Simulation and Performance Analysis of PDSCH in 5G NR

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Abstract**:** ***5G is the new upcoming digital wireless communication network, which has high speed data transmission cellular network also called as New Radio (NR). It is industry associated third generation partnership project (3GPP) defines any system using "5G NR". Beyond the speed, it will allow many new mobile capabilities to be realized-high data capacity, low latency and IoT capability. The major research issue for 5G is to design fruitful and trustworthy Physical Downlink Shared Channels (PDSCH). In this paper, the design, simulation and its results are discussed, based on different parameter like subcarrier spacing and modulation schemes such as 64QAM and 256QAM techniques using MATLAB. The overall discussion and its conclusion will benefit to develop the better 5G communication system.***

Keywords: 5G, PDSCH, QAM, Simulation

I. INTRODUCTION

Digital 5G cellular network uses millimeter waves, which provides short range of communication. The antenna used for communication is of smaller size (Several Centimeters). In order to enhance the data rate, Multiple-Input-Multiple-Output (MIMO) concept is used; each cell consists of several antennas communicating with the wireless device, thus multiple bit streams of data will be transmitted simultaneously in parallel. The 5G systems consist of mainly three channels such as transport, logical, and physical channels, these interns subdivided into downlink and uplink channels. The downlink consist of Paging Channel (PCH), Broadcast Channel (BCH), Downlink Shared Channel (DL-SCH), Physical layer Downlink Shared Channel (PDSCH), Physical Downlink Control Channel (PDCCH).Uplink channel consist of Uplink layer Shared Channel (UL-SCH), Physical Downlink Shared Channel (PUSCH), Physical Downlink Control Channel (PUCCH). 5G wireless mobile network uses Orthogonal Frequency Division Multiple Access (OFDMA) technique, which is a one of the popular modulation scheme in digital modulation and has capable of converting the wide-band frequency selective channel into a set of multiple fading sub-channels. These channels have the capability of acceptance from optimum receivers, even in case of MIMO transmission with sensible complication. PDSCH has most of the utility to support numerous MIMO transmissions, Hybrid Automatic Repeat Request (HARQ), MAC layer scheduling and many additional functions. This paper describes and analyzes the 5G physical channel (Downlink) based on 3GPP criterion. The proposal implements a standard compliant of 5G downlink with its major description being Error checking, MIMO transmission and Adaptive Modulation and Coding (AMC). It can be used to calculate the performance of PDSCH and afford the useful reference for the realistic design of 5G system.

The paper is structured as defined: In Section 2, the overview of PDSCH is illustrated in proper way. The simulation results and conclusion are expressed in Section 3 and 4.

II. THE DESIGN OF PHYSICAL DOWNLINK SHARED CONTROL CHANNEL

The physical channel (PDSCH) holds encoded client data and paging information to that of User Equipment (UE) on a dynamic as well as opportunistic basis. In fig. 1, it shows how the transmission block is passed to DL-SCH, which gives output of 1 or 2 codeword and information of every codeword are encrypted as well as modulated to produce a chunks of complex-valued modulation symbols. The symbols are mapped on up to 4 MIMO layers. A PDSCH can have two codeword to support up to 8-layer transmission. The layers are linked to antenna ports in a requirement transparent manner, hence beam forming or MIMO precoding process is carried to network implementation and transparent to the UE. For every antenna ports (layers) used for broadcast of the PDSCH, The RBs are assigned with symbols.

A.Downlink Shared Channel (DL-SCH)

DL-SCH channel holds client data as well as other pieces of information such as different type of System Information Block (SIB). The coding chain consist of Rate Matching, Code block (CB) Segmentation, cyclic redundancy code (CRC), LDPC and CB. In the above fig. 2, Transport block is forwarded to CRC which first appends error detection code, followed by section of the transport block into code blocks and code block CRC attachment are achieved. Each code block is independently Low Density Parity Check Code (LDPC) encoded. LDPC is a channel encoding technique which clears errors of the channel by defining parity bits for a selection of the data bits. Later, LPDC coded blocks they are independently rate matched.

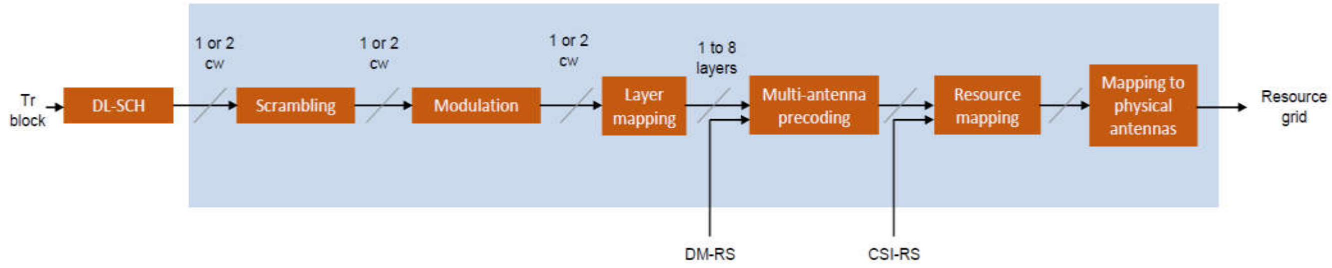


Fig. 1: Physical layer processing chain of PDSCH

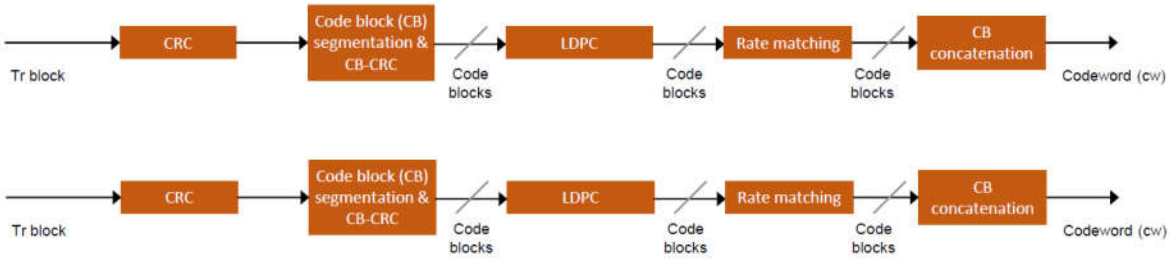


Fig. 2: Physical layer processing chain of Downlink Shared Channel

The essential purpose of rate matching module is to match the number of bits that can be broadcasted in the afford allocation to the number of bits in transport block and it also engage sub-block interleaving, bit collection and pruning. Ultimately, code block concatenation is done to produce a codeword and maximum to 2 codeword can be broadcasted at the same time on the PDSCH. Physical channels correspond to a set of time-frequency resources used for broadcasting of particular transport channel data, control or indicator information. Each transport channel data and control, indicator information is mapped to its respective physical channel and it is further classified as PBCH, PDSCH and PDCCH.

B. PDSCH Scrambling and Modulation

Maximum of two codeword can be broadcasted in a subframe and for each codeword; the data bits are scrambled with a various verity of scrambling patterns. The scrambling pattern is initialized at the start of every subframe and depends on RNTI, NCellID, NSubframe and the codeword index. The modulation scheme used form PDSCH are 'QPSK', '16QAM', '64QAM', or '256QAM' and these specifies modulation category of the codeword and the number of bits used per modulation symbol.

C. PDSCH Layer Mapping

The intricate modulated symbols are further mapped to single or many layers as per the transmission standards used. The ports used for single layer are generally 0, 5, 7 or 8 and usually for the broadcast diversity, only single codeword is permitted. Generally the number of layers such as 2 or 4 should be equivalent to various antenna ports that are used for the broadcast of the physical channel. For spatial multiplexing, codeword (1 or 2) can be broadcasted on up to 8 layers. The number of communication antenna ports larger than or equivalent to number of layers to be used for broadcast of the physical channel.

D. PDSCH Multi-Antenna Precoding and Resource Mapping

Precoding is the operation that map’s the layers to as many or more antenna ports. Multiple layers undergo precoding antenna ports using a matrix multiplication with the pre corner. the special case of precoding is mapping one layer to multiple antennas which enables beam forming for line-of-sight transmission this would likely mean targeting particular direction another case of precoding is mapping several layers to multiple antennas this more general case is sometimes referred to as spatial multiplexing one key aspect of precoding in 5G is that the associated demodulation reference signals or DM-RS must undergo the same precoding as a result the UE doesn’t need to be made aware of pre coder as the effect of a pre coder is included in channel estimation this is why the exact pre coder the GnodeB is to use is not specified in the standard the pre-code specified in the standard the pre-coder out is further linked to physical resource blocks either directly or indirectly. PDSCH initially mapped to virtual resource blocks (VRB) one mapped to grid PDSH symbols avoid locations reserved for other purposes, this includes all physical signal DMRS, CSI-RS. Mapping of VRB to physical resource blocks are interleaved or Non-interleaved mapping. Non Interleaved Mapping consists directly mapping each virtual block to the same position in the physical resource grid. Interleaving mapping provides frequency diversity by distributing virtual blocks over the whole bandwidth part. The Interleaving granularity is 2 or 4 resource blocks this scheme let’s assign consecutive virtual resource block to a PDSCH pattern that is easy to signal simply with a resource block and number of resource block while still getting frequency diversity. In this paper, we measure the PDSCH throughput performance parameter of a 5G NR and realize the transport and physical communication channels.

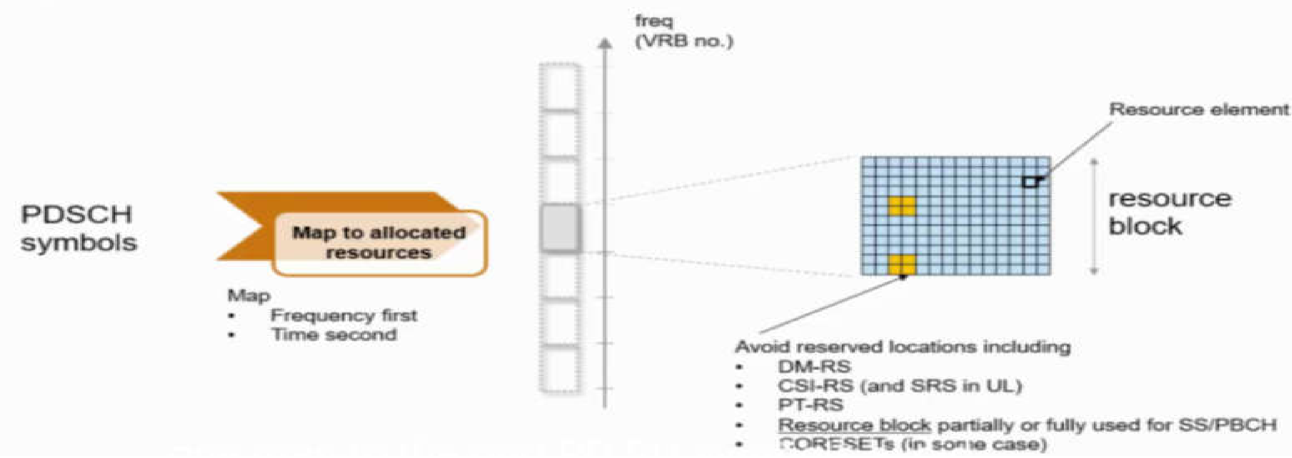


Fig. 3: Mapping to VRB

Parameters Used	*Values*
Signal to Noise Ratio(dB) Range	-5,0,5
Number of 10ms Frames	2
Modulation Technique	64QAM and 256QAM
Number of UE Receive Antenna	2
Subcarrier Spacing(kHz)	15, 30, 60, 120, 240
Number of PDSCH Layers	2
PDSCH Transmission Antennas	8
Number of Codewords	2
PDSCH symbol allocation in each slot	0:13
Propagation Channel Type	CDL

Table I. Parameter settings for different subcarrier Spacing/mapping techniques in the simulation

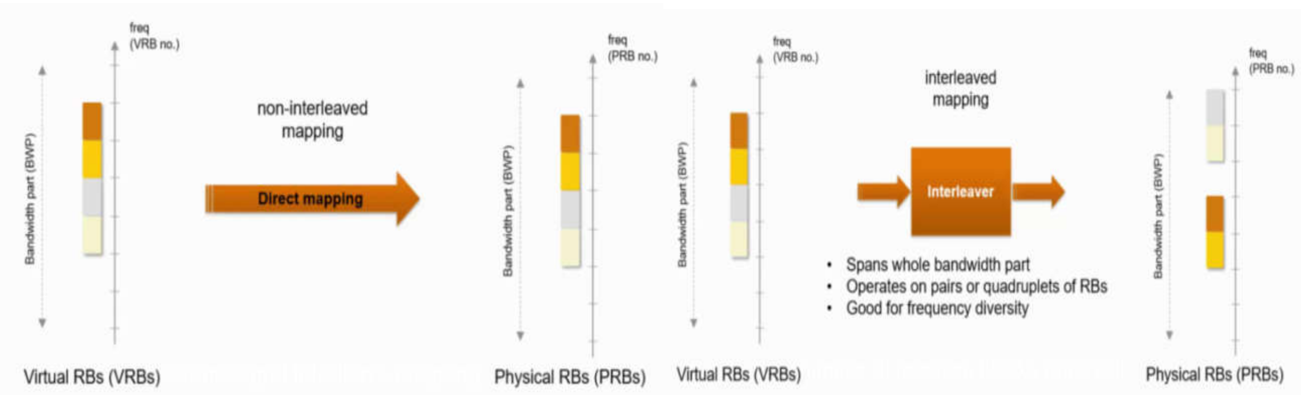


Fig. 4: Mapping from Virtual RBs to Physical RBs

Subcarrier Spacing (kHz)	*Mapping Technique*	*Throughput (%)*
15	64QAM/256QAM	20/20
30	64QAM/256QAM	40/40
60	64QAM/256QAM	40/40
120	64QAM/256QAM	50/50
240	**64QAM/256QAM**	**100/50**

Table II. Subcarrier Spacing and Throughput for different mapping techniques at SNR (5 dB)

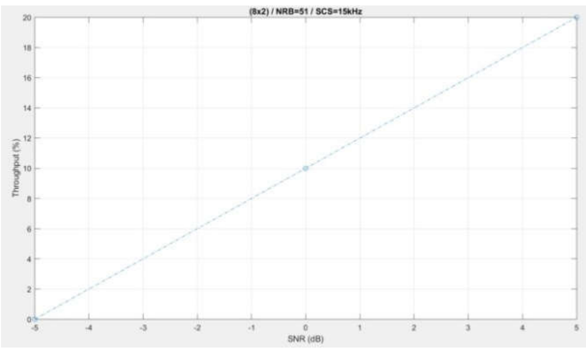
Subcarrier Spacing (μ)	Number of OFDM Symbols per Slot (N_{symb}^{slot})	Number of Slots per Subframe ($N_{slot}^{subframe,\mu}$)	Number of Slots per Frame ($N_{slot}^{frame,\mu}$)
0 15 kHz	14 1 ms	1 1 slot x 1 ms = 1 ms	10 10 ms
1 30 kHz	14 500 μs	2 2 slots x 500 μs = 1 ms	20 10 ms
2 60 kHz (normal CP)	14 250 μs	4 4 slots x 250 μs = 1 ms	40 10 ms
2 60 kHz (extended CP)	12 250 μs	4 4 slots x 250 μs = 1 ms	40 10 ms
3 120 kHz	14 125 μs	8 8 slots x 125 μs = 1 ms	80 10 ms
4 240 kHz	14 62.5 μs	16 16 slots x 62.5 μs = 1 ms	160 10 ms

Table III. Frame Structure

III. SIMULATION RESULTS

This section shows the experiment result of a 5G NR link and its performance parameters, as expressed according to standard of 3GPP NR. The outcome of simulation, describes the highest achievable throughput of the link provided by the existing resources for data communication. The graph defines the throughput over Signal to Noise ratio (SNR) across all antennas. Subcarrier Spacing of 240 kHz with 64 QAM modulation scheme produces 100% of throughput, whereas 15 kHz with 64QAM/256QAM provides very low throughput of 20%.

In 5G wireless technologies, we have variable subcarrier spacing, greater the value more the number of slots per frame, lesser the symbol duration (up to 4μs), and maximum bandwidth (up to 400MHz), minimum scheduling interval (up to 0.06ms) and provides better performance. (up to 400MHz), minimum scheduling interval (up to 0.06ms) and provides better performance.



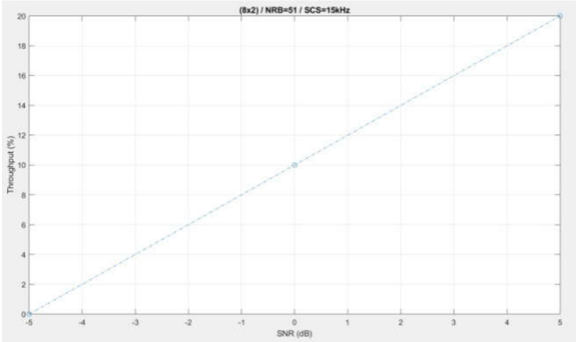
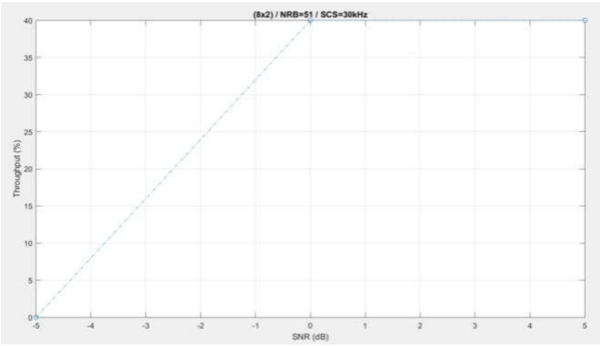


Fig. 5 (a) and (b): Throughput (%) versus SNR (dB) with 64QAM, 256QAM Modulation Scheme and subcarrier spacing of 15 kHz



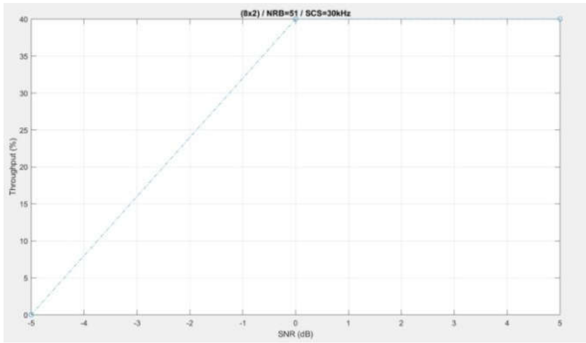
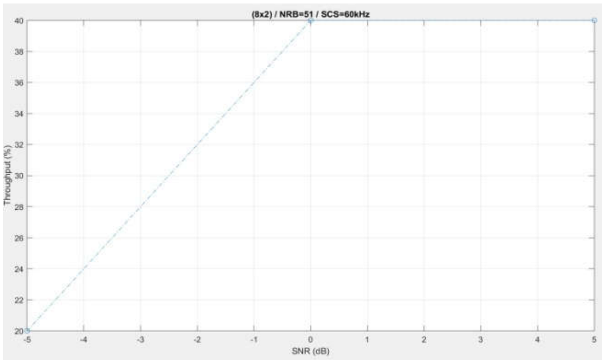


Fig. 5 (c) and (d): Throughput (%) versus SNR (dB) with 64QAM, 256QAM Modulation Scheme and subcarrier spacing of 30 kHz



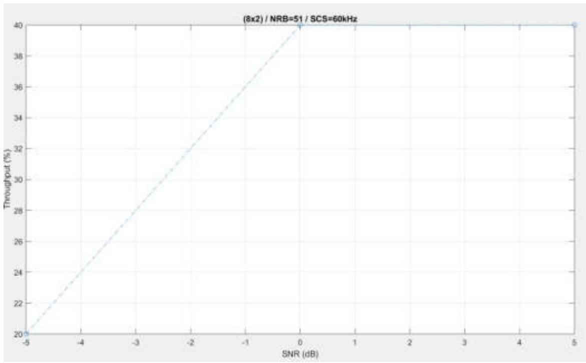
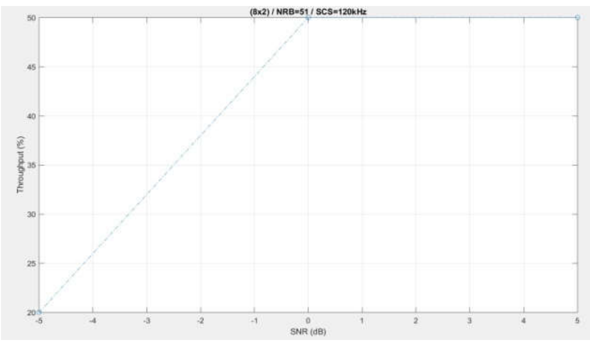


Fig. 5 (e) and (f): Throughput (%) versus SNR (dB) with 64QAM, 256QAM Modulation Scheme and subcarrier spacing of 60 kHz



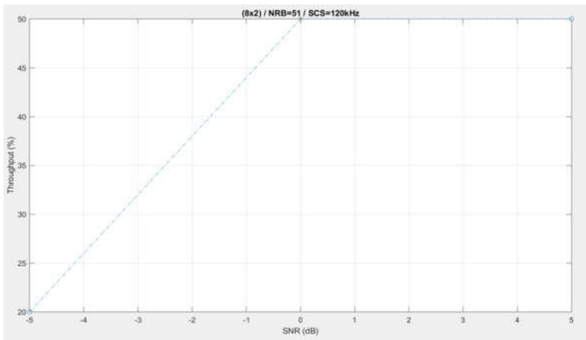
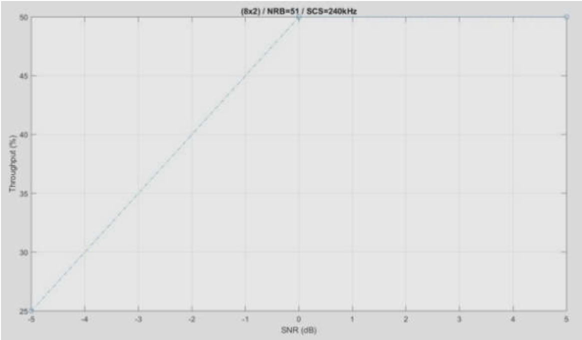


Fig. 5 (g) and (h): Throughput (%) versus SNR (dB) with 64QAM, 256QAM Modulation Scheme and subcarrier spacing of 120 kHz



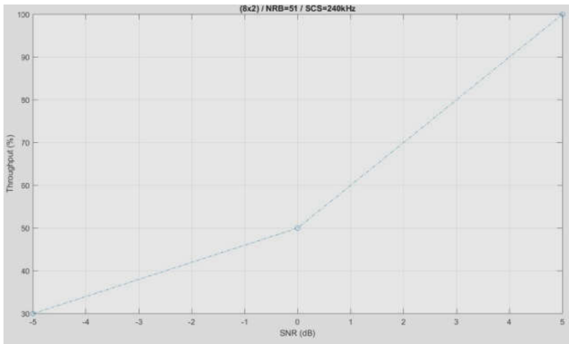


Fig. 5 (i) and (j): Throughput (%) versus SNR (dB) with 64QAM, 256QAM Modulation Scheme and subcarrier spacing of 240 kHz

IV. CONCLUSION

The next generation, digital 5G cellular network uses millimeter waves, which provides short range of communication. The data rate is enhanced by using MIMO technique; each cell consists of several antennas communicating with the wireless device, thus multiple bit streams of data will be transmitted simultaneously in parallel. This paper have provided an outline of the fundamental of 3GPP NR condition defining the state of art in 5G wireless system, with a focus on the physical layer. The simulation result concludes that the throughput performance of a 5G NR link, as expressed by 3GPP NR criterion is high in case of subcarrier spacing of 250 kHz, 64QAM modulation with 8*2 antenna feature.

V. REFERENCES

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