LteSystem User Guide

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Quick Start

To perform your first simulation using the LteSystem Toolbox with the default parameters open a new MATLAB® session, move to the installation folder and run the LteSystem.m script.

The default configuration corresponds to a simulation duration of 50 subframes, 10 category-1 UEs randomly dropped inside a cell of 500 meter radius, an eNodeB with one antenna port, transmission bandwidth of 14 resource blocks, 8 H-ARQ processes per user, a common UE speed of 3 km/h, a 'UE-selected' periodic reporting mode and use of the 3GPP Spatial Channel Model (Suburban Macro scenario) with correlated shadow fading.

Parameter Configuration

The user-configurable LteSystem parameters are contained inside the LteSystem_config function. This can be edited accordingly in order to perform custom system-level simulations.

Note: The evaluation version of LteSystem has the following restrictions

Simulator functionality:

- Up to 100 subframes are allowed
- The transmission bandwidth is fixed to 14 resource blocks
- The number of antennas at the eNodeB is limited to one
- Only UE-category 1 users are allowed.

Function visibility:

- Only MATLAB code for high-level functions (LteSystem, LteSystem_config, scheduler_PF, Lte_DL_nopdsch and Lte_DL) is visible to the user. The commercial version allows access to lower level functions as well.

Parameter Initialization

LteSystem_init handles the simulation parameter initialization based on the configuration structures provided by LteSystem_config and sets additional parameter structures.

Running the simulation

After the configuration/initialization of the simulator, the LTE resource grid is initialized for one radio frame. This includes the generation of the values and the locations of the physical signals (reference, synchronization) and control channels (PBCH and PDCCH) in the resource grid. These are fixed throughout the simulation and therefore are only generated once from the function phy_signals.

The simulation then proceeds on a per-subframe basis. The channel response of each user is generated via the get_channel_response function.

Next, the simulation proceeds on a per-user basis. The LTE Tx-Rx downlink physical layer is simulated by the Lte_DL and Lte_DL_nopdsch functions. Given the resource allocation and modulation and coding scheme selection, Lte_DL is accessed when a user is scheduled for PDSCH transmission, whereas Lte_DL_nopdsch is accessed when a user is not scheduled and only needs to perform channel estimation to support the uplink feedback.

Lte_DL outputs the updated parameter structures (DL_INFO, CHANNEL, HARQ_INFO) as well as the simulation results structure RESULTS per user. On each subframe, information about the current subframe (SF) number, the UE id, the (re)transmission number of the current HARQ process and the resulting transmission status of the current transport block (ACK/NACK/DROP) per codeword is displayed.

Lte_UL is an simplified uplink implementation which provides the needed functionality to allow CQI/PMI/RI estimation and reporting. Lte_UL outputs structures UPLINK and REPORTING which contain the uplink reports and reporting information, respectively.

Then, the lower Medium Access Control (MAC) sub-layer is accessed. LteSystem provides two basic functionalities: 1) Scheduling and, 2) Link-adaptation.

The MAC scheduler is composed by functions Lte_SC and scheduler_PF. LTE_SC updates the stored CQI value and age information of the users' reports. scheduler_PF performs frequency dependant resource allocation given a proportional fair (PF) scheduling algorithm which can be adjusted towards 'Maximum cell throughput' or 'User fairness' by fixing the PF numerator and denominator exponent values. For more information on scheduling please refer to scheduler_PF.

Link adaptation is performed in Lte_LA and its functionality includes rank adaptation, precoding matrix selection as well as modulation and coding scheme selection, given the CQI and the allocated resource blocks per user.

Finally, if plotting is enabled, the function LteSystem_plots provides several graphical representations.

The LteSystem plots are composed of the 5 graphs indicated below (see Best CQI example):

1. *User legend*. Each user is matched to a specific color shown in the legend

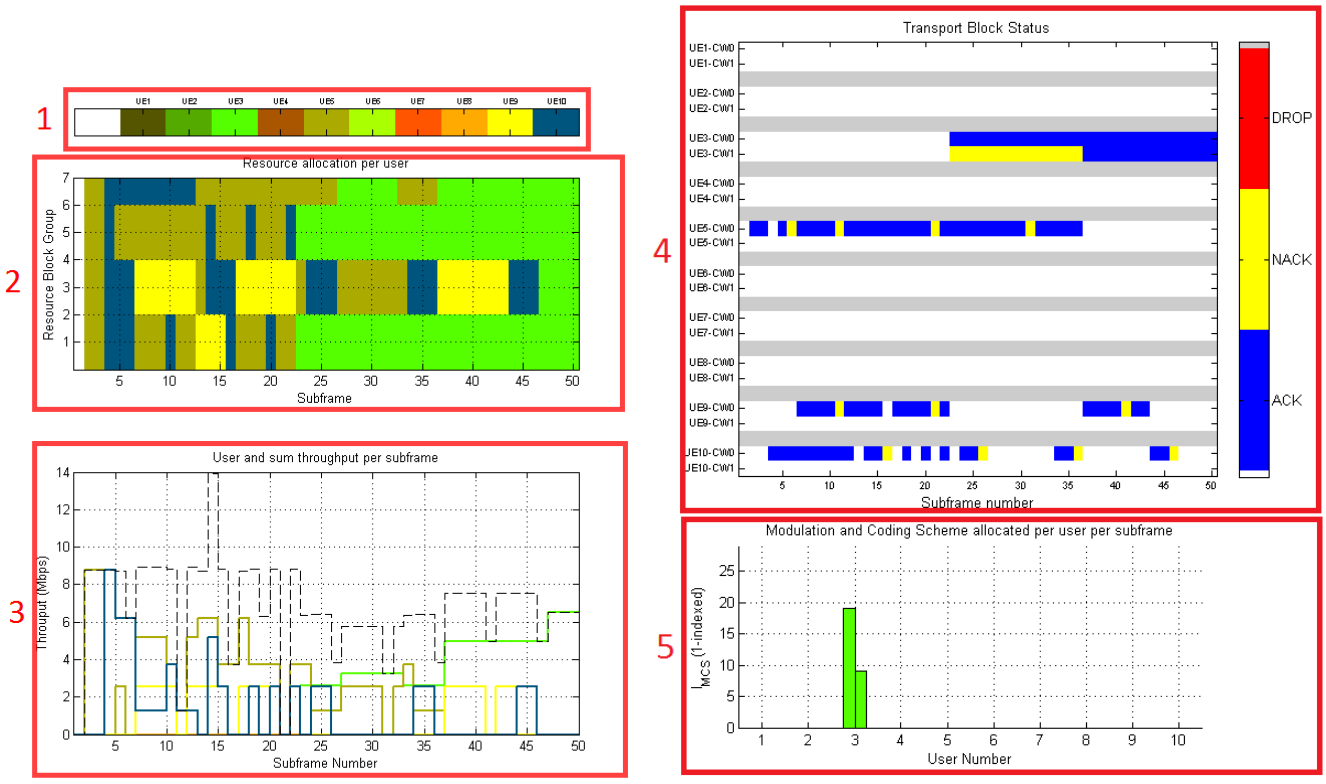
2. *Resource allocation*. This graph depicts the time/frequency resource allocation decisions of the scheduler
3. *User and Cell throughput*. Graphical representation of each user's throughput per subframe, plotted along with the cell sum-throughput (dashed line)
4. *User TBS status*. This plot demonstrates the UEs' transport block status (ACK/NACK/DROP) per codeword whenever a UE is scheduled for PDSCH transmission
5. *User MCS*. This graph displays the modulation and coding scheme per codeword (1-indexed values) of the scheduled users per subframe

Example

Below you can see the simulation results for three different scheduling techniques by adjusting the proportional fair numerator and denominator exponent. These cases correspond to the 'Best CQI', 'Round Robin' and 'Proportional Fair' scheduling strategies, respectively.

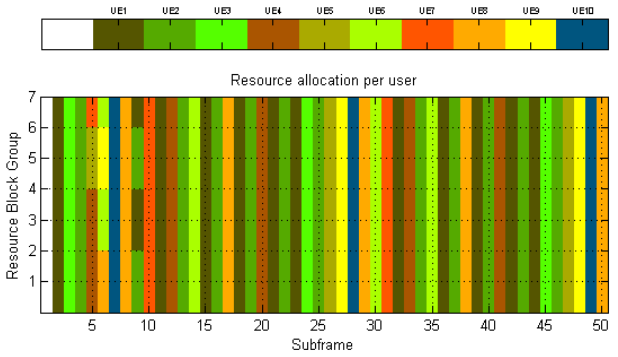
Best CQI

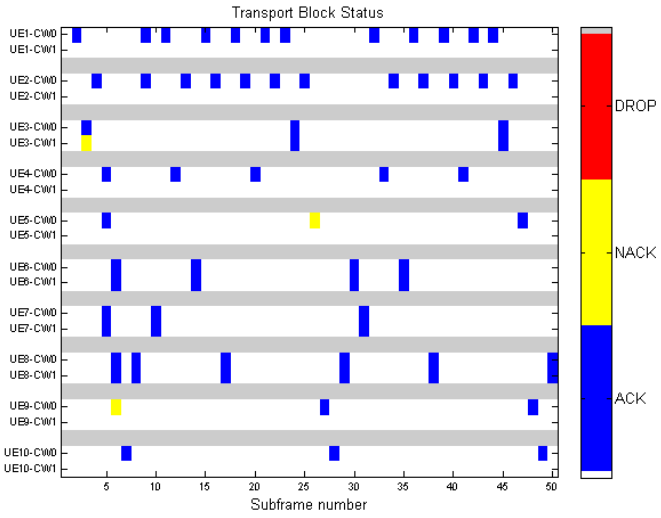
Best CQI aims to maximize the cell throughput by scheduling the user with the best channel conditions for every resource block group. This technique can be achieved by setting the PF numerator and denominator exponents to 1 and 0, respectively. Running the simulator with these values for 10 users (2 users per UE-category) and the default parameter setup, we get the results shown below.

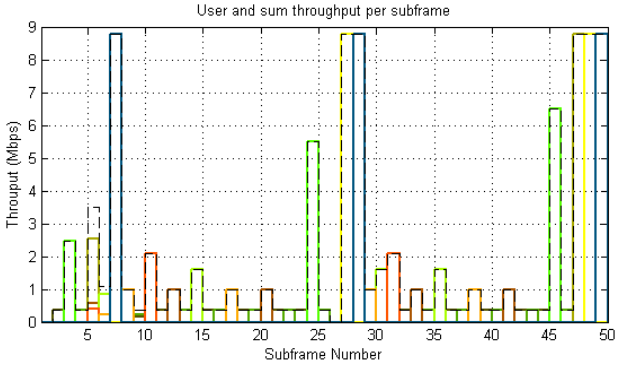


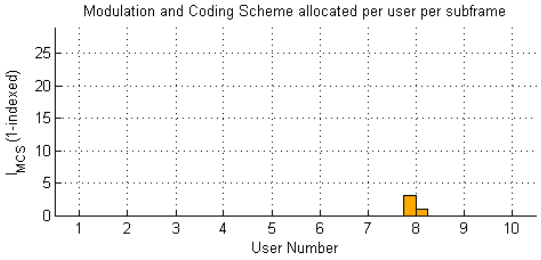
Round Robin

By setting the PF numerator and denominator exponents to 0 and 1 respectively, the scheduler takes decisions based only on the throughput achievement during the specified time-window. Hence, this scheduling technique aims to keep a certain allocation fairness between the users. By changing the duration of the time-window we can adjust the scheduler's long or short-term fairness.









Proportional fair

Setting both the PF numerator and denominator exponents to 1, leads to a balanced performance between maximum cell throughput and user fairness.