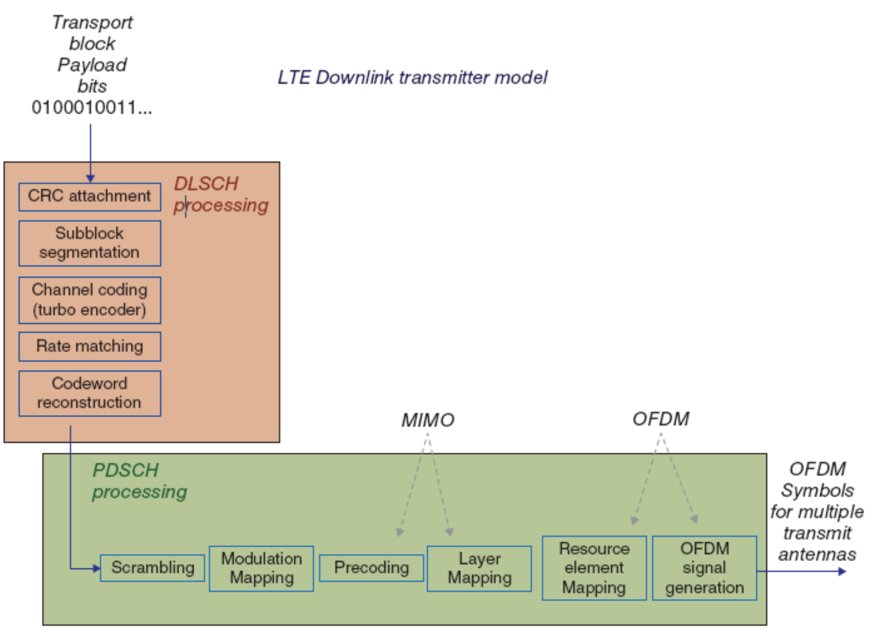
SDMN-Wireless HW 2 – EE Dept SUT –

Due Date 28 Esfand 1398

LTE Link-level Simulations using MATLAB

The LTE (Long Term Evolution) downlink PHY (Physical Layer) chain can be viewed as the combination of processing applied to the Downlink Shared Channel (DLSCH) and Physical Downlink Shared Channel (PDSCH). These include a series of processing steps mapping the logical channels and user bit payload to code-words which are then passed to the shared physical channel, involving e.g. Cyclic Redundancy Check (CRC) code attachment, channel coding based on standard LTE turbo coders, rate matching and modulation. The baseband signal processing chain applied to the combination of DLSCH and PDSCH (illustrated in the block diagram below) can be summarized as follows:

- Transport-block CRC (Cyclic Redundancy Check) attachment
- Code-block segmentation and code-block CRC attachment
- Turbo coding based on a one-third rate
- Rate matching to handle any requested coding rates
- Code-block concatenation to generate code-words
- Scrambling of coded bits in each of the code-words to be transmitted on a physical channel
- Modulation of scrambled bits to generate complex-valued modulation symbols
- Mapping of the complex-valued modulation symbols on to one or several transmission layers
- Precoding of the complex-valued modulation symbols on each layer for transmission on the antenna ports
- Mapping of complex-valued modulation symbols for each antenna port to resource elements
- Generation of complex-valued time-domain OFDM signal for each antenna port



The sequence of operations performed at the receiver side can be regarded as the inverse of those described above.

1. PHY Layer Performance Evaluation

Based on the implementation of an LTE transceiver algorithm comprising a combination of CRC generation, turbo coding, scrambling, and modulation and their inverse operations while excluding MIMO and OFDM processing modules and taking a simple **Additive White Gaussian Noise (AWGN)** channel model into account where no fading or multi-paths exists:

i. Illustrate the performance of the LTE PHY Layer (DLSCH + PDSCH) in terms of Block Error Rate (BLER) versus Signal-to-Noise Ratio (SNR) in dB for the *QPSK* modulation scheme using LTE specific Turbo coding of the rate 1/3 when the number of decoding iterations varies *from 1 to 6* and show the BLER performance becomes successively better with a greater number of iterations. Moreover, compare the BLER performance using *early-termination criteria* based on CRC checking indication mechanism for updating the state of HARQ.

ii. Figure out the BLER performance versus SNR with different coding rates (rather than 1/3) varying form *0.3 to 0.95 with step size of 0.05*, while implementing the CRC-based early-termination mechanism and applying rate-matching operations, for the modulation schemes *QPSK, 16QAM and 64QAM*.

iii. Based on selecting the Modulation Coding Scheme (MCS) driven from (ii) which leads to the maximum achievable throughput of LTE for BLER = 10%, depict the effective Rate-to-SNR mapping function. Moreover, illustrate the throughput (bit/Hz) according to different SNRs.

2. OFDM and Channel Equalization

The operations described above completely specify how user data bits are processed to produce the input symbols for the subsequent MIMO and OFDM functional blocks for transmission. However, most real channels add to the transmitted signal various forms of fading and other correlated distortions. These fading profiles introduce inter-symbol interference, which must be compensated using equalization.

Here considering more realistic channel models while dealing with dynamic channel response due to **small-scale fading effects** such as multipath fading along with an AWGN channel model for a **Single Input Single Output (SISO)** configuration and *64QAM* modulation scheme:

i. Investigate channel effects by demonstrating the frequency response of the transmitted and received signals within the transmission bandwidth together with the constellation of the received signal, i.e. In-phase/Quadrature Amplitude, with different fading delay profiles realizing *Flat-fading and Frequency Selective Channel.*

ii. Finally, integrate a Resource Mapping module, which places the components of the resource grid in the locations specified in the standard, followed by an OFDM signal Generator to the components developed so far and the inverse of these operations at the receiver, respectively. Then by applying a *Zero Forcing (ZF) frequency-domain equalization* of the OFDM signal at the receiver illustrate an improvement of spectral efficiency when comparing the frequency spectrum of received signal with and without equalization together with the spectrum of transmited signal over a *frequency-selective fading channel*. Moreover, perform the same comparison in terms of the received signal constellation.

Important Parameters

SampleRate = 30.72e6;
PathDelays = [0 10 20 30 100];
AvePathGains = [0 -3 -6 -8 -17.2];
MaximumDpplerShift = 0;
maxNumErrs = 5e7;
maxNumBits = 5e7;
BW = 20e6;

Deliverables: the *simulation m.files* generating the results of individual parts, all generated *mat.files* comprising the output data and the *plotting m.files* demonstrating the outputs.
For each sub-task please submit only one main m.file generating the results given different input variables, e.g. modulation mode, code rate, and etc., to be saved in different mat.files and also one plotting m.file which loads these mat.files and generates the plots.

Due date: 18th May, 2020 (28th Esfand, 1398)

Supplementary Material: *Understanding LTE with MATLAB: From Mathematical Modeling to Simulation and Prototyping*, John Wiley & Sons, 2014