV). Duplexing has also been covered as regards to TDD and FDD.

Furthermore, a general overview of the 5G NR releases under 3GPP has also been done. Frequency Spectrum and Licensing has been discussed. Specifically, a couple of use cases have been reviewed too, to better see the plethora of opportunities the 5G network can offer. There is an on-going review of the 5G NR Standard, Frequency bands, and channel bandwidths, published under 3GPP TS 38.101.

5 Findings

The academic materials provided by the Professor, that are related to this topic were first considered. This is to give the needed basic understanding of the 5G network. The 3GPP publications were taken as a guide since the international body helps to harmonize the various solutions being used in 5G. Selected reference materials from the telecommunication OEM vendors were used. This is not limited to Ericsson, Qualcomm, Nokia and Huawei.

Furthermore, related audio-visual materials were also used to better clarify the abstract parts of the information, already gathered. Online-discussion among the members of the group is on-going for proper knowledge sharing. For further clarifications, the professor and the teaching assistant will be contacted.

6 Outline of Final Report

- **Abstract**
This is a concise summary of the write-up on 5G NR. It will highlight specific details to be covered.
- **Background**
This gives a study context to the write-up. It states the research question on 5G NR and clearly enunciates the usefulness of it in the technological space.
- **Introduction**
This is to establish the scope, context, and significance of the 5G NR research write-up by summarizing the current understanding and background information about the topic. Then, stating the purpose of the work in the form of the research problem, with possible outcomes and outlining the structure and organization of the paper.
- **Before 5G**
This is to give an overview of the previous mobile communication technologies before 5G, and related use cases. This is to give the foundation to why 5G NR is highly needed, going forward.
- **Architecture of the 5G Network**
This is to delve into the standard structure of the 5G network and the related network entities being used. This is also for comparison with other existing mobile communication architecture.
- **5G NR**
This is to clearly define what the 5G NR is all about. It will cover the fundamentals, the driving forces and highlight possible use cases.
- **5G NR Design**
This is to enunciate all the various technologies, solutions, considerations and specifications to achieve the 5G NR radio access network.
- **5G Standardization and Specifications**
This will dwell on what the 3GPP and other related bodies have put forward as a global standard for the 5G network

- **Spectrum Allocation for 5G**

This will look into the frequency spectrum, both licensed and unlicensed, that can be used by 5G network. It will also explain the technical thought behind the selection of the frequency bands.

- **5G and 4G LTE Coexistence**

4G LTE is the closest technology to 5G for now and they are both compatible. This will look into a co-utilization, co-location of 4G and 5G, using the same physical resources, and further expansion of such a network.

- **Deployment modes of 5G**

This will look at the practical deployment scenarios of the 5G Network

- **Benefits of 5G Network**

This will touch a selected few of the use cases for 5G NR, and concisely, on network slicing, or virtualization.

- **Conclusion**

This is the conclusion, or summary of the main points and answers gotten from the write-up.

- **References**

A comprehensive list of all the references used for the write-up.

7 List of References

The reference list can still be modified based on further review. The list below is for the references used so far. They are:

1. Ericsson Technology review, February 2020, 5G New Radio Evolution, IEEE Communications Standards Magazine, December 2017. pp 2-14
2. Stefan Parkvall, Erik Dahlman, Anders Furuskär, and Mattias Frenne. December 2017, “NR: The New 5G Radio Access Technology”, IEEE Communications Standards Magazine, December 2017 pp. 24-30,
3. SHIV K. BAKHSHI, Ph.D., February 2018, “5G and standards: managing complexity, ensuring interoperability”. Ericsson presentation. pp 2-18
4. GSMA publication, April 2018, Road to 5G: Introduction and Migration. pp 6-27
5. Qualcomm Technologies, Inc. September, 2016. Making 5G NR a reality Leading the technology innovations for a unified, more capable 5G air interface. pp 2-63

6. Qualcomm Technologies Inc., September 2018, Expanding the 5G NR ecosystem. 5G NR roadmap in 3GPP Release 16 and beyond. pp 3-25
7. Amitabha Ghosh, Nokia, May 2018, “5G New Radio (NR): Physical Layer Overview and Performance”, IEEE Communication Theory Workshop 2018. pp 2-37
8. Joaquin RESTREPO, September 2019, “Spectrum Allocation for 5G International Framework , Workshop on Economics, Finance and Business models for 5G and new Technologies for Digital Africa (RED-AFR19)”, pp. 2-33
9. Alexander Serbin, May 2018, “On the roads to 5G: theory and practice”. Huawei Technologies, ITU Seminar .pp 2-18
10. 3GPP publication. The 5G Evolution: 3GPP Releases 16-17, Jan 2020 .pp 22-27
11. Qualcomm Technologies Inc. ,December 2017, “What can we do with 5G NR Spectrum Sharing that isn’t possible today?” Available at <https://www.qualcomm.com/media/documents/files/new-3gpp-effort-on-nr-in-unlicensed-spectrum-expands-5g-to-new-areas.pdf>. pp. 4-32